NORTH ATLANTIC TREATY ORGANIZATION

SCIENCE AND TECHNOLOGY ORGANIZATION

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STO TECHNICAL REPORT **TR-MSG-140**

Urban Combat Advanced Training Technology Live Simulation Standards

(Normes de simulation instrumentée de la technologie avancée d'entraînement au combat urbain)

Final Report of Modelling and Simulation Group MSG-140.

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The NATO Science and Technology Organization

Science & Technology (S&T) in the NATO context is defined as the selective and rigorous generation and application of state-of-the-art, validated knowledge for defence and security purposes. S&T activities embrace scientific research, technology development, transition, application and field-testing, experimentation and a range of related scientific activities that include systems engineering, operational research and analysis, synthesis, integration and validation of knowledge derived through the scientific method.

In NATO, S&T is addressed using different business models, namely a collaborative business model where NATO provides a forum where NATO Nations and partner Nations elect to use their national resources to define, conduct and promote cooperative research and information exchange, and secondly an in-house delivery business model where S&T activities are conducted in a NATO dedicated executive body, having its own personnel, capabilities and infrastructure.

The mission of the NATO Science & Technology Organization (STO) is to help position the Nations' and NATO's S&T investments as a strategic enabler of the knowledge and technology advantage for the defence and security posture of NATO Nations and partner Nations, by conducting and promoting S&T activities that augment and leverage the capabilities and programmes of the Alliance, of the NATO Nations and the partner Nations, in support of NATO's objectives, and contributing to NATO's ability to enable and influence security and defence related capability development and threat mitigation in NATO Nations and partner Nations, in accordance with NATO policies.

The total spectrum of this collaborative effort is addressed by six Technical Panels who manage a wide range of scientific research activities, a Group specialising in modelling and simulation, plus a Committee dedicated to supporting the information management needs of the organization.

- AVT Applied Vehicle Technology Panel
- HFM Human Factors and Medicine Panel
- IST Information Systems Technology Panel
- NMSG NATO Modelling and Simulation Group
- SAS System Analysis and Studies Panel
- SCI Systems Concepts and Integration Panel
- SET Sensors and Electronics Technology Panel

These Panels and Group are the power-house of the collaborative model and are made up of national representatives as well as recognised world-class scientists, engineers and information specialists. In addition to providing critical technical oversight, they also provide a communication link to military users and other NATO bodies.

The scientific and technological work is carried out by Technical Teams, created under one or more of these eight bodies, for specific research activities which have a defined duration. These research activities can take a variety of forms, including Task Groups, Workshops, Symposia, Specialists' Meetings, Lecture Series and Technical Courses.

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List of Acronyms

AAR	After Action Review
AG	Architecture Group (MSG-098)
AMSP	Allied Modelling and Simulation Publication
APC	Armoured Personnel Carrier
ASM	Air Space Management
AWE	Area Weapon Effect
BCT	Brigade Combat Team
BIT(E)	Built In Test (Equipment)
BLUFOR	Blue Forces (friendly)
BMS	Battlefield Management System
C2SIM	Command and Control Systems - Simulation
C4I	Command, Control, Communications, Computers and Intelligence
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
CBML	Coalition Battle Management Language
CBRNe	Chemical, Biological, Radioactive, Nuclear and Explosives
COTS	Commercial Off-The-Shelf
CSS	Combat Service Support
CTC	Combat Training Centre
DDS	Data Distribution Service
DIS	Distributed Interactive Simulation
DO	Dynamic Object
DSEEP	Distributed Simulation Engineering and Execution Process
EOD	Explosives Ordnance Disposal
EW	Electronic Warfare
EXCON	Exercise Control
FA	Functional Architecture
FARP	Forward Armament and Refuel Point
FOM	Federation Object Model
FTP	File Transfer Protocol
GPS	Global Positioning System
GÜZ	GefechtsübungsZentrum Heer
HLA	High Level Architecture
ID	Identification
IDL	Interface Definition Language
IED	Improvised Explosive Device
IEEE	Institute of Electrical and Electronics Engineers
IR	Infrared
ISTAR	Intelligence, Surveillance, Target Acquisition, and Reconnaissance
IUC	International User Community

JCATS	Joint Conflict and Tactical Simulation
JSON	JavaScript Object Notation
L2L	Live To Live
LRF	Laser Range Finder
LRR	Long Range Radio
LSS	Live Simulation Standards
LTEC	Live Training Engagement Composition
LVC	Live Virtual Constructive
MBSE	Model-Based Systems Engineering
MCTC	Mobile Combat Training Centre
MILES	Multiple Integrated Laser Engagement System
MLTIS	Multinational Live Training Interoperability Study
MOUT	Military Operations in Urban Terrain
MSaaS	Modelling and Simulation as a Service
MSDL	Military Scenario Definition Language
MSG	Modelling and Simulation Group
NAAG	NATO Army Armaments Group
NAF	NATO Architecture Framework
NATO	North Atlantic Treaty Organization
NC	Network Controller
NETN	NATO Education and Training Network
NGVA	NATO Generic Vehicle Architecture
NMSG	NATO Modelling and Simulation Group
O/C	Observer Controller
OPFOR	Opposing Forces
ORBAT	Order of Battle
PDG	Product Development Group
PDU	Protocol Data Unit
PfP	Partnership for Peace
PSG	Product Support Group
RC-IED	Radio Controlled Improvised Explosive Device
REST	Representational State Transfer
RPR-FOM	Real-time Platform-level Reference Federation Object Model
RTMP	Real Time Messaging Protocol
RTO	Research and Technology Organisation
SE	Systems Engineering
SG	Standards Group (MSG-099)
SIMPLE	Standard Interface for Multiple Platform Link Evaluation
SISO	Simulation Interoperability Standards Organization
SOA	Service Oriented Architecture
SRR	Short Range Radio
STANAG	Standardisation Agreement
STO	Science and Technology Organisation
STOG	Simulation Training and Operations Group
STOG-L	Simulation Training and Operations Group – Land
STOG NG	Simulation Training and Operations Group New Generation

TAP	Technical Activity Proposal
TBD	To Be Defined / To Be Determined
TCP/IP	Transmission Control Protocol/Internet Protocol
TENA	Test and Training Enabling Architecture
TESS	Tactical Engagement Simulation System
TG	Task Group
TOR	Terms Of Reference
UAV	Unmanned Aerial Vehicle
UCATT	Urban Combat Advanced Training Technology
UDP	User Datagram Protocol
U-FOM	UCATT Federation Object Model
U-LEIS	UCATT- Laser Engagement Interface Standard
U-NITE	UCATT Networking Instrumentation and TESS Equipment
USB	Universal Serial Bus
VPN	Virtual Private Network
WAN	Wide Area Network
WG	Working Group

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Urban Combat Advanced Training Technology Live Simulation Standards

(STO-TR-MSG-140)

Executive Summary

The Urban Combat Advanced Training Technology (UCATT) effort consists of several consecutive Task Groups (TG) within the NATO Modelling and Simulation Group (NMSG): MSG-032, MSG-063, MSG-098, MSG-099 and MSG-140. Related to this are the SISO UCATT Product Development Group (PDG) and the UCATT Product Support Group (PSG).

The UCATT aim is to identify, create and maintain a standard set of interfaces that enable interoperability of live training components without inhibiting future research and enhancements. Initially focussed on the urban environment, the UCATT family of standards is applicable for live training exercises in many different operational environments. Prior to MSG-140, UCATT has provided NATO with a site register, a generic Functional Architecture of live training systems, the identification of interfaces and their associated datasets that need to be standardised in order to enable different levels of interoperability, a documented live interoperability demonstration, best practices and a usable SISO standard for a laser engagement interface (the UCATT Laser Engagement Interface Standard U-LEIS).

The objective of MSG-140 "UCATT Live Simulation Standards" (UCATT-LSS) was to further develop and support the SISO UCATT family of standards. The TG has:

- Validated the applicability of existing and evolving standards for interfacing to the simulation environment, developed by other NATO or SISO working groups, in order to ensure synchronisation and avoid overlap in effort and products;
- Elaborated the user requirements and functional requirements of the interfaces based on current training practices and military and technological developments;
- Transferred the currently used functional architecture into the NATO Architecture Framework (NAF) where applicable, to verify the validity of the architectural approach in relation to physical implementations;
- Prepared for handover to the SISO UCATT PSG the drafting of a new standard for transferring data from a Dynamic Object (DO) to Exercise Control (EXCON). This interface is located on a DO between the Tactical Engagement Simulation System (TESS) and the Instrumentation System (IS) and it is named UCATT Networking Instrumentation and TESS Equipment (U-NITE); and
- Prepared for handover to the SISO UCATT PSG the drafting of a standard data exchange model that is required for System to System interoperability. This model is named the UCATT Federation Object Model (U-FOM).

Perhaps uniquely within NMSG, the UCATT Task Groups from the outset drew their members from active duty military, government and industry. With the involvement of military, government and industry all involved in live simulation, UCATT has developed to become a focal point of knowledge and information exchange on live simulation within NATO and PfP. The continuation of the UCATT activities within MSG-174 "UCATT Live Simulation Standards 2" (UCATT-LSS(2)) secures not only a vehicle for continued work on standardisation within the live simulation community, but also one to embed and support the goals already achieved.

Normes de simulation instrumentée de la technologie avancée d'entraînement au combat urbain

(STO-TR-MSG-140)

Synthèse

Les travaux sur la technologie avancée d'entraînement au combat urbain (UCATT) consistent en plusieurs groupes de travail consécutifs au sein du Groupe OTAN sur la modélisation et la simulation (NMSG) : le MSG-032, le MSG-063, le MSG-098, le MSG-099 et le MSG-140. Le groupe de développement de produits (PDG) UCATT de la SISO et le groupe de soutien aux produits (PSG) UCATT sont liés à ces travaux.

Le but de l'UCATT est d'identifier, créer et entretenir un ensemble standard d'interfaces qui permettent l'interopérabilité des composants d'entraînement en conditions réelles sans freiner les recherches et améliorations futures. Initialement focalisée sur l'environnement urbain, la famille de normes UCATT s'applique aux exercices d'entraînement en conditions réelles dans de nombreux environnements opérationnels différents. Avant le MSG-140, l'UCATT a fourni à l'OTAN un registre de sites, une architecture fonctionnelle générale de systèmes d'entraînement en conditions réelles, l'identification d'interfaces et de leurs ensembles de données associés qui doivent être standardisés afin de permettre différents niveaux d'interopérabilité, une démonstration documentée de l'interopérabilité en conditions réelles, les meilleures pratiques et une norme SISO utilisable pour une interface d'engagement laser (la norme d'interface d'engagement laser UCATT U-LEIS).

L'objectif du MSG-140 « Normes de simulation instrumentée UCATT » (UCATT-LSS) était de développer et d'étayer la famille des normes UCATT de la SISO. Le groupe de travail :

- a validé l'applicabilité des normes existantes et en évolution pour assurer l'interface avec l'environnement de simulation, lui-même développé par d'autres groupes de travail de l'OTAN ou de la SISO, afin de garantir la synchronisation et d'éviter le chevauchement des travaux et des produits ;
- a élaboré les besoins de l'utilisateur et les besoins fonctionnels des interfaces, à partir des pratiques d'entraînement actuelles et des évolutions militaires et technologiques ;
- a transféré l'architecture fonctionnelle actuellement utilisée dans le cadre d'architecture de l'OTAN (NAF) le cas échéant, pour vérifier la validité de l'approche architecturale en lien avec les mises en œuvre physiques ;
- s'est préparé à transmettre au PSG UCATT de la SISO la rédaction d'une nouvelle norme de transfert des données entre un objet dynamique (DO) et un contrôle de l'exercice (EXCON). Cette interface est située sur un DO entre le système de simulation d'engagement tactique (TESS) et le système d'instrumentation (IS) et porte le nom d'U-NITE (UCATT Networking Instrumentation and TESS Equipment, instrumentation de réseau UCATT et équipement TESS) ;
- s'est préparé à transmettre au PSG UCATT de la SISO la rédaction d'un modèle standard d'échange de données, nécessaire à l'interopérabilité entre systèmes. Ce modèle est nommé U-FOM (UCATT Federation Object Model, modèle d'objet de fédération UCATT).

Dès le départ, les groupes de travail UCATT ont recruté leurs membres au sein du personnel militaire en service actif, des gouvernements et de l'industrie, ce qui est peut-être unique au sein du NMSG. Avec

l'implication des armées, des gouvernements et des industriels, l'UCATT s'est développée au point de devenir le carrefour des connaissances et de l'échange d'informations sur la simulation instrumentée au sein de l'OTAN et du PPP. La poursuite des activités UCATT au sein du MSG-174 « Normes de simulation instrumentée 2 » (UCATT-LSS(2)) est non seulement l'assurance de la continuité des travaux de normalisation au sein de la communauté de simulation instrumentée, mais également le moyen d'intégrer et soutenir les buts déjà atteints.

URBAN COMBAT ADVANCED TRAINING TECHNOLOGY LIVE SIMULATION STANDARDS

1.0 OVERVIEW

1.1 Introduction

Ground based warfare in an urban context is perhaps the most complex type that tends to neutralise much of the technical superiority of modern armies. As such preparedness for operations in such an environment is vital for success. Investments in the first generation of modern combat training centres (with instrumentation for data collection and analysis) with urban training facilities began in the 1990s. These capabilities are generally bespoke simulation designs to national requirements not lending themselves easily to support training events for contemporary coalition style operations as they have limited ability to achieve standardisation and interoperability. The NATO structure and objectives make NATO a suitable organisation to seek to harmonise training requirements and move toward a common technical architecture and standards for the next generation facilities in order to support live instrumented training among members of the Alliance.

The UCATT sequence of activities was created to identify and standardise the interfaces that allow interoperability of different systems for live training. Initially focussed on the urban environment, the UCATT family of standards is applicable for live training exercises in many different operational environments.

1.2 Background

1.2.1 Team of Experts (TOE)

Two NATO studies have been fundamental to taking the work of the UCATT WG forward: the NATO Research and Technology Organisation (RTO) 1999 Technical Report, Land Operations in the Year 2020 (LO2020) and the 2003 Urban Operations in the Year 2020 (UO2020) report. LO2020 concluded that NATO forces would likely have to conduct future operations in urban areas.

Urban warfare is arguably the most deadly type of warfare and tends to neutralise the technical superiority of modern militaries. Nation's investments in the first generation of Military Operations in Urban Terrain (MOUT) training facilities began in the early 1990s. Much had been learned over the past decade but there was minimal effort in the area of formal standardisation and interoperability. The NATO structure and objectives make it the most suitable organisation to harmonise training requirements and spearhead the effort toward common technical architecture and standards for the next generation of MOUT facilities and CTCs.

The NATO Modelling and Simulation Action / Master Plan (MSMP) identifies the need for common open standards and technical frameworks to promote the interoperability and reuse of models and simulations across the Alliance. Included in this requirement is the need for a common technical framework for "Live" training among members of the Alliance.

In 2002, a Team of Experts from the NATO Army Armaments Group (NAAG) completed a feasibility study in order to investigate the need for a generic set of requirements for NATO/PfP countries in relation to live instrumented training. The conclusion was that a number of potential interoperability areas were identified and assessed to be worthy of further investigation.

1.2.2 MSG-032 UCATT-1

The Urban Combat Advanced Training Technology (UCATT) Task Group (TG) was established within the NATO Modelling and Simulation Group (NMSG) in 2003 as MSG-032 TG 023. The UCATT TG was tasked to exchange and assess information on MOUT facilities and training/simulation systems with a view toward establishing best practice. In addition, it was required to identify interoperability requirements, a suitable architecture and a standard set of interfaces that would enable interoperability of MOUT training components. Uniquely the UCATT TG, from the outset, drew its members from both government and industry.

Over a three-year period, the UCATT TG held 12 meetings in various NATO and PfP countries.

Although in its Terms of Reference it was required to liaise with a number of groups both within Supreme Headquarters Allied Powers Europe (SHAPE) and outside of NATO, which included the STOG-L (formerly the Training and Simulation Working Group (TSWG)), Topical Group 3 from the NAAG and SISO, the main contact group was the NATO Urban Operations TG (formerly FIBUA/MOUT WG).

1.2.3 MSG-063 UCATT-2

The UCATT-2 WG was the successor of the first UCATT WG within NMSG and was chartered in 2007 as MSG 063 TG 040. The UCATT-2 WG was tasked to continue the work of the previous UCATT WG; to exchange and assess information on MOUT facilities and training/simulation systems with a view toward establishing best practice. In addition, it was required to organise an interoperability demonstration to prove standards and start the process of defining standards for laser communication, data communication and audio and visual effects.

It did just that, which resulted in a successful technical demonstration in 2011, held at the Marnehuizen MOUT training facility in the Netherlands. During this demonstration a proof-of-concept was presented, showing systems from multiple manufacturers exchanging information and simulated battlefield effects.

1.2.4 MSG-098/099 UCATT-3

The success of the UCATT-2 technical demonstration led to the institution of two new WG's: the MSG-098 UCATT Architecture Group (AG) and the MSG-099 Standards Group (SG). Since UCATT had now

reached the “delivery phase”, the decision was made to split up into two WG’s to bring focus to the work at hand. Although officially being two groups with two different NMSG mandates, both WGs operated in close cooperation with joint meetings to aid communication and reduce delay.

The AG was tasked to revise and develop requirements for each individual interface (see the Functional Architecture in Section 2). It then handed over those requirements to the SG, which was tasked with standardising, based on those requirements.

In accordance with NATO and SISO policy, a UCATT Product Development Group (PDG) was instated at the end of 2013. The UCATT PDG was tasked with formalising and ratifying the products as developed by MSG-098/099 through the provided formal framework known as the Balloted Products Development and Support Process (BPDSP). This has resulted in the successful publication of three SISO products:

- SISO-STD-016-00-2016: Standard for UCATT Laser Engagement Interface;
- SISO-GUIDE-003-00-2016: Guide for UCATT Live Simulation Standards and Architecture; and
- SISO-REF-059-00-2015: Reference for UCATT Ammunition Table.

Although the balloting and publication of these products took place following the MSG-098/099 timeframe, the products themselves may be considered important deliverables of both groups and the UCATT WG.

The different groups which have been part of the UCATT activity throughout the years are depicted in Figure 1.

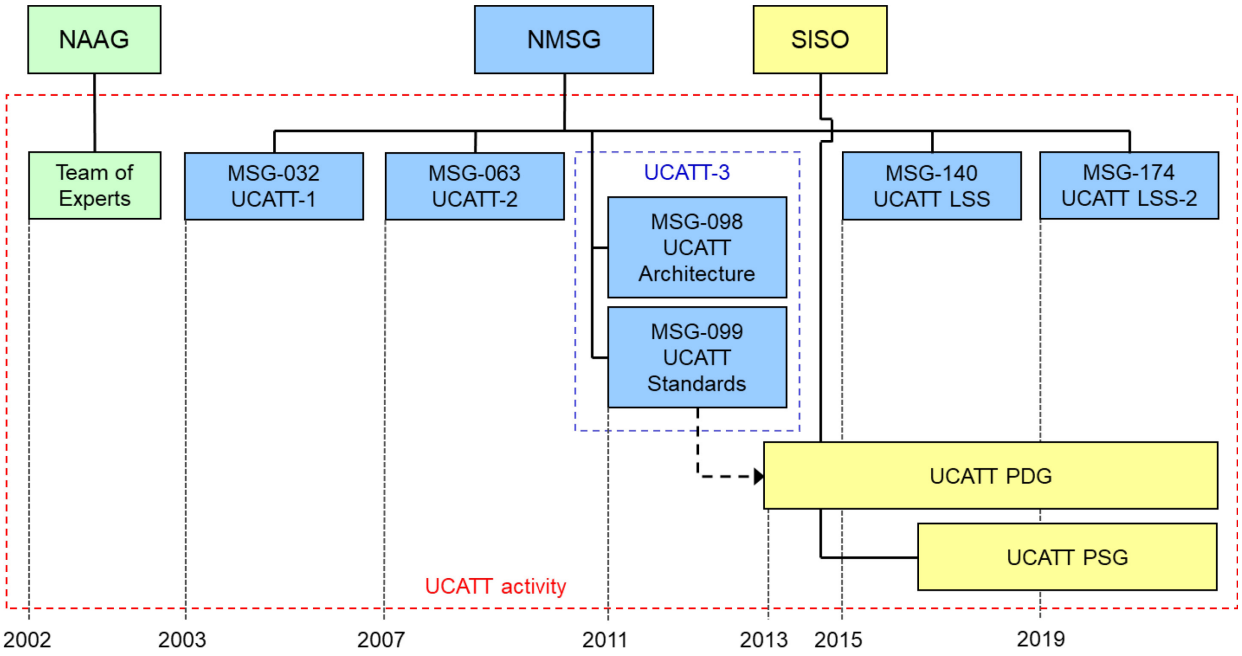


Figure 1: Composition of the UCATT Activity.

Each UCATT MSG has produced a report. Each subsequent report is built on the previous ones and as such they can still be used to gain insight into for example analysis of topics, description of typical example situations and foundations of decisions made. However, each report also supersedes the previous reports regarding the construction of the Functional Architecture and definitions and datasets of the interfaces.

1.3 Working Methodology

This section describes the process followed by MSG-140.

1.3.1 Staged Approach

To achieve the objectives of MSG-140 and to make optimal use of the expertise and time of the participants, MSG-140 organised itself into several subgroups (Task Groups), which met simultaneously three times a year where they worked alternately in specific Task Group and collective plenary sessions.

The meeting schedule of MSG-140 is depicted in Figure 2.

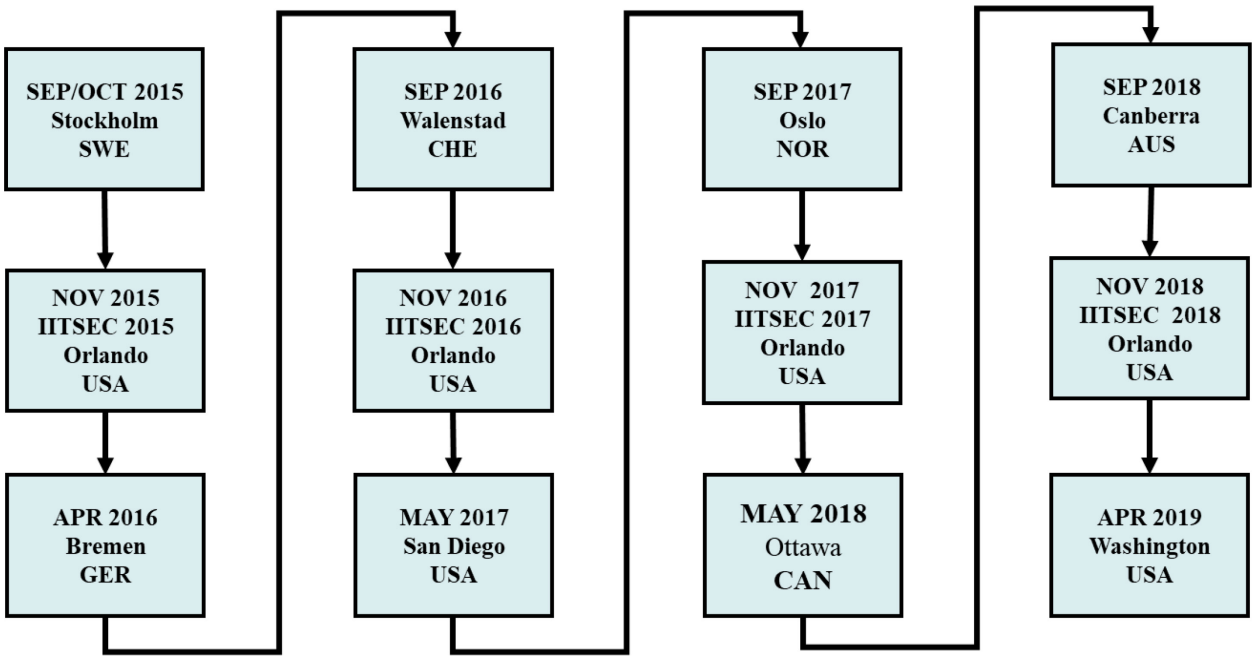


Figure 2: MSG-140 Meeting Schedule.

1.3.2 Interaction with NATO and Other Groups

Although UCATT is creating interface standards to enable interoperability, it was fully recognised from the beginning that existing or evolving standards, developed by other NATO or SISO working groups, could be likely candidates for some of the UCATT external interfaces. In order to assess applicability of such standards and avoid overlap in effort and products, MSG-140 tried to follow the activities and developments of some specific working groups. In addition, MSG-140 also kept a close relation with the military training community.

- **MSG-146 Simulation for Training and Operations Group – Land (STOG-L)** is a NATO working group where information about military simulation and associated training requirements is exchanged by military experts in the field of training simulation. During their mandate from 2016 to the beginning of 2019, UCATT has had 1-2 members overlapping with the STOG-L group. This has enabled a “delayed face-to-face communication” between the two groups in a form of updates from the previous meeting of the other group. UCATT-LSS has relayed a question to STOG-L regarding the future needs in Live Simulation. STOG-L responded with a “Gap analysis” report that also deals with other forms of simulation.

The mandate of STOG-L expired at the beginning of 2019 but is continued in the MSG-173 STOG New Generation (STOG NG) group. It is recommended to maintain at least "one linking member" in both the STOG NG and UCATT-LSS(2) group. Reason being, STOG concentrates on all (LVC) simulation from the perspective of military training and use in operations, while UCATT focuses on Live Simulation standardisation.

STOG wishes to work closer with UCATT. This would allow UCATT to focus on Live simulation while STOG focuses on Virtual and Constructive simulation. This would start with UCATT updating the overview of simulation systems of member countries for Live simulators and STOG updating the overview of the Virtual and Constructive simulators. The results could be combined through the Science Connect website or through the common member(s) of both groups.

In any case, STOG will keep sharing best practices on the use of military training simulation, updating the simulation overview and recognising the "gaps" in training and operations regarding the use of simulation among STOG-member countries.

- UCATT-LSS became aware of the potentially transformational nature of goals of two other NMSG Working Groups, **MSG-145 Operationalisation of Standardised C2-Simulation Interoperability (C2-SIM) and MSG-164 Military Simulation as a Service (MSaaS)** which could have significant benefit for the live training community, especially for the construct and preparation of international training exercises. Thus, UCATT ensured it was briefed at each meeting, noting progress and developments and offering comment as appropriate. This was achievable by virtue of having a single person with both the MSG-145 and MSG-164 WGs. This was a mutual benefit advantage as Live training input to the MSaaS was collated within UCATT and delivered as a single deliverable.
- The **Interoperability User Community (IUC)** is a SAAB led community of users of live simulation equipment manufactured by SAAB. The purpose of which is to achieve interoperability between customers and to steer product development for company and user benefit. UCATT has a strong relationship with the IUC and many UCATT members are also IUC members. This relationship has facilitated the exchange of relevant information, which was used for the benefit of UCATT analyses and products. Examples of exchanged data include the OSAG-2 Standard for laser codes, ammunition enumerations, vulnerability data and medical treatment enumerations. Also, lessons identified and best practices of training in a common live simulation environment between IUC member states (e.g., Austria, Germany and the Netherlands in the German Army Combat Training Centre) proved valuable use cases and thus have enriched the UCATT analyses and products.
- During the period of UCATT-LSS the US Army (PEO STRI) commenced a study into the issues associated with real-world interoperability challenges for live training. The first of a series of **Multinational Live Training Interoperability Study (MLTIS)** meetings took place in late 2016 and continues. Key UCATT members were invited to provide advice and assistance. Since that initial meeting the direction and focus of MLTIS work has matured and been defined. Now MLTIS is a collaborative partner with UCATT with UCATT members providing both understanding, challenge and review of emergent MLTIS products. Whereas the focus of UCATT is architectural in nature and the development of a series of published standards, MLTIS will provide the ability to observe, conduct analysis, and document the actual interoperability between different systems. The aim is to develop multiple data-driven products including an Interoperability Readiness Assessment Methodology (IRAM) based upon user experience, combined with a 'Common Picture' of multinational live training interoperability. In effect MLTIS is the characterisation of interoperability in the field.

1.3.3 SISO Related Activities

Even though MSG-140 is a NATO NMSG driven activity, its focus is to define and prioritise interfaces to be standardised through the SISO process as mandated by STO. As the standardisation process has to be driven

by a Product Development Group (PDG) which is formed by experts from the live simulation community (military, government and industry), the members of MSG-140 agreed to all join SISO and to affiliate to the UCATT PDG. Members of MSG-140 took the positions of SISO PDG chair (Capt Sander Cruiming) and vice chair (Mr Staffan Martinsen, who was succeeded by Mr. Tom Ståle Christoffersen when he changed position to SISO PDG secretary).

For efficiency, SISO PDG meetings were aligned with the UCATT meetings and time allocated to SISO activities. But much of the development of the SISO Standard documents was done between the UCATT meetings. The SISO portion of the meetings was then used to conduct formal elections and balloting. This method of integrating SISO work into UCATT work has proved to work very effectively and should be continued in the future.

1.3.4 Benefit and Continued Involvement of Industry, Government and Military

The unique composition of the UCATT group with members from government, military and industry in the spirit of an open minded and cooperative collaborative working method creates a win-win situation for all participating parties. Governments and military users benefit from the experiences and knowledge of their respective counterparts and industry can give guidance on technological possibilities and feasibility. In exchange, the industry members get first-hand information on future user requirements and on government desired standards. The concept of a mixed group has been proved for over 16 years and should be kept for the follow-up activity.

During the MSG-140 mandate period the SISO PDG has published a number of both balloted (GUIDE, STANDARD) and un-balloted (REFERENCE) products that needed to be maintained and updated in accordance with SISO rules and procedures. To that extent a Product Support Group was instated. To reduce overhead and optimally coordinate the activities of both groups it was decided to merge the groups into one combined PDG/PSG under leadership of the same SISO officers.

As a result of the publication of a technical standard for the optical engagement interface, the group had already recognised the need for a formal vetting procedure to certify compliance with the standard interface description. Therefore, a Drafting Group (DG), led by Mr Lilian Héry, was created to work on an Accreditation Test Plan which is projected to be released in the year 2019. This document is meant to provide a foundation of confidence in the level of interoperability a live simulation is able to provide by formally demonstrating compliance and prevents deviations from the standard.

1.4 Results of UCATT-LSS

Several tasks were assigned to UCATT-LSS. Those tasks are listed below, followed by the achieved results. Elaborations of those results can be found elsewhere in this report and in the attached annexes.

- Identify, maintain and improve a suitable architecture and a standard set of interfaces that enable interoperability of LIVE training and simulation components covering the urban aspects that does not inhibit future research and enhancements.

  During the UCATT-LSS timeframe the UCATT Use Cases were re-validated, and the impact of emerging technological and military developments, including military training requirements, was analysed and taken into account. UCATT benefitted immensely from lessons identified from contemporary multinational live training exercises and the fact that representatives from more nations joined the UCATT working group. This resulted in a review of the Functional Architecture and a revision and elaboration of the datasets of the functional external interfaces (see Annex A).

- Transfer the currently used functional architecture into the NATO Architecture Framework (NAF).

  A special Task Group within UCATT-LSS was established to create a set of relevant NAF views. The results of TG NAF are published in Annex B.

- Further development and support of the SISO family of UCATT standards.

  Since this was the main effort of UCATT-LSS which required substantial efforts, two special Task Groups within UCATT-LSS were created. The E4 TG has drafted a standard for a physical interface between a Training Equipment Simulation System (TESS) and a Player Unit (PU) accommodating information transfer of E2, E3 and E4. This draft standard is named U-NITE and is described in Annex C.

  The E8 TG has created a data exchange model to enable data exchange between EXCONs of (different) LVC simulation systems. The resulting UCATT Federation Object Model (U-FOM) is described in Annex D.

  The results of these TGs are handed over to the UCATT PDG for further processing within SISO.

- Feedback as to the effectiveness of the physical implementation solutions will be given from the groups military experts with respect to the existing Use Cases.

  After the publication of a standard for the optical engagement interface standard (U-LEIS, STANREC 4816) and the enumerations for that standard in 2016, the group sought to collect lessons identified on their operational field use. Two exemplary cases led to the discovery of physical hardware differences that were not part of the standard, which mainly focussed on the coding level:

  1) The Dutch Mobile Combat Training Centre (MCTC) operates a combination of higher-powered lasers and lower sensitivity laser detectors. The German CTC, Gefechtsübungszentrum Heer (GefÜbZH / GÜZ) Altmark, operates lower powered lasers combined with higher sensitivity laser detectors. Combined exercises between the two then led to disrupting fair play issues when Dutch high-power lasers were engaging highly sensitive German laser detectors and vice versa. In practice, Dutch soldiers were able to engage at much higher ranges than the German soldiers, resulting in a disgruntled training audience and an incorrect simulation of battle. The issue was addressed and solved by a combined bilateral effort between Germany and the Netherlands.

  2) In a similar case the US, preparing their fleet for the transition from MILES to the U-LEIS code, ran into an issue with ammunition codes. The U-LEIS code was designed to leverage two-way laser transmitters in combination with retro reflectors for range finding to simulate effects of large calibre weapons. Therefore, the UCATT ammunition table did not include large calibre (above .50) codes in the ranges that are reserved for one-way laser transmitters and detectors. A separate meeting was held in Amersfoort (the Netherlands) to resolve the issue under the SISO PSG effort and recommendations were made to make editorial changes to the ammunition table reference document.

- Validate the applicability of existing standards for interfacing to the simulation environment.

  UCATT-LSS followed the developments of several other NATO NMSG and SISO working groups in order to assess applicability of existing and evolving standards and avoid overlap in effort and products. These liaison activities are described in section 0. As a concrete result, the HLA RPR FOM 2.0 was chosen as a basis for the U-FOM standard and other standards are identified as likely candidates for some other UCATT external interfaces.

- Ratification of published SISO products by the NATO Standardization Office (NSO).

  After the publication of the optical engagement interface standard and the accompanying ammunition tables, UCATT-LSS has sought ratification from NATO to ensure those standards become part of NATO's framework of standards and recommendations. Through the proper channels this process was successfully completed, leading to the approval of NATO STANREC 4816 on "Urban Combat Advanced Training Technology (UCATT) Standard for Laser Engagement Interface and Ammunition Table".

1.5 Recommendations

The recommendations resulting from the MSG-140 work are outlined below. Some are task-related, while other recommendations address organisational aspects.

1) Continue the UCATT work. The UCATT efforts and evolving products are becoming better known and already used in the international military training community. The family of UCATT standards is growing, but the work is not completed yet. The UCATT work therefore needs to be continued, as is for example also recommended in the Allied Modelling and Simulation Publication AMSP-1. To facilitate these efforts, it is recommended to continue the UCATT work within an NMSG Task Group. A successor of MSG-140, MSG-174 UCATT-LSS(2) has been approved.
2) NMSG is requested to provide guidance on how to enable and support the growing UCATT work. Standards need not only be created, but also maintained. SISO has procedures for this (for example the PDGs and PSGs), but as the UCATT family of standards is growing, also the associated effort increases. Both government and industry need to continue their contribution, but the work is more extensive than can be done in three meetings a year of a normal NMSG TG. Moreover, UCATT is the only group focussing on simulation in the live domain from the NATO perspective, while there is a large community focussing on virtual and constructive simulation. As the need for LVC integration increases, UCATT should reach out more to other NATO and SISO groups. This requires a substantial organisational effort. UCATT-LSS(2) is requested to investigate a strategy how to proceed and organise these efforts, while NATO is requested for guidance on how to enable and support these efforts.
3) Support the extant SISO UCATT standards (which are published as STANREC).
4) Process through SISO the UCATT player interface U-NITE. UCATT-LSS has delivered the content of that standard, which needs to be balloted on and adopted by the SISO community.
5) Process through SISO the U-FOM, the data exchange model that is required for UCATT System to System interoperability.
6) Initiate a STANREC for U-NITE and U-FOM as identified above.
7) Study and produce a draft SISO standard for a short range radio interface (E1/E9, I3). The UCATT family of standards is not complete yet and the next recommended standard to be drafted is an interface for short range data exchange for engagements and DO association and equipment pairing.
8) Further investigate the connection of external systems with regards to new physical implementations of E6/E7/E8/E11.
9) Transform and expand UCATT ammunition tables into UCATT enumerations.
10) Apply the NATO Architecture Framework (NAF) to the UCATT architecture where applicable.
11) Evaluate applicability and impact of the US Live Training Engagement Composition (LTEC) architecture on the UCATT functional architecture.
12) Maintain the function as focal point for live training and simulation technologies and standards. Information exchange and collaboration with other simulation working groups is required for this, also to ensure the recognition of live simulation related aspects, for example of C4I integration in training.
13) Investigate cyber risks related to training systems, and the integration of cyber effects in the live training environment.
14) Outline recommendations for the E10 interface that could be provided to industry to take of the design of operational equipment. Although a standard for an interface between training systems and operational equipment (weapons and weapon systems) is very complicated due to the vast amount of different use cases, it seems feasible to outline at least a set of general recommendations and guidelines that could facilitate better integration of training systems and operational equipment.

15) Create a reference document for vulnerability models. UCATT-LSS has analysed several existing vulnerability models and associated vulnerability calculation mechanisms. Moreover, Germany has provided the VEMAG model and the USA has provided the MILES model, based on which UCATT could create a reference vulnerability model (as opposed to a standardised vulnerability model).

2.0 THE FUNCTIONAL ARCHITECTURE

2.1 Introduction of the Functional Architecture

It is the purpose of UCATT to set requirements for interoperability, which is the ability of systems to exchange data, information and services to enable them to operate effectively together. So the focus of UCATT is on identifying and standardising interfaces between different systems. To support these activities, a Functional Architecture (FA) was created. This FA captures **what** a live training system can or might do, not **how** such a capability is implemented. The UCATT FA is illustrated in Figure 3.

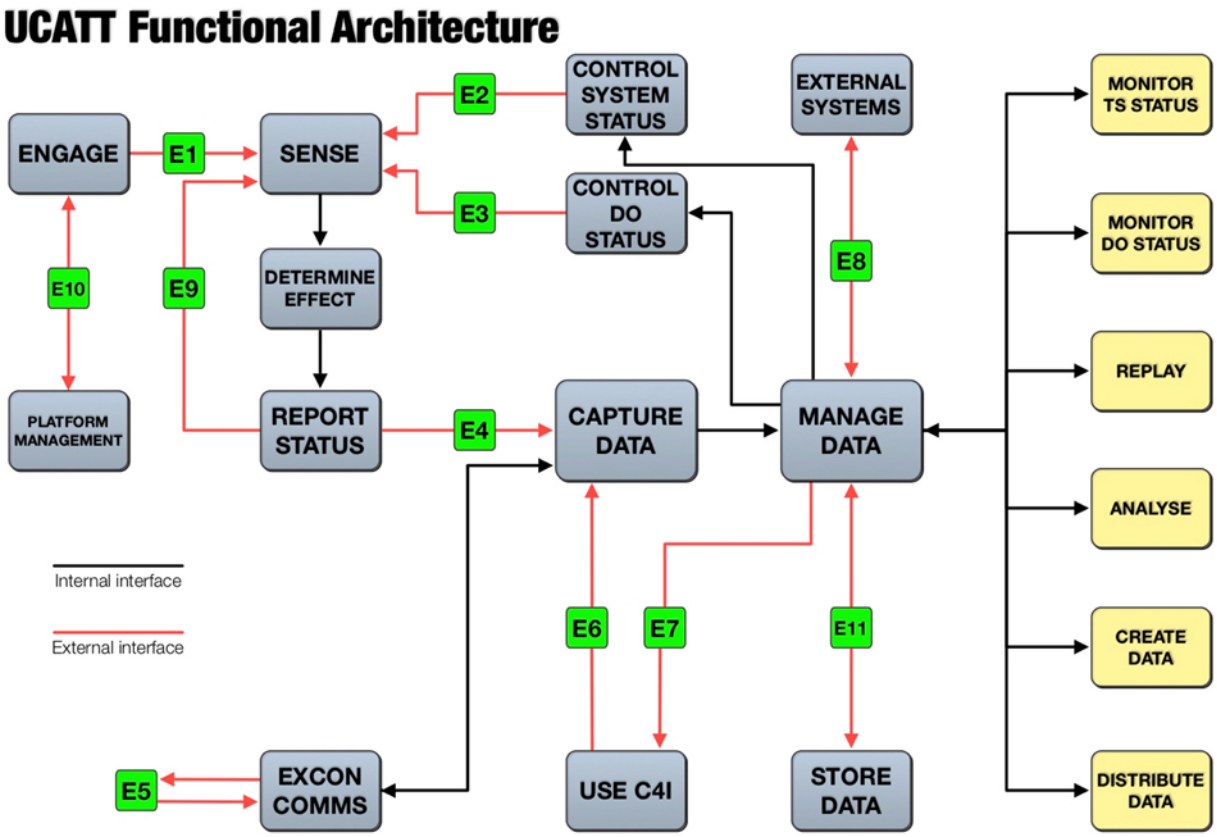


Figure 3: The UCATT Functional Architecture.

An interface allows data exchange between systems or system components. To enable interoperability, not every identifiable interface needs to be standardised, but only those interfaces that handle data communication to either the outside of the system or to a system component that can be replaced by a non-native component. Those interfaces are called external interfaces and are marked red and are numbered E1 through E11 in Figure 3. A definition of each external interface is defined in Section 2.2.5. Internal interfaces are defined as those interfaces that transfer data only to components of the same system or that is not relevant to provide to other systems. These are the black unnumbered arrows in Figure 3.

Special care has been taken in the definition of the FA to allow for different implementations. For example, an engagement between a shooter and a target can be modelled in two different ways:

- **Decentralised Solution –** The shooter engages the target. Subsequently, the target senses this engagement through its "Sense" capability and activates its "Determine effect" capability. The resulting change of status is then reported by the target.
- **Centralised Solution –** If the "Determine effect" capability does not reside locally in a target, the result of engagements is determined centrally in the capability "Control Dynamic Object status". The data flow will then be: the target senses an engagement, the local "Determine effect" is not present or will have no effect, the target reports the characteristics of the engagement, which is captured by the central system and through "Manage data" provided to "Control Dynamic Object status". Alternatively, in implementations where the players have no sensing capability themselves, but instead the training system detects engagements, the sensing capability of the training systems determines that a player is engaged and through "Capture data" and "Manage data" the engagement characteristics are provided to the central "Control Dynamic Object status" capability. That capability determines the effects of the engagement and subsequently provides the results to the target. The target senses the command to change its status, performs the status change and reports its new status, so other components of the system are aware of this.

2.2 Key Elements of the Functional Architecture

2.2.1 Functional Components and External Interfaces

For practical purposes, it is useful to distinguish several functional components within a UCATT training system. A functional component is a logical grouping of functions that are related to each other from a user's point of view. Although functional components do have a relation with physical components or facilities, it is not intended to influence the physical implementation or location of a UCATT training system. The breakdown of the training system into functional components serves purely to facilitate in defining interoperability. In the UCATT-1 report six main functional components were distinguished, three of them are extensively used in this UCATT-LSS report and its Annexes: the Dynamic Object (DO), Exercise Control (EXCON) and Observer/Controller (O/C). They are described in Sections 2.2.2 through 2.2.4.

The second type of key elements of the functional architecture are the external interfaces. UCATT has identified 11 external interfaces which are described in Section 2.2.5.

2.2.2 Dynamic Object (DO)

A Dynamic Object (DO) is defined as a live, virtual or constructive element in the training environment that:

1) Has a presence in the environment; and either
2) Has a valid status; or
3) May influence the status of other DOs (execute engagements) or possesses both of these characteristics.

Regarding 1: Presence. A DO can be seen, observed or detected in the training environment. For example, a vehicle can be seen by the naked eye, observed in infrared, detected by radar and be tracked by C4I systems and a CBRNe area can be detected with specific sensors. Associated with its presence is its position. During an exercise the position of a DO can be dynamic (e.g., a soldier can move around) or static (e.g., a structure or feature which stays on the same position during an exercise).

Regarding 2: Status indicates the (level of) capabilities of a DO. It can be very basic (such as for example dead/alive for human beings, or operational/destroyed for weapon systems and infrastructure), or it can be more complex, distinguishing between more levels of degraded performance. The status of a DO can be changed during an exercise, either resulting from engagements from other DOs or by (interventions from) the training system for exercise effect or administration. Although it could be required that a certain DO has a fixed status that cannot be changed rendering it "untouchable" or "indestructible" in an exercise. A typical example of such a DO is an O/C, whose status cannot be changed, yet it can engage other DOs.

Regarding 3: Engagement. A DO can influence the status of other DOs. For example, a soldier can fire an anti-tank weapon at a vehicle or at a building, a wall could be destroyed and with its debris it can engage DOs in its vicinity, and a CBRNe area can affect unprotected DOs that enter it. However, examples of DOs that cannot engage are a pop-up target or an unarmed UAV, which is just a sensor platform. The mechanism of engagement areas is also used when the area does not actively engage another DO (e.g., when a vehicle DO drives into an obstacle engagement area) or only generates a marker when a DO enters the area.

2.2.3 Exercise Control (EXCON)

EXCON is the capability to define and (remotely) monitor and control an exercise. Generally this is done from a central location. For sake of simplicity, in this document it is also assumed that EXCON also contains the capability to analyse the results of an exercise and provide feedback to the trainees in an After Action Review (AAR), and the capability to monitor and control the training system itself, necessary to support the training exercise (System Control).

2.2.4 Observer/Controller (O/C)

An Observer/Controller (O/C) is the capability to monitor, influence and evaluate an exercise by distributed, local means. It is a role in the training area played by exercise staff. The O/C component might seem a logical part of EXCON. They share much functionality, but the O/C capability also has some other functionality that clearly distinguishes it from EXCON.

In addition, an O/C is also a DO. The O/C is present in the simulated battlefield and can engage other DOs, either by directly changing their status or by imitating engagements from a virtual actor.

2.2.5 External Interface Descriptions

The UCATT external interfaces describe a number of transactions, and each type of transaction is mapped on one or more transportation methods, requiring a physical interface. The following subsections describe each an external interface. Compared to the previous UCATT report (MSG-098), only E1 and E3 have changed.

2.2.5.1 E1 – DO Interaction (Engage ⇒ Sense)

This interface enables actions on and status changes of DOs for the purpose of resolving tactical interactions of elements in the battlefield. This dataset can contain:

- A new status and the cause of that status change (the tactical engagement and the result of the engagement are determined externally from the affected DOs);
- Engagement parameters, so the affected DOs can determine the effects of the tactical engagement themselves; and
- Definition of tactical engagement areas, so DOs can determine engagement with those areas and the results of such engagement themselves.

2.2.5.2 E2 – Training System Status Change (Control Training System Status ⇒ Sense)

This interface controls the technical status of a DO, enabling its functioning in the training environment. Through this interface it is possible that a DO is initialised, reset, calibrated, etc. It also accommodates the distribution of an (altered) terrain representation or damage models for systems that require this data at decentralised nodes, for example in each DO for determination of engagement effects.

2.2.5.3 E3 – Executive DO Interaction (Control Dynamic Object Status ⇒ Sense)

This interface enables actions on and status changes of DOs for the purpose of exercise control (as opposed to tactical interactions, which are covered by E1.) This dataset can contain:

- A new status imposed by EXCON or an O/C, and if applicable, the reason of that status change;
- Parameters of engagement with administrative or exercise imposed restricted areas, so the affected DOs can determine the effects of these administrative or restricted area engagements themselves; and
- Definition of administrative or exercise imposed restricted areas, so DOs can determine engagement with those areas and the results of such engagement themselves.

The differences between E1 and E3 are further explained and exemplified in Section 2.3 and Annex A.

2.2.5.4 E4 – DO Reporting (Report Status ⇒ Capture Data)

A dynamic object reports its (change of) status through this interface to the rest of the world. The status contains for example operational status, location, supplies, engaging or being engaged, etc.

This interface exists in different physical domains, for example the communication of the status to:

- EXCON (typically radio communication); and
- Players, including visual presentations (smoke, lights) or sounds (explosion).

Remark: the interfaces to trigger the physical devices (for example pyrotechnics when shooting or being hit) are considered internal interfaces.

2.2.5.5 E5 – EXCON Communication (Use EXCON Communication ⇔ Use EXCON Communication)

This interface enables the communication between training staff members of different systems operating in the same exercise. It covers:

- Voice radio communication; and
- Exchange of for example electronic notes, pictures, video.

2.2.5.6 E6 – Receive C4I data (Use C4I ⇒ Capture Data)

This interface transfers data from C4I systems to a UCATT training system. This includes combat net radio voice communication and digital battlefield management system data. This data can be stored in the training system for analyses purposes and can be used during AAR.

2.2.5.7 E7 – Send C4I Data (Manage Data ⇒ Use C4I)

This interface transfers data from a training system to C4I systems. For example, an operational overlay created by the training staff and used in EXCON can be distributed to the C4I systems of the troops that are training. It could also be possible that the training system provides status information of (simulated) entities (either “live” dynamic objects or “virtual” players) to the C4I systems.

2.2.5.8 E8 – Event Data Exchange (Manage Data ⇔ Interface with External Systems)

This interface enables the exchange of data between systems, which can influence the course of the training session and generally has a dynamic, time critical character. Examples of event data exchange are (updates of) status of DOs and the creation of a minefield in one system (System A), which is communicated to another (System B).

2.2.5.9 E9 – DO Association and Pairing (Report status ⇒ Sense)

This interface enables the logical linking of objects in the training environment, this includes linking of DOs amongst each other (DO association) and linking equipment that is not modelled as a DO with DOs (equipment pairing). Examples are:

- Personnel mounting and dismounting vehicles;
- Personnel or vehicles entering or leaving (parts of) buildings; and
- Personnel picking up weapons.

2.2.5.10 E10 – Exchange platform data (Platform management ⇔ Engage)

This interface enables the exchange of data between the training system and computers (such as the fire control system or platform management system) of the instrumented real systems. This is a bidirectional interface. Data exchange from the platform to the training system is used to enable or influence the behaviour and the engagements of the DO in the training environment. Examples are selected ammunition type, dynamic lead, environmental parameters and relevant vehicle parameters.

Data exchange from the training system to the platform is used to influence the behaviour of the real platform, for example providing the platform with target distance information delivered from the training system in case of a laser based training system, visualising tracers and fall of shot in the visual sensors or adding sounds to the communication systems (e.g., explosions, messages for training purposes).

2.2.5.11 E11 – Reference data exchange (Manage data ⇔ Store data)

This interface enables the exchange of data that is generally used for reference purposes, e.g., the transfer from System A to System B of an ORBAT definition, damage model definitions, geospatial (terrain) data such as the layout of a building composed of separate walls, a created scenario or a recorded exercise. It generally contains non-time critical information and is therefore used mostly prior to an exercise, but it can be used during the execution of an exercise.

2.2.6 The Relation Between External Interfaces and Internal Interfaces

The Functional Architecture and the datasets for each external interface (E-interface) are described at the application level. To create standards, the external interfaces need to be translated to the lower levels, down to the physical layer, resulting in physical implementations (I-interface). The same physical interface can be used to implement several functional interfaces. For example, the laser interface (I2) is used for direct engagement simulation (E1), DO technical or operational status control by the O/C using an umpire gun (E2 and E3) and for indoor positioning (E3).

As of this report, the identified links between functional and physical interfaces are summarised in Table 1.

Table 1: The Identified Relation Between Functional and Physical Interfaces.

		E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11
I1	Long Range Radio (LRR), DO to DO	X										
I2	Laser	X	X	X								
I3	Short Range Radio (SRR)	X										
I4	Infrared – short range											
I5	TBD											
I6	TBD											
I7	TBD											
I8	Ethernet, EXCON to EXCON								X			
I9	TBD											
I10	RS232 interface between TES and radio modem		X	X	X							
I11	Long Range Radio, DO to EXCON		X	X	X							
I12	Ethernet, NC to EXCON				X							

The numbering of the physical interfaces in the table above is not an exhaustive enumeration. Instead it contains gaps or "placeholders" in the numbering for interfaces which need to be elaborated further. For example, in the UCATT MSG-099 report it is suggested that I5 could be used for indoor positioning, I6 for outdoor positioning and I9 for interfacing with fire control units. The list also can and will be expanded with new physical interfaces as the work of UCATT progresses.

2.3 Changes to the FA During the UCATT-LSS Timeframe

The UCATT Functional Architecture was introduced in the UCATT-1 report (RTO-TR-MSG-032) in April 2010 and is still the basis for the continuing UCATT work. Successive UCATT Task Groups have identified improvements or additions to the FA. The UCATT-2 report (TR-MSG-063) identified the need for two additional external interfaces E9 and E10. The UCATT-3 report (TR-MSG-098) identified one additional external interface (E11) and redirected the E9 external interface.

The reviews and further investigations of use cases during the UCATT-LSS timeframe did not identify additional external interfaces. However, the definition of the external interfaces E1 and E3 was changed. Both interfaces enable data transfer regarding possible status changes of DOs. Previously E1 "DO engagement" was the interface, typically between DOs, where certain engagement parameters would be transferred to a targeted DO (e.g., being hit by a bullet), which would adjudicate the outcome of that engagement. E3 "DO status change" would be used when only the new status had to be transferred (typically from EXCON to the targeted DO), either because the adjudication of an engagement was performed by

EXCON or by a decision of the training staff. So in fact, the distinction between E1 and E3 was made based on implementation choices, not on functional arguments. Based on functional arguments it was decided that the E1 interface should represent real life interactions, irrespective where they are implemented in the training system, while the E3 interface should represent deliberate interventions from exercise control. This redefinition impacts both the E1 and E3 names and datasets as described in the MSG-098 UCATT Architecture report. It does not result in the creation of new parameters in the datasets but implies a redistribution of parameters.

Furthermore, the datasets of several external interfaces were elaborated. The new datasets are described in Annex A.

2.4 Priorities for Standardisation

2.4.1 Introduction

Although for some UCATT external interfaces existing standards can be used, it is unrealistic to expect that the whole family of UCATT standards (in one or more of their physical implementations) can be defined simultaneously. Therefore, the UCATT TG prioritised the sequence in which standards for external interfaces will be developed, both in terms of functional interfaces and of physical interfaces.

2.4.2 Priorities for the Functional Interfaces

An analysis of user requirements confirmed the priorities set in the UCATT-3 timeframe:

1) The first priority is to develop an implementation for the **E1** interface, enabling engagements on DOs. The standardisation effort has resulted in the **U-LEIS** standard and an ammunition table reference document, formalised in NATO STANREC 4816.

2) The second priority is to develop an implementation for the **E4** interface, the functionality of DOs to report their (changes in) status and engagements both to other DOs and to EXCON(s). A concept standard for E4 (**U-NITE**) has been developed in the UCATT-LSS timeframe. In the development of that draft standard, it was discovered that the proposed physical implementation of E4 also largely covered the functional requirements of **E3** (the functionality to execute actions on and status changes of DOs for the purpose of exercise control, as opposed to tactical interactions) and **E2** (the functionality to monitor and control the training system status) as they were established by the Architecture Group. From a user point of view both the E2 and E3 interfaces had no high priority due to the fact that by moving the engagement data tables from E3 to E1, their functional relevance to the simulation of tactical exercises was reduced. With these four functional interfaces (E1, E2, E3 and E4) implemented it is possible to use DOs from different training systems in the same exercise, without requiring their own EXCON capabilities. However, precautions have to be taken by the host and the guest nations to cope with system specific functions and configuration procedures and data outside of the U-NITE standard.

3) The third priority is the **E8** interface, enabling data exchange between training systems at the system level. With this functionality it is possible that all involved systems can display all relevant information in a synchronised way, resulting in a complete and up-to-date operational picture of the exercise. In addition, this interface can contain functionality to control DOs of another training system through their own EXCON. A draft standard data exchange model for E8 (**U-FOM**) has been developed in the UCATT-LSS timeframe. U-FOM does not standardise the physical interface itself. It relies on the assumption that both EXCONs will be able to connect with each other physically and on lower ISO/OSI levels, generally referred to as “Ethernet” and TCP/IP.

4) The fourth priority is the **E9** interface, which enables the logical linking of objects in the training environment, such as linking DOs amongst each other (DO association) and linking DOs with equipment that is not modelled as DOs (equipment pairing).

The remaining external interfaces have a lesser priority for UCATT to start working on, either from a user requirement perspective (such as E10 and E11) or because there are standards available or evolving in other domains that are likely candidates for a UCATT external interface (such as E5, E6 and E7).

2.4.3 Priorities for the Physical Interfaces

1) A functional interface can be implemented by one or more different physical interfaces. In the case of E1, the physical interface depends for example on training system design (e.g., are DO engagements implemented by a line-of sight mechanism such as laser or by a geo-referencing mechanism) or on short versus long range engagement (triggered by a nearby DO or triggered by EXCON). UCATT decided to first develop a standard for interactions between DOs based on laser engagement (E1/I2 called U-LEIS).

   UCATT decided for the next mandate to develop a new draft standard for E1 based on short range radio (I3). With such a physical interface it is for example possible to implement engagements between hand grenades, Improvised Explosive Devices (IEDs) and DOs in the proximity. Moreover, this physical interface can also be used to implement the functional interface E9 (DO association and equipment pairing).

2) For E4 (DO reporting) it was decided to standardise the physical interface between the training equipment system and a radio (E4/I10). This physical interface can also be used for long range engagements (E1), E3 (Executive DO status change) and E2 (Training system status change). The current draft U-NITE therefore needs to be extended to also incorporate the E1, E2 and E3 datasets.

3.0 UCATT-LSS SUBGROUPS

3.1 Introduction

This section outlines how UCATT-LSS was led, managed and organised using a Steering Group (SG) for leadership and direction and five Task Groups (TGs) to undertake detailed work reported in this document. These Groups met together for joint working three times a year where they worked both in specific TG member only sessions and collectively as part of plenary sessions. Additional meetings – both real and virtual were organised as needed. The SG and TGs are set out below.

3.2 Steering Group

The SG acted as the executive group for UCATT-LSS. The SG determined the strategy of the UCATT WG and secured the resources to undertake the work by TGs. It was responsible for generating and maintaining the momentum within the group, preparing and administering the meetings so they could to be productive (given the size of the group). The SG was represented by all interested factions; the Military, Industry and Government (Acquisition) and typically met between main events to react to developments and plan accordingly. The SG also managed the “marketing” activity of the LSS and provided resources to support other related activities such as support to SISO activity and the US Army (PEO STRI) Multinational Live Training Interoperability Study (MLTIS) work. The SG provided status reporting material to NATO as required.

The SG approach was considered a success and delivered clarity and focus to the effort and it intended to be replicated in the new UCATT-LSS(2) mandate (MSG-174).

3.3 TG Architecture

The goal of TG Architecture was to identify, maintain and improve a suitable functional architecture and a set of functional interface descriptions that enable interoperability of live training and simulation systems and their components. The focus was on urban aspects, but also other training settings were considered, not inhibiting future research and enhancements. The training needs of the contributing nations were and are the starting point for the work of TG Architecture. A firm foundation is laid in the previous UCATT reports, but user requirements and technical developments can evolve, possibly impacting the UCATT FA and the functional interface descriptions. Therefore, TG Architecture identified and analysed amongst others common practices and relevant and expected developments in current Combat Training Centres, interoperability requirements derived from actual multinational exercises, requirements emerging from new military systems and the ways they are or will be employed, and developments in (commercial) technology relevant for the physical interfaces in military training systems. TG Architecture was able to analyse these topics by means of example situations, because it consisted of military and procurement experts and representatives from industry.

TG Architecture interacted closely with the other UCATT TGs. On the one hand the results of TG Architecture were used as the input for the UCATT TGs which worked on the definition of physical interfaces. This covered the priority of standardisation of external interface candidates and the associated functional requirements. On the other hand, TG Architecture acted as a sounding board for the solutions proposed by the other UCATT TGs and answered the questions they came up with. These investigations and the interaction with the other UCATT TGs confirmed the design of the FA and led to the elaboration of several of the datasets associated with each of the external interfaces. The compiled results are documented in Annex A “Architecture”.

TG Architecture also monitored the activities and results of other relevant STO working groups, in order to assess the applicability of other existing or evolving standards or concepts for UCATT purposes and to avoid duplicating work. Of particular interest have been MSG-145 “Operationalisation of Standardised C2-Simulation Interoperability” and MSG-168 “Modelling and Simulation as a Service (MSaaS)”.

3.4 TG NATO Architecture Framework (NAF)

> *An Architecture is the fundamental concepts or properties of a system in its environment embodied in its elements, relationships, and in the principles of its design and evolution.*
>
> ISO/IEC/IEEE 42010

The goal of TG NAF was to evaluate if an Architecture Framework approach:

- Can increase consistency in information in and between UCATT reports;
- Can, by a systematic approach, capture the interfaces; and
- Can represent UCATT products within a common architecture framework.

In the UCATT community there is a need for a structured approach to manage the complexity of creating an integrated and consistent set of standards. The number of standards will increase over time and will evolve to reflect the needs of the community. Architectural frameworks may support this objective; therefore, a task group was initiated (TG NAF) with the aim to examine the potential effects of introducing an architecture framework.

The Study Report (Annex B of this report) aims to examine and document the current state of practice of Systems Engineering (SE) and architectural artefacts and information, within the UCATT programme, and how an architecture standard such as the NATO Architecture Framework version 4 (NAF v4) may be applicable to the programme.

The results in the Study Report are based on an analysis that highlights the potential to capture MSG 098/099 UCATT documentation and information in an architectural description, according to NAF v4, by introducing a Model-Based Systems Engineering (MBSE) methodology. Compiled findings indicate that an MBSE methodology, in combination with NAF v4, will improve several key quality aspects of SE artefacts, including aspect such as completeness, unambiguousness, traceability, information management, clarity and understanding. The study also shows that an MBSE approach can enhance the capability to perform SE processes, according to ISO/IEC/IEEE 15288 System and Software Engineering-System Life Cycle Process.

A UCATT Architectural Description can be considered as a deliverable artefact, by itself, which can be used by organisations that develop, procure, maintain or use live simulation systems. In a larger perspective, a formal architectural description can also facilitate the communication and integration with other SISO standardisation initiatives and NATO Modelling and Simulation Groups.

The first essential step to introduce an MBSE approach is to create a Systems Engineering Plan (SEP), covering both how to implement a new methodology as well as how to perform the systems engineering tasks, including processes, methods, resources and information management. The recommendation is to develop the SEP during the initial phase of LSS2.

3.5 TG E4 (Report DO Status)

The E4-I10 interface is defined as the first stage for transferring tactical data from the Tactical Engagement Simulation System (TESS) to the Instrumentation System (IS)'s Exercise Control (EXCON). It exists between the TESS and the IS's Player Unit (PU) radio. Since the E4-I10 Task Group (TG) formed at the beginning of the UCATT-4 mandate, the standard has evolved in many ways, precipitating a name change (to Ex-I10) along the way. It was developed during the UCATT-4 (MSG-140) mandate (2015-2019) by a multinational group of engineers from the government and civilian sectors.

Data transfer is performed via the Recommended Standard 232 (RS232) serial connection, chosen for its proven performance in similar applications. The interface uses a bipolar, asynchronous link over 3 wires. The standard also provides a mechanism for power transfer over the connection and specifies requirements for a physical connector. Ex-I10 can facilitate both bounded- and variable-length messages.

After experiencing the E1-I2 TG's successes through basing the U-LEIS standard on a mature, fielded standard, the E4-I10 TG commenced looking for an existing standard to serve as the basis for E4-I10. They settled on COMLOC, a French standard that, while quite old, provided a mature, proven interface that featured most of the mechanisms needed for satisfying the E4 interface's requirements. The group set out creating a new standard by modifying the existing standard, adding and modifying functions to match their needs.

Halfway through the development process, the US succeeded in getting their new IS-TESS Interface Control Document (ICD) certified for public release. This standard, while much newer than COMLOC, had already been proven mature, as it had been implemented into many US Instrumentation Systems with great results. In addition, IS-TESS provided many more required functions and had been designed with expansion in mind. The US standard was provided to the E4-I10 group for their evaluation. After performing an extensive comparison of the two standards, the TG realised that basing the E4-I10 standard on the IS-TESS ICD would reduce the amount of work required to develop the new UCATT standard, as many more messages and data types had already been developed in IS-TESS when compared to COMLOC. The TG took their current draft and applied it to a new draft, which was based on IS-TESS.

The resultant draft Ex-I10 standard provides a robust message set that satisfies E4 requirements while remaining extensible – it can be easily modified to support future as new systems or capabilities are fielded.

3.6 TG E8 (Exchange Event Data Between Training Systems)

The E8 interface enables the exchange of data between systems, which can influence the course of the training session and generally has a dynamic, time critical character. Examples of such event data exchange are (updates of) status of DOs and the creation of a minefield in System A, which is communicated to System B.

From another point of view E8 enables data exchange between different EXCONs of (different) Live Simulation Systems (L2L use case) and between EXCONs and virtual and/or constructive simulation environments (LVC use case).

With this interface it is possible that all involved systems can display all relevant information in a synchronised way, resulting in a complete and up-to-date operational picture of the exercise. In addition, this interface can contain functionality to control DOs of another training system through their own EXCON. Having E1 and E8 implemented in this way, it is possible to use DOs from different training systems in the same exercise, however requiring all related EXCONs to be present and interconnected.

The work on E8 has taken the following steps:

1) Define the scope of E8.

   The E8 interface is driven by the data to be exchanged. Therefore, the task was to specify the data that will enable interoperability regarding the exchange of DO status and DO commands.

2) Define the data exchange protocol for E8.

   Different data exchange protocol standards are existing and in use which are candidates for E8. The candidates were analysed and evaluated. The decision was to use HLA.

3) Define the data exchange model for E8.

   The decision for a data exchange protocol standard resulted in a determination of the data exchange model format. In the case of HLA, the data exchange model is a FOM. The task was to analyse and evaluate existing FOMs for reuse and extension or to create a complete new FOM.

   Regarding the L2VC Use Case and the L2L Use Case the evaluation resulted in the decision to create the so-called U-FOM (UCATT-FOM) that is based on the RPR FOM 2.0 standard. Re-using the RPR FOM 2.0 enables the main interoperability of the live simulation domain with the virtual and constructive simulation domain.

3.7 TG Marketing

The objective of TG Marketing was to create a baseline for UCATT promotional products, such as presentations, flyers and handouts, in order to provide standardised overviews of the UCATT objectives and standards. The products were used by MSG-140 UCATT-LSS members for a series of marketing activities during the mandate to educate and inform the wider community of the TG aims and objectives together with current and planned activity plus achievements and outputs (NATO and SISO products). Highlights were:

- **NATO MSG Symposium:** UCATT-LSS presented a comprehensive paper at the Oct 2016 event in Bucharest ROU (MSG-143) and the Oct 2017 Lisbon PRT event (MSG-149).
- **I/ITSEC:** UCATT-LSS presented a comprehensive paper at the Nov 2018 Conference held in Orlando FL USA.
- **ITEC:** UCATT-LSS presented a summary on activity on the show floor at the NATO Booth at the London GBR show in May 2016.

- **SISO:** UCATT-LSS presented TG activity to the SISO seminar linked to the ITEC Shows held in 2015 in Prague CZE in 2018 in Stuttgart DEU and at the DSET in Bristol GBR (2019).
- **Levels of Fidelity Conference:** UCATT-LSS presented comprehensive papers at the 2016 and 2018 events in Walenstadt CHE.
- **MS &T Magazine:** At the request of UCATT-LSS and with cooperation of the editor, activity of the TG has been reported at several points during the mandate.

The TG also investigated the creation of a UCATT website. It was decided not to have an own website but to store and maintain UCATT related information on the SISO Science Connect website.

Annex A – FUNCTIONAL REQUIREMENTS AND DEFINITION OF EXTERNAL INTERFACES

A1.0 OVERVIEW

This Annex contains the results of the TG Architecture. The goal of TG Architecture was to identify, maintain and improve a suitable functional architecture and a set of functional interface descriptions that enable interoperability of live training and simulation systems and their components. TG Architecture based its work on the content of the previous UCATT reports, but since user requirements and technical developments evolve, they can impact the UCATT FA and the functional interface descriptions. Therefore, TG Architecture identified and analysed amongst others common practices and relevant and expected developments in current Combat Training Centres (CTCs), interoperability requirements derived from actual multinational exercises, requirements emerging from new military systems and the ways they are or will be employed, and developments in (commercial) technology relevant for the physical interfaces in military training systems. Also, feedback from the other UCATT TGs working on physical standards, have triggered critical review and elaboration of existing work.

Section A2 describes the analyses performed by the TG Architecture, providing the rationale for changes or additions to the external interface datasets.

Section A3 lists the definitions of the tactical statuses of the different categories of DOs: (weapon) systems, personnel and infrastructural objects. Some minor revisions have been made since the UCATT-3 MSG-098 report, and the definitions have been extended with “additional DO statuses” and statuses for equipment pairing and DO association.

Sections A4.0 to Section A8.0 define the datasets for respectively:

- E1 – DO interaction;
- E2 – Training system status change;
- E3 – Executive DO interaction;
- E4 – DO reporting; and
- E9 – DO association and pairing.

E8 (event data exchange) enables the exchange of data between simulation systems. HLA was chosen as the implementation of this interface, which contains the datasets of E1 to E4.

There are currently no dataset definitions for the other external interfaces:

- For E5 (EXCON communication) existing protocols for radio communication and electronic data transfer seem applicable.
- For E6 and E7 (receive and send C4I data) the developing C2SIM standard seems a likely candidate. This developing standard will be based on two other standards: Military Scenario Definition Language (MSDL), SISO-STD-007-2008 and Coalition Battle Management Language (C-BML), SISO-STD-011-201.
- E10 (exchange platform data) enables data exchange between the training system and instrumented operational (weapon) systems. Developments regarding the NATO Generic Vehicle Architecture (NGVA) seem applicable. NGVA is a NATO Standardisation Agreement (STANAG 4754) based on open standards to design and integrate multiple electronic subsystems onto military vehicles which are controllable from a multifunction crew display and control unit.
- Finally, for E11 (reference data exchange) also MSDL seems a likely candidate for part of the dataset.

A2.0 ANALYSIS TOPICS

A2.1 Definition of External Interfaces E1 and E3

Ever since the early UCATT working groups, the UCATT Functional Architecture (FA) has been the main reference for structuring the working groups' activities and results: from identifying topics to investigate, definition of datasets and specification of physical interfaces. The FA enables discussing functionality of training systems from a user's requirement perspective, instead of driven by technical implementation or specific solutions. For each of the identified functional external interfaces (denoted by an "E" number) one or more physical interfaces (denoted by an "I" number) are derived. This allows that the same functionality can be implemented differently and that a certain dataset can be transferred by different physical mechanisms, e.g., by a laser, radio or wired interface.

The UCATT-1 and UCATT-2 working groups mainly focused on defining the UCATT concept and demonstrating its feasibility and usability. Subsequently, the UCATT-3 working group focused on creating the first UCATT standards. UCATT-LSS elaborates on the previous work and aims to enlarge the set of UCATT standard interfaces.

It has always been known that although the FA is a generic, functional decomposition of a training system, its design has been influenced by several typical physical implementations. So far, this has not negatively impacted the work of the UCATT working groups. However, now that the UCATT effort is more focused at the definition of physical interfaces, it appears that certain adaptations of the FA are required regarding engagement of Dynamic Objects (DOs) and the definition of the involved E1 and E3 external interfaces.

When creating physical implementations of these two functional interfaces, decisions must not only be made on how data is physically transferred, but also where in the physical system which function is executed. In case of an engagement, relevant sub-functions are for example determination of which DOs are affected by that engagement and subsequently what the results of that engagement are for each of the affected DOs. Examples of different implementations of a direct fire engagement are:

1) Local solution, affectation and result are determined at each target. For example, DO1 fires its rifle, sending a laser beam, which contains the relevant parameters, amongst others ammunition type. The laser beam hits DO2. DO2 senses this engagement and determines that it is affected by the engagement. Subsequently, DO2 determines its new status, based on the received engagement parameters and own protective parameters.
2) Central solution, affectation and result are determined centrally at EXCON. For example, DO1 fires its rifle. The training system captures this action, for example by video cameras, and determines the trajectory of the bullet. Knowing the location and status of all DOs, EXCON determines that DO2 is affected by this engagement. Subsequently, EXCON determines the new status of DO2 and sends the new status to DO2.
3) Mixed solutions, where for example the affectation of DO2 is determined centrally, but the new status of DO2 is determined locally at DO2.

Previously, in the UCATT FA, the different implementations of engagements would map on a combination of the functional interfaces E1 and E3. E1 "DO Engagement", was defined as the interface that represents an action of one DO on (one or more) other DOs, with the purpose to change the status of those other DOs. The E1 engagement dataset contained only the characteristics of the action, not the resulting status of the affected DOs. The resulting status had to be determined based on the engagement parameters. E3 "DO status change", was defined as the interface to change the (simulated) operational status of a DO. In the examples described above, a pure local solution would involve E1 and not E3, a pure central solution would involve E3 and not E1, and a mixed solution would involve both E1 and E3.

From a physical point of view, it is possible that a certain function (e.g., an engagement) can be implemented in different ways, making use of different physical interfaces. However, from a functional point of view, it can be confusing when one function can be explained in different ways, making use of different functional interfaces.

This confusion led the UCATT-LSS group to reformulate the definitions of E1 and E3. It was decided that the E1 interface should enable all types of tactical engagements, implementing the normal flow of activities on the battlefield. E3 should then enable executive control of the status of a DO.

The difference between E1 and E3 thus lies in the motivation of an engagement or status change: E1 represents real life activities, while E3 represents deliberate interventions from exercise control.

This redefinition impacts both the E1 and E3 names and datasets as described in the MSG-098 UCATT Architecture report. It does not result in the creation of new parameters in the datasets but implies a redistribution of parameters. The new definitions of the E1 and E3 datasets are described in Sections A4.0 and A6.0.

E1 – DO Interaction

This interface enables actions on and status changes of DOs for the purpose of resolving tactical interaction of elements in the battlefield.

E3 – Executive DO Interaction

This interface enables actions on and status changes of DOs for the purpose of exercise control, where EXCON initiates the engagement or status change. Depending on the chosen implementation, these E1 and E3 datasets can contain:

- A new status and the cause of that status change (the engagement and the result of the engagement are determined externally from the affected DOs);
- Engagement parameters, so the affected DOs can determine the effects themselves; and
- Definition of engagement areas, so DOs can determine engagement with those areas and the results of such engagement themselves.

A number of examples follow to clarify the distinction between E1 and E3:

- DO1 (say a live instrumented soldier) fires with a laser engagement system at DO2 (a live instrumented vehicle), which is sensed by DO2, so DO2 determines it is engaged. This is an E1 interaction, (E1/I2 (U-LEIS)), containing the relevant engagement parameters. In such implementations, DO2 most likely contains the capability to determine the effect of the engagement locally.

  If however determination of the engagement effect is performed centrally, DO2 sends the engagement parameters to EXCON (through E4) where the effect on DO2 is determined and subsequently EXCON sends the resulting status change to DO2, which is again an E1 interaction. This transmission could for example be done through a long range radio interface (E1/I1).

- DO1 (for example a live soldier) fires its weapon. This action is sensed by EXCON, for example by cameras. EXCON determines that DO2 (a live vehicle), is affected by this action. Most likely the result of this engagement is determined centrally by EXCON and the resulting status change, if any, is sent to DO2 by for example a short-range radio interface. This is an E1 interaction (E1/I3), containing the new status and cause of the status change.

  If however determination of the engagement effect is performed locally at the DO level, EXCON sends the relevant engagement parameters through E1 to DO2.

- DO1, a virtual UAV, fires at DO2, a live tank. This is an example of LVC integration. Either EXCON determines the resulting status change of DO2 and sends the new status and cause to DO2 or it sends the relevant engagement parameters to DO2, so DO2 can determine the outcome of the engagement. In both cases this is an E1 interaction, only requiring different data sets.

- A tank (DO1) fires at an APC (DO2), the APC is damaged and as a result the APC wounds the driver (DO3). The APC wounding the driver is an example of effect propagation. Both DO1 engaging DO2 and DO2 engaging DO3 are E1 interactions.

- EXCON kills a DO, for example because a player is cheating during the exercise or EXCON interferes to manage the balance of the fight. This is an E3 interaction, containing the new status.

- An O/C in the field resets or resupplies a live DO with a laser device. This is an E3 interaction (E3/I2).

- An O/C in the field engages a DO as an imitated entity, meaning that it appears to the affected DO it is engaged by a certain other DO, while that DO does not exist in the battlefield. The engagement is performed by the O/C for training purposes and thus this is an E3 interaction.

- An indirect fire weapon platform (aircraft, ship or artillery system) fires ammunition that affects one or more DOs. This is an E1 interaction and can be implemented in different ways:

  - The firing DO distributes detonation location(s) to all DOs, each DO determines if it is engaged and if so, what the effect is;
  - The firing DO sends firing characteristics or detonation locations to EXCON. EXCON determines which DOs are affected and sends engagement parameters to the affected DOs, which each determine what the effect is; and

  - The firing DO sends firing characteristics or detonation locations to EXCON. EXCON determines which DOs are affected and determines the effects on those DOs and subsequently sends the results to each affected DO.
- From EXCON ammunitions are dropped on the battlefield, without simulating the firing platforms. EXCON determines which DOs are engaged and either distributes engagement parameters to the specific targets, which can each determine what the effects is or EXCON determines what the effect is for each of the affected DOs and sends the results to each affected DO. If this bombardment was planned or requested by a player in the exercise, this is an E1 interaction. However, if it is executed by EXCON to force the targets to act, it is an imitated engagement and thus an E3 interaction.
- Fire support can also be simulated as an area wherein a DO has a certain probability of getting engaged, without simulating each individual projectile. Based on the characteristics of a fire support mission, a dice is rolled when and as long as the DO is within the influence of the active fire support target area. EXCON can send the definition of the engagement area to the DOs (so they can determine engagements and results themselves) or EXCON can determine when a DO is affected by an engagement area and sends the relevant engagement parameters or the results of the engagement to the affected DOs. Tactically relevant engagement areas are E1 interactions and it is assumed that these areas are not used for exercise control reasons.
- A DO drives on a bridge and because the DO is too heavy for the bridge, the bridge collapses and the DO suffers damage. This is an E1 interaction.
- A live DO has suffered a mobility kill. Because it is a live DO, for safety reasons the driving mechanism is not really inhibited, so it is still possible to move. When the DO drives away, EXCON sends it a cheating kill. This is an E3 interaction.

A2.2 Elaboration of Engagement Areas

The discussions on the redefinition of the E1 and E3 interfaces unveiled some use cases related to engagement areas that previously have not or not thoroughly enough been analysed. They are described below. However, it was concluded that the required mechanisms to implement the various types and uses of engagement areas are already present in the UCATT architecture.

In a live training environment natural and man-made objects are present, and DOs can interact with those objects. For example, a building can provide cover and concealment, it blocks passage for certain vehicles and the building can also be damaged or destroyed, affecting the mentioned cover, concealment and blocking characteristics. Another example is an anti-tank ditch, it blocks passage for certain vehicles, but with specific actions the anti-tank ditch can be breached (e.g., laying a mobile bridge over it or filling the ditch with fascines or earth).

However, the live training environment can impose restrictions on the presence of and interactions with physical objects. It can be imagined that it is not allowed to physically damage or destroy existing buildings and bridges or physically dig anti-tank ditches and create abatis[1] in the training environment. A solution to use or be confronted with the tactical implications of such objects in the live training environment, while respecting the restrictions to physically alter the terrain or infrastructure, are engagement areas. An engagement area is a virtual area that is imposed over objects or over the terrain and the status of which can be changed. Live DOs can interact with these virtual areas, simulating engagements with physical objects.

Engagement areas can be implemented by simple outline shapes, generally a 2-dimensional polygon or 3-dimensional polyhedron, defined by a limited number of points. Often a rectangular is sufficient, but in

[1] An abatis is a field fortification consisting of an obstacle formed of the branches of trees laid in a row. The trees are usually interlaced or tied with wire and mined, to make clearing the obstacle more difficult.

order to allow to follow significant terrain features, up to 20 points should be adequate. The points are connected by straight lines, there is no need for concave lines.

A2.2.1 Physically Present Objects

Objects that are physically present in the training environment have of course their influence on DOs, some of which can be changed (virtually) by implementation of engagement areas, while others types of influence cannot be changed in the live environment, not even by imposing a virtual representation over it. Typical examples are:

- Buildings provide cover and concealment for DOs and block passage for vehicles, while personnel can enter buildings. When a building also has a virtual representation, it can be damaged and destroyed in the virtual world. The consequence in the physical world of this virtual status change of the building can be that the cover value of the building can be reduced i.e., simulated ammunitions and shrapnel can travel through the now unobstructed space of the collapsed building. This requires that the training system can sense the engagement, for example by instrumentation of the building or that EXCON is informed of the engagement in an alternative way. Another consequence can be that personnel is not allowed to enter the collapsed building (when they do, they suffer a kill).

  But since the building is not physically damaged or destroyed, some types of influence cannot be simulated in the live training environment: although a building can be virtually flattened, in the training environment it is still possible to hide behind the physical building and it is still not possible to drive through it.

- Bridges allow passage of vehicles and personnel to cross rivers and gaps. When a virtual representation of a bridge is created on top of it, it is possible to destroy it or let it collapse when the (combined) weight of the DOs on the bridge is larger than the load class of that bridge. Trying to pass over a collapsing or collapsed bridge can virtually damage the DOs on the bridge. And it even becomes possible to repair the bridge or put a mobile bridge on top of it, to allow crossing the bridge again.

Somehow the changed status of physically present objects must be indicated in the live training environment, otherwise the trainees have no way to distinguish a damaged or destroyed object from an intact one. Several solutions exist, using for example signs, flags, coloured plates or augmented or virtual reality.

Physically present obstacles like for example anti-tank ditches, roadblocks or physically destroyed bridges, physically block vehicles from passing. It is not very useful to create an engagement area over such obstacles, because although those objects can be breached or cleared in the virtual world, they still cannot be negotiated in the live training environment, for this requires actual physical measures.

A2.2.2 Virtually Present Objects

It is also possible to create virtual objects which have no or only a symbolic representation in the live training environment. They can influence the status of DOs when DOs make contact with the engagement area and DOs can take certain actions regarding the engagement area. The following categories of engagement areas can be distinguished:

- **Man-made obstacles** like for example minefields, anti-tank ditches, abatises and craters can be created in the virtual world. This can be done in EXCON, by an O/C in the field or even by a live DO signalling an obstacle creation activity, providing the type of obstacle and associated geographical coordinates. When the obstacle has been created and DOs enter the engagement area, they can suffer damage (e.g., a mobility or catastrophic kill).

  Virtual obstacles can also be cleared or **breached** by live DOs, creating a passage through the obstacle.

- **Chemical, Biological, Radiological, Nuclear and explosives (CBRNe) areas** are areas which contain a toxic agent and can affect DOs. CBRNe areas come in, at least, two forms: 1) a contaminated area, which is static and sticks to the ground, infrastructure and other objects or 2) a cloud, which is dynamic and due to the influence of atmospheric conditions (wind, temperature, humidity, etc.), changes its location, shape, size and density (and therefore its effect) over time.
- Using engagement areas it is possible to model **tactically relevant restricted or impassable parts of the terrain**, like for example swamps. When entering such an area, the affected DOs can suffer certain damage, like getting stuck (a mobility kill) or even sinking (a catastrophic kill). It is also possible to define rivers or "upgrade" shallow rivers to more challenging obstacles, so that when DOs without amphibious or fording capability try to cross it, the DOs and their crew suffer damage.
- **Exercise imposed restricted areas** are areas where for exercise purposes certain restrictions on the DOs in those areas are enforced. Three types of exercise imposed restricted areas are defined:
  - Out of bounds area, an area which DOs are not allowed to enter for exercise reasons (e.g., because of environmental or reconstruction reasons). Generally, an out of bounds area applies to DOs of all parties, but it should be possible to assign a set of parties to an out of bounds area. When a DO belonging to one of the "serviced" parties enters an out of bounds area, it suffers a cheating kill.
  - No-strobe area, where the training system inhibits the operation of strobe lights of instrumented DOs that are in that area.
  - No-pyro area, where the training system inhibits the operation of pyro instrumentation of DOs in that area.

  Since engagements with exercise imposed restricted areas are not tactical but exercise control measures, they are E3 engagements, while all other described uses of engagement areas are tactical interactions with the battlefield, so these are E1 engagements.
- The effects of (ammunition) explosions on DOs can depend on the type of terrain the targeted DO is in. For example, when an artillery shell explodes on a rocky underground, blast and shrapnel patterns are different from when it explodes on a sandy or snowy underground, possibly resulting in different damages or injuries to a DO in the vicinity. When a DO is in a part of the terrain full of ditches or (low) walls, it gets partial protection from these terrain structures. But when a DO is in a wood and attacked by artillery, the explosions generate additional fragments from the shattered trees, possibly increasing the injuries to the DO. The influence of the type of terrain on the vulnerability of DOs can be modelled by **weapon effect modification areas**. When an explosion occurs in such an area, the effects on DOs can be reduced or increased.
- **Combat Service Support (CSS) areas** are an abstract representation of real world facilities. To model the type of service they provide, they have a rule set attached to it and when DOs of a certain type enter it, certain status changes are applied based on that rule set. In the simplest form, the CSS areas are only virtual objects, without any physical representation of related personnel or equipment in the live training environment. To make them (a little) more realistic, CSS areas can be marked in the training environment by for example tape to show its location and size, signs to denote the type of area and maybe some vehicles, tents and personnel that correspond to the type of CSS area. Since CSS areas represent real world (service) facilities, they have an affiliation (they belong to one of the parties in the exercise). In addition, it must be specified to which parties the service of the facility applies. By default, the service of the CSS area applies to DOs with the same affiliation as the CSS area, but the scope can be larger. For example, the service is also provided to neutral DOs or even to adversary DOs. The following types of CSS areas are distinguished:
  - **Medical treatment area** models the presence and function of a certain type of medical treatment facility. A distinction is made between a casualty collection point, Role 1, Role 2 and Role 3 medical facility. When DOs belonging to one of the serviced parties of the medical treatment area

remain a certain dwell time in that area, they are treated. Treatment of injured DOs can result in stopping further deterioration of their health status or in cure of their (minor) injuries. By specifying the parties which will be serviced, it is possible to treat friendly, neutral or even adversary DOs. Besides changing the status of DOs, medical treatment areas can also be used to evaluate the functioning of the medical transport chain. By registering the times when which DO is brought to which medical treatment area it can be assessed if injured DOs are brought within the critical times to the right type of medical treatment facility.

- Repair area models the presence and function of a certain type of maintenance and repair facility. When DOs belonging to one of the serviced parties of the repair area remain a certain dwell time in that area, they are repaired (i.e., their status is set to operational).
- Resupply area models the presence and function of a resupply unit or facility. When DOs belonging to one of the serviced parties of the resupply area remain a certain dwell time in that area, their ammunition load is set to the standard load of the DO type. When they spend less than the dwell time in the resupply area, only a proportional amount of supplies is transferred. There is no requirement to transfer categories of supply other than Class 5, since other categories of supply like Class 1 (food and drinks) and Class 3 (fuel, oil and lubricants) are not simulated in a live training environment but exist for real.
- Forward Armament and Refuel Point (FARP) models the presence and function of a temporary facility where in reality helicopters can be re-armed, refuelled and in some cases can be repaired of minor damage. Like a resupply area, for training there is no requirement for refuelling, because fuel is not simulated in a live training environment. A FARP is in fact a combination of a resupply and repair area for helicopters.
- Decontamination area models the presence and function of a CBRNe decontamination unit. When DOs belonging to one of the serviced parties of the decontamination area remain a certain dwell time in that area, they are decontaminated (i.e., the contamination status is removed).

If a CSS area is occupied by opposing forces, the CSS area is not functional anymore. The exact definition of "occupied"2 or the mechanism to deactivate a CSS area (rule based or manually) does not need to be standardised, as long as the new status is published and transmitted to all relevant system components.

- **Electronic Warfare (EW) influence area**, models the interference of a range of electromagnetic frequencies. Equipment of all DOs in the EW influence area using any of the frequencies in the specified range is influenced, it is not restricted to equipment of DOs belonging to a certain party. The shape of an EW influence area is either a directed cone or a sphere.

  An EW influence area can either be generated by a DO (for example a vehicle or a person equipped with a jamming device for the purpose of protection against radio-controlled IEDs or a specialised EW vehicle, airplane or ship to influence electromagnetic equipment over larger distances) or by EXCON without an associated DO. EW influence areas generated by a DO cease to exist when the generating DO switches off the jamming device or when it suffers a communication or total kill. EW influence areas generated by EXCON without an associated DO cannot be captured or deactivated by DOs, deactivation has to be done by EXCON.
- **Administrative areas** are areas that have no effect in the training environment but which are useful for monitoring and AAR purposes. The time and identification of DOs entering and leaving an administrative area must be registered. Typical examples of administrative areas are prisoner holding areas and Air Space Management (ASM) areas/zones.

[2] A possible definition of "occupied" is that at least one opposing DO is in the CSS area, while all present friendly DOs are either killed or have the status "captured".

The location, geometry and type of engagement area should be visible in the EXCON applications, and most of them also in the physical training environment. For the latter tape is usually applied in the terrain to mark the existence of specific engagement areas.

It is not useful to create virtual obstacles in order to provide cover and concealment or apply virtual mobility measures on physically impassable terrain, because they have no actionable effect in the live training environment.

A2.2.3 Ownership of Engagement Areas

The determination if DOs enter an engagement area and the subsequent determination of the effects of that engagement can take place in different parts of the training system, for example centrally by EXCON or locally by the DOs themselves. In the latter case, the definitions of the engagement areas must be provided to the DOs (through the E1 and E3 interfaces). When the definitions of engagement areas are dynamic, i.e., during their existence or activation their locations, shapes or other characteristics change, it is more logic that the engagement areas are centrally managed by EXCON. It is at least required that characteristics of engagement areas, like type and location, are distributed, in order to ensure that all EXCONs display the same situation.

When multiple training systems are interconnected and multiple EXCONs are involved in a training event, it is possible that through the E1 and E8 interfaces area engagements from any EXCON could influence any DO from any other system. Sometimes the simulation of area engagements requires detailed knowledge of the local infrastructure, for example to determine the effects of indirect fire in and on infrastructure, or the dynamic displacement of CBRNe areas. In those cases, it would be efficient and sufficient that only one EXCON (for example the EXCON that created the engagement area, which will typically be the host EXCON) is responsible for managing the engagement areas.

A2.2.4 Dynamic Affiliation of Infrastructural Objects and Terrain

For monitoring and AAR purposes it is useful to indicate which party occupies or controls a certain piece of terrain or a (part of an) infrastructural object. The latter can be a room, a floor, a building or a building complex. This is information only displayed in EXCON. A possible way to display the required information is:

- The space is coloured dark blue if a friendly DO is present (not killed and not a prisoner) in the space;
- The space is coloured light blue if there is no DO present, but it was latest occupied by a friendly DO;
- The space is coloured dark red if an opposing DO is present in the space;
- The space is coloured light red if there is no DO present, but it was latest occupied by an opposing DO;
- The space is coloured pink if both friendly and opposing DOs are present in the space;
- The space is coloured grey if it is not yet affiliated by one of the above events; and
- Other colours can be used to show affiliation to other parties, but it is not considered as a requirement to affiliate spaces to neutral (green/white) parties.

The used colours should be selected so they can be distinguished when displayed on monitors or projected on screens, for example for AAR purposes.

A2.3 Vulnerability Models

A2.3.1 Introduction

The UCATT group's point of view regarding vulnerability models is that from a technical perspective neither vulnerability models nor the associated vulnerability calculation mechanisms need to be standardised in order to achieve technical interoperability. As long as the input to the model (the ammunition involved in the engagement) and the output of the model (a damage status of the targeted DO) are standardised, technical interoperability can be achieved, while the underlying vulnerability model and calculation mechanism can be considered a "black box".

There are several reasons why altering or standardising a vulnerability model and vulnerability calculation mechanism is useful, for example to ensure a fair fight or when a new vulnerability model has to be set up. Therefore, the UCATT group decided to analyse several existing vulnerability models and associated vulnerability calculation mechanisms, with the purpose of creating a reference vulnerability model (as opposed to a standardised vulnerability model). The following five models were analysed:

- The SAAB model;
- The German VEMAG model;
- The Swiss RUAG model;
- The US MILES LEAR model; and
- The French GDI model.

As a result, a SISO reference document will be created which will contain two example models, based on the German VEMAG model and the US MILES model. This reference model is to be published in the UCATT-LSS (2) timeframe. For each model, tables are provided for six categories of targets: human, civilian vehicle, light armoured vehicle, medium armoured vehicle, heavy armoured vehicle and a typical piece of infrastructure (a house).

Generic Characteristics. Although each of the analysed models is different, they share many common characteristics. All models decompose a target into sides and those sides into areas. Some models use only a few, while others use many areas, allowing for a more precise relation between point of impact and specific damage effect (e.g., using more areas allows to model that a weapon kill is more likely to occur when the target is hit near the position of a weapon on the target). Figure A-1 shows an example of a simple and a more complex decomposition of the side of a combat vehicle into areas.

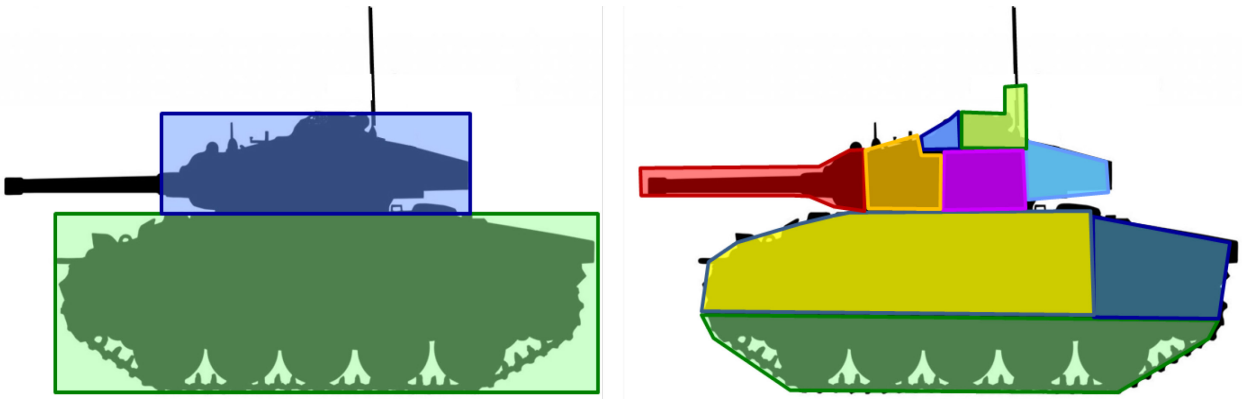


Figure A-1: Example Target Area Decomposition.

It is worth to note that all models consider a target as a two- or three-dimensional object, but none of the analysed models have more than four sides (left, right, front, back). However, most models have provisions to address top and/or bottom attacks, but they lack a top or a bottom side. Instead, adjudication of attacks on these horizontal sides is incorporated in the four vertical sides.

Each area of a target is related to a set of effects which each can be obtained when the target is hit on that area. For each defined combination of incoming ammunition, area and effect, a value is specified in a table that drives the vulnerability calculation mechanism. That calculation can be probabilistic (the value in the table is a percentage of chance) or deterministic (the value can be a simple YES/NO or number of hits that are minimally required to obtain the effect). When a target is hit, the incoming ammunition is mapped on the area that corresponds with the point of impact and the values in the cells of the associated effects are fed to the vulnerability calculation mechanism. The generic vulnerability table is depicted in Figure A-2.

None of the analysed models take angle of impact for damage calculation into account, while some models take the speed of the impact as a function of firing distance into account. Also, the probabilistic models have no memory: i.e., each engagement is evaluated independently, hitting an area multiple times does not change the likelihood of a certain effect to occur. Furthermore, the effects have a certain hierarchy, implying that the result of an ammunition engagement will only be taken into account if it is different and of a higher order than the damage already sustained on a target. So for example, if a target already has a communication kill and the adjudication of a subsequent engagement will result in a mobility kill, this mobility kill will either replace or be added to the communication kill (some models restrict a DO to have only one type of kill simultaneously, while other models allow a DO to have certain combinations of types of kill). A catastrophic kill or cheating kill will overrule all other existing types of damage. When a catastrophic kill has been administered, subsequent engagements cannot lower this status, i.e., it cannot be changed into for example a fire power kill. The exception to this is specific EXCON or O/C reset actions, but these are executed for training purposes and not as tactical engagements.

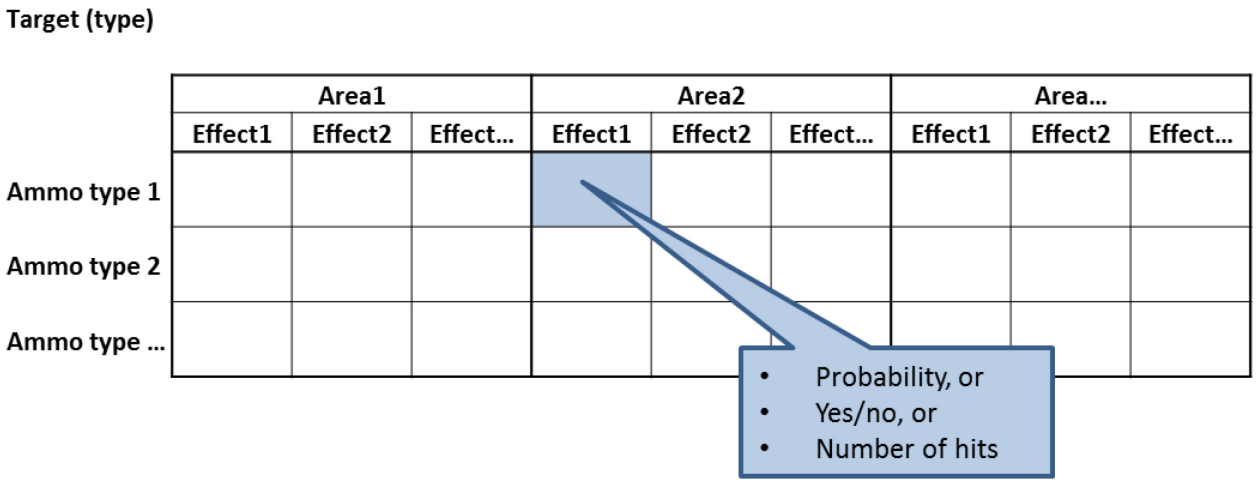


Figure A-2: Generic Vulnerability Table.

The characteristics of the vulnerability model (level of detail, probabilistic or deterministic) are first and foremost a matter a choice, based on criteria such as:

- **Training Philosophy:** some nations want to model the unpredictability and chances that can occur in reality and therefore opt for a probabilistic model. Other nations deliberately want engagements to have predictable outcomes each and every time in order to create confidence in the operators of the weapon systems. They therefore choose a deterministic model.

- **(Training) Objectives:** it can be understood that for collective force-on-force tactical training a less detailed vulnerability model would suffice, while weapon handling/precision gunnery training or weapon concept development and experimentation requires a more detailed model.

None of the models is therefore better or worse than another model, as long as it is fit for purpose.

A2.3.2 SAAB Model

This probabilistic model can define many areas on each of the four sides of a target (front, back, left, right), a typical example of such a model for a tanks is shown in Figure A-3.

The shape of an area is a polygon, which size can be defined in centimetres, but which should be larger than the accuracy of a laser beam (something in the order of magnitude of 10 cm). Although a top and bottom side are not present in the model, the sensors placed on a DO are capable of registering a hit from an elevated angle. The hit will then be registered on an area on one of the sides. A shot fired from a too steep angle, such as from the top of a building to a DO standing below it, will not be registered. The model does have provisions for registering fly-over top-attack weapons: on each vertical side, areas can be defined which are just above the physical surfaces of the DO (see areas L, M, N and O in Figure A-3). When an engagement is registered in such an area and the engaging ammunition has a top-attack capability, a top-attack hit is adjudicated. Similarly, areas can be defined just below the physical volume of the DO to adjudicate ground shots that can damage the DO (area R in see Figure A-3). This model also includes near miss areas (which are areas close to but not on the target, the outermost blue area in Figure A-3).

Figure A-3: SAAB Vulnerability Model.

To keep the vulnerability tables manageable, each ammunition type is first mapped onto one of some 22 ammunition classes, before it is used as index in the vulnerability table of the target. This way, adding a new ammunition type does not require to change the vulnerability tables, as long as the new ammunition type can be mapped on an existing ammunition class. Only when a new ammunition type requires a new ammunition class, each vulnerability table for each area of each target must be extended with an extra row.

Another measure to reduce the size of the table is that not every possible effect can be obtained from a hit on an area. Instead, the table contains one probability for one selectable effect and a second probability for another two selectable effects. The table thus contains two probabilities to achieve a maximum of three different effects.

The model takes the speed of kinetic ammunition into account: the firing distance is used as a reduction factor on the probability listed in the vulnerability table.

A2.3.3 German VEMAG Model

This model is similar to the SAAB model. The difference is that this model does not only accommodate ammunition classes in a vulnerability table, but also ammunition types. The structure of the vulnerability tables is thus the same, but instead of some 22 rows (one for each ammunition class), a table can contain a row for each ammunition type, resulting in tables of over a hundred rows. When a new ammunition type is added and it is not mapped onto a used ammunition class, each vulnerability table for each area of each target must be extended with an extra row.

A2.3.4 Swiss RUAG Model

This is a deterministic model which uses five areas for each of the four sides of a target (front, back, left, right), see Figure A-4. Each area has a rectangular shape and is associated with one specific effect (weapon kill, mobility kill, catastrophic kill, near miss, total miss). Three of the areas are stacked on top of each other and map onto the target: the bottom area is associated with a mobility kill, the middle area is associated with a catastrophic kill and the top area is associated with a weapon kill. Two areas surrounding the target are associated with a near and total miss respectively. The structure of this model is the same for every target, only the size of the areas and the values per area can differ. Engagements from an elevated angle can be registered, but attacks from steep angles cannot be registered. Also, there are no provisions for adjudicating fly-over top-attack engagements.

The vulnerability table contains one row for each ammunition type. The value provided is a Boolean value, it expresses when the area is hit, the associated effect will occur or not. Moreover, the tables only contain Swiss operated systems and associated ammunitions.

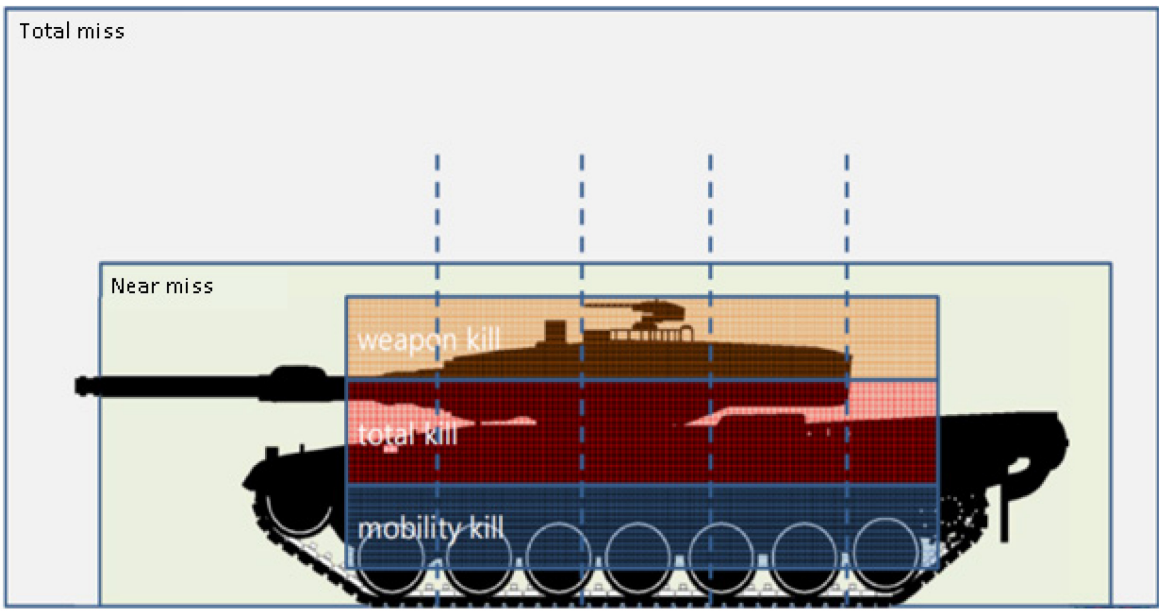


Figure A-4: Swiss RUAG Vulnerability Model.

A2.3.5 US MILES LEAR Model

The MILES Lethality Effects Assessment Routine (LEAR) distinguishes four sides of a target (front, back, left, right), but no further subdivision into areas is made. See Figure A-5. Five different effects can result from an engagement (catastrophic kill, fire power kill, mobility kill, communications kill and hit (no kill)[3]). For dismounts a uniform cylinder is used in combination with two effects (catastrophic kill and hit (no kill)).

For each of the used ammunition codes (there are 36 different codes) the vulnerability table contains:

- A probability of catastrophic kill (Pk) for each of the four sides of a target;
- Three effect factors (respectively for a Fire power Kill (FpK), Mobility Kill (MobK) and Communications Kill (ComK)); and
- Several ammunition factors (to model subcategories of a certain ammunition type, in that case the ammunition factor is sent by the shooter as part of the engagement data).

The vulnerability calculation mechanism is a multi-step process: first, it is assessed whether a catastrophic kill is suffered. The probability is calculated as the given Pk for the applicable side, multiplied by the appropriate ammunition factor, multiplied by an aspect angle modifier for turreted vehicles. This probability is denoted as CatK.

If a catastrophic kill is not assessed, then a fire power kill assessment is made, where the probability is calculated as CatK multiplied by the FpK factor.

If a fire power kill is not assessed, then a mobility kill assessment is made, where the probability is calculated as CatK multiplied by the MobK factor.

If a mobility kill is not assessed, then a communications kill is assessment is made, where the probability is calculated as CatK multiplied by the ComK factor.

Finally, if a communications kill is not assessed, then a hit is assessed.

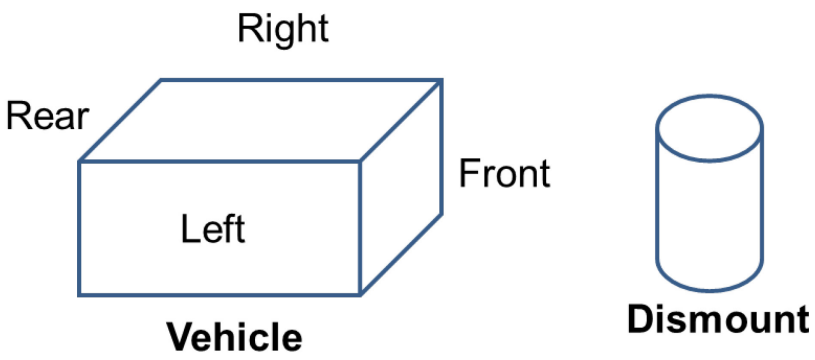


Figure A-5: MILES Vulnerability Model.

A2.3.6 French GDI Model

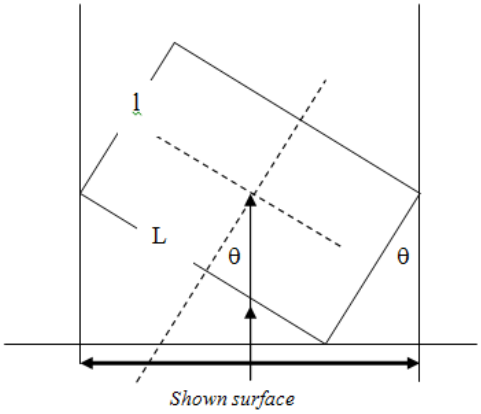
A fifth model, used by France and created by GDI, was discussed. In this model a target has three different sides (front, side and rear, where the left and right side share the same structure and data).

[3] Near misses are also possible in MILES, but these are modelled as ammunition codes sent by the firing DO, not as a result of a vulnerability calculation. In fact, the firing laser contains intermittent series of ammunition codes and near miss codes. If a target does not sense the ammunition codes but only a near miss code, a near miss is registered.

Moreover, a distinction is made between the hull and the turret of a target. See Figure A-6. Generally, each side contains only one area, but for some targets a side consists of several areas with different shapes (e.g., for heavily armoured targets). A target is equipped with only 2 or 3 sensors, which are mounted on the hull or turret, depending on the type of target. Because the training system knows the angle between the hull and the turret (either provided by the vehicle itself or sensors of the training system), the system can determine the shown surfaces of the hull and turret relative towards the direction of the shooter, consisting of the shapes and sizes of the relevant sides and areas (see Figure A-2). The top of a vehicle is not modelled. Neither is the bottom of the vehicle, but engagements with mines or IEDs are adjudicated centrally by EXCON.

When a shooter engages a target, based on the laser's reflection on a sensor's mirror, the laser first calculates the distance between the shooter and the target and the distance between the mirror and the aiming point on the target. The laser code that is subsequently sent to the target contains the target distance, the aiming point distance and the ammunition type.

This model is deterministic: each area has an ammunition table specifying how many hits of each type of ammunition are required to destroy that area from an undamaged state. This translates into an ammunition efficiency. For example, when five hits of a certain type of ammunition are required to destroy the undamaged area, that ammunition has an efficiency of 1/5 for that area. This is the amount of points that will be subtracted from the current life value of the area in case of a hit. An undamaged area starts with a life value of 1.



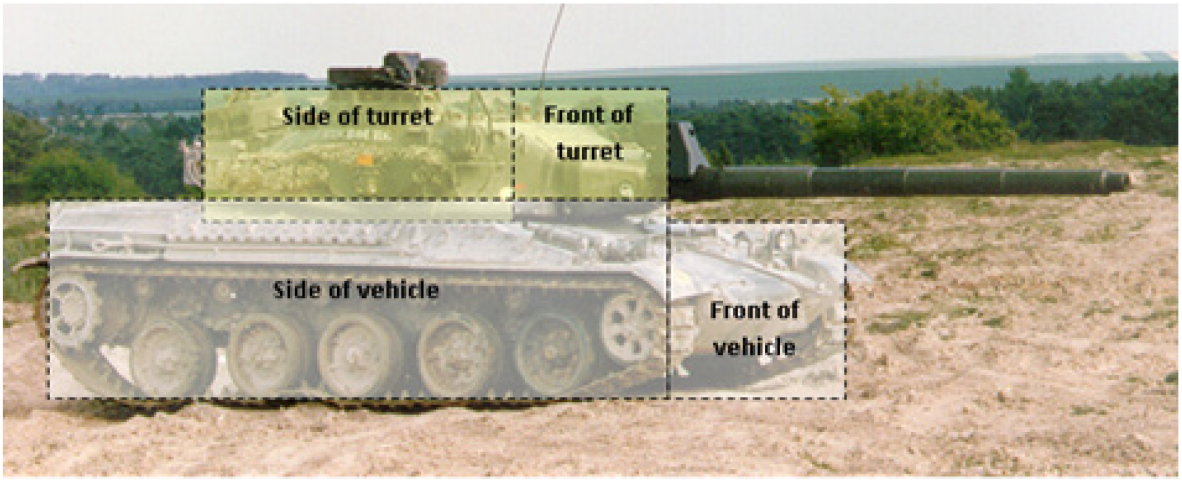


Figure A-6: French Vulnerability Model.

Furthermore, a distance correction can be applied. All ammunitions have a specified maximum range, so that when the target is hit from farther than the maximum range, no damage is sustained. The distance below the maximum range can be split into one or more segments, which each can be assigned a distance reduction factor (1, 2/3, 1/2, 1/3 and 0 are used). A hit with an ammunition will affect the current life value of an area based on the combination of the ammunition efficiency and the distance correction. For example, when the listed ammunition efficiency is 1/10 (meaning 10 hits are required to destroy the undamaged area) and the distance correction is 1/3, a value of 1/30 (= 1/10 * 1/3) will be subtracted from the current life value. This means that 30 hits with this ammunition type are required to destroy an undamaged area from this specific distance.

When an area of the hull is destroyed, the vehicle sustains a mobility kill. When an area of the turret is destroyed, the vehicle sustains a fire kill. The vehicle sustains a total kill when both the hull and turret are killed (thus a mobility and fire kill) or when either the hull or turret has received enough damage to kill it twice.

A2.4 Refinement of E9 Interactions

The E9 interface implements the logical linking of objects in the training environment. This includes linking DOs amongst each other (this is called “DO association”) and linking DOs with equipment that is not modelled as a DO (called “equipment pairing”).

DO association, described in Section 3.3.4.4. of the UCATT-3 report, registers grouping of DOs in order to synchronise their position (for example when a soldier mounts a vehicle, so his position will be derived from that of the vehicle) or to enable the propagation of effects (when the vehicle is hit, also the mounted DOs can be wounded or killed as a consequence). Equipment pairing, described in Section 3.3.4.3. of the UCATT-3 report, registers that a piece of equipment, which is not modelled as a DO, is picked up by a DO. In the first place this allows to report which DO uses the particular piece of equipment (e.g., a weapon or medical treatment device). Secondly, it allows to determine if the DO is able to use the equipment either due to his training (for example, an advanced medical treatment device can only be used effectively by a medic) or due to his operational status (a severely wounded soldier is not able to fire a heavy machine gun).

DO association and equipment pairing are dynamic processes, relations can change many times during the execution of an exercise. Also, a DO can be involved in multiple associations and pairings simultaneously.

A2.4.1 DO Association

DO association first allows synchronisation of position of DOs. There are several reasons why this can be useful or necessary. When position sensors are not very accurate, but have a deviation of a metre or more like in the case of GPS receivers, it is often not possible to distinguish purely based on the received position information of DOs whether DO A is next to DO B or sitting in or on DO B. For example, is a soldier walking next to a truck or sitting in the truck? Is a soldier inside a house looking out a window or standing outside a house looking in? Is he standing on the roof of a building or on the top floor? This becomes even more important when the position sensor is not capable to provide position information from inside vehicles or structures. In that case the DO inside another DO can inherit the position of the containing DO (often sufficient when the containing DO is a vehicle) or another position determination system inside the containing DO must take over (often the case for large buildings, where other techniques than GPS have to be implemented to determine where a DO is inside the building).

More accurate position information is not only required for monitoring purposes, but also for targeting and damage calculation. It makes a difference if a soldier is located in front or on top of a vehicle or building or if he is located in that vehicle or building. In the latter case he can benefit from the protection of the vehicle or building. While this situation could be solved naturally for direct fire engagements in a training system that uses line-of-sight engagement simulators (like for example a laser, where a small arms fire laser cannot activate a laser receptor or reflector that is shielded by the skin of a vehicle or a wall), other types of

engagement still need the more accurate information, for example indirect fire or a CBRNe cloud. Protection can also be partial, for example when a soldier is sitting or standing out of the hatch, when only his head or upper body is exposed to bullets and shrapnel. For example, sustaining a leg injury due to small calibre direct fire should not be possible then.

But DO association can also be used to implement propagation of effects: when the containing DO sustains damage or gets CBRNe contaminated, also the contained DOs can be affected. For example, when a building is hit by artillery, soldiers inside the building can be wounded or killed, when a vehicle falls from a bridge, its crew and mounted soldiers can suffer injuries, and when a flatbed trailer is destroyed, also a vehicle it is carrying can be damaged or destroyed.

To implement the mechanism of DO association, the training system must at least have the capability to register when a DO mounts and dismounts another vehicle DO through its doors and hatches and when a DO enters and exits a building DO through its doors, windows and other types of (prepared) entrances (for example a breach in a wall). Of secondary importance are the capability to register if a DO is on top of another DO and the capability to register if a DO is in an out of the hatch position in a vehicle.

A2.4.2 Equipment Pairing

In case of equipment pairing, the equipment concerned has no status of its own (otherwise it would have been a DO). But it does have an ID and type indicator. In order to register which DO carries and uses which piece of equipment and to determine if that DO is able to use that equipment, information between the DO and piece of equipment needs to be exchanged. Several solutions for this could be implemented, for example:

- The DO retrieves the ID and type information from the equipment, performs the ability check and informs the equipment whether the DO is allowed to operate the equipment or not;
- The equipment retrieves the type and status information from the DO and performs the ability check; and
- The DO retrieves the ID and type information from the equipment, the DO sends this information to EXCON which performs the ability check and informs the DO whether it is allowed to operate the equipment or not and subsequently this information is passed from the DO to the equipment.

In all cases the DO reports the equipment pairing to EXCON.

Equipment pairing can be implemented either by requiring the DO to actively pair the equipment or it can be done automatically based on proximity between the DO and the equipment concerned. An example of active pairing is when a soldier picking up a weapon first has to press a special pairing button on the weapon, or he first has to reload the weapon to trigger the pairing process and enable him to fire the weapon. A disadvantage of this active solution is that a soldier is required to perform an action in a training environment which he does not have to do in reality. The main advantage of this solution is that wrong pairings are avoided, which could occur when several DOs and/or pieces of equipment are located very close to each other.

In the case of automatic pairing, no additional human interaction is required, other than picking up a piece of equipment. The distance over which equipment pairing must become active is within touching distance between the DO and the equipment (1 metre). Also, it is sufficient when a piece of equipment is paired simultaneously with maximum one DO. For example, for a crew-served weapon like a machine gun, it suffices to pair the weapon only with the gunner, not (also) to his aid who feeds the ammunition. Of course, during the execution of a training session, the equipment pairing can change, for example when the gunner of a machine gun is killed and his helper or another soldier picks up the machine gun. A DO can be paired with more than one piece of equipment, for example a soldier can be equipped with an assault rifle, a shotgun and a medical treatment device.

A2.5 Analysis of Interactions Between Real Platforms and Training Systems (E10 Interface)

The E10 external interface "exchange platform data" enables the exchange of data between a training system and computers of the instrumented real platforms. In UCATT-3 it was already recognised that the number of different types of operational platforms and systems that can be used in live training exercises is large and that each type of system probably will require a different dataset to be exchanged with a training system. Also, in the UCATT-LSS timeframe no E10 datasets were produced, but several possible use cases were analysed more deeply to get a better understanding of the requirements and advantages and disadvantages of an E10 interface.

A2.5.1 Data Exchange Between Real Platforms and Training Systems

The E10 interface is a bidirectional interface. Data exchange from a real platform to a training system is used firstly to control simulated engagements instead of for example firing a real bullet or grenade or performing actual logistical activities. Where for small arms no data interface with the weapon is required (for example firing blanks and using the resulting pressure or sound can suffice to trigger a laser shot to simulate a bullet), for larger weapon systems this is not a viable solution. The added engagement simulation equipment must be triggered via the E10 interface to simulate a shot, and sometimes also visual and audio effects must be initiated to simulate the associated muzzle flash, smoke and sound blast. Another example is when a vehicle or weapon is equipped with a powerful Laser Range Finder (LRF). Generally, these are not eye-safe (laser Class 1) and when used against reflectors of a training system, the operational LRF may get damaged, so it is undesirable to use them in a live training environment. Several solutions exist, for example the power of the LRF is diminished, degrading the laser to a lower laser class or the real LRF is disabled and the system is equipped with a less powerful LRF as part of the training suite. Ideally this training LRF should be operated by the original vehicle or weapon LRF controls, requiring the E10 interface. It is even possible to have a mixed solution (currently in use by the Norwegian CTC): the operational fighting vehicle is equipped with two LRFs, a combat LRF and a lower-class barrel LRF. For training purposes, a third LRF (BT46) is added. The barrel LRF and the training LRF roughly have the same specifications. At first, the training LRF and the barrel LRF simultaneously fire a laser shot. When the training LRF receives an echo from a target's reflector, the corresponding distance is fed to the fire control system of the fighting vehicle. If the training LRF receives no echo (i.e., no target detected) and the barrel LRF returns a value smaller than 300 metres, then the value of the barrel LRF is fed to the fire control system. This situation could indicate there is an object preventing the training LRF from receiving echoes from a target's reflector. Otherwise, when the training LRF has received no echo and the barrel LRF has not received echoes from closer than 300 metre, the situation is considered safe and the vehicle's combat LRF is fired and its returned value is fed to the fire control computer.

Other reasons to provide information of a real platform to a training system are engagement adjudication (e.g., to determine if the DO enters an engagement area based on its position), monitoring and/or After Action Review. Typical examples are the reporting of positional data, turret position and platform status. In many cases the platform itself has this kind of data available for its own internal purposes. From a design point of view, this data can either be tapped from the real platform or the instrumentation equipment can collect or calculate the data itself. The first solution, using the platform data, has the advantage that only one data source is used instead of multiple sources, thus identical parameters in the platform and in the training system have always exactly the same value. Using different sources can lead to situations where identical parameters in the platform and training system have different values, for example the platform position displayed in a vehicle, displayed on a battlefield management system and displayed on a training system view all can have (slightly) different values, caused by different sensors and by different timings of providing the data.

However, despite the advantage of data consistency, one should ask whether this solution is desirable, because also some disadvantages can be identified. From a technical point of view, the more interfaces are created and if not the proper design, detection and counter measures are taken, the higher the risk of creating

more cyber-attack vectors. The training equipment contains many ICT components with several data connections, be it wired or wireless. Possibly there are also some data ports, for example to initialise the training equipment or to retrieve collected data. It may even be possible that non-authorised devices can be connected to the training system, a soldier can be creative enough to use an open USB port to recharge his personal mobile phone. And this creates risks that malware can enter the training system and can travel from the training system to the real platforms. And of course, malware can also travel from real platforms to the training system, from where it can infect other systems, either through the interfaces of the training system or when the training equipment is connected in a following training exercise to a new platform. It is not the objective of UCATT to provide solutions for cyber security, but both manufacturers and users of training systems must at least be aware of the risks and take the appropriate preventive and responsive measures.

Also, from an operational point of view, providing actual platform data can reveal sensitive performance characteristics and tactics of the platform, which might not be desirable in an unclassified training environment. Therefore, despite the fact that such an E10 interface it is technically possible, for operational reasons it might still be valid to choose not to (fully) implement an E10 interface and have the training suite collect or calculate less accurate and/or open source platform specific data.

The E10 interface cannot solve all issues with providing relevant platform data to a training system. This is the case when the required data is not or only partially available in the platform. Take for example a weapon system that can fire different types of ammunition. When the platform can detect the loaded type of ammunition itself or requires the operator to select the appropriate ammunition type to enable the fire control computer to calculate the correct ballistic trajectory, this parameter can be transferred through an E10 interface to the training system. However, this is impossible when the platform or weapon system does not register the parameter. A simple weapon system like a mortar does not register the angle of fire, which type of ammunition is fired, what fuse settings of the round are used or how many charges are used. This information is essential for a training system to determine both the point of impact and the type of effect (e.g., explosion, smoke screen or illumination). In such situations other solutions are required, for example to instrument the launching tube, the training rounds and/or to have the operator provide the required data on a specific interface of the training system. Although technically possible, instrumenting solutions for mortars proved to be complex and expensive, while alternatives for simulating indirect fire without the real firing platforms are available and much cheaper.

Another example is when the CBRNe overpressure system of a platform is activated. This information is available in the platform and can be transferred to a training system by means of an E10 interface. However, when simultaneously a door, hatch or window of the platform is opened, the CBRNe protection will be disrupted and therefore the training system needs to know this type of information. When the platform does not register the open or closed status of doors, etc., specific sensors as part of the training system suite need to be added to the platform.

A2.5.2 Data Exchange from Training System to Real Platform

The E10 interface also enables data exchange from a training system to real platforms. This functionality can serve several purposes:

- To feed the platform computers with data that is generated by a replaced or added simulated sensor, for example distance parameters generated by a training LRF or positional data from the training equipment positioning system.
- To insert data in platform sensors that is not present in the live training environment. Examples are visualising in the platform's visual sensors tracers or missiles fired by the platform's weapons or visualising the fall of shot of aircraft or artillery delivered ordnance. Another example is adding sounds or messages in the platform's communication system, such as platform sounds, battlefield sounds or specific status or EXCON messages.

- To disable or otherwise influence capabilities of the platform. One reason to disable platform functionality is that the training system cannot deal with the effects of correctly operating the platform. A typical example is the dynamic lead functionality: when firing at a moving target, the aiming point is centred mid target, while the barrel is pointed ahead of the target to compensate for the target movement. When laser engagement training equipment is attached to the barrel, the simulation of a shot might not get the desired results. Therefore, the dynamic lead should be disabled in combination with the training equipment. When the gunner has to actively operate a dynamic lead control, he could also be told not to use that control, but this is a less preferred solution, because it can lead to negative training effects.

  A different reason to disable platform functionality is to simulate engagement results. For example, in case of a weapon or communication kill, the ability to fire the platform's weapons or to communicate over the radios is inhibited. Similarly, the effects of cyber-attacks (disabling or changing functionality, altering displayed values, etc.) or other simulated malfunctions can be initiated.

  However, safety of the platform and its crew must always be ensured, so it can be decided that certain capabilities should not be affected, like for example that even in case of a simulated mobility kill, the platform should always be allowed to move out of danger or to prevent causing dangerous situations. Likewise, it can be decided that one or more communication channels should remain unaffected to allow sending and receiving non-exercise related or safety messages.

Note that an E10 interface can be inserted in many different places in a platform system. Take for example an acoustic sensor or laser detector that provides input to a defensive aid suite to trigger an automatic defensive measure (which in the training system might modify the vulnerability parameters). Simulated data can be inserted by interfacing with the sensor, with the processing unit that interprets sensor input or with the datalink between the sensor and the processing unit. However, placing a loudspeaker in front of an acoustic sensor to trigger it, is not an E10 interface.

Creating interfaces with existing platforms, which are not designed to interface with additional systems, such as a UCATT training system, might not be easy or even possible at all. It would therefore be advisable for platform manufacturers to take interface requirements with training systems into account already in the design phase of a platform and its subsystems. A development which is very relevant in this respect and the E10 interface in particular, is the Generic Vehicle Architecture (GVA). This initiative strives to create a platform design based on standardised modules which communicate via standardised interfaces. Such an architecture would be applicable for both real platforms and simulators, thus also facilitating the interface between the two of them. However, at this moment, the GVA is very much work in progress and in addition there is not one GVA project, but several companies, nations, NATO and EDA all sponsor their own initiatives. Consequently, UCATT-LSS cannot make use of or even refer to a specific GVA, but it is clear that UCATT should monitor these GVA developments closely and actively promote the UCATT ideas and requirements to be taken into account in the GVA(s).

A2.5.3 Embedded Simulation in the Live UCATT Context

Modern operational systems sometimes are ex-factory equipped with training functionality or even training simulation. Such embedded training functionality is of interest for UCATT, because it could drive functional specifications for the E10 interface or might even be reason to define a new external interface.

The UCATT working group first explored some existing implementations of embedded training functionality to set the scene. It was found that not each case is relevant for UCATT. Take for example the case of an air defence vehicle, which has the possibility to generate targets and display them in its sensors. The targets are not distributed to other systems. In fact, the fighting vehicle is used as a mock-up in a stand-alone training session. However useful in itself, integrating such a weapon system in a UCATT training session would not be very useful, because the weapon system neither can act as a DO, nor can interact with other DOs while in training mode.

Embedded simulation is relevant for UCATT, which focusses on live training, when an operational system contains training functionality which can be used while the operational system still can perform its normal functions in a live environment, such as move, communicate, sense and "engage" (all within the safety regulations of course). Examples of such training functionality are:

- The operational system has built-in UCATT-compatible Tactical Engagement Simulation System (TESS) components, so the system can participate in UCATT training sessions without much physical preparation.
- In addition to what its own sensors can retrieve from the live environment, the operational system can inject or even generate additional information, such as virtual DOs. It is important that generated DOs are processed by a UCATT EXCON to ensure that the data can also be distributed to other DOs that can possibly observe or interact with the generated DOs, preventing that a live DO is involved in a local, stand-alone scenario, leading to behaviour which cannot be explained by other players in the training session.

It was concluded that examples of embedded training functionality such as described above, can be covered by current identified UCATT interfaces. The example of DO injection or DO generation can be implemented when a live DO possesses an E8 interface. When new types of interaction with embedded simulation arise, the impact on the UCATT interfaces should be reassessed.

A2.6 Geo-Referencing and Geo-Pairing

In some live training system implementations, a shooter DO directly transfers engagement parameters to a target DO. A laser engagement system is a typical example of such an implementation. Generally, in such cases no location data of shooter nor target is required to resolve the engagement, because the target is within range of the physical "engagement beam".

In other implementations of engagements location data of shooter and/or target is required to resolve an engagement. An example is when EXCON senses that a DO fires a weapon and calculating the projectile's trajectory, determines that another DO is hit. Interactions with engagement areas always require the use of the location of DOs. And even in case of laser engagements positional data of the shooter can be transferred, for example to take the distance of the engagement into account.

Engagements where geographical data is required are referred to as geo-referencing or geo-pairing. However, there are no standardised definitions of these terms. Some consider them to be equal, while others see a clear distinction. Within the UCATT context the following definitions are adopted:

> **Geo-Referencing** is a method where geographical position data is used to determine (the outcome of) an engagement.

Typical use cases of geo-referencing are determination if the activity of one DO affects other DOs (e.g., by simulation of the trajectory of projectiles or taking the distance between shooter and target into account) and determination if a DO is within an engagement area.

> **Geo-Pairing** is a method which resolves which DO fires at which other DO(s) using geographical position data.

Geo-pairing is confined to resolving firing activities between DOs, typically where EXCON determines if a weapon engagement of one DO affects other DOs. Interactions with engagement areas are not considered as geo-pairing, but as geo-referencing. Geo-pairing is thus a subset of geo-referencing.

Geo-referencing is a physical implementation of the external interfaces E1 and E3. LVC integration always involves geo-referencing. Both geo-referencing and geo-pairing may make use of a digital terrain database representation.

A2.7 Live-Virtual-Constructive Integration: Practical Examples

Although primarily focusing on standardisation of live-to-live integration of training systems, the UCATT working groups have always put substantial effort in investigating the integration with the virtual and constructive domains. Throughout the years, the importance and practical application of LVC integration have grown and several use cases have been described in the MSG-098 report. In the UCATT-LSS timeframe, user requirements and developments regarding LVC integration have been closely monitored. Examples of every kind of interaction have been identified, reconfirming the need for further development of interoperability standards.

Live-Live Integration. Military budget cuts and the changing security situation have led the last decade to an increase in military cooperation and combined training, proving the validity of the UCATT Use Cases. Use Case 1, where multinational forces bring their operational equipment to train on a national site, is common practice. Use Case 2, where the multinational forces also bring part of their training and instrumentation equipment, also occurs more frequently. Examples are exercise NOBLE LEDGER and exercise BISON DRAWSKO 2017, a brigade level exercise conducted by the Netherlands, Czech and German units. A further integrated variation of Use Case 2, where visiting troops also bring their EXCON facilities, is seen in the exercises where the Netherlands bring their Mobile Combat Training Centre (MCTC) to the German Gefechtsübungszentrum Heer (GÜZ). These integrated exercises make use of the available UCATT standards and drive further development of UCATT standards, both in terms of priorities and required functionality.

Use Case 3a, distributed combined training, where remote live combat training centres are connected, is observed in case of the connection of a South-Korean CTC and a US CTC in South-Korea (Figure A-7). Interoperability is mainly achieved by interfacing between the EXCONs (E8). The most significant example is the RESOLVE series of exercises held yearly with Republic of Korea and US Armed Forces. The exercise is the world's largest simulation exercise integrating Live, Virtual and Constructive simulation across the globe to create a theatre level exercise. Specifically, the US Eight Army has limited live manoeuvre space, but is required to train a Brigade Combat Team (BCT) in the Live and Virtual environment, whilst the remainder of the force is represented using Constructive simulation. Independent sub-unit Live simulation areas with their own EXCON are used simultaneously with sub-unit Virtual simulation using their EXCON to create an overall BCT level of combat power. The BCT EXCON is then federated again into the larger Theatre level exercise.

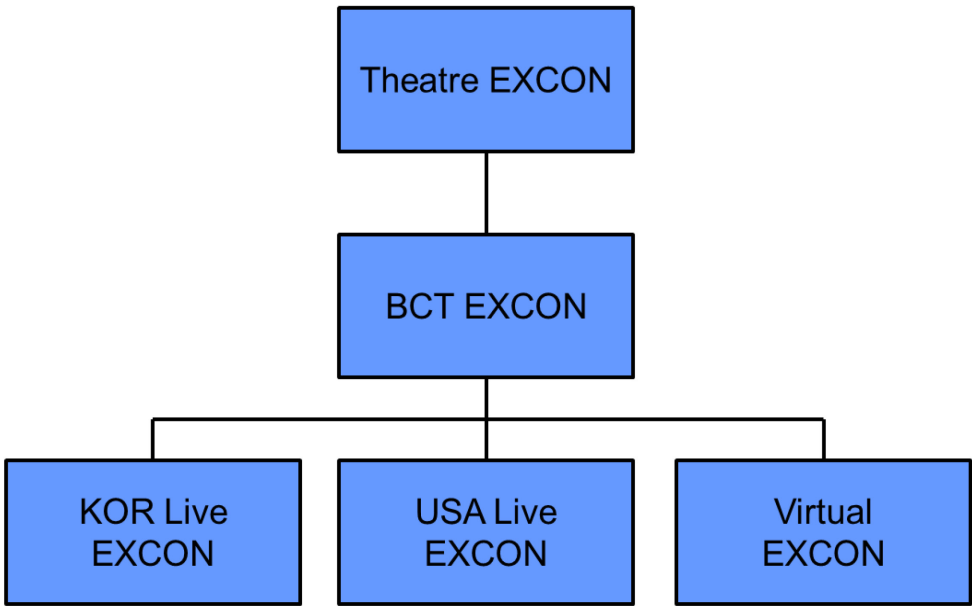


Figure A-7: South-Korean CTC and US CTC Exercise Configuration in South-Korea.

A variation of Use Case 3a, where also EXCONs interface with DOs of another training system, is observed in the United Kingdom. In the exercise JOINT WARRIOR, exercising troops move to several locations and successively are "handed over" to different EXCONs. A "relieved" EXCON can then be moved to a next exercise location.

Use Case 3b, combined training in a mission area, is functionally similar to Use Case 1, except that the training system must be deployable. It is decided that this Use Case is renamed "Expeditionary", because this term reflects that this Use Case does not only require mobility of the training system, but also be able to operate under austere conditions (climate and physical) and be self-sustainable (regarding resources, frequencies). This Use Case is current practice for – amongst others – France, the Netherlands, Sweden, United Kingdom and United States.

Live-Virtual Integration. Interactions from a virtual to live environment exist from the early implementations of live combat training systems. Examples are engagement areas, where a virtual minefield or artillery area can engage a live DO. Also, a virtual weapon system can engage live DOs, for example a virtual mortar, airplane or UAV. Generally such interactions are confined to beyond-line-of-sight situations, to avoid a live DO being engaged by a system that it could observe in reality (and thus could take preventive or countermeasures), while in the training environment it cannot detect the virtual DO. However, as technology progresses, live DOs can be equipped with special training equipment or training functionality can be integrated in operational systems, allowing live DOs to detect and even engage virtual DOs. Examples of this augmented reality are synthetic fall of shot, where virtual ammunitions and/or their effects are visualised in live sensors (e.g., guiding a missile or directing indirect fire) and projecting virtual targets in live sensors so these targets can be engaged.

Another application of feeding live training data into a virtual environment is synthetic wrap: the live training exercise is embedded in a larger exercise, consisting of virtual entities. In such a setting, use can be made of synthetic ISTAR, where for example a virtual UAV is fed with live data to create a battlefield picture, used for intelligence or targeting purposes.

Live-Constructive Integration. The main reason for this kind of integration is synthetic wrap, where the live training exercise is integrated in a larger exercise, consisting of constructive entities, which can represent flanking and higher units. Engagements between the different domains are also possible, for example where a live indirect firing platform can create an area effect and so engage a constructive aggregate unit.

Based on the investigation of the different types of integration and particular uses cases it was concluded that no new requirements for UCATT interfaces have been identified and that the current datasets for the UCATT external interfaces are sufficient to enable the integration with other domains as described above.

The further investigation of LVC integration has led to a strengthened synchronisation and cooperation with other NATO (MSG) working groups that focus on virtual and constructive developments, to avoid parallel and disconnected developments.

A2.8 Information and Psychological Operations

Military forces have a large set of capabilities at their disposal to be able to operate effectively in the whole spectrum of military operations and to obtain their objectives. They can achieve both lethal and non-lethal effects. Two types of capabilities related to the latter category are information operations in general and psychological operations specifically. These capabilities can be used in any military operation and on any level. A single soldier can influence others by his presence, posture and profile, and the way he acts. Key leader engagements are another example of influence activities that can occur at the individual

level. Influence activities can also be executed at higher levels, such as media campaigns involving distribution of leaflets, transmission of radio messages and using social media, and strategic communication (STRATCOM) at the highest level.

These types of activities are aimed at affecting the believes and/or mental condition of individuals and groups. For example, people might become more or less supportive towards ideas, missions, groups and organisations. Or they might become more or less motivated.

But also, the use of kinetic capabilities can have psychological (side) effects: the overflight of a fighter aircraft can frighten opponents and encourage own troops; being exposed to the sound, blast and shrapnel of explosions can even temporarily render someone unable to act.

These psychological effects might not always be easy to detect and at best manifest themselves by a change of behaviour of personnel. Modelling these types of psychological effects makes perfectly sense in constructive and virtual simulation environments, because human behaviour models are an essential part of those environments. However, in a live (simulation) environment, human behaviour models are not required, because the humans themselves are part of the training environment. Also, the activities and products used to create psychological effects are physically present or at least simulated in the live environment. Psychological effects therefore have no impact on the simulated DO status, nor introduce new types of interactions in the live simulation environment.

A2.9 Sensors Not Triggered Naturally in the Training Environment

There are several types of events or signals which occur on the real battlefield, which can be sensed by special sensors, but which are not present in their original appearance or only present in a reduced form in the live training environment. The most obvious example is firing live ammunitions, which can kill, injure or damage. Reasons for prohibiting such triggers are generally based on safety considerations. However, some of these triggers are essential because they can influence the battle. In these cases, solutions should be found to represent or simulate these triggers at a level that enables the training objectives to be achieved. Instead of firing real bullets, direct fire interactions between shooter and target can be simulated by for example laser engagement systems or other methods to calculate ballistic trajectories. But there are more types of events and signals that should be represented differently than in their original appearance in order to trigger sensors that can warn crew members or initiate automatic reactions of a DO. Such sensors include:

- Laser sensors, to detect being illuminated by a laser (either for ranging or ammunition guidance);
- Infrared sensors, to detect for example a missile launch or a gun being fired. Although blanks or pyrotechnics can be used in a live training environment to better simulate these events, these signals might not be sufficient to reliably trigger the sensors;
- Radar, to detect incoming projectiles. Clearly no projectiles will actually fly in a live training environment, so there is nothing to sense; and
- Acoustic sensors, to detect the firing of a gun or the sonic boom of ammunitions. Not all simulated engagements generate sound, and if they do (for example firing blanks), they might produce a sound that is significantly weaker than that of live ammunition and they do not generate the sound of a moving bullet, which is necessary in order to find the position of the shooter.

When such sensors detect a designated signal, they can trigger automatic reactions. For example, they can pop smoke to obstruct the line of sight between the shooter and the target, turn the turret of the DO into the direction where the detected trigger is coming from, so the crew can engage the threat faster, activate automatic countermeasures to engage an incoming projectile, and they can warn the crew of the DO, by displaying the type of event and the direction where the threat is coming from. This information can also immediately be shared through the C4I system to other DOs in the same unit, so these DOs can take proper countermeasures

themselves (automatically pop smoke or turn the turret into the direction of the threat) or take coordinated action (while the targeted DO moves into cover, another DO of the unit can engage the threat).

Some automatic reactions can be allowed unaltered in a live training environment, such as turning the turret in the proper direction or distributing the sensor information to other DOs through the C4I systems. Other automatic reactions however, such as engaging an incoming projectile, must meet safety requirements and should be disabled or better, be simulated as well to allow the benefits of being equipped with a defensive aid suite.

Several solutions can be envisioned to trigger the operational sensors of a DO or in most cases, to bypass the operational sensors and simulate the appropriate sensor output. For example, based on the laser shots of a laser engagement training system, be it a hit or a near miss on a DO, that DO can generate a message as if coming from an acoustic sensor, to signal that is has detected (the firing of) a projectile. However, with current laser engagement training systems only the azimuth of the shot relative to the target can be determined, not the elevation or distance of the shot. This could partially be solved by incorporating the location of the shooter in the laser code, so the shooting distance can be computed by the target DO. Another drawback of using a laser engagement system is that the laser shot only informs the targeted DO, while some signals in the real world can be detected by multiple DOs simultaneously (for example, the sound of a shot travels in all directions and probably some DOs located close together can independently detect an incoming projectile from a certain sector). So directed interfaces could provide a partial solution, but in many cases the shooter needs to send information to multiple DOs or to EXCON, so EXCON can distribute the information to the relevant DOs. There is however an essential requirement for all solutions for these use cases: response time is critical! In reality the time periods between starting an engagement, the targeted DO detecting the engagement and the subsequent triggering of countermeasures are very short and so they must be in the training environment, otherwise engagements are not simulated realistically, possibly leading to incorrect outcomes of engagements and negative training.

A2.10 Use of Laser Target Designators

In real life a laser target designator can be used to illuminate a target, so that an ammunition (for example a missile, a smart bomb or a smart artillery shell) can home in on the target. Assuming the ammunition is simulated in the training environment, it cannot detect the aiming point in the live training environment by itself, it must be provided with the aiming point. When the laser target designator is used by the same DO who fires the ammunition (for example when the laser target designator is built in in the launching platform), it is quite straightforward to provide the simulated ammunition with the right aiming point, even during flight of the ammunition. The current dataset for missile engagements already includes parameters for the identity and location of a (laser target) designator who is a different DO than the shooter. But the use case of a designating DO and a shooting DO is broader than only for missiles (for example the aforementioned aircraft delivered bomb and artillery shell), and a mechanism needs to be in place to transfer aiming point information from the designator to the shooter.

A laser target designator is generally used by a specialist, such as a Forward Observer (FO) or a Forward Air Controller (FAC) / Joint Terminal Attack Controller (JTAC). This specialist calls for fire and marks a target with a laser target designator. The target can be another DO, a piece of infrastructure or just a point in the terrain. If the target is a DO or an instrumented piece of infrastructure, that target could sense it is being painted by a laser target designator and can send relevant info (target ID, aiming point, laser target designator ID) to EXCON. As an alternative, but required if the target is not instrumented, the laser target designator must send the aiming point to EXCON. EXCON can then determine if the aiming point is on a DO or not. If EXCON is simulating the ammunition, it has all relevant information to execute the engagement. If another DO is simulating the ammunition, EXCON must transfer the aiming point and if applicable the targeted DO ID to the shooting DO who further executes the engagement. These dataflows are all part of an E1 engagement.

A2.11 Tracking Exercise Enablers

The training environment is populated with different types of DO. Since each DO has a presence, its position can be tracked. Tracking positions and movements of DOs is important for engagement adjudication and for monitoring and evaluation purposes. A special type of DO is the Observer/Controller (O/C). He can engage other DOs, but this is for the purpose of exercise control. An O/C cannot be engaged, or at least his status cannot be changed. In addition to O/Cs, also other exercise enablers are moving in and around the training environment. These exercise enablers are not part of the tactical environment, but it is useful to track their positions, so other members of EXCON know where they are and can direct them to the right position at the right time. Different types of exercise enablers are:

- Fire markers, who have the task to create smoke screens or indirect fire representations in the live environment at the locations where and the time when virtual fires are executed. Fire markers need time to move to the proper location and prepare their effects. In many cases this time is available, or they can be timely prepositioned, for example in case of pre-planned fires or when a fire mission is requested through EXCON. However, in some training systems it is possible that DOs can execute indirect fire missions themselves, for example with instrumented guns and mortars. These platforms can also be highly mobile, for example the CV90 with an integrated mortar. Their fire missions can be executed on short notice, making it very difficult for fire markers to timely create their effects. That is the reason why some training system users have decided to not deploy fire markers anymore.
- Video teams, to capture live actions of selected members of the training audience for evaluation purposes.
- Maintenance personnel, to solve technical problems of training system elements in the field. Tracking their position can be required for safety reasons, for example in hostile environments (e.g., Kenya).

A2.12 DO ID Numbers

It is important that all DOs participating in an exercise have unique identification numbers. When DOs with identical identification in the same exercise are allowed, strange situations can occur, such that apparently a DO is simultaneously at two different locations, that a DO is dead but also alive, that a DO engages itself, etc. Therefore, when operating with DOs of two or more training systems in one exercise, the DO identification numbers must be de-conflicted and for some set of DOs the IDs may need to be changed. Since some current training systems might have a limited ID range, it is not possible to assign each training system or each nation a unique ID range. Therefore, UCATT will create a reference document which proposes a mechanism to assign ID ranges to nations based on likelihood to participate in the same exercises and thereby minimising the need to change the DO IDs.

A2.13 Supplies

Supplies like water, fuel, ammunition, etc. are generally represented by the real materiel in the live training environment. There is no requirement identified to simulate their physical presence or simulate a particular status (intact, damaged, contaminated, etc.).

A2.14 UCATT Related Activities and Developments

A2.14.1 Introduction

Parallel to the UCATT effort, other concepts and products are developed which can have an impact on the UCATT user requirements and UCATT standards. They can be produced by other international working groups (for example NATO STO MSG-136 and MSG-164 Modelling and Simulation as a Service (MSaaS), NATO STO MSG-145 C2-Sim Interoperability, STANAG 4754 NATO Generic Vehicle Architecture (NGVA), but also all the SISO activities regarding HLA, CBML, etc.), or by nations in ad hoc collaboration or individually. An example of the latter case are the US efforts regarding Live Training Engagement Composition (LTEC).

A2.14.2 Live Training Engagement Composition (LTEC)

The US Army currently performs live training with many different Multiple Integrated Laser Engagement System (MILES) training devices. Although these systems provide many similar capabilities (the same laser code, the same battle damage calculations and similar EXCON functionality), hardware and software for these systems is vendor proprietary. The US Army has fielded more than 250,000 Tactical Engagement Simulation Systems (TESS) devices worldwide and this number is still growing. This has led to an exponential growth in sustainment cost as multiple hardware and software baselines must be maintained and supported, each for 20 years or longer. To provide a solution for this problem, the Project Manager for Training Devices (PM TRADE), part of the US Army's Program Executive Office for Simulation, Training and Instrumentation (PEO STRI) has architected a software product line – the Live Training Engagement Composition (LTEC)4. The vision of LTEC is to reduce development cost, promote technology insertion and lower testing/integration risks, while also providing PM TRADE the ability to realise cost avoidance not afforded by stove-piped Force-on-Force TESS acquisitions. LTEC promotes interoperability at the software service level and was designed using a Service Oriented Architecture (SOA) approach. This organically promotes custom composable applications and discounts un-needed and un-desired bloat.

LTEC is a SOA that consists of a collection of services that either perform training simulation or communicate with devices, and these services are supported by a framework that facilitates communication between services. The LTEC concept is depicted in Figure A-8.

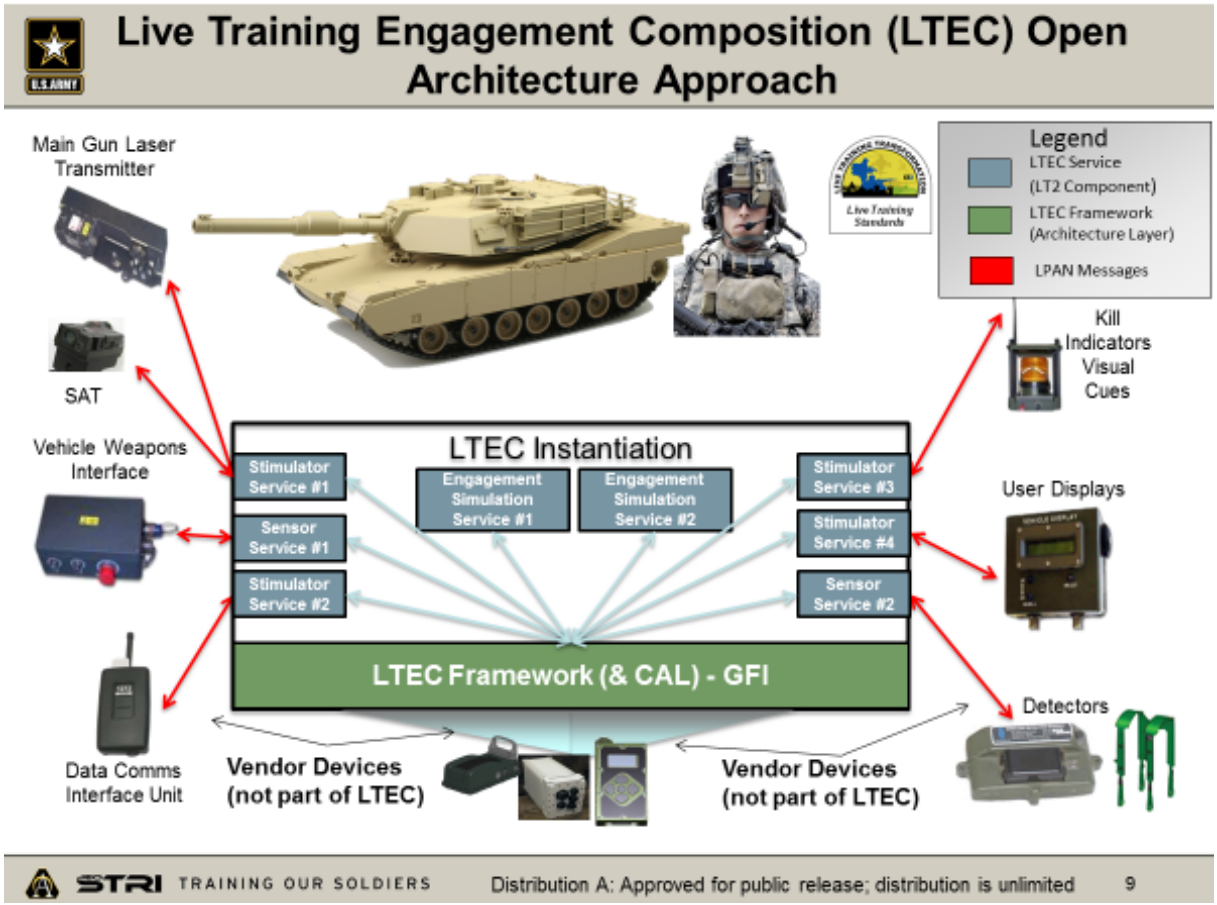


Figure A-8: LTEC Open Architecture Approach.

[4] An extensive description of LTEC is provided in the I/ITSEC 2013 paper No. 13282, "LTEC: Enabling Componentized TESS Procurement using a Service Oriented Architecture", Matt Janisz, Phil Sowden, Kyle Platt, James Grosse, Gary Hall.

At a high level, the currently implemented and planned functional requirements for the architecture are to provide the MILES shooter and target system functionality provided by a generic MILES (TESS) Control Unit or TCU that represents a single entity (vehicle, dismount, or crew-served weapon) in the live training simulation. Each service provides an engagement simulation capability, integration with a sensor device, or integration with a stimulator device that is required for live training.

Since LTEC must support an assortment of different entities which share a significant overlap of MILES capabilities, there is also a requirement for LTEC to provide common software that is entity type agnostic. Not only does this requirement make sense from a software reuse perspective, but the common software also provides consistent behaviour for all MILES systems leveraging LTEC. Existing MILES sub-system interfaces are all vendor-unique and are not interchangeable even for systems of the same entity type. Therefore, to facilitate supporting integration with vendor-unique subsystems and to support embedded training, LTEC has a requirement to integrate with specific training or tactical system hardware configurations using adapter software.

It can be concluded that the LTEC concept perfectly fits in the UCATT philosophy. LTEC takes advantage of and incorporates the UCATT concept, it also is an architecture where interfaces and software components are standardised. LTEC can be seen as standardising some of the UCATT internal interfaces, but it also has relations with some of the external interfaces of UCATT, most notably:

- E4/I10 can provide guidelines or can be the standard for the interface between stimulator service #2 and a data communications interface unit.
- DO pairing and association as described by E9.
- Interfacing between training equipment and real systems, as described by E10.

Since representatives from PM TRADE are part of the UCATT group, coordination between UCATT and LTEC is assured.

A3.0 DO STATUS DEFINITION

This section lists the different statuses of the three categories of DOs (Table A-1, Table A-2 and Table A-3). By standardising the DO statuses as possible outcomes of interactions, the vulnerability model and associated damage calculation do not need to be standardised. To further facilitate interoperability and acknowledging that different systems have implemented different levels of detail, UCATT describes several levels of DO statuses and proposes a mapping between the levels. For a discussion about the rationale of these statuses, please see Annex D of the MSG-098 report.

Table A-1: Damage Statuses of (Manned) Weapon Systems.

Damage State	Level 1	Level 2	Level 3	Level 4	Description
Operational	0	0	0	0	
CBRNe crew Kill		0.1	0.1.0	0.1.0.0	Crew killed, but vehicle is operational, can be recovered by a new crew
CBRNe contaminated		0.2	0.2.0	0.2.0.0	Vehicle is contaminated, but still operational, can be recovered by decontamination

Damage State	Level 1	Level 2	Level 3	Level 4	Description
Hit, no damage/effect	1	1.0	1.0.0	1.0.0.0	Target was engaged and hit, but no damage was assessed
Miss	2	2.0	2.0.0	2.0.0.0	Target was engaged but not hit (could result in an audio cue for the crew)
Near miss		2.1	2.1.0	2.1.0.0	
Far miss		2.2	2.2.0	2.2.0.0	
Mobility kill	3	3.0	3.0.0	3.0.0.0	Target cannot change location by itself
Engine kill			3.0.1	3.0.1.0	
Track/wheel fallen off/kill			3.0.2	3.0.2.0	
Mobility kill visual		3.1	3.1.0	3.1.0.0	Observable mobility kill
Weapon kill	4	4.0	4.0.0	4.0.0.0	All weapons inoperative
Main gun kill		4.1	4.1.0	4.1.0.0	
Weapon <x> kill			4.1.<x>	4.1.<x>	Kill of a specific weapon system of the vehicle (can be up to 100)
Secondary weapon kill		4.2	4.2.0	4.2.0.0	Definition of what the secondary weapon is, depends on the type of vehicle
Missile weapon kill		4.3	4.3.0	4.3.0.0	Valid when the vehicle has a missile firing system
Turret drive kill		4.4	4.4.0	4.4.0.0	The turret of the vehicle cannot rotate
Ammunition kill		4.5	4.5.0	4.5.0.0	
Automatic ammo load off			4.5.1	4.5.1.0	
Ammo turret storage kill			4.5.2	4.5.2.0	
Ammo hull storage kill			4.5.3	4.5.3.0	
LRF kill		4.6	4.6.0	4.6.0.0	
Weapon kill visual		4.7	4.7.0	4.7.0.0	Observable that all weapons are inoperative
C4ISR kill	5	5.0	5.0.0	5.0.0.0	C4I functionality not available
Communications kill		5.1	5.1.0	5.1.0.0	Loss of (voice and data) communication
Voice comms damage/kill			5.1.1	5.1.1.0	

Damage State	Level 1	Level 2	Level 3	Level 4	Description
Voice comms kill				5.1.1.1	
Voice comms jammed				5.1.1.2	Exposed to meaningless electromagnetic data
Data comms damage/kill			5.1.2	5.1.2.0	
Data comms kill				5.1.2.1	
Data comms jammed				5.1.2.2	Exposed to meaningless electromagnetic data
Data comms spoofed				5.1.2.3	Exposed to meaningful misleading electromagnetic data
BMS computer kill		5.2	5.2.0	5.2.0.0	
Sight/sensor kill		5.3	5.3.0	5.3.0.0	Contains all different kind of sensors, optical, radar, etc. that enable it to perform its primary function
Primary sight kill			5.3.1	5.3.1.0	
Secondary sight kill			5.3.2	5.3.2.0	
Auxiliary sight kill			5.3.3	5.3.3.0	
IFF kill			5.3.4	5.3.4.0	
Payload kill	6	6.0	6.0.0	6.0.0.0	Destruction of the cargo of the vehicle
Total kill	7	7.0	7.0.0	7.0.0.0	Catastrophic kill
Crew affected		7.1	7.1.0	7.1.0.0	Relevant for occupants not being DOs (DOs have their own status)
Crew member <x> killed			7.1.<x>	7.1.<x>	Relevant for occupants not being DOs
Crew member <x> injured			7.2.<x>	7.2.<x>	Relevant for occupants not being DOs
Tampering kill	8	8.0	8.0.0	8.0.0.0	Automatic kill when the crew violates certain conditions
Administrative kill	9	9.0	9.0.0	9.0.0.0	Killed by an OC or through EXCON administrative kill

Table A-2: Damage Statuses of Personnel.

Damage State	Level 1	Level 2	Level 3	Move	Fire	Communicate
Operational	0	0	0	YES	YES	YES
CBRNe contaminated		0.1	0.1.0	YES	YES	YES
Hit No Damage/effect	1	1.0	1.0.0	YES	YES	YES
Incapacitated/stunned		1.1	1.1.0	NO	NO	NO
Miss	2	2.0	2.0.0	YES	YES	YES
Far Miss		2.1	2.1.0	YES	YES	YES
Near Miss		2.2	2.2.0	YES	YES	YES
Wounded	3	3.0	3.0.0	NO	NO	YES
Head		3.1	3.1.0	NO	NO	NO
Bleeding			3.1.1	NO	NO	NO
Blast			3.1.2	NO	NO	NO
Burn			3.1.3	NO	NO	NO
Neck		3.2	3.2.1	NO	NO	NO
Bleeding			3.2.2	NO	NO	NO
Blast			3.2.3	NO	NO	NO
Burn			3.2.4	NO	NO	NO
Fracture			3.2.5	NO	NO	NO
Chest		3.3	3.3.0	NO	NO	NO
Bleeding			3.3.1	NO	NO	NO
Blast			3.3.2	NO	NO	NO
Burn			3.3.3	NO	NO	NO
Abdomen		3.4	3.4.0	NO	NO	NO
Bleeding			3.4.1	NO	NO	NO
Blast			3.4.2	NO	NO	NO
Burn			3.4.3	NO	NO	NO
Back		3.5	3.5.0	NO	NO	NO
Bleeding			3.5.1	NO	NO	NO
Blast			3.5.2	NO	NO	NO
Burn			3.5.3	NO	NO	NO
Fracture			3.5.4	NO	NO	NO

Damage State	Level 1	Level 2	Level 3	Move	Fire	Communicate
Pelvis		3.6	3.6.0	NO	YES	YES
Bleeding			3.6.1	NO	YES	YES
Blast			3.6.2	NO	YES	YES
Burn			3.6.3	NO	YES	YES
Fracture			3.6.4	NO	YES	YES
Left arm		3.7	3.7.0	YES	NO	YES
Bleeding			3.7.1	YES	NO	YES
Blast			3.7.2	YES	NO	YES
Burn			3.7.3	YES	NO	YES
Fracture			3.7.4	YES	NO	YES
Dismembered			3.7.5	YES	NO	YES
Right arm		3.8	3.8.0	YES	NO	YES
Bleeding			3.8.1	YES	NO	YES
Blast			3.8.2	YES	NO	YES
Burn			3.8.3	YES	NO	YES
Fracture			3.8.4	YES	NO	YES
Dismembered			3.8.5	YES	NO	YES
Left leg		3.9	3.9.0	NO	YES	YES
Bleeding			3.9.1	NO	YES	YES
Blast			3.9.2	NO	YES	YES
Burn			3.9.3	NO	YES	YES
Fracture			3.9.4	NO	YES	YES
Dismembered			3.9.5	NO	YES	YES
Right leg		3.10	3.10.0	NO	YES	YES
Bleeding			3.10.1	NO	YES	YES
Blast			3.10.2	NO	YES	YES
Burn			3.10.3	NO	YES	YES
Fracture			3.10.4	NO	YES	YES
Dismembered			3.10.5	NO	YES	YES
C4ISR kill	4	4.0	4.0.0	YES	YES	NO
Communications Kill		4.1	4.1.0	YES	YES	NO

Damage State	Level 1	Level 2	Level 3	Move	Fire	Communicate
Voice comms damage/kill			4.1.1	YES	YES	NO
Voice comms kill				YES	YES	NO
Voice comms jammed				YES	YES	NO
Data comms damage/kill			4.1.2	YES	YES	NO
Data comms kill				YES	YES	NO
Data comms jammed				YES	YES	NO
Data comms spoofed				YES	YES	NO
BMS computer kill		4.2	4.2.0	YES	YES	NO
Sensor kill		4.3	4.3.0	YES	YES	NO
Kill	5	5.0	5.0.0	NO	NO	NO
Administrative kill	6	6.0	6.0.0	NO	NO	NO
Tampering kill	7	7.0	7.0.0	NO	NO	NO

Table A-3: Damage Statuses of Infrastructural Objects.

Damage State	Level 1	Level 2	Description
Undamaged	0	0	
Door/window open		0.1	
Door/window closed, not bolted		0.2	
Door/window closed, simulated bolted		0.3	
Door/window bolted and barred		0.4	
CBRNe contaminated		0.5	Structure is contaminated
Hit, no damage/effect	1	1.0	Structure was engaged (could result in an audio cue for the occupants of the structure)
Miss	2	2.0	Structure was engaged but not hit (could result in an audio cue for the occupants of the structure)
Near Miss		2.1	
Far Miss		2.2	
Damaged	3	3.0	
C4ISR kill	4	4.0	
Voice comms damage/kill		4.1	
Voice comms kill		4.1.1	

Damage State	Level 1	Level 2	Description
Voice comms jammed		4.1.2	
Data comms damage/kill		4.2	
Data comms kill		4.2.1	
Data comms jammed		4.2.2	
Data comms spoofed		4.2.3	
Destroyed	5	5.0	
CBRNe Kill			For example, a structure could protect against fluids, but not against gasses
Payload Kill	6	6.0	Destruction of the content of a structure, e.g., supplies
Tampering Kill	7	7.0	Automatical destruction when trainees violate certain conditions
Administrative Kill	8	8.0	Destroyed by an OC or through EXCON administrative kill

A structure can contain built-in communication equipment, which can be influenced and destroyed.

A DO can have multiple active damage statuses at the same time. For example, a DO can be wounded in his chest and in his left leg and in addition have a communication kill. However, any other status overrules the status “Operational” (“Undamaged” for infrastructure). Also, the statuses “Total kill” (“Destroyed” for infrastructure), “Tampering kill” and “Administrative kill” overrule all other damage status.

In addition to the damage statuses, a DO can have a set of **additional statuses**, which are not covered by the previously described datasets. Some of which can be automatically derived from engagements (e.g., “burning”), while others must be set by OCs or EXCON personnel, because the training system has no means to determine them. The statuses can be used for administrative purposes (like the status “prisoner”), while others can change the level of protection (for example “dug in” for personnel or weapon systems and “reinforced” for buildings).

Some of these statuses are not really relevant in a pure live training environment, because the associated properties and consequences are inherent in the physical environment. For example, a DO being dug in, is protected from laser engagement systems by the surrounding earth, similar to real bullets. Also, a camouflaged DO is less easy to detect by daylight sensors. However, when this live training environment is integrated with virtual or constructive simulation elements, then these statuses should also be known in those realms, otherwise unrealistic of unfair situations might occur. If a direct or indirect fire originating from the virtual world, like for example a fire support mission, does not take into account that a live target is dug in, more damage can be sustained in the training environment than would be the case in the real world. If a virtual UAV does not know a live DO is camouflaged, it is more easily detected and identified than would be the case in the real world. Similarly, elements of infrastructure can have statuses that indicate situations that are obvious in the live environment but are important to register both for monitoring purposes and for interoperability with virtual and constructive environments.

Table A-4: Additional DO Statuses.

Personnel	(Weapon) Systems	Infrastructure
Prisoner		
Dug in	Dug in	
Camouflaged	Camouflaged	Camouflaged
	Burning	Burning
		Reinforced

The mechanism of **equipment pairing** requires to register some status information for DOs. A human DO can be associated with multiple pieces of equipment of different types simultaneously, sometimes even with multiple instances of the same type (indicated in the second column of Table A-5 below). For example, a soldier can carry and use different firearms simultaneously, not only an assault rifle and a pistol, but also two assault rifles. However, he can only wear one helmet or CBRNe mask which contributes to his protection. A piece of equipment can be associated to maximum one DO at a time.

Table A-5: DO Using Equipment.

DO Using Equipment	Multiple Instances
Carrying equipment <type x>	YES
Wearing helmet <type x>	NO
Wearing body armour <type x>	YES
Wearing CBRNe mask <type x>	NO
Wearing CBRNe suit <type x>	NO

The mechanism of **DO association** also results in a set of statuses (Table A-6). A DO can be inside or on top of another DO and a DO can have multiple of such associations at any given time. For example, a soldier (DO-1) can be in a vehicle (DO-2), which is on top of a trailer (DO-3), which is inside a hangar (DO-4). It is sufficient to register associations only one layer deep, because other associations can be inferred by following the links. For example, it can be inferred through the vehicle and the trailer that the soldier (DO-1) is also in the hangar (DO-4).

DO position associations can be used to inherit a position from another DO, for example a soldier in a vehicle can derive its position on the battlefield from the position of the vehicle he is in.

However, DO association relations sometimes also need to be used the other way around, starting from the containing DO, for example in order to propagate effects: when a vehicle is damaged, it might also have implications for the crewmembers inside that vehicle. Therefore, it might be useful to also register which DOs are contained by a certain DO, where a DO can contain multiple other DOs.

Table A-6: DO Position Association.

Contained DO	Containing DO
is on DO <x>	carries <list of DOs>
is in DO <y>	contains <list of DOs>

A4.0 E1: DO INTERACTION

A4.1 Introduction

The tables in this section define the superset of data elements for several types of engagement. The E1 interface consists of three types of interactions:

- The DO is supplied with the result of an engagement in terms of a change of status. The associated tables are defined in Section A4.2;
- The DO is supplied with the relevant engagement parameters so it can determine the outcome of an engagement itself; and
- The DO is supplied with the definition of an engagement area so the DO can determine when it engages with that area and subsequently determine the outcome of that engagement. The latter two categories of datasets are defined in Section A4.3 through A4.14.

This interface is also used for propagation of engagements, which occurs when one DO is engaged and as a result of that engagement, the DO itself engages one or more other DOs. Those subsequent engagements can be of the same type as the original one or they can be different types of engagements. Typical examples are that a vehicle DO is destroyed and as a consequence the human DOs inside the vehicle are killed or wounded; a bridge is destroyed and as a consequence all DOs on that bridge are destroyed or killed; a wall is hit and as a consequence the wall initiates an engagement with debris and/or blast to affect DOs behind the wall.

The tables in this Annex contain different columns defined as:

1) **Parameter**: this is a data element required to simulate an interaction;
2) **Purpose**: the reason the data element is required. Several categories are used:
    a) TARGETING: the data is used to determine which and where dynamic object(s) is or are affected by the interaction;
    b) EFFECT or DAMAGE CALCULATION: the data is used to determine the outcome of the interaction;
    c) MONITORING: the data is used for on-line monitoring of the execution of the exercise and system performance and for After Action Review, the evaluation and feedback of the performance towards the training audience;
    d) ANALYSIS: the data is used for other purposes, e.g., statistical or trend analysis, not directly used for monitoring or feedback towards the training audience.
3) **Unit**: the unit in which the data element is expressed, e.g., distance or location in metres, time in seconds. When the data is a system internal identifier, it is expressed as dynamic object ID or enumeration;
4) **Max**: the maximum value of the data element;
5) **Resolution**: the required resolution of the data element, expressed in (sub)units. This means that the actual value of the data element must be expressed in multiples of the mentioned resolution.

A4.2 Results of Interactions

Table A-7 and Table A-8 contain the datasets for communicating a status change to a DO. There are two types of data that can be changed: the operational status and the supply state (since in a live training environment only simulated ammunition supply is relevant, the supply is only related to ammunition).

Table A-7: Status Change Dataset.

Parameter	Purpose	Unit	Max	Resolution
Cause ID	MONITORING	ID	100,000	-
Cause means	MONITORING	Enumeration		-
Affected DO ID	EFFECT CALCULATION	ID	100,000	-
Affected DO location (x, y, z), plus accuracy indicator	MONITORING	Metres	World coordinate	Centimetre
New status	EFFECT CALCULATION	Enumeration		-
Engagement time	MONITORING	Seconds	-	Second

Cause ID

The identification of the entity that caused the status change. It can be:

- The “shooter ID”, in case of contact, proximity, missile or energy weapon engagements;
- The “fire support target area ID”, in case of fire support target area engagements;
- The “minefield ID”, in case of minefield engagements;
- The “obstacle ID”, in case of engagements with man-made obstacles other than minefields;
- The “CBRNe area ID”, in case of CBRNe area engagements;
- The “bridge ID”, “swamp ID” or “river ID”, in case of engagements with a tactically relevant restricted or impassable part of the terrain;
- The “CSS area ID”, in case of engagements with a medical treatment area, repair area, FARP or decontamination area;
- The “medic DO ID”, in case of medical treatment by a medic DO;
- The “repair DO ID”, in case of repair by a mechanic DO;
- The “EW influence area ID”, in case of engagements with an EW influence area.

Cause Means

The identification of the means used in the engagement. It can be:

- The “ammunition type”, in case of contact, proximity, missile, fire support target area or minefield engagements;
- The “agent type”, in case of CBRNe area engagements;
- The “CSS area type”, in case of CSS area engagements;
- The “EW influence area type”, in case of EW influence area engagements;
- The “energy type”, in case of energy weapon engagements;

This parameter is omitted in case of:

- Engagements with man-made obstacles other than minefields and tactically relevant restricted or impassable part of the terrain;
- Medical treatments and repair activities. When, however, more detail is required, then this parameter could contain the "medical activity type" or "repair activity type" respectively.

Affected DO ID

The identification of the DO whose status is changed.

Affected DO Location

The location of the affected DO.

New Status

The value to which the status of the DO is set. They are defined in Table A-1, Table A-2, and Table A-3.

Engagement Time

The instance in time when the DO's status is changed.

Table A-8: Ammunition Supply Change Dataset.

Parameter	Purpose	Unit	Max	Resolution
Supplier ID	MONITORING	ID	100,000	-
Affected DO ID	EFFECT CALCULATION	ID	100,000	-
Affected DO location (x, y, z), plus accuracy indicator	MONITORING	Metres	World coordinate	Centimetre
Supply type	EFFECT CALCULATION	Enumeration		-
Ammunition type	EFFECT CALCULATION	Enumeration		-
Supply quantity	EFFECT CALCULATION	Number	10,000	1
Engagement time	MONITORING	Seconds	-	Second

Supplier ID

The identification of the entity that executed the supply. It can be:

- The "CSS area ID", in case of engagements with a resupply area or FARP;
- The "Supplier DO ID", in case of engagements with resupply DOs.

Affected DO ID

The identification of the DO whose ammunition supply is changed.

Affected DO Location

The location of the affected DO.

Supply Type

The type of supply activity that was performed. It can be:

- "Take", in case of a resupply activity executed by a resupply DO or an engagement with a CSS area (resupply area or FARP). The "ammunition supply" will be added to the current stock of the DO; and
- "Give", in case of a resupply activity executed by a resupply DO. The "ammunition supply" will be subtracted from the current stock of the DO.

Ammunition Type

The type of ammunition being resupplied.

Supply Quantity

The amount of shells added or subtracted to the ammunition stock of the DO.

Engagement Time

The instance in time when the DO's ammunition supply is changed.

Engagements with administrative areas do not result in a DO status or supply change. Also, engagements with weapon effect modification areas and breaches do not result in a status change, although they can influence the outcome of other engagements.

A4.3 Contact and Proximity Engagements

Table A-9 contains the data for contact and proximity engagements. A contact engagement is an engagement where a projectile hits the target. A proximity engagement is an engagement where the ammunition does not hit a target but explodes in the vicinity of a target and thereby affects it, e.g., an ammunition with a time or proximity fuse. Not all parameters are required, depending on weapon and ammunition involved and on training system implementation.

The properties of a target are also very important to calculate the results of an engagement. Properties such as its current operational status (damaged or not) or its level of protection (wearing body armour or CBRNe mask). However, this is not part of the engagement. The engagement function will trigger another function to determine the effect(s) of the engagement.

Table A-9: Superset of Data for Contact and Proximity Engagements.

Parameter	Purpose	Unit	Max	Resolution
Shooter ID	MONITORING	ID	100,000	-
Shooter location (x, y, z), plus accuracy indicator	TARGETING MONITORING	Metres	World coordinate	Centimetre
Shooter velocity (vector), plus accuracy indicator	TARGETING MONITORING	Metres/sec		Centimetre
Weapon type	TARGETING MONITORING	Enumeration		-
Weapon ID	ANALYSIS	ID	100	-
Shooter weapon mode	TARGETING MONITORING	Enumeration		-
Weapon direction/angle (vector), plus accuracy indicator	TARGETING			VERY HIGH
Ammunition type	DAMAGE CALCULATION MONITORING	Enumeration		-
Fuse type	TARGETING MONITORING	Enumeration		-
Fuse settings	TARGETING MONITORING			-
Engagement range	DAMAGE CALCULATION MONITORING	Metres		Metre
Detonation location (x, y, z), plus accuracy indicator	DAMAGE CALCULATION MONITORING	Metres	World coordinate	Centimetre
Effect direction/angle (vector) at the moment of detonation	DAMAGE CALCULATION MONITORING			HIGH
Projectile impact velocity (vector), plus accuracy indicator	DAMAGE CALCULATION	Metres/sec		Centimetre
Effect volume	DAMAGE CALCULATION MONITORING	Metres		Metre
Terrain	TARGETING DAMAGE CALCULATION	Metres		Centimetre
Atmospheric data	TARGETING			-

Parameter	Purpose	Unit	Max	Resolution
Affected DO(s) ID	DAMAGE CALCULATION MONITORING	ID		-
Affected DO(s) location (x, y, z), plus accuracy indicator	TARGETING MONITORING	Metres	World coordinate	Centimetre
Affected DO(s) velocity (vector), plus accuracy indicator	TARGETING MONITORING	Metres/sec		Centimetre
Time of start of the engagement (trigger time), plus accuracy indicator	TARGETING MONITORING	Seconds		Micro-second
Time of end of the engagement (impact time), plus accuracy indicator	TARGETING MONITORING	Seconds		Micro-second
Point of impact	DAMAGE CALCULATION	Metres		Centimetre

Shooter ID

The unique identifier to identify the DO that causes the engagement. It is assumed that based on this ID the characteristics of this DO can be retrieved, such as the DO type or the name of the player or crew members. Three example situations can be distinguished:

- The weapon used in the engagement is an integral part of a DO and has no ID of itself, e.g., the main gun of a tank. The shooter ID in this example is the ID of the tank;
- The weapon used is not an integral part of the DO but can be used by other DOs during the same exercise, and the weapon is not modelled as a DO. This is called equipment pairing. A typical example is a rifle that can be handed over to another soldier. The shooter ID in this example is the ID of the soldier, not of the rifle; and
- The weapon used is modelled as a DO itself and can be used by other DOs during an exercise. A typical example is a crew-served machine gun operated by two soldiers. The shooter ID in this example is the ID of the machinegun, not of (one of) the soldiers who operate the gun. The identity of the soldiers can be retrieved through DO association.

Shooter Location (x, y, z)

The three-dimensional position of the shooter at the start of the engagement.

Shooter Velocity (Vector)

The three-dimensional speed of the shooter at the start of the engagement. This is for example required for targeting purposes, to determine the correct lead angle. It can also be used for monitoring purposes when training skills of crews of moving (stabilised or non-stabilised) weapon systems.

Weapon Type

The type of the weapon that is used to execute the engagement, such as launching the ammunition. It is used mainly for monitoring purposes, because the effects of the engagement are not determined by the weapon type, but by the properties of the ammunition at the point of impact.

Weapon ID

When a weapon is an integral part of a DO (such as a coax machine gun on a tank or the different weapon systems on a naval vessel), this parameter identifies the weapon that was used in the engagement, relative to the Shooter ID. Land based systems generally have only a few weapons, but a battleship can have dozens of weapons installed on it, therefore the maximum value is set to 100.

Shooter Weapon Mode

The mode of the weapon at the moment of engagement. It contains for example the settings of a fire control computer, the used sighting device, etc. It is used for correct targeting and monitoring purposes when training gunnery skills.

Weapon Direction/Angle

The direction/angle of the weapon at the moment of engagement, used for targeting, calculation of the trajectory of the fired ammunition. Because of this function, the resolution of this parameter needs to be very high.

Ammunition Type

The type of the used ammunition, mainly used for damage calculation (can also be used for determining the trajectory of the projectile) and monitoring purposes. The type of ammunition should also contain types as blast and debris, to enable propagation of engagements when for example a wall is hit and as a consequence pieces of the wall can affect DOs in the vicinity.

Fuse Type

The type of fuse used for an ammunition. For certain ammunition types the operator can select the type of fuse, for example applicable to artillery and mortar rounds, anti-tank rounds, etc. This determines whether the detonation of the ammunition is triggered by for example physical contact, time, a sensor (e.g., heat signature, radar signature, laser pointed) or a combination of triggers. The type of fuse determines the point of detonation and thus is used for targeting.

Fuse Settings

Depending on the type of fuse, certain settings can be applied. For example, a time triggered fuse needs a specified time or delay after impact to detonate, while other fuses need a specified time after firing to become active (e.g., to allow a proximity fuse to be shot through foliage). The parameter is used for targeting.

Engagement Range

The distance over which a target is engaged. It is used for monitoring purposes but it can also be used for damage calculation, to take the effective range of the ammunition into account, to prevent that a weapon affects targets beyond its effective range (e.g., a pistol killing a target at 1,000 metre).

Detonation Location

For proximity engagements, where the ammunition does not impact directly on a target, this is the three-dimensional location where the ammunition detonates. It is used to determine which DOs are affected.

Effect Direction / Angle (Vector) at the Moment of Detonation

The direction in which the effect of the ammunition is projected. This can be either omnidirectional (e.g., a hand grenade) or a particular angle or sector (e.g., a horizontal effect weapon). It is used to determine the direction of the influence sphere of the resulting explosion and thereby which DOs are affected by it. It can also be useful for monitoring purposes (e.g., evaluation of an ambush when using horizontal effect weapons).

Projectile Impact Velocity (Vector)

The three-dimensional speed of the projectile at the moment of impact. From this, the direction or three-dimensional angle of the projectile relative to the target can be inferred. It is used for damage calculation, for the speed and angle of impact are important factors to determine if the projectile penetrates the armour of a target, both for kinetic and high explosive ammunitions.

Effect Volume

The three-dimensional volume of effect of the exploding ammunition in which objects can be affected and used for damage calculation. However, it can also be used for monitoring purposes to visualise the effect volume of the ammunition.

Terrain

The terrain is an important factor for targeting (e.g., is there line of sight between the DOs), projection of the trajectory of the projectile (e.g., are there any objects in between the shooter and target) and damage calculation (e.g., shielding a target from the detonation effects or reflection of blast).

Atmospheric Data

Atmospheric data contains information about for example wind direction and wind force, air pressure, temperature and humidity. It can influence the trajectory of projectiles. Advanced weapon systems take atmospheric conditions into account in their fire control computer.

Affected DO(s) ID

The unique identification of the DO(s) that are affected by the engagement. It is used for damage calculation and monitoring purposes.

Affected DO(s) Location

The three-dimensional location(s) of the affected DO(s) used for targeting and monitoring purposes.

Affected DO(s) Velocity

The three-dimensional speed of the affected DO(s) used for targeting and monitoring purposes.

Time of Start of the Engagement (Trigger Time)

The instance in time when the engagement starts, for example the time when a bullet is fired. When used for targeting purposes, a high level of resolution is required (microseconds). When used for monitoring purposes, a lower level of resolution is required (seconds).

Time of End of the Engagement (Impact Time)

The instance in time when the engagement ends, for example when a bullet hits a target or when an explosive round detonates. Used for targeting and monitoring purposes.

Point of Impact

The location on the target DO where the engagement affects the target. Typically, it is the location where a bullet or other projectile impacts. It is used for damage calculation. When concerning human targets, it must be possible to at least make a distinction between the different body parts, therefore a resolution of a centimetre is required.

> **Note:** Some types of ammunition do not have their primary effect at the point of impact, but elsewhere. The location of detonation can only be determined in combination with the properties of the affected target. When highly armoured, the ammunition will not penetrate the object or, conversely, when not armoured at all, the ammunition could fly through the object. It is assumed that the vulnerability model takes care of this calculation.

A4.4 Missile Engagements

The missile engagements are closely related to the contact and proximity engagements, they differ from ballistic ammunition in propulsion, targeting / homing capabilities, flight duration, trajectory and payload. Given these differences, there are several new parameters to be added to the dataset for contact and proximity engagements. They are “designator properties”, “flight duration” and “engagement validation”. The focus in the dataset for missile engagements is on the missile, not on the launcher. Launcher parameters are captured in the existing superset with the “Shooter weapon Mode” parameter or can otherwise be differentiated with weapon or ammunition codes (Table A-10).

Table A-10: Engagement Dataset for Missiles.

Parameter	Purpose	Unit	Max	Resolution
Shooter ID	MONITORING	ID	100,000	-
Shooter location (x, y, z), plus accuracy indicator	TARGETING MONITORING	Metres	World coordinate	Centimetre
Shooter velocity (vector), plus accuracy indicator	TARGETING MONITORING	Metres/sec		Centimetre
Designator ID	TARGETING MONITORING	ID	100,000	-
Designator location (x, y, z), plus accuracy indicator	TARGETING MONITORING	Metres	World coordinate	Centimetre
Designator velocity (vector), plus accuracy indicator	TARGETING MONITORING	Metres/sec		Centimetre
Weapon type	MONITORING	Enumeration		-
Weapon ID	ANALYSIS	ID	100	-
Shooter weapon mode	TARGETING MONITORING	Enumeration		-
Trigger type of the event	ANALYSIS	Enumeration		-

Parameter	Purpose	Unit	Max	Resolution
Weapon direction/angle (vector), plus accuracy indicator	TARGETING			VERY HIGH
Ammunition type	DAMAGE CALCULATION	Enumeration		-
Flight duration	TARGETING	Seconds		Micro-second
Engagement range	DAMAGE CALCULATION MONITORING	Metres		Metre
Engagement validation	TARGETING	YES/NO		-
Detonation location (x, y, z), plus accuracy indicator	DAMAGE CALCULATION MONITORING	Metres	World coordinate	Centimetre
Effect direction/angle (vector) at the moment of detonation	DAMAGE CALCULATION			HIGH
Projectile impact velocity (vector), plus accuracy indicator	DAMAGE CALCULATION	Metres/sec		Centimetre
Effect volume	DAMAGE CALCULATION	Metres		Metre
Terrain	TARGETING DAMAGE CALCULATION	Metres		Centimetre
Atmospheric data	TARGETING			-
Affected DO(s) ID	DAMAGE CALCULATION	ID		-
Affected DO(s) location (x, y, z), plus accuracy indicator	TARGETING MONITORING	Metres	World coordinate	Centimetre
Affected DO(s) velocity (vector), plus accuracy indicator	TARGETING MONITORING	Metres/sec		Centimetre
Time of start of the engagement (trigger time), plus accuracy indicator	TARGETING MONITORING	Seconds		Micro-second
Time of end of the engagement (impact time), plus accuracy indicator	TARGETING MONITORING	Seconds		Micro-second
Point of impact	DAMAGE CALCULATION	Metres		Centimetre

Designator

It is possible that the weapon system or person who fires the missile, is not the same as who aims/guides the missile (the designator). Therefore, there is a need to incorporate both the shooter properties and the designator properties (ID, location, velocity).

Flight Duration

The duration it takes for the missile to fly from the moment of launch until the point of impact/detonation. The resolution should be in microseconds, because of the high speed a missile can have and therefore the distance it can cover in a single timeframe.

Engagement Validation

During the flight of the missile, the designator can adjust the flight path to compensate for movements of the target or even to switch to another target. However, when making too many, too large or too sudden adjustments, the designator can lose the control over the missile. Only when the designator stays within the limits of these conditions, the missile can hit the target. It is noted that the fidelity of simulating the accuracy of missile control should be sufficient to ensure fair play between designator and target. Skills training for the missile designator could require a higher fidelity simulation.

The missile engagement dataset is one of the more challenging datasets to be covered under the UCATT standard. The proposed solution for missile engagement is not perfect. It has some flaws and loopholes. From fair play perspective however, it is probably sufficient to meet training needs at this moment. Future technology advancement might provide higher levels of fidelity and have to be addressed in future versions of the UCATT standard.

A4.5 Fire Support Target Areas

A fire support target area is the 3-dimensional space where the ammunitions of a fire support mission land or detonate. This can be mortar or artillery fire or aerial bombardments. When fire support is modelled as (a series of) individual munitions, the interaction with the ammunitions are proximity engagements as described in Section A4.3. When fire support is simulated as an area wherein a DO has a certain probability of getting engaged by delivered projectiles, a dice is rolled when and as long as the DO is within the influence of the active fire support target area (Table A-11).

Table A-11: Fire Support Target Area Creation Dataset.

Parameter	Purpose	Unit	Max	Resolution
Fire support target area ID	MONITORING	ID	10,000	-
Shooter ID	MONITORING	ID	100,000	-
Fire support target area location	TARGETING	Metres	World coordinate	Metre
Fire support target area shape	TARGETING	Set of points	20	Metre
Ammunition type(s)	DAMAGE CALCULATION	Enumeration		-
Fuse type(s)	TARGETING	Enumeration		-
Fuse settings	TARGETING			
Number of received salvos	TARGETING	Integer		1
Ammunition rounds per received salvo	TARGETING	Rounds/ salvo		1

Parameter	Purpose	Unit	Max	Resolution
Angle of impact	DAMAGE CALCULATION			-
Activation time	TARGETING	Seconds		Second
Deactivation time	TARGETING	Seconds		Second

Fire Support Target Area ID

Unique identifier identifying a fire support target area.

Shooter ID

The identification of the DO that executes the fire support mission. However, it can also be a unit identification, since a fire mission is executed by one or more mortars, artillery guns, rocket launchers or airborne platforms. When applicable, it is used for monitoring purposes.

Fire Support Target Area Location

The location of the fire support area expressed in world coordinates.

Fire Support Target Area Shape

The shape or volume of the fire support target area is defined as a 3D polyhedron (for ammunitions exploding on impact a 2D shape could suffice, but to also take ammunitions with time or proximity fuses into account, a 3D shape is required). The boundaries of the shape are to be specified with a resolution of 1 metre.

Ammunition Type(s)

The type(s) of ammunition used in the fire mission. Generally, only one type of ammunition is used in a fire mission, but is must be possible that a fire support target area supports a mix of different ammunition types, fuse types and fuse settings.

Fuse Type(s)

The type(s) of fuse used for an ammunition. This determines whether the detonation of the ammunition is triggered by for example physical contact, time, a sensor (e.g., heat signature, radar signature, laser pointed) or a combination of triggers. The type of fuse determines the point of detonation and thus is used for targeting.

Fuse Settings

Depending on the type of fuse, certain settings can be applied.

Number of Received Salvos

Artillery is typically fired in layers: a number of guns fire, reload and fire again. This parameter is the number of salvos in the fire mission. This is seen from the target point of view: the number of salvos is

the number of times a series of shells explode roughly simultaneously. When artillery uses techniques like Multiple Rounds Simultaneous Impact (MRSI), a gun can fire several times consecutively, but the rounds impact at the same time, thus making up one received salvo. At each receiving salvo, the DOs can be engaged again.

Ammunition Rounds per Received Salvo

The number of shells per salvo. It is assumed the shells are evenly spread over the fire support target area, so from this parameter the density can be inferred (and thus the probability of being hit).

Angle of Impact

The angle at which shells fall influences their lethality. For example, mortar rounds come in at a very steep angle and consequently have a more or less proportionally omnidirectional effect. Artillery shells can come in at a lower angle, where part of the blast and fragmentation is dispersed in the ground and in the air.

Activation Time

The instance in time when the fire support target area is activated (the first round detonates).

Deactivation Time

The instance in time when the fire support target area is deactivated (end of the fire mission, the last round detonates).

Table A-12 contains the dataset for engagements with a fire support target area.

Table A-12: Fire Support Target Area Engagement Dataset.

Parameter	Purpose	Unit	Max	Resolution
Fire support target area ID	MONITORING	ID	10,000	-
Engagement time	MONITORING	Seconds		Second
Terrain	TARGETING DAMAGE CALCULATION			-
Affected DO(s) ID	DAMAGE CALCULATION	ID		-
Affected DO(s) location	DAMAGE CALCULATION	Metres	World coordinate	Metre

Engagement Time

The instance in time when the DO is engaged (the dice is rolled). A DO can be engaged multiple times by the same fire support target area (as long as it stays located in the fire support target area and rounds are being fired, typically at each salvo)

Terrain

The terrain can influence the damage to DOs, either (partly) shielding them from the fire support effects or even increasing the effects (e.g., firing in woods).

Affected DO(s) ID

The identification of the DO(s) that are affected by the engagement.

Affected DO(s) Position

The three-dimensional location(s) of the affected DO(s).

A4.6 Man-Made Obstacles

There are several types of man-made obstacles that can engage with DOs. Because of their characteristics, a difference must be made in datasets between minefields and the other types of obstacles.

A4.6.1 Minefields

Minefields are a collection of mines located in the same area. They can be simulated as individual mines, either physically placed in the live environment or virtually simulated in the training system ("EXCON"). In both cases the interaction with these mines is a contact or proximity engagement as described in Section A4.3. Although the engagement is between an individual mine and one or more DOs, the minefield has a tactical relevance. Therefore, it is important to register how many DOs were affected by a minefield to assess how effective a minefield was. For this reason, it is required that the mines can be grouped into a higher-level concept of minefield, with a specific minefield identification. However, minefields can also be simulated by an area wherein a DO has a certain probability of getting struck by a mine, without simulating each individual mine. In this case and dependent on the characteristics of the minefield (mine type, density, etc.), a dice is rolled for any DO upon entering the minefield and whilst the DO moves within the minefield.

A4.6.1.1 Minefield Creation, Deactivation, Reactivation and Engagement

Table A-13: Minefield Creation Dataset (When Modelled as Probability Areas).

Parameter	Purpose	Unit	Max	Resolution
Minefield ID	MONITORING	ID	10,000	-
Minefield type	MONITORING DAMAGE CALCULATION	Enumeration		-
Emplacer ID	MONITORING	ID	100,000	-
Minefield location	TARGETING	Metres	World coordinate	Centimetre
Minefield shape	MONITORING TARGETING	Set of points	20	Centimetre
Ammunition type(s)	DAMAGE CALCULATION	Enumeration		-
Ammunition type density	TARGETING	Mines/m^2		0.01
Activation time	TARGETING	Seconds		Second

Minefield ID

Unique identifier identifying a minefield.

Minefield Type

The type of the minefield, selected from:

- Buried: the mines are buried just below the surface;
- Laid: the mines lay on top of the surface; and
- Dummy: an area marked as a minefield, but that actually does not contain any mines.

There is no distinction in damage calculation between buried and laid minefields. There is no damage calculation for dummy minefields. A dummy minefield can also be implemented by setting the ammunition density to 0, but for AAR purposes it is important to explicitly label a minefield as "dummy".

Emplacer ID

The identification of the DO that created the minefield. A buried or laid minefield can be created by a minelaying vehicle or emplaced by hand, while a laid minefield can also be delivered by artillery (FASCAM) or by air. In training systems, they can also be laid by EXCON. When applicable, for monitoring purposes, the ID of the emplacer can be recorded.

Minefield Location

The location of the minefield expressed in world coordinates.

Minefield Shape

The shape is a 2D polygon defined by a set of geographic reference points. They are relative to the "Minefield location". The reference points are to be specified with a resolution of a centimetre. This high resolution is required because in an urban environment the locations of DOs are also very accurate. It is also noted that minefields in an urban environment are smaller than tactical minefields in open country to deny access to large fields and block access ways. A minefield created in the training system can have an associated representation in the live training environment (e.g., marked by tape).

Ammunition Type(s)

The type(s) of mine of which the minefield is made up. A minefield can contain multiple types of mines (e.g., a combination of anti-personnel and anti-tank mines).

Ammunition Type Density

The number of mines per square metre, specified for each type of mine in the minefield. Typically, mines are laid in rows and a density of an order of magnitude of 0.4 mines/m^2 is considered sufficient to create an effective minefield. But it must also be possible to create large minefields with a smaller density, hence the resolution of 0.01 mines/m^2.

Activation Time

The instance in time when the minefield is laid or activated.

Table A-14 contains the dataset to deactivate a minefield.

Table A-14: Minefield Deactivation Dataset (When Modelled as Probability Areas).

Parameter	Purpose	Unit	Max	Resolution
Minefield ID	MONITORING	ID	10,000	-
Deactivation time	TARGETING	Seconds		Second

Deactivation Time

The instance in time when the minefield is cleared or deactivated.

There should also be a possibility to reactivate a deactivated minefield (Table A-15). Reactivation is not a simulation of an action that can be applied to real minefields but should be implemented as an exercise control function for training purposes. Reactivation will not reset the properties of a minefield but will retain earlier made changes like for example breach lanes).

Table A-15: Minefield Reactivation Dataset (When Modelled as Probability Areas).

Parameter	Purpose	Unit	Max	Resolution
Minefield ID	MONITORING	ID	10,000	-
Reactivation time	TARGETING	Seconds		Second

Reactivation Time

The instance in time when the minefield is reactivated

Table A-16 contains the dataset for engagements with a minefield.

Table A-16: Minefield Engagement Dataset (When Modelled as Probability Areas).

Parameter	Purpose	Unit	Max	Resolution
Minefield ID	MONITORING	ID	10,000	-
Engagement time	MONITORING	Seconds		Second
Terrain	TARGETING DAMAGE CALCULATION			-
Affected DO(s) ID	DAMAGE CALCULATION	ID		-
Affected DO(s) location	DAMAGE CALCULATION	Metres	World coordinate	Centimetre

Engagement Time

The instance in time when the DO is engaged (the DO enters the minefield) A DO can be engaged multiple times by the same minefield (as long as it keeps moving in the minefield).

Terrain

The soil can influence the triggering of buried mines and can also influence the damage to DOs.

Affected DO(s) ID

The identification of the DO(s) that are affected by the engagement. Although one DO can trigger a mine, multiple DOs in its direct vicinity might be affected.

Affected DO(s) Position

The three-dimensional location(s) of the affected DO(s).

A4.6.1.2 Clearing of Mines

Mines can be cleared individually (like for example IEDs) or a breach can be created through a minefield. This section defines the dataset to clear an individual mine (Table A-17). The dataset to create breaches is defined in Section A4.6.3.

Table A-17: Single Mine Clearing Dataset.

Parameter	Purpose	Unit	Max	Resolution
Operator ID	MONITORING	ID	100,000	-
Mine ID	TARGETING	ID	100,000	-
Clearing activity	DAMAGE CALCULATION	Enumeration		-
Time of start of the engagement	TARGETING MONITORING	Seconds		Second
Time of end of the engagement	TARGETING MONITORING	Seconds		Second

Operator ID

The DO that attempts to clear the mine of IED. If required, this ID can be used to determine if the operator is qualified to clear the mine, influencing the result of the activity.

Mine ID

The identification of the mine or IED that is to be cleared.

Clearing Activity

The activity that the operator has chosen to clear the mine or IED. There are several possibilities:

- Shooting at it. This means the mine has to be visible in the training environment and the mine needs to be modelled as a DO, able to sense it is shot at. Under these conditions this is a contact engagement.
- Placing and initiating an explosive charge next to it. If the mine and explosive charge both are modelled as a DO, this is a proximity engagement.
- If there is a requirement that the mine can be influenced by fire support (artillery or aerial bombs), this can be modelled as an artillery area engagement.
- EOD clearance. Depending on the type of mine or IED, the EOD operators will take the appropriate measures regarding the device. It is important that the deployment of an EOD team and the required conditions and associated timings can be simulated. Therefore, it will suffice that the training system allows the operator to initiate the type of activity and subsequently after a specified time the status of the mine or IED will be changed. The exact operations on the device with realistic sensitivity do not need to be simulated.

Time of Start of the Engagement

The instance in time the clearing activity is started.

Time of End of the Engagement

The instance in time the clearing activity is interrupted or ended, resulting in a changed state or not.

A4.6.1.3 Use of Minesweepers

- When used in combination with physically placed (simulated) mines, the real equipment can be used.
- Nowadays systems exist to instrument minesweeping equipment. It can be used to collect data on the use of minesweepers for monitoring purposes, so it can be determined if the users operate the equipment according to standard.
- Physical minesweeping equipment could be used in combination with virtual mines and minefields but since visual cues for the operators are an important part of the mine sweeping process and would not be easily available, this functionality is not required.

A4.6.2 Other Obstacles

Man-made obstacles other that minefields can be defined with the following datasets (Table A-18).

Table A-18: Obstacle Creation Dataset.

Parameter	Purpose	Unit	Max	Resolution
Obstacle ID	MONITORING	ID	10,000	-
Obstacle type	DAMAGE CALCULATION MONITORING	Enumeration		-
Emplacer ID	MONITORING	ID	100,000	-
Obstacle shape	MONITORING TARGETING	Set of points	20	Centimetre

Parameter	Purpose	Unit	Max	Resolution
Obstacle location	MONITORING TARGETING	Metres	World coordinate	Centimetre
Activation time	TARGETING	Seconds		Second

Obstacle ID

Unique identifier identifying an obstacle.

Obstacle Type

The type of obstacle, the following types are distinguished:

- Anti-tank ditch (3D polyhedron, an anti-tank ditch has both a depth and a height relative to the surface it is created on, i.e., the earth to dig the ditch is generally used to create a berm on the friendly side);
- Abatis (3D polyhedron, an abatis has a height relative to the surface);
- Log obstacle (3D polyhedron, a log obstacle has a height relative to the surface);
- Beam post obstacle (3D polyhedron, a beam post obstacle has a height relative to the surface);
- Cratering (3D polyhedron, a cratering has a depth relative to the surface);
- Rubble (3D polyhedron, rubble has a height relative to the surface);
- Berm (3D polyhedron, a berm has a height relative to the surface); and
- Flooding (2D polygon, a flooded area technically also has a height relative to the surface (indicating the depth of the water), but it is the responsibility of the training staff to make sure the location and shape of the flooded area are realistic given the terrain contours).

A minefield is also an obstacle, but due to its specific properties it has a dataset of its own, see Section A4.6.1. There are more types of obstacle, for example a wire barrier, but when used in a live environment they are most likely created for real, instead of simulated by an engagement area. For monitoring and AAR purposes it should be possible to draw the positions of such obstacles as “drawing objects” on overlays used in the applications in EXCON.

Emplacer ID

The identification of the DO that created the obstacle. Obstacles can be created by specialised engineering vehicles; some can be created manually by personnel and all obstacles can be created by EXCON.

Obstacle Shape

The shape is a 2D polygon or 3D polyhedron (see the parameter “Obstacle type” for the details per type of obstacle), defined by a set of geographic reference points. They are relative to the “Obstacle location”.

Obstacle Location

The location of the obstacle.

Activation Time

The instance in time when the obstacle is created or activated.

The possible effects of an engagement between a DO and an obstacle depend amongst others on the type of DO and the type of obstacle. For example, a berm will generally stop vehicles but will at most restrain personnel on foot. But the engagement effects depend on more factors, such as the height of the obstacle and the capabilities of the type of DO. Therefore it is assumed that the relevant factors are taken into account by the effect calculation algorithm associated to each type of obstacle and that therefore there is no need for an additional parameter in the obstacle creation dataset to indicate which types of DO are affected by the obstacle.

It must be possible to deactivate and reactivate obstacles. The corresponding datasets are defined in Table A-19 and Table A-20.

Table A-19: Obstacle Deactivation Dataset.

Parameter	Purpose	Unit	Max	Resolution
Obstacle ID	MONITORING	ID	10,000	-
Deactivation time	TARGETING	Seconds		Second

Table A-20: Obstacle Reactivation Dataset.

Parameter	Purpose	Unit	Max	Resolution
Obstacle ID	MONITORING	ID	10,000	-
Reactivation time	TARGETING	Seconds		Second

Deactivation/Reactivation Time

The instance in time when the obstacle is deactivated or reactivated. In case of reactivation, earlier made changes to the obstacle (breach lanes or other damages) will be retained

Table A-21 contains the dataset for engagements with an obstacle.

Table A-21: Obstacle Engagement Dataset.

Parameter	Purpose	Unit	Max	Resolution
Obstacle ID	MONITORING	ID	10,000	-
Engagement time	MONITORING	Seconds		Second
Affected DO(s) ID	DAMAGE CALCULATION	ID		-
Affected DO(s) location	DAMAGE CALCULATION	Metres	World coordinate	Centimetre

Engagement Time

The instance in time when a DO collides with the obstacle.

Affected DO(s) ID

The identification of the DO(s) that are affected by the engagement. Generally, only one DO (in time) will collide with an obstacle, but multiple DOs can be affected, for instance when a DO contains other DOs or when the obstacle is mined and as a result other DOs in its direct vicinity might be affected.

Affected DO(s) Location

The three-dimensional location(s) of the affected DO(s).

A4.6.3 Breaches

Many of the obstacles can also be breached, i.e., a passage through them can be created. For example, part of a ditch can be filled to create a crossing point and in a berm a gap can be created. The only type of obstacle that cannot be breached but requires different measures is a flooded area. A breach can be modelled as a polygon with a certain width and which can contain one or more angles, depending on the breaching method and the travelled route of the breaching vehicle (if applicable). Generally, a breach ensures safe passage through the obstacle. The exception is a breach through a minefield, where a breach will not necessarily clear all mines in a lane. When a minefield is modelled as a set of individual mines, then breaching will result in removing particular mines. When a minefield is modelled as a probability area, creating a breach lane will reduce the density of mines in the lane, where depending on the method of clearing, the density can become zero (i.e., completely free of mines) (Table A-22).

Table A-22: Breach Creation Dataset.

Parameter	Purpose	Unit	Max	Resolution
Breach ID	MONITORING	ID	10,000	-
Obstacle ID	MONITORING	ID	10,000	
Breach type	DAMAGE CALCULATION MONITORING	Enumeration		-
Breach modifier	DAMAGE CALCULATION	Percentage	100	1%
Breacher ID	MONITORING	ID	100,000	-
Breach shape	MONITORING TARGETING	Set of points	20	Centimetre
Breach location	MONITORING TARGETING	Metres	World coordinate	Centimetre
Activation time	TARGETING	Seconds		Second

Breach ID

Unique identifier identifying a breach through an obstacle.

Obstacle ID

Unique identifier identifying the obstacle to which the breach applies.

Breach Type

The type of breach, the following types are distinguished:

- Minefield breach lane (2D polygon, mapped on the surface of the terrain). The following types of mine clearing methods (subtypes) can be distinguished for a mine breach lane:
  - Manual: removal by hand;
  - Mechanical:
    - Mine plough;
    - Mine roller; and
    - Mine flail.
  - Explosive:
    - Explosive clearance (e.g., Viper, Bangalore torpedo, Mine Clearing Line Charge (MCLC), fuel air explosion);
    - Artillery / carpet bombing;
  - Electromagnetic destruction.
- Fill in an obstacle (3D polyhedron), applicable for anti-tank ditches and craterings. The following types of closing methods (subtypes) can be distinguished:
  - Fascines; and
  - Filling up by an engineer tank with soil or rubble.
- Mobile bridge to cross an obstacle (2D polygon crossing a gap), applicable for anti-tank ditches and craterings.
- Push or pull parts of an obstacle aside (3D polyhedron), applicable for abatis, log obstacles, beam post obstacles, rubble and berms.

Breach Modifier

In case of breaches through a minefield, the percentage of which the ammunition type density is reduced. 0% means that the breach is totally ineffective, while 100% means that all mines in the breach lane are cleared. Depending on system implementation, this modifier can be fully user-controlled or be a fixed percentage associated with each breach type.

Breacher ID

The identification of the DO that created the breach. Breaches can be created by specialised engineering vehicles, some can be created manually by personnel and all breaches can be created by EXCON.

Breach Shape

The shape is a 2D polygon or 3D polyhedron (see the parameter “Breach type” above for the details per type of breach), defined by a set of geographic reference points. They are relative to the “Breach location”.

Breach Location

The location of the breach.

Activation Time

The instance in time when the breach is created or activated.

For training purposes there is also the requirement to deactivate and reactivate breaches (Table A-23 and Table A-24).

Generally, a breach ensures safe passage through an obstacle, except for breaches through a minefield, where a breach will not necessarily clear all mines in a breach lane. This is controlled by the parameter "breach modifier". When a DO is damaged whilst moving through the breach, the damage is caused by the underlying minefield. In fact, a breach is then a man-made weapon effect modification area, therefore, there is no requirement for a breach engagement dataset.

Table A-23: Breach Deactivation Dataset.

Parameter	Purpose	Unit	Max	Resolution
Breach ID	MONITORING	ID	10,000	-
Deactivation time	TARGETING	Seconds		Second

Table A-24: Breach Reactivation Dataset.

Parameter	Purpose	Unit	Max	Resolution
Breach ID	MONITORING	ID	10,000	-
Reactivation time	TARGETING	Seconds		Second

A4.7 CBRNe Areas

CBRNe areas are areas which contain a toxic agent and can affect DOs. There are, at least, two different types of CBRNe areas:

1) Contaminated area, which is static and sticks to the ground, infrastructure and other objects; and
2) Cloud, which is dynamic and due to the influence of atmospheric conditions (wind, temperature, humidity, etc.), changes its location, shape, size and density (and therefore its effect) over time. It is assumed that the simulation of the dynamic behaviour of a CBRNe area is a separate function, not part of the engagement.

A CBRNe attack can result in both a static contaminated area and a dynamic cloud. In that case it is assumed that the attack resulted in two different CBRNe areas, a static and a dynamic area (Table A-25).

Table A-25: CBRNe Area Creation Dataset.

Parameter	Purpose	Unit	Max	Resolution
CBRNe area ID	MONITORING	ID	10,000	-
Shooter ID	MONITORING	ID	100,000	-
CBRNe area location	TARGETING	Metres	World coordinate	Metre
CBRNe area shape	MONITORING TARGETING	Set of points	20	Metre
Agent type	DAMAGE CALCULATION	Enumeration		-

Parameter	Purpose	Unit	Max	Resolution
Agent density	DAMAGE CALCULATION	Ppm or mSv		1
Persistence	DAMAGE CALCULATION	YES/NO		-
Activation time	TARGETING	Seconds		Second

CBRNe Area ID

Unique identifier identifying a CBRNe area.

Shooter ID

The identification of the DO that initiated the CBRNe area. However, just like artillery, it can also be a unit identification, since a CBRNe area can be caused by one or more actors. When applicable, it is used for monitoring purposes.

CBRNe Area Location

The location of the CBRNe area, expressed in world coordinates.

CBRNe Area Shape

The shape or volume of CBRNe areas is a 2D polygon (for contaminated areas) or a 3D polyhedron (for clouds). In the latter case it can be a simple 3D polyhedron, such as a rectangular box. For training purposes there is no requirement to simulate more complex shapes. In reality CBRNe areas are dynamic (i.e., changing shape over time depending on amongst others the weather conditions), but it suffices to limit the changes to the dimensions of the rectangular box. The boundaries of the shape are to be specified with a resolution of 1 metre.

In complex built up areas, CBRNe areas can sometimes take very irregular shapes, for example when a CBRNe area is confined to a specific space, like a closed room or a tunnel segment. A rectangular box might then not be sufficient to cover the whole room (with all its corners, alcoves, extensions, etc.) and simultaneously prevent any overspill of the CBRNe area into neighbouring spaces which would not be contaminated. Different solutions than a simple rectangular shape of a CBRNe area might then be required, for example to declare specific parts of a structure as CBRNe contaminated, so that when DOs enter that space, they will be exposed to the CBRNe area. Another solution is that the CBRNe area is simulated by a simulation program external to the training system, that tracks the positions of DOs and determines the effects on those DOs.

Agent Type

The type of agent the CBRNe area contains. Analogous to the definition of DO (damage) states, the CBRNe agent types are defined for different levels of fidelity. At the top level no breakdown is made, it consists only of the indication “CBRNe agent”. Subsequently CBRNe agent is broken down into three subcategories (Chemical, Biological and Radiological/Nuclear). Only chemical agents can be even further detailed (Table A-26).

Table A-26: CBRNe Agent Types.

CBRNe Agent Type	Level 1	Level 2	Level 3
CBRNe agent	1	1.0.0	1.0.0
Chemical agent		1.1	1.1.0
Harassing agent			1.1.1
Incapacitating agent			1.1.2
Blister agent			1.1.3
Blood agent			1.1.4
Choking agent			1.1.5
Nerve agent			1.1.6
Biological agent		1.2	1.2.0
Radiological/nuclear agent		1.3	1.3.0

For training purposes in the live training environment, it is in general sufficient to use only the top level type of CBRNe agents, without the need for its subcategories. The reason for this is that when a CBRNe agent is detected or its presence suspected, the reaction drill is always the same, irrespective of the type of CBRNe agent. Crews of vehicles that can be CBRNe protected, should close the hatches and invoke the overpressure system. Other personnel should put on their CBRNe masks and maybe their CBRNe suits. That are the basic protective measures. There are some additional protective reactions, such as using a Reactive Skin Decontaminant Lotion in case of liquid chemical agents or using atropine autoinjectors in case of exposure to nerve agents. But one should consider whether it is worthwhile to be able to automatically detect and monitor these activities.

The more detailed levels of CBRNe agent types are only relevant when CBRNe specialists are trained. In that case those trainees should be able to distinguish between the different types, for example by means of detection equipment. Chemical agents can be detected by specific devices and detection stickers, radiological and nuclear agents can be detected by specific radiation detection equipment, but biological agents are difficult to detect easily, in practice the presence can only be inferred from environmental situations (e.g., dead animals) and human reactions.

Agent Density

The unit of agent density depends on the type of CBRNe agent. In case of chemical and biological agents the unit is “parts per million” (ppm). In case of radiological and nuclear agents the unit is milliSievert (mSv).

Persistence

Some CBRNe agent types are persistent. If any type of DO moves into a persistent CBRNe area, that DO gets contaminated and becomes in fact a small CBRNe area in itself. It will remain contaminated until decontaminated, even if it moves out of the CBRNe area where it got contaminated. If unprotected personnel get into contact with the contaminated DO (for example crew dismounting from a contaminated vehicle or personnel touching a contaminated person), they also get contaminated and may become incapacitated, injured or die. In a non-persistent CBRNe area DOs will not become contaminated, but unprotected personnel may become incapacitated, injured or die.

Activation Time

The instance in time when the CBRNe area is activated.

It must be possible to deactivate and reactivate CBRNe areas (Table A-27 and Table A-28).

Table A-27: CBRNe Area Deactivation Dataset.

Parameter	Purpose	Unit	Max	Resolution
CBRNe area ID	MONITORING	ID	10,000	-
Deactivation time	TARGETING	Seconds		Second

Table A-28: CBRNe Area Reactivation Dataset.

Parameter	Purpose	Unit	Max	Resolution
CBRNe area ID	MONITORING	ID	10,000	-
Reactivation time	TARGETING	Seconds		Second

Deactivation/Reactivation Time

The instance in time when the CBRNe area is deactivated or reactivated respectively.

Table A-29 contains the dataset for engagements with a CBRNe area.

Table A-29: CBRNe Area Engagement Dataset.

Parameter	Purpose	Unit	Max	Resolution
CBRNe area ID	MONITORING	ID	10,000	-
Engagement time	MONITORING	Seconds		Second
Engagement duration	DAMAGE CALCULATION	Seconds		Second
Affected DO(s) ID	DAMAGE CALCULATION	ID		-
Affected DO(s) location	DAMAGE CALCULATION	Metres	World coordinate	Metre
Terrain	TARGETING			-
Atmospheric data	TARGETING			-

Engagement Time

The instance in time when the DO is engaged, upon entering the CBRNe area

Engagement Duration

The duration of time the affected DO is exposed to the CBRNe area. The longer it stays within the CBRNe area and is not properly protected, the more severe the effect will be.

Affected DO(s) ID

The identification of the DO(s) that are affected by the engagement.

Affected DO(s) Position

The location(s) of the affected DO(s).

Terrain

The terrain can influence the properties of the CBRNe area.

A4.8 Tactically Relevant Restricted or Impassable Parts of the Terrain

Tactically restricted or impassable terrain are areas where DOs entering can suffer damage due to the characteristics of the terrain. Three types of tactically relevant restricted or impassable parts of the terrain are identified: bridges, swamps and rivers. These objects most likely will exist during the whole scenario, so there is no need for an emplacer ID nor an activation and deactivation time or action. It is assumed these objects come into effect when created and cease to exist when removed.

A4.8.1 Bridge

This construct of an engagement area for a bridge can also be used for mobile bridges, but when emplacer ID or (de)activation time are important, alternative ways for implementation are to model mobile bridges as DOs or as breach lanes. The dataset to create a bridge is defined in Table A-30.

Table A-30: Bridge Creation Dataset.

Parameter	Purpose	Unit	Max	Resolution
Bridge ID	MONITORING	ID	10,000	-
Bridge shape	MONITORING TARGETING	Set of points	20	Metre
Bridge location	MONITORING TARGETING	Metres	World coordinate	Metre
Bridge weight class	DAMAGE CALCULATION	Tons	1,000	Ton

Bridge ID

Unique identifier identifying a bridge.

Bridge Shape

Although the bridge area is likely mapped on the road surface of a bridge, the shape is a 3D polyhedron to distinguish it from the underlying terrain and to accommodate curved bridges. The shape is defined by a set of geographic reference points relative to the “Bridge location”.

Bridge Location

The location of the bridge.

Bridge Weight Class

The weight, measured in tons, the bridge can carry. When the weight of a DO exceeds the weight class of the bridge, the bridge will collapse and the DOs on the bridge will suffer damage.

Table A-31 contains the dataset for engagements with a bridge.

Table A-31: Bridge Engagement Dataset.

Parameter	Purpose	Unit	Max	Resolution
Bridge ID	MONITORING	ID	10,000	-
Engagement time	MONITORING	Seconds		Second
Affected DO(s) ID	DAMAGE CALCULATION	ID		-
Affected DO(s) location	DAMAGE CALCULATION	Metres	World coordinate	Metre

Engagement Time

The instance in time when the bridge collapses.

Affected DO(s) ID

The identification of the DO(s) that are at that moment on the bridge and are affected by the engagement

Affected DO(s) Location

The three-dimensional location(s) of the affected DO(s).

A4.8.2 Swamp

The dataset to create a swamp is defined in Table A-32.

Table A-32: Swamp Creation Dataset.

Parameter	Purpose	Unit	Max	Resolution
Swamp ID	MONITORING	ID	10,000	-
Swamp shape	MONITORING TARGETING	Set of points	20	Metre
Swamp location	MONITORING TARGETING	Metres	World coordinate	Metre
Swamp weight class	DAMAGE CALCULATION	Kilos	100,000	Kilo

Swamp ID

Unique identifier identifying a swamp.

Swamp Shape

The shape is a 2D polygon (but the swamp follows the contours of the terrain), defined by a set of geographic reference points, relative to the "Swamp location".

Swamp Location

The location of the swamp.

Swamp Weight Class

The weight, measured in kilos, the swamp can withstand. When the weight of a DO exceeds the weight class of the swamp, the DO will get immobilised or even sink (total kill).

Table A-33 contains the dataset for engagements with a swamp.

Table A-33: Swamp Engagement Dataset.

Parameter	Purpose	Unit	Max	Resolution
Swamp ID	MONITORING	ID	10,000	-
Engagement time	MONITORING	Seconds		Second
Affected DO(s) ID	DAMAGE CALCULATION	ID		-
Affected DO(s) location	DAMAGE CALCULATION	Metres	World coordinate	Metre

Engagement Time

The instance in time when a DO enters the swamp.

Affected DO(s) ID

The identification of the DO(s) that are affected by the engagement. Generally, each DO entering the swamp is a separate engagement, but multiple DOs can be affected, for instance when a DO contains other DOs.

Affected DO(s) Location

The three-dimensional location(s) of the affected DO(s).

A4.8.3 River

The dataset to create a river is defined in Table A-34.

Table A-34: River Creation Dataset.

Parameter	Purpose	Unit	Max	Resolution
River ID	MONITORING	ID	10,000	-
River shape	MONITORING TARGETING	Set of points	20	Metre
River location	MONITORING TARGETING	Metres	World coordinate	Metre
River fording DO types	DAMAGE CALCULATION	List of DO types		-

River ID

Unique identifier identifying a river.

River Shape

The shape is a 2D polygon (but the river follows the contours of the terrain), defined by a set of geographic reference points, relative to the “River location”.

River Location

The location of the river.

River Fording DO Types

In reality, whether a DO can cross a river or not depends on the characteristics of the river (for example the river depth, the strength of the current, the slope and soil type of the river banks, etc.) and the characteristics of the DO (for example the fording height of a vehicle, whether it is wheeled or tracked, if the crew has taken the proper fording measures, if it has amphibious capabilities, etc.). For the training purposes related to river engagement areas this is too complex, it suffices to select from the list of all DO types used in the exercise, the DO types which can cross the river.

If different segments of a river have different characteristics and different types of DO are able to cross, than multiple river engagement areas should be created.

Table A-35 contains the dataset for engagements with a river.

Table A-35: River Engagement Dataset.

Parameter	Purpose	Unit	Max	Resolution
River ID	MONITORING	ID	10,000	-
Engagement time	MONITORING	Seconds		Second
Affected DO(s) ID	DAMAGE CALCULATION	ID		-
Affected DO(s) location	DAMAGE CALCULATION	Metres	World coordinate	Metre

Engagement Time

The instance in time when a DO enters the river.

Affected DO(s) ID

The identification of the DO(s) that are affected by the engagement. Generally, each DO entering the river is a separate engagement, but multiple DOs can be affected, for instance when a DO contains other DOs.

Affected DO(s) Location

The three-dimensional location(s) of the affected DO(s).

A4.9 Administrative Areas

Administrative areas are used to monitor the position of DOs in relation to some designated areas. They have no effect in the training environment. They can be created by EXCON or can be imported from a C4I system, so there is no need for a creator ID.

Table A-36: Administrative Area Creation Dataset.

Parameter	Purpose	Unit	Max	Resolution
Administrative area ID	MONITORING	ID	10,000	-
Administrative area type	MONITORING	Enumeration		-
Administrative area affiliation	MONITORING	Enumeration		-
Administrative area shape	MONITORING	Set of points	20	Metre
Administrative area location	MONITORING	Metres	World coordinate	Metre
Activation time	MONITORING	Seconds		Second

Administrative Area ID

Unique identifier identifying the administrative area.

Administrative Area Type

The following types and subtypes of administrative areas are distinguished:

- Prisoner holding area (2D polygon). When a DO with status “captured” enters or exits a prisoner holding area, a marker is generated for monitoring purposes. There are two subtypes:
  - Detention control point (used for temporary holding); and
  - Detention holding area (used for permanent holding).
- Air Space Management (ASM) area (3D polyhedron, it can start on the surface or exist fully in the air). When an aircraft DO (airplane, helicopter, UAV) belonging to one of the affiliated parties enters or exits an ASM area, a marker is generated for monitoring purposes. There are multiple subtypes[5]:

[5] Reference: JP 3-52 Joint Airspace Control, 13 NOV 2014.

  - Air corridor;
  - Minimum risk route;
  - Temporary minimum risk route;
  - Transit corridor;
  - Transit route;
  - Low level transit route;
  - Special corridor;
  - Standard use army aircraft flight route;
  - Restricted operation zone;
  - Air-to-air refuelling area;
  - Airborne command and control area;
  - Airborne early warning area;
  - Close air support area;
  - Combat air patrol;
  - Electronic combat;
  - Drop zone;
  - Landing zone;
  - Pick-up zone;
  - Reconnaissance area;
  - Special operations force area;
  - Surface-to-surface missile system area;
  - Surface-to-surface munitions area; and
  - Unmanned aircraft area.
- No-go area (2D polygon). When a surface-bound DO (person, land vehicle, ship) belonging to one of the affiliated parties, enters or exits a no-go area, a marker is generated for monitoring purposes.
- No-fly area (3D polyhedron). When an aircraft DO (airplane, helicopter, UAV) belonging to one of the affiliated parties, enters or exits a no-fly area, a marker is generated for monitoring purposes.
- No-fire area (2D polygon for ground-based areas and 3D polyhedron for aerial areas). When a DO belonging to one of the affiliated parties, fires a weapon or releases ammunition from or into a no-fire area, a marker is generated for monitoring purposes.

Administrative Area Affiliation

Because administrative areas are tactically relevant, they are affiliated to one or more of the parties in the exercise.

Administrative Area Shape

The shape is a 2D polygon or 3D polyhedron (see the parameter “Administrative area type” above for the details per type of administrative area), defined by a set of geographic reference points. They are relative to the “Administrative area location”.

Administrative Area Location

The location of the administrative area.

Activation Time

The instance in time when the administrative area is created or activated.

It must be possible to deactivate and reactivate administrative areas. The corresponding datasets are defined in Table A-37 and Table A-38.

Table A-37: Administrative Area Deactivation Dataset.

Parameter	Purpose	Unit	Max	Resolution
Administrative area ID	MONITORING	ID	10,000	-
Deactivation time	MONITORING	Seconds		Second

Table A-38: Administrative Area Reactivation Dataset.

Parameter	Purpose	Unit	Max	Resolution
Administrative area ID	MONITORING	ID	10,000	-
Reactivation time	MONITORING	Seconds		Second

Deactivation/Reactivation Time

The instance in time when the administrative area is deactivated or reactivated.

Table A-39 contains the dataset for engagements with an administrative area.

Table A-39: Administrative Area Engagement Dataset.

Parameter	Purpose	Unit	Max	Resolution
Administrative area ID	MONITORING	ID	10,000	-
Engagement time	MONITORING	Seconds		Second
Involved DO(s) ID	MONITORING	ID		-
Involved DO(s) location	MONITORING	Metres	World coordinate	Metre

Engagement Time

The instance in time when a DO enters or exits the administrative area. Except for a no-fire area, then the engagement time is the time when a DO fires from or into the no-fire area.

Involved DO(s) ID

The identification of the DO(s) that are involved in the engagement.

Involved DO(s) Location

The three-dimensional location(s) of the involved DO(s).

A4.10 Weapon Effect Modification Area

In a weapon effect modification area, the type of the terrain can increase or reduce the effects of ammunitions on affected DOs, to simulate extra shrapnel from the environment or absorption of blast and shrapnel by the underground (Table A-40). Contrary to other types of engagement areas, there is no engagement event generated when a DO enters a weapon effect modification area, but when a DO is engaged in this area, the outcome of the engagement can be modified. Weapon effect modification areas are simplified approaches to modify the damaging effects on DOs. There is no requirement to take the direction of explosions or the direction of terrain features into account. When a higher accuracy of damage calculation is required, the actual geometry of the terrain or infrastructure must be taken into account, a weapon effect modification area is then not the right mechanism. It is assumed these areas come into effect when created and cease to exist when removed.

Table A-40: Effect Modification Area Creation Dataset.

Parameter	Purpose	Unit	Max	Resolution
Effect modification area ID	MONITORING	ID	10,000	-
Effect modification area type	DAMAGE CALCULATION	Enumeration		-
Effect modification area modifier	DAMAGE CALCULATION	Percentage	-100% to 100%	1 %
Effect modification area shape	MONITORING TARGETING	Set of points	20	Metre
Effect modification area location	MONITORING TARGETING	Metres	World coordinate	Metre

Effect Modification Area ID

Unique identifier identifying the effect modification area.

Effect Modification Area Type

The following types of terrain are distinguished:

- Ditch(es);
- Wall(s). This type of effect modification terrain is not intended to represent urban terrain with buildings and where DOs can be located on different floors. For such a level of accuracy separate buildings should be modelled as objects consisting of walls, floors etc.
- Trees;
- Open terrain (although this could be the default terrain type);
- Boggy terrain;

- Rocky terrain;
- Sandy terrain;
- Frozen terrain;
- Snowy terrain;
- Undulating terrain; and
- Flooded terrain.

Effect Modification Area Modifier

The effect modification can decrease (negative percentage) or increase (positive percentage) the probability of a DO getting injured or sustaining damage when engaged in this area by ammunitions which are resolved by geo-referencing (e.g., indirect fire, explosives, virtual ammunitions). A decrease simulates for example the absorption of an explosion by the soil or the shielding of shrapnel by objects (walls, trees). An increase simulates for example ricochets of shrapnel or the additional tree fragments created when artillery shells with proximity fuses explode among trees.

Depending on system implementation, this modifier can be fully user-controlled or be a fixed percentage associated with each terrain type.

> **Note:** This effect might not be applicable for all types of ammunition, but this should be taken care of internally in the training system. This solution does not provide for the use case that trees protect against hand grenades (negative percentage) but increase the probability for indirect fire (positive percentage). If required, the mechanism should be more complex.

Effect Modification Area Shape

The shape is a 2D polygon defined by a set of geographic reference points. They are relative to the “Effect modification area location”.

Effect Modification Area Location

The location of the effect modification area.

> **Note:** breaches (as defined in Section A4.6.3) are man-made weapon effect modification areas across obstacles.

A4.11 Combat Service Support (CSS) Areas

Combat Service Support (CSS) activities are an integral part of and influence the tactical operation: they consume resources for execution, they require protection, they take time and the results of the activities influence the combat power of a unit. Therefore, it is important that these functionalities can be trained in the context of live tactical training exercises.

During operations wounded personnel can be treated in the field by other (medical) personnel. When treatment cannot be executed or completed in the field, wounded personnel is transported or evacuated to higher echelon medical facilities. Similarly (minor) damages to vehicles and large weapon systems can be repaired in the field, either by the crew themselves or by combat service support units. When repair is not possible in the field, damaged equipment can be recovered and transported to a higher-level repair facility.

Also supplies can be brought forward to the units in the field, or the units can move to a resupply facility.

This section defines the implementation of CSS areas, which are an abstract representation of real world facilities, that do not require the simulation of associated CSS personnel or equipment. When it is required that CSS personnel and equipment participate in the exercise, they also require CSS engagements, which are defined in Section A4.12.

To model the type of service the CSS areas provide, they have a rule set attached to it and when DOs of a certain type enter it, certain status changes are applied based on that rule set. Five types of CSS area are distinguished: medical treatment area, repair area, resupply area, forward armament and refuel point and decontamination area. The dataset to create a CSS area is defined in Table A-41.

Table A-41: CSS Area Creation Dataset.

Parameter	Purpose	Unit	Max	Resolution
CSS area ID	MONITORING	ID	10,000	-
CSS area type	DAMAGE CALCULATION	Enumeration		-
CSS area affiliation	TARGETING	Enumeration		-
CSS area serviced parties	TARGETING	Enumeration		-
CSS area serviced DO categories	TARGETING	Enumeration		-
CSS area dwell time	DAMAGE CALCULATION	Seconds		Second
CSS area shape	MONITORING TARGETING	Set of points	20	Metre
CSS area location	MONITORING TARGETING	Metres	World coordinate	Metre
Activation time	TARGETING	Seconds		Second

CSS Area ID

Unique identifier identifying the combat service support area.

CSS Area Type

The following types and subtypes of CSS areas are distinguished:

- Medical treatment area (3D polyhedron, since a medical treatment area can also be located in a part of a large building):
  - Casualty collection point, used for assembly, triage (sorting), medical stabilisation and subsequent evacuation of casualties;
  - Role 1, can provide triage, first aid and lifesaving measures;
  - Role 2, can provide triage and resuscitation, treatment and holding of patients until they can be returned to duty or evacuated, emergency dental treatment and emergency surgery; and
  - Role 3, can provide specialist diagnostic, specialist surgical, preventive medicine, food inspection, dentistry and operational stress management services. Classically this is a field hospital.

- Repair area (2D polygon);
- Resupply area (2D polygon);
- Forward Armament and Refuel Point (FARP) (2D polygon), consisting of the following subtypes:
  - Cargo helicopter FARP, in this area helicopters can be re-armed and refuelled (the latter is not simulated or registered in case of live training systems);
  - Attack helicopter FARP, in this area helicopters can be re-armed, refuelled and minor damage can be repaired (maintenance personnel is part of the ground crew);
- Decontamination area (2D polygon), consisting of the following subtypes:
  - Hasty decontamination area; and
  - Deliberate decontamination area.

CSS Area Affiliation

A CSS area can be affiliated to one of the parties in the exercise or to EXCON.

CSS Area Serviced Parties

The effect of the CSS area is applied only to DOs belonging to the set of serviced parties.

CSS Area Serviced DO Categories

The categories of DO which are serviced by the CSS area. A selection should be made from one or more (or all) of the following DO categories:

- Personnel;
- Wheeled;
- Tracked; and
- Aircraft.

Medical treatment areas are only relevant for personnel, repair areas are only relevant for vehicles and FARPs are only relevant for aircraft.

CSS Area Dwell Time

The time required to remain in the CSS area in order to apply the specific effect. The dwell time can be zero. In case of a repair area, only after the dwell time has passed, the damage will be repaired. The dwell time should be made damage type specific. In case of a resupply activity (resupply area or FARP), only a proportional amount of supplies is transferred when a DO remains less than the required dwell time in the resupply area. In all other cases (medical treatment, repair or decontamination), the full dwell time must pass before the effect is applied. The dwell time depends on the type of injury or damage and the following categories must be distinguished:

For personnel:

- CBRNe contaminated (requires a decontamination activity);
- Wounded (requires a medical treatment); and
- C4ISR kill (requires a repair activity).

For weapon systems:

- CBRNe contaminated (requires a decontamination activity);
- Mobility kill (requires a repair activity);
- Weapon kill (requires a repair activity); and
- C4ISR kill (requires a repair activity).

CSS Area Shape

The shape is a 2D polygon or 3D polyhedron (see the parameter "CSS area type" above for the details per type of CSS area), defined by a set of geographic reference points. They are relative to the "CSS area location".

CSS Area Location

The location of the CSS area.

Activation Time

The instance in time when the administrative area is created or activated.

It must be possible to deactivate and reactivate CSS areas. The corresponding datasets are defined in Table A-42 and Table A-43.

Table A-42: CSS Area Deactivation Dataset.

Parameter	Purpose	Unit	Max	Resolution
CSS area ID	MONITORING	ID	10,000	-
Deactivation time	TARGETING	Seconds		Second

Table A-43: CSS Area Reactivation Dataset.

Parameter	Purpose	Unit	Max	Resolution
CSS area ID	MONITORING	ID	10,000	-
Reactivation time	TARGETING	Seconds		Second

Deactivation/Reactivation Time

The instance in time when the CSS area is deactivated or reactivated.

Table A-44 contains the dataset for engagements with a CSS area.

Table A-44: CSS Area Engagement Dataset.

Parameter	Purpose	Unit	Max	Resolution
CSS area ID	MONITORING	ID	10,000	-
Engagement time	MONITORING	Seconds		Second

Parameter	Purpose	Unit	Max	Resolution
Affected DO(s) ID	DAMAGE CALCULATION	ID		-
Affected DO(s) location	DAMAGE CALCULATION	Metres	World coordinate	Metre

Engagement Time

The instance in time when a DO enters the CSS area.

Affected DO(S) ID

The identification of the DO(s) that are affected by the engagement.

Affected DO(S) Location

The three-dimensional location(s) of the affected DO(s).

A4.12 Combat Service Support (CSS) Engagements

CSS areas do not require physically present CSS personnel or equipment to generate CSS effects, it is sufficient when the receiving DOs enter such a virtual area to achieve the desired effects. However, when CSS personnel and equipment is required to participate in the exercise, either because they are also part of the training audience or to represent CSS activities more realistically to the other players, certain CSS engagements between CSS personnel or CSS equipment and other players must be implemented. Three different types of CSS engagements are distinguished: medical treatment, repair and resupply. In contrast, there are five types of CSS areas, but there is no need to define FARP or decontamination engagements: engagements at a FARP are a combination of repair and resupply engagements, while UCATT has not identified training requirements to simulate decontamination vehicles, decontamination liquids, etc. The implementation of decontamination areas is sufficient for the CSS training requirements.

A4.12.1 Medical Treatment Engagements

In reality, when a wound is not treated, the victim's situation will deteriorate, and the victim will lose capabilities and can eventually die. When the training system supports a rich set of health statuses and associated diagnostic data for personnel, it is also logical that there is a simulation model that determines such degradation of the health status. The purpose of medical treatment in the field is to stop or slow the deterioration of the health of a wounded person. Actual healing of a wound will generally require medical facilities and will take more time than is available in an exercise. It should also be possible for an affected DO's health to deteriorate when the wrong treatment is given, even faster than when no action is taken at all. Therefore, a treatment can have a negative effect.

In order to enable the implementation of medical treatment, it is required that players can diagnose the health status of personnel DOs and can interact with the wounded DOs to change the health status by means of a simulated medical activity. For the simulation of medical engagements, currently two implementation solutions are known, depending on where the medical treatment model resides, either in the injured DO or in the treatment device of the medic:

- In the case where the model resides in the injured DO, the medic interrogates the medical model of the injured DO manually to retrieve relevant data such as the type of injury and the associated vital signs (these include blood pressure, heart rate and respiratory parameters). Based on this information

the medic decides on the treatment to apply and uses a specific medical treatment device to transfer the identification of the chosen medical activity to the injured DO. The medical treatment model of the injured DO determines the outcome of this medical activity. In this case the identification of the medical activity is transferred from the medic DO to the injured DO. To ensure interoperability the list of medical activities should be standardised. Currently this data is nation and training system specific. An engagement dataset for this type of solution is defined in the remainder of this section.

- In the case where the model resides in the medical treatment device of the medic, this device is used to read out the type of injury of the injured DO (the list of damage statuses of personnel is specified by UCATT). Subsequently, the medical treatment device generates relevant vital signs associated with the particular injury. Vital signs include blood pressure, heart rate and respiratory parameters. The medic then inputs a medical activity on the medical treatment device, which calculates the outcome of the medical activity. The outcome is a modifier on the clock that runs in the injured DO. When that clock reaches a certain value, the injury will worsen or the injured DO will die. An appropriate medical activity will slow down the clock (reversing the clock to model to heal the injury is not realistic for a medical treatment in the field and within the timeframe of an exercise), while a wrong activity might speed up the deteriorating process, causing more severe damage and even death. In this case, the dataset to be transferred from the medic DO to the injured DO is the clock modifier. The dataset that defines a medical engagement is listed in Table A-45.

Since these solutions transfer different types of information, they are not interoperable and injured DOs can only be engaged by medics who are equipped with medical treatment devices from the same training system.

Medical treatment activities in the field, that must be supported by the training system, can be performed by:

- The wounded DO itself (care under fire). The associated medical activities are limited to those activities that a person can perform by himself in reality, such as taking medication or applying pressure to stop a bleeding;
- Any non-medical personnel, also they are only capable to perform very basic medical activities;
- Medically trained personnel. They have more knowledge, skills and tools and therefore can perform more complicated medical activities. They also can decide on medical evacuation or transportation to a medical facility. This transportation can be executed in the live environment, without need for special training equipment functionality; and
- Members of EXCON, including O/Cs in the field. EXCON must have the possibility to initiate a medical treatment, either taking into account the treatment time it would take another actor or instantaneously. For analytical and monitoring purposes it is useful to make a distinction between an instantaneous medical treatment and an EXCON reset.

Table A-45: Medical Engagement Dataset.

Parameter	Purpose	Unit	Max	Resolution
Medic DO ID	ENGAGING MONITORING	ID	100,000	-
Medic DO location (x, y, z), plus accuracy indicator	ENGAGING MONITORING	Metres	World coordinate	Centimetre
Medical activity type	EFFECT CALCULATION MONITORING	Enumeration		-

Parameter	Purpose	Unit	Max	Resolution
Engagement time	MONITORING	Seconds		Second
Treatment duration	EFFECT CALCULATION MONITORING	Number	43,200 seconds (12 hours)	Second
Affected DO ID	ENGAGING MONITORING	ID		-
Affected DO location (x, y, z), plus accuracy indicator	ENGAGING MONITORING	Metres	World coordinate	Centimetre

Medic DO ID

The ID of the DO that performs the medical activity.

Medic DO Location

The location of the medic DO, mainly used for monitoring purposes, but conditions can be checked that the medic DO must be and stay during the medical treatment in the direct vicinity of the wounded DO.

Medical Activity Type

The activity type of the performed medical activity. The following types are distinguished:

- Open airway;
- Position correctly;
- Reassure wounded;
- Apply pressure dressing;
- Apply airtight dressing;
- Apply protective dressing;
- Apply tourniquet;
- Splint limb;
- Immobilise spine;
- Patch wounded eye;
- Patch good eye;
- Apply artificial respiration;
- Apply Cardio-Pulmonary Resuscitation (CPR);
- Remove fragment;
- Apply oral airway;
- Apply nasopharyngeal (NP) airway;
- Apply O_2 mask;
- Apply ventilation;

- Apply pneumo decompression;
- Apply traction;
- Apply moist dressing;
- Defibrillate;
- Apply IV;
- Administer morphine; and
- Administer antibiotic.

Engagement Time

The instance in time when the medical treatment starts and is mainly used for monitoring purposes.

Treatment Duration

The duration in seconds of how long the medical activity will take to become in effect.

Affected DO ID

The ID of the DO to be treated.

Affected DO Location

The location of the DO to be treated.

There will be a mapping of which (type of) DO are allowed to perform what medical activities on what wounds. Those permissions are considered as properties of the DO that wants to perform a medical activity and are therefore not part of the engagement data. If a DO has insufficient permission to perform a particular medical activity, either it cannot select or initiate such activity, or the activity will have no effect.

A4.12.2 Repair Engagements

In order to enable the implementation of repair activities, it is required that players can diagnose the sustained damage of a DO and can interact with the DO to change the degraded status by means of a simulated repair activity (Table A-46). How these interactions are physically implemented is not prescribed. But one can for example think of a display in or on a vehicle to read off the damage status and select the proper repair activity. Of course, the physical actions to perform the repair do not need or even cannot be executed in the live training environment. Instead it is sufficient that after initiating the repair activity, a certain repair time is taken into account. Only after that time period has finished, the repair is considered to have taken place successfully and the damage status will be changed. During the repair time the damage status and the associated limitations for the vehicle and crew will stay in effect.

It is currently assessed that it suffices to record only the ID of one repairing DO, this can be the ID of the person who initiates the repair activity or the ID of the vehicle (unit) that person belongs to. In reality, a repair activity can be executed by multiple persons working as a team, for example changing a vehicle engine in the field generally involves the whole crew of a repair vehicle. Administrating the IDs of all persons involved in the repair activity is currently not required.

Repair activities in the field, that must be supported by the training system, can be performed by:

- The crew of the damaged vehicle. The repair activities are limited to those activities that the crew can perform by themselves in reality. Since this is only a very limited set of activities, this possibility has a low priority.

- The crew of a recovery vehicle. They have more knowledge, skills, tools and spare parts than the crew of the damaged vehicle and therefore they can repair more serious damage.

  If the damage cannot be repaired in the field, the damaged vehicle can be transported to a repair facility. This recovery can be executed in the live environment, without need for special training equipment functionality.

- Members of EXCON, including O/Cs in the field. EXCON must have the possibility to initiate a repair activity, either taking into account the repair time it would take another actor (the crew themselves or the crew of a recovery vehicle), or instantaneously. This latter possibility is useful to make optimal use of the training time. Note that for analytical and monitoring purposes it is useful to make a distinction between an instantaneous EXCON repair and an EXCON reset. Although the effects are exactly the same (both can result in immediately changing the damage status), an EXCON repair is within the tactical context of the exercise, while an EXCON reset is an intervention outside that scope, e.g., due to a (sub)system failure, therefore the data in the generated reports will be treated differently.

It is assumed that one repair activity will repair only one type of damage. Multiple damages require multiple repair activities, that could be executed simultaneously or successively. For example, to repair a communication kill and a mobility kill, requires a “repair communication system” and a “repair engine” activity. Those repair activities can be executed by the same repair DO or by two separate repair DOs.

Table A-46: Repair Engagement Dataset.

Parameter	Purpose	Unit	Max	Resolution
Repair DO ID	ENGAGING MONITORING	ID	100,000	-
Repair DO location (x, y, z), plus accuracy indicator	ENGAGING MONITORING	Metres	World coordinate	Metre
Repair activity type	EFFECT CALCULATION MONITORING	Enumeration		-
Engagement time	MONITORING	Seconds		Second
Repair duration	EFFECT CALCULATION MONITORING	Number	43,200 seconds (12 hours)	Second
Affected DO ID	ENGAGING MONITORING	ID		-
Affected DO location (x, y, z), plus accuracy indicator	ENGAGING MONITORING	Metres	World coordinate	Metre

Repair DO ID

The ID of the DO that performs the repair activity. This is required to determine if the DO is permitted or has the capability to perform the repair activity. Also, for analytical and monitoring purposes the IDs of the involved DOs are required.

Repair DO Location

The location of the repair DO, mainly used for monitoring purposes, but conditions can be checked that the repair DO must be in the direct vicinity of the DO to be repaired.

Repair Activity Type

The activity type of the initiated repair activity. When this data element is required, these types need to be defined.

Engagement Time

The instance in time when the repair activity starts and is mainly used for monitoring purposes.

Repair Duration

The duration in seconds of how long the repair activity will take to become in effect. This can be zero, to immediately change the damage status of the affected DO. In practice, the duration of a repair activity is generally measured in minutes, rather than seconds.

Affected DO ID

The ID of the DO to be repaired.

Affected DO Location

The location of the DO to be repaired.

There will be a mapping of which (type of) DO are allowed to perform what repair activities on what type of damaged DO. Those permissions are considered as properties of the DO that wants to perform a repair activity and are therefore not part of the engagement data. If a DO has insufficient permission to perform a particular repair activity, either it cannot select or initiate such activity, or the activity will have no effect.

A4.12.3 Resupply Engagements

During actual operations supplies are consumed and also replenished. Several categories of supply are distinguished[6:]

Class I. Items which are consumed by personnel or animals at the approximately uniform rate, irrespective of local changes in combat or terrain conditions. Food is a typical example.

Class II. Supplies for which allowances are established by tables of organisation and equipment.

Class III. Petrol, oil and lubricants.

Class IV. Supplies for which initial issue allowances are not prescribed by approved issue tables. Normally such supplies include fortification and construction materials, as well as additional quantities of items identical to those authorised for initial issue (Class II), such as additional vehicles.

Class V. Ammunition, explosives and chemical agents of all types.

[6] Source: APP-6(C), NATO joint military symbology.

For tactical exercises mainly classes III and V are relevant:

- Class III supplies are not simulated, but the real materials are used in realistic quantities. There is no requirement for the training system to register or analyse the consumption and resupply of fuel;
- Class V supplies are simulated, and it is required to register and analyse ammunition consumption and resupply; and
- It is noted that medical treatment also consumes material, but there is no requirement to simulate such medical materials and thus there is no requirement for resupply.

Resupply activities, that must be supported by the training system, can be performed by:

- A resupply vehicle. Such a vehicle is equipped with specific types of ammunition in certain quantities. A resupply activity will reduce the stock available for subsequent resupplies. In reality resupply of ammunition will take (some) time, this must also be simulated; and
- Members of EXCON, including O/Cs in the field. EXCON must have the possibility to initiate a resupply activity, either taking into account the resupply time it would take a resupply vehicle or instantaneously. For analytical and monitoring purposes it is useful to make a distinction between an instantaneous resupply activity and an EXCON reset of the (initial) supplies.

Resupply activities that can take place in reality, but need not to be supported by the training system:

- Resupply of blank ammunition. This ammunition exists in reality and can therefore be physically distributed without interaction with the training system. This applies for example to ammunition of small calibre weapons.
- Redistribution of supplies by the elements of a tactical unit amongst themselves. For example, tank crews of a platoon redistributing shells within the platoon; and
- Resupply in special resupply depots. Such large-scale resupply in specific logistical areas can be performed by EXCON.

To enable the implementation of resupply of simulated ammunition, it is required that players can interact with a DO to request the current stock of simulated ammunition of that DO and, when authorised, to change the stock (Table A-47). How these interactions are physically implemented is not prescribed.

Table A-47: Resupply Engagement Dataset.

Parameter	Purpose	Unit	Max	Resolution
Supplier DO ID	ENGAGING MONITORING	ID	100,000	-
Supplier DO location (x, y, z), plus accuracy indicator	ENGAGING MONITORING	Metres	World coordinate	Metre
Supply activity type	EFFECT CALCULATION MONITORING	Enumeration		-
Ammunition type	EFFECT CALCULATION MONITORING	Enumeration		-

Parameter	Purpose	Unit	Max	Resolution
Supply quantity	EFFECT CALCULATION MONITORING	Number	10,000	1
Engagement time	MONITORING	Seconds		Second
Supply duration	EFFECT CALCULATION MONITORING	Number	3,600 (1 hour)	Second
Affected DO ID	ENGAGING MONITORING	ID		-
Affected DO location (x, y, z), plus accuracy indicator	ENGAGING MONITORING	Metres	World coordinate	Metre

Supplier DO ID

The ID of the DO that performs the resupply activity.

Supplier DO Location

The location of the supplying DO, mainly used for monitoring purposes, but conditions can be checked that the supplying DO must be and stay during the resupply activity in the direct vicinity of the supplied DO.

Supply Activity Type

The activity type of the performed resupply activity. It can be:

- "Take": the "supply quantity" is added to the stock of the DO; and
- "Give": the "supply quantity" is subtracted from the stock of the DO.

Ammunition Type

The type of ammunition being resupplied. If more than one type of ammunition is supplied, then multiple engagements are required, one for each ammunition type.

Supply Quantity

The amount of shells involved in the resupply activity.

Engagement Time

The instance in time when the resupply activity starts and is mainly used for monitoring purposes.

Supply Duration

The duration in seconds of how long the resupply activity will take to become in effect.

Affected DO ID

The ID of the DO to be resupplied.

Affected DO Location

The location of the DO to be resupplied.

A4.13 Electronic Warfare (EW) Influence Area

The objective of incorporating EW activities and EW associated effects in the training environment is twofold, on the one hand to train commanders and EW operators to employ EW capabilities integrated in their tactical operations and on the other hand to train personnel to operate in a contested EMS (Electromagnetic Spectrum) environment, by exposing them to certain EW effects. In this context two types of EW effects are relevant, namely "jamming" and "spoofing". Jamming is defined as degrading or disrupting communication links (voice or data), sensors or navigation systems by transmitting interfering radio signals on the specified frequencies. Jamming can also be used as protection measure when Radio-Controlled Improvised Explosive Devices (RC-IEDs) are denied receiving a trigger command and thereby (temporarily) disabling them to be set off. Spoofing is defined as exposing targets to false but meaningful signals in order to mislead them. For example, overriding a GPS signal can disrupt the situational awareness of a target or can prevent him from (accurately) delivering fire effects. Injecting false command and control orders in an adversary's communication system can confuse the adversary and delay or disrupt his operation.[7]

EW effects can be integrated in the training environment by simulation or by using real EW capabilities. In the first case the operational systems must be able to receive the simulated EW data and simulate the jamming or spoofing effects. In the latter case no modifications of the operational systems are required but employing real EW capabilities might interfere with the monitoring or safety of the training.

An EW influence area is a type of engagement area, but its parameters are substantially different than those of the other types. For example, it has no affiliation (all DOs in the EW influence area suffer the same effects, in the tactical training environment there is no protection or neutralisation), it has no dwell time (or it is always zero since the effect is applied to a DO the moment it enters the EW influence area) and its shape is not a 2D polygon or 3D polyhedron (Table A-48).

Generally, EW equipment is associated with a DO, it can be built into a vehicle or carried by a dismounted soldier. However, it is also possible to place a portable jammer on a certain location in the field, for example when investigating an IED. Therefore, EW equipment can be modelled as a property of a DO (when built into it) or as a separate DO itself (for example a portable jammer that can be placed in the environment).

Table A-48: EW Influence Area Creation Dataset.

Parameter	Purpose	Unit	Max	Resolution
EW influence area ID	MONITORING	ID	10,000	-
EW carrier ID	MONITORING	ID	100,000	
EW influence area type	DAMAGE CALCULATION	Enumeration		-
EW influence data	DAMAGE CALCULATION	EW data		-
EW influence area frequency range: minimum frequency maximum frequency	DAMAGE CALCULATION	MHz		1 MHz

[7] Note that EW and cyber are closely related, but are different. EW can inject extra or override data on electromagnetic dataflows, while cyber can modify or destroy data(flows) or applications.

Parameter	Purpose	Unit	Max	Resolution
EW influence area shape	MONITORING TARGETING	Sphere: metres Cone: metres and degrees for direction and apex		Metre Degree
EW influence area location	MONITORING TARGETING	Metres		Metre
Activation time	TARGETING	Seconds		Second

EW Influence Area ID

Unique identifier identifying the EW influence area.

EW Carrier ID

When the EW influence area is generated by a DO (an entity equipped with a jammer or a specialised EW entity), the carrier ID is the identification of the generating DO.

EW Influence Area Type

The following two types of EW influence areas are distinguished:

- EW jamming area;
- EW spoofing area.

EW Influence Data

This is the data that is sent on the specified frequency range. Especially in the case of spoofing this is relevant, since its purpose is to mislead the targets with meaningful data.

EW Influence Area Frequency Range

The frequency range which is influenced, denoted by a minimum and maximum frequency. There is no need to specify multiple ranges of frequencies influenced by one EW influence area. The primary training purpose of EW influence areas is to expose trainees to the effects of EW influence, not to train EW specialists. Therefore, when EW influence areas are created by EXCON personnel (generally no EW experts) it is preferable when, instead of specifying a frequency range, they can specify the type of equipment to be influenced. The EXCON software should then automatically retrieve the proper frequency range to exchange this dataset with external systems.

EW Influence Area Shape

The shape of an EW influence area is either a 3D right circular cone (with an associated direction and aperture) or a 3D sphere relative to the “EW influence area location”.

EW Influence Area Location

The location of the EW influence area.

Activation Time

The instance in time when the EW influence area is activated

It must be possible to deactivate and reactivate EW influence areas. The corresponding datasets are defined in Table A-49 and Table A-50.

Table A-49: EW Influence Area Deactivation Dataset.

Parameter	Purpose	Unit	Max	Resolution
EW influence area ID	MONITORING	ID	10,000	-
Deactivation time	TARGETING	Seconds		Second

Table A-50: EW Influence Area Reactivation Dataset.

Parameter	Purpose	Unit	Max	Resolution
EW influence area ID	MONITORING	ID	10,000	-
Reactivation time	TARGETING	Seconds		Second

Deactivation/Reactivation Time

The instance in time when the EW influence area is deactivated or reactivated.

Table A-51 contains the dataset for engagements with an EW influence area.

Table A-51: EW Influence Area Engagement Dataset.

Parameter	Purpose	Unit	Max	Resolution
EW influence area ID	MONITORING	ID	10,000	-
Engagement time	MONITORING	Seconds		Second
Terrain	TARGETING			-
Affected DO(s) ID	DAMAGE CALCULATION	ID		-
Affected DO(s) location	DAMAGE CALCULATION	Metres	World coordinate	Metre

Engagement Time

The instance in time when a DO enters or exits the EW influence area

Terrain

The terrain can influence the shape of the generated EW influence area because objects in the terrain can diminish or shield the volume.

Affected DO(S) ID

The identification of the DO(s) that are affected by the engagement, i.e., are inside the shape of the EW influence area. It can for example be RC-IEDs that are inhibited from detonating on command or DOs whose radio communication is hampered when their frequency is covered by the frequencies of the EW influence area.

Affected DO(S) Location

The three-dimensional location(s) of the involved DO(s).

A4.14 Energy Weapon Engagements

Energy weapons emit energy and thereby can influence Dynamic Objects. There are two types of energy weapons:

1) Weapons that emit one burst of energy, like for example a (nuclear) Electro Magnetic Pulse (EMP) or a flash-bang grenade, which generates simultaneously an intense flash of light and a pressure and strong sound wave. These types of weapon can be modelled as a proximity engagement (see Section A4.3).
2) Weapons that emit energy for a certain amount of time, typically the start and end time are under user control. For example sound waves or micro waves can be generated by a weapon when it is activated and the energy emission stops when the weapon is deactivated (trigger released). When the emission stops, also the influence stops. The emission of this type of weapons requires a new engagement definition.

When energy weapons emit energy during a certain timeframe, it is important to note that many of the engagement parameters can change during the engagement. For example, the shooter and target(s) can move, the direction of the weapon can change and maybe even the energy level can change (Table A-52).

Table A-52: Energy Weapons Engagement Dataset.

Parameter	Purpose	Unit	Max	Resolution
Shooter ID	MONITORING	ID	100,000	-
Shooter location (x, y, z), plus accuracy indicator	TARGETING MONITORING	Metres	World coordinate	Centimetre
Shooter velocity (vector), plus accuracy indicator	TARGETING MONITORING	Metres/sec		Centimetre
Weapon type	MONITORING	Enumeration		-
Weapon ID	ANALYSIS	ID	100	-
Shooter weapon mode	TARGETING MONITORING	Enumeration		-
Weapon direction/angle (vector), plus accuracy indicator	TARGETING			+/- 10% compared to actual weapon
Energy type	DAMAGE CALCULATION	Enumeration		-

Parameter	Purpose	Unit	Max	Resolution
Energy level	DAMAGE CALCULATION	Enumeration		-
Effect volume	DAMAGE CALCULATION	Metres		Centimetre
Activation time	TARGETING MONITORING	Seconds		Second
Deactivation time	TARGETING MONITORING	Seconds		Second
Engagement time	MONITORING	Seconds		Second
Engagement duration	DAMAGE CALCULATION	Seconds		Second
Terrain	TARGETING DAMAGE CALCULATION	Metres		Centimetre
Atmospheric data	TARGETING			-
Affected DO(s) ID	DAMAGE CALCULATION	ID		-
Affected DO(s) location (x, y, z), plus accuracy indicator	TARGETING MONITORING	Metres	World coordinate	Centimetre
Affected DO(s) velocity (vector), plus accuracy indicator	TARGETING MONITORING	Metres/sec		Centimetre
Point of impact	DAMAGE CALCULATION	Metres		Centimetre

Shooter ID

The unique identifier to identify the DO that causes the engagement.

Shooter Location (x, y, z)

The three-dimensional position of the shooter during the engagement.

Shooter Velocity (Vector)

The three-dimensional speed of the shooter during the engagement, for targeting and monitoring purposes.

Weapon Type

The type of weapon that is used to cause the engagement, mainly used for monitoring purposes.

Weapon ID

The unique identification of the weapon that was used to cause the engagement.

Shooter Weapon Mode

The mode of the weapon during the engagement. It contains for example the settings of a fire control computer, the used sighting device, etc.

Weapon Direction/Angle

The direction/angle of the weapon, and thus that of the energy beam, during the engagement, used for targeting. If the energy beam is very narrow, e.g., a laser beam, the resolution needs to be very high. If the energy beam covers an arc, the resolution can be 1 degree.

Energy Type

The type of the emitted energy used for damage calculation and monitoring. It is more specific than only the category. Like for example “sound” or “light” but contains for example the used frequency or frequency range of sound or light energy.

Energy Level

It is possible that the shooter can set or control the level of the emitted energy, even during the engagement. This parameter specifies the power or intensity of the emitted energy.

Effect Volume

The three-dimensional space in which the emitted energy has an effect. Typically, it will be a beam or a cone, having a direction, width, height and length. In practice a beam of energy generally will not have clear cut edges, but for simulation purposes this will suffice.

The instance in time when the energy weapon is activated and starts emitting energy. It is used for targeting and monitoring purposes.

Deactivation Time

The instance in time when the energy weapon is deactivated and stops emitting energy. It is used for targeting and monitoring purposes.

Engagement Time

The instance in time when the DO(s) are engaged, each upon colliding with the effect volume. Depending on the type of energy, the effect will be immediate, delayed or increase over time the longer the DO stays within the energy field.

Engagement Duration

The duration of time the affected DO(s) are exposed to the energy field.

Terrain

The terrain is an important factor for targeting and damage calculations.

Atmospheric Data

Atmospheric conditions can influence the effect of energy weapons.

Affected DO(s) ID

The unique identification of the DO(s) that are affected by the engagement.

Affected DO(s) Location

The three-dimensional location(s) of the affected DO(s) during the engagement, used for targeting and monitoring purposes.

Affected DO(s) Velocity

The three-dimensional speed of the affected DO(s), used for targeting and monitoring purposes.

Point of Impact

The location on the target DO where the engagement affects the target. In case of a narrow beam of energy, the resolution needs to be centimetre. In case of a wide beam of energy, the side of the target DO will suffice.

A5.0 E2: TRAINING SYSTEM STATUS CHANGE

This section contains the definition of the E2 dataset, the interface that controls the technical status of a training system and its components. Through this interface it is possible that a DO is initialised, reset, calibrated, etc. (Table A-53).

Table A-53: DO Status Change.

Data Element	Latency
Setting the DO ID, the system identification of a DO	Near real-time
Setting the equipment ID for components not modelled as DO	Near real-time
Turning a DO on and off	Near real-time
Resetting a DO	Near real-time
Requesting a BITE response	Near real-time
Providing a DO with A-GPS data to enable it to fast acquire the GPS signal	Near real-time
Providing D-GPS data to increase the accuracy of the DO position	Near real-time

A6.0 E3: EXECUTIVE DO INTERACTION

A6.1 Introduction

The E3 interface enables specific EXCON or O/C interactions for specific exercise control purposes. There are three types of such interactions:

- Enforcing a status change of a DO;
- Engaging a DO as if the O/C is a normal player; and
- Monitoring and enforcing certain restrictions on the DOs. This is implemented by means of exercise imposed restricted areas.

The datasets for each of these types of interactions are defined in the following sections.

A6.2 DO Enforced Status Change

There can be several reasons why a member of EXCON must be able to change the value of certain DO parameters as an exercise control measure. The most apparent is the changing of the operational and supply status of a DO. For example when a DO needs a reset after it has suffered a technical malfunction, or when the training staff wants to reset a training situation so the players can redo the action, or when a player needs to be notified when he is not playing by the exercise rules. If the affected DO is notified who caused the interaction, it will be notified it was an O/C or EXCON interaction (Table A-54).

This mechanism is also used to set the location of a DO when it (temporarily) has not the capability to determine its location itself.

Table A-54: Enforced Status Change Dataset.

Parameter	Purpose	Unit	Max	Resolution
O/C ID	ENGAGING MONITORING	ID	100,000	-
O/C location (x, y, z), plus accuracy indicator	MONITORING	Metres	World coordinate	Centimetre
Affected DO ID	ENGAGING MONITORING	ID	100,000	-
Affected DO location (x, y, z), plus accuracy indicator	MONITORING	Metres	World coordinate	Centimetre
Parameter ID	EFFECT CALCULATION	-	-	-
Parameter value	EFFECT CALCULATION	Enumeration	-	-
Engagement time	MONITORING	Seconds		Second

O/C ID

The ID of the O/C or EXCON who caused the status change of the affected DO. This parameter is also listed as part of this dataset to provide the relevant data across training systems. For example, when EXCON of system A changes the status of a DO of system B, system B needs to know the source of the status change.

O/C Location

The location of the O/C used for monitoring purposes. When the O/C ID indicates EXCON, the location parameter is not relevant.

Affected DO ID

The ID of the DO that is subject of the status change. In some implementations this parameter could be omitted, since the affected DO is the receiver of this data message.

Affected DO Location

The location of the DO whose status is changed.

Parameter ID

The identification of parameter to be changed. Exercise management must be able to set or change the following parameters:

- DO call sign;
- DO category (e.g., personnel, wheeled, tracked, aircraft);
- DO type;
- DO force ID;
- DO health or operational status ("damage status"). The possible values of this parameter are defined in Table A-1, Table A-2, and Table A-3 in Section A3.0;
- DO logistic/supplies state. In a live simulation environment this only applies to the ammunition supply of a DO;
- DO location. When a DO has its own capabilities to determine its location, there is generally no need to set its location from EXCON. Overriding the location of such a DO could possibly result in erroneous behaviour of the training system. However, when a DO (temporarily) has no access to its position (e.g., indoor), EXCON can provide its position. Another example is a mine or IED device, which has no capability to determine its location by itself, but when placed, is provided its location from EXCON or an O/C;
- DO association. Normally, DO association must be performed automatically by the training system. However, if relevant DOs have no capability to associate with each other (by means of the E9 interface), e.g., a vehicle entering a house, but the association is important for the outcome of the tactical exercise (in this example the vehicle is protected by the infrastructure and it allows propagation of engagements and of effects), then the association can be given by EXCON by means of the E3 interface. This can either be an automatic function (for example, when the systems detects the locations of the DOs are the same) or can be done manually; and
- DO additional status information. The possible values of this parameter are defined in Table A-4 in Section A3.0.

In addition to the above defined capabilities, the training system must have a broadcast capability to trigger recorded audio messages to all DOs, e.g., for emergency situations to stop the exercise. The list of recorded messages needs to be standardised.

Parameter Value

The new value to which the specified parameter will be set.

Engagement Time

The instance in time when the engagement occurs, used for monitoring purposes.

A6.3 O/C Imitated Engagements

It is required that an O/C can interact with other DOs, as if he were a normal player, simulating their engagements. This capability is required for training purposes of the affected DO, within the context of the tactical training exercise. Examples of this situation are exposing the weak spots of an attack or defence, by simulating fire from a dug in enemy tank or an enemy sniper, or stepping in when the trainee interactions are not delivering the required results in the training context for whatever reasons (e.g., incapable trainees, system malfunctions, etc.).

If for E1 engagements the affected DO is notified who or what caused the interaction, in this case the DO will not be notified it was an O/C or EXCON interaction, but it will be provided with imitated information, such as for example the party of the shooter (e.g., BLUEFOR, REDFOR, NEUFOR, etc.) and the ammunition type. Since an O/C has no party (he is impartial) and should be able to simulate any type of weapon, he must specify these values before the engagement.

For monitoring purposes, the ID of the O/C will be part of the engagement to distinguish between O/C and other DO engagements. Although the O/C will simulate an engagement, operational conditions or restrictions regarding associated skills and drills (such as for example time, distance, speed of the shooter, accuracy, etc.) will not apply, because it is not the objective to train the O/C, but to deliberately expose a DO to the engagement.

The tables in Section A6.3.1 are derived from the engagement tables of the E1 interface, described in Section A4.1. Certain parameters have been omitted and only the additional O/C specific parameters are explained.

A6.3.1 O/C Imitated Contact, Proximity and Missile Engagements

Table A-55: O/C Imitated Contact and Proximity Engagement Dataset (Including Missiles).

Parameter	Purpose	Unit	Max	Resolution
O/C ID	MONITORING	ID	100,000	-
O/C location (x, y, z), plus accuracy indicator	TARGETING MONITORING	Metres	World coordinate	Centimetre
Imitated party ID	MONITORING	Enumeration		-
Imitated weapon type	MONITORING	Enumeration		-
Weapon direction/angle (vector), plus accuracy indicator	TARGETING			VERY HIGH
Imitated ammunition type	DAMAGE CALCULATION	Enumeration		-
Flight duration	TARGETING	Seconds		Microseconds
Engagement range	DAMAGE CALCULATION MONITORING	Metres		Metre

Parameter	Purpose	Unit	Max	Resolution
Detonation location (x, y, z), plus indicator of accuracy	DAMAGE CALCULATION MONITORING	Metres	World coordinate	Centimetre
Effect direction/angle (vector) at the moment of detonation	DAMAGE CALCULATION			HIGH
Projectile impact velocity (vector), plus accuracy indicator	DAMAGE CALCULATION	Metres/sec		Centimetre
Effect volume	DAMAGE CALCULATION	Metres		Metre
Terrain	TARGETING DAMAGE CALCULATION	Metres		Centimetre
Affected DO(s) ID	DAMAGE CALCULATION	ID		-
Affected DO(s) location (x, y, z), plus accuracy indicator	TARGETING MONITORING	Metres	World coordinate	Centimetre
Affected DO(s) velocity (vector), plus accuracy indicator	TARGETING MONITORING	Metres/sec		Centimetre
Time of start of the engagement, plus accuracy indicator	TARGETING MONITORING	Seconds		Micro-second
Time of end of the engagement, plus accuracy indicator	TARGETING MONITORING	Seconds		Micro-second
Point of impact	DAMAGE CALCULATION	Metres		Centimetre

Note that parameters such as “O/C velocity”, “weapon ID”, “ammunition ID” and “atmospheric data” are not part of the engagement dataset. This dataset also covers O/C imitated missile engagements (through the parameter “time of flight”). The other missile specific parameters (“designator” and “engagement validation”) are not applicable for the O/C imitated engagement.

O/C ID

The identification of the O/C that initiates the engagement.

O/C Location

The three-dimensional position of the O/C at the start of the engagement.

Imitated Party ID

The party of the imitated shooter. In normal DO engagements, the shooter ID will also give access to the party and the platform type of the shooter. This is not the case for an O/C engagement; therefore, the O/C must specify this value before the engagement.

Imitated Weapon Type

The weapon type of the imitated shooter. In normal DO engagements, the weapon type is implicitly set by the shooter, based on the DO platform type and settings by the gunner (e.g., a main battle tank firing with the main gun or the coax machine gun). Since an O/C can simulate fire of any weapon type, the O/C must specify this value before the engagement.

Imitated Ammunition Type

The type of the imitated ammunition. Since an O/C can simulate fire of any weapon type, the O/C must specify this value before the engagement. The value of the imitated ammunition type should not be in conflict with the value of the imitated weapon type.

A6.3.2 O/C Imitated Energy Weapon Engagements

Table A-56: O/C Imitated Energy Weapon Engagement Dataset.

Parameter	Purpose	Unit	Max	Resolution
O/C ID	MONITORING	ID	100,000	-
O/C location (x, y, z), plus accuracy indicator	TARGETING MONITORING	Metres	World coordinate	Centimetre
Imitated party ID	MONITORING	Enumeration		-
Imitated weapon type	MONITORING	Enumeration		-
Weapon direction/angle (vector), plus accuracy indicator	TARGETING			VERY HIGH
Imitated energy type	DAMAGE CALCULATION	Enumeration		-
Imitated energy level	DAMAGE CALCULATION			-
Effect volume	DAMAGE CALCULATION	Metres		Metre
Activation time	TARGETING MONITORING	Seconds		Second
Deactivation time	TARGETING MONITORING	Seconds		Second
Engagement time	MONITORING	Seconds		Second
Engagement duration	DAMAGE CALCULATION	Seconds		Second
Terrain	TARGETING DAMAGE CALCULATION	Metres		Centimetre
Atmospheric data	TARGETING			-
Affected DO(s) ID	DAMAGE CALCULATION	ID		-

Parameter	Purpose	Unit	Max	Resolution
Affected DO(s) location (x, y, z), plus accuracy indicator	TARGETING MONITORING	Metres	World coordinate	Centimetre
Affected DO(s) velocity (vector), plus accuracy indicator	TARGETING MONITORING	Metres/sec		Centimetre
Point of impact	DAMAGE CALCULATION	Metres		Centimetre

O/C ID

The identification of the O/C that initiates the engagement.

O/C Location

The three-dimensional position of the O/C at the start of the engagement.

Imitated Party ID

The party of the imitated shooter, set by the O/C before the engagement.

Imitated Weapon Type

The type of the imitated energy weapon, set by the O/C before the engagement.

Imitated Energy Type

The type of the emitted energy, set by the O/C before the engagement.

Imitated Energy Level

The level of the emitted energy, set by the O/C before the engagement.

A6.3.3 O/C Imitated CSS Engagements

An O/C can also simulate the following combat service support engagements:

- Medical engagements;
- Repair engagements; and
- Logistic engagements.

The datasets for the O/C imitated engagements are exactly the same as the datasets for the respective activities of normal DOs, taking into account that the "O/C ID" and "O/C location" are replacing the respective "Repair DO", "Medic DO" and "Supplier DO" parameters. Also, certain conditions for the engagement to take effect do not need to apply, such as the O/C being and staying in the direct vicinity of the affected DO.

There is no need to imitate engagement areas, since they will be under control of the training staff.

A6.4 Exercise Imposed Restricted Areas

An exercise restricted area is an area where for exercise purposes certain restrictions on the DOs in those areas are enforced. The three types of exercise imposed restricted areas are out of bounds areas (the training system will enforce a cheat kill when a DO enters the area), no-strobe areas (the training system will inhibit the operation of strobe lights of instrumented DOs that are in the area) and no-pyro areas (the training system will inhibit the operation of pyrotechnical instrumentation of DOs in the area). Exercise imposed restricted areas can be activated, deactivated and reactivated during an exercise. There is no need for an emplacer ID, since they can only be created by EXCON.

A6.4.1 Out of Bounds Area

Table A-57: Out of Bounds Area Creation Dataset.

Parameter	Purpose	Unit	Max	Resolution
Out of bounds area ID	MONITORING	ID	10,000	-
Out of bounds area serviced parties	TARGETING	Enumeration		-
Out of bounds area shape	MONITORING TARGETING	Set of points	20	Metre
Out of bounds area location	MONITORING TARGETING	Metres	World coordinate	Metre
Activation time	DAMAGE CALCULATION	Seconds		Second

Out of Bounds Area ID

Unique identifier identifying the out of bounds area.

Out of Bounds Area Serviced Parties

The effect of the out of bounds area is applied only to DOs belonging to the set of "serviced" parties.

There is no requirement to make a distinction in types of DO to which the out of bounds area applies, for example that (certain types of) vehicles are not allowed to enter, but personnel is.

Out of Bounds Area Shape

The shape is a 2D polygon (but the out of bounds area follows the contours of the terrain), defined by a set of geographic reference points, relative to the "Out of bounds area location".

Out of Bounds Area Location

The location of the out of bounds area.

Activation Time

The instance in time when the out of bounds area is created or activated.

It must be possible to deactivate and reactivate out of bounds areas. The corresponding datasets are defined in Table A-58 and Table A-59.

Table A-58: Out of Bounds Area Deactivation Dataset.

Parameter	Purpose	Unit	Max	Resolution
Out of bounds area ID	MONITORING	ID	10,000	-
Deactivation time	TARGETING	Seconds		Second

Table A-59: Out of Bounds Area Reactivation Dataset.

Parameter	Purpose	Unit	Max	Resolution
Out of bounds area ID	MONITORING	ID	10,000	-
Reactivation time	TARGETING	Seconds		Second

Deactivation/Reactivation Time

The instance in time when the out of bounds area is deactivated or reactivated.

Table A-60 contains the dataset for engagements with an out of bounds area.

Table A-60: Out of Bounds Area Engagement Dataset.

Parameter	Purpose	Unit	Max	Resolution
Out of bounds area ID	MONITORING	ID	10,000	-
Engagement time	MONITORING	Seconds		Second
Affected DO(s) ID	DAMAGE CALCULATION	ID		-
Affected DO(s) location	DAMAGE CALCULATION	Metres	World coordinate	Metre

Engagement Time

The instance in time when a DO enters the out of bounds area.

Affected DO(s) ID

The identification of the DO(s) that are affected by the engagement. Generally, each DO entering the out of bounds area is a separate engagement, but multiple DOs can be affected, for instance when a DO contains other DOs.

Affected DO(s) Location

The three-dimensional location(s) of the affected DO(s).

A6.4.2 No-Strobe Area

Table A-61: No-Strobe Area Creation Dataset.

Parameter	Purpose	Unit	Max	Resolution
No-strobe area ID	MONITORING	ID	10,000	-
No-strobe area shape	MONITORING TARGETING	Set of points	20	Metre
No-strobe area location	MONITORING TARGETING	Metres	World coordinate	Metre
Activation time	DAMAGE CALCULATION	Seconds		Second

No-Strobe Area ID

Unique identifier identifying the no-strobe area.

No-Strobe Area Shape

The shape is a 2D polygon (but the no-strobe area follows the contours of the terrain), defined by a set of geographic reference points, relative to the "No-strobe area location".

No-Strobe Area Location

The location of the no-strobe area.

Activation Time

The instance in time when the no-strobe area is created or activated.

It must be possible to deactivate and reactivate no-strobe area. The corresponding datasets are defined in Table A-62 and Table A-63.

Table A-62: No-Strobe Area Deactivation Dataset.

Parameter	Purpose	Unit	Max	Resolution
No-strobe area ID	MONITORING	ID	10,000	-
Deactivation time	TARGETING	Seconds		Second

Table A-63: No-Strobe Area Reactivation Dataset.

Parameter	Purpose	Unit	Max	Resolution
No-strobe area ID	MONITORING	ID	10,000	-
Reactivation time	TARGETING	Seconds		Second

Deactivation/Reactivation Time

The instance in time when the no-strobe area is deactivated or reactivated.

Table A-64 contains the dataset for engagements with a no-strobe area.

Table A-64: No-Strobe Area Engagement Dataset.

Parameter	Purpose	Unit	Max	Resolution
No-strobe area ID	MONITORING	ID	10,000	-
Engagement time	MONITORING	Seconds		Second
Affected DO(s) ID	DAMAGE CALCULATION	ID		-
Affected DO(s) location	DAMAGE CALCULATION	Metres	World coordinate	Metre

Engagement Time

The instance in time when a DO enters the no-strobe area

Affected DO(s) ID

The identification of the DO(s) that are affected by the engagement. Generally, each DO entering the no-strobe area is a separate engagement, but multiple DOs can be affected, for instance when a DO contains other DOs.

Affected DO(s) Location

The three-dimensional location(s) of the affected DO(s).

A6.4.3 No-Pyro Area

Table A-65: No-Pyro Area Creation Dataset.

Parameter	Purpose	Unit	Max	Resolution
No-pyro area ID	MONITORING	ID	10,000	-
No-pyro area shape	MONITORING TARGETING	Set of points	20	Metre
No-pyro area location	MONITORING TARGETING	Metres	World coordinate	Metre
Activation time	DAMAGE CALCULATION	Seconds		Second

No-Pyro Area ID

Unique identifier identifying the no-pyro area.

No-Pyro Area Shape

The shape is a 2D polygon (but the no-pyro area follows the contours of the terrain), defined by a set of geographic reference points, relative to the “No-pyro area location”.

No-Pyro Area Location

The location of the no-pyro area.

Activation Time

The instance in time when the no-pyro area is created or activated.

It must be possible to deactivate and reactivate no-pyro area. The corresponding datasets are defined in Table A-66 and Table A-67.

Table A-66: No-Pyro Area Deactivation Dataset.

Parameter	Purpose	Unit	Max	Resolution
No-pyro area ID	MONITORING	ID	10,000	-
Deactivation time	TARGETING	Seconds		Second

Table A-67: No-Pyro Area Reactivation Dataset.

Parameter	Purpose	Unit	Max	Resolution
No-pyro area ID	MONITORING	ID	10,000	-
Reactivation time	TARGETING	Seconds		Second

Deactivation/Reactivation Time

The instance in time when the no-pyro area is deactivated or reactivated.

Table A-68 contains the dataset for engagements with a no-pyro area.

Table A-68: No-Pyro Area Engagement Dataset.

Parameter	Purpose	Unit	Max	Resolution
No-pyro area ID	MONITORING	ID	10,000	-
Engagement time	MONITORING	Seconds		Second
Affected DO(s) ID	DAMAGE CALCULATION	ID		-
Affected DO(s) location	DAMAGE CALCULATION	Metres	World coordinate	Metre

Engagement Time

The instance in time when a DO enters the no-pyro area.

Affected DO(s) ID

The identification of the DO(s) that are affected by the engagement. Generally, each DO entering the no-pyro area is a separate engagement, but multiple DOs can be affected, for instance when a DO contains other DOs.

Affected DO(s) Location

The three-dimensional location(s) of the affected DO(s).

A7.0 E4: DO REPORTING

A7.1 Introduction

This section contains the definition of the E4 interface, that reports on the status, status changes and activities of a DO. It covers both tactical status information for training purposes and technical status for system operating purposes.

The tables in this section describe the datasets of the E4 interface. Compared to the tables of the datasets of the other external interfaces, they contain one extra column, "priority", to guide the standardisation effort with a user point of view, to be combined with technical possibilities, in determining the extent of the first version of the UCATT E4 standard. The levels of priority for the parameters concerning the tactical outcome of the exercise, analysis of the exercise or administrative purposes or for future growth are defined below:

- Important for the tactical outcome of the exercise = 1;
- Important for analysis of the exercise = 2;
- Important for administrative purposes = 3; and
- Not important for the first version of the UCATT E4 standard but is intended for future growth = 4.

It is recognised that the need of a data element to be part of an interface (also) depends on the technical implementation of the training system (e.g., laser versus geo-referencing). Currently the levels of priority are based on the importance of that parameter for the training staff, not the physical implementation.

Some data can be derived from other parameters, for example speed and direction can be derived from the velocity vector. If provided as two separate parameters, speed and direction can have different priorities. Also, if a higher level of parameter is not present in the dataset, a lower level parameter can become more important.

A7.2 DO Status Report

The DO status report provides information about the current condition of a DO. An important characteristic is the update rate, which is the frequency information is refreshed. Generally, an update needs to be sent when a parameter has changed. Some changes are caused by the behaviour of the DO itself, such as moving around, changing speed, direction or posture. But even the operational status of a DO can change without external influence, for example the health of a wounded soldier who is not treated can degrade over time. Status changes caused by external events are covered by a different dataset (see Table A-71).

For some parameters an update is required after each change (for example "DO operational status"), while for other parameters the new value needs to cross a certain threshold (for example the "DO location" does not need to be reported after a DO has moved only a centimetre). Also it can be required that a status update is sent after an update request or that the system sends an update of certain parameters with a certain minimum frequency, irrespective of changes of the values (e.g., to confirm that a DO is still connected to the system and functioning).

Related to update rate is latency. Latency is defined as the delay between a change occurring and the report of that change appearing in EXCON. It is a measure of how critical the current value of the data element is for monitoring and control purposes. For simplicity it is assumed that the update rate and the latency have the same order of magnitude in case the data has changed.

These timings are divided into three categories:

- Real-time, and in effect this implies the data needs to be sent in fractions of a second after changing;
- Near real-time, and in effect implies in seconds; and
- Administrative time is less time critical and implies a time longer than seconds.

Not the complete dataset needs to be sent each time, since not every data element will change at the same moment or has the same latency requirement. The dataset therefore consists of (Table A-69):

Table A-69: DO Status Report Dataset.

Parameter	Purpose	Unit	Max	Resolution
DO ID	MONITORING	ID	100,000	-
Reporting time	MONITORING	Seconds		Second
Parameter ID	MONITORING	Enumeration		-
Parameter value	MONITORING	-	-	-

DO ID

The identification of the DO whose data is reported.

Reporting Time

The instance in time when the “parameter value” of the “parameter ID” is valid.

Parameter ID

The identification of the parameter whose value is reported. The possible IDs are defined in Table A-70 together with the associated latency/update rate indication.

Parameter Value

The value of the parameter identified by the “parameter ID”. The possible values are listed in Table A-70.

Table A-70: DO Status Parameter IDs.

Parameters	Latency/Update Rate	Priority
DO ID, the system identification of the DO	Near real-time	1
DO location	Real-time	1
DO velocity	Near real-time	2
DO direction	Near real-time	1
DO orientation	Near real-time	1
DO articulation parameters. An articulated part of a DO is an element that can move relative to the main body of the DO	Near real-time	2

Parameters	Latency/Update Rate	Priority
DO posture, e.g., standing, kneeling, lying	Near real-time	2
DO health or operational status (‘kill codes’)	Real-time	1
Equipment pairing	Near real-time	2
DO association	Near real-time	1
DO logistic/supplies state	Near real-time	2
DO additional status information	Near real-time	2

It is assumed that only the “DO ID” is part of the E4 dataset and that when required the parameters “DO call sign”, “DO category”, “DO type indication” and “DO force ID” are derived from this parameter.

The latency of DO location and DO status is low, because EXCON requires this information to trigger certain events or effects (for example to control targetry).

Equipment pairing and DO association are E9 interactions, but the results also need to be reported to EXCON. Since the physical implementation of E9 is likely be a short-range interface, the DO needs to report these status changes through the E4 interface. The elements of equipment pairing and DO association are defined in Table A-5 and Table A-6 in Section A3.

The elements of the “DO additional status information” are defined in Table A-4 in Section A3.

A7.3 DO Engagement Report

When a DO is engaged, either by another DO or by an engagement area, EXCON needs to be notified.

An engagement can result in a change of DO status or a change of its ammunition supply, but not necessarily. For example, a DO can be hit by an ammunition, but no damage is sustained, or no ammunition is transferred in a resupply activity. For completeness the status information is included in the engagement reporting dataset Table A-71, but the changed status can also be reported by a separate data message, as defined in Table A-69.

Table A-71: DO Engagement Reporting Dataset.

Parameter	Purpose	Unit	Max	Resolution	Prio
Engaged DO ID	MONITORING	ID	100,000	-	1
Engaged DO location (x, y, z), plus accuracy indicator	MONITORING	Metres	World coordinate	Centimetre	1
Engaging entity ID	MONITORING	ID	100,000	-	1
Engaging means	MONITORING	Enumeration		-	1
New status	MONITORING	Enumeration		-	1
Engagement time	MONITORING	Seconds	-	Second	1

Engaged DO ID

The identification of the DO which is engaged.

Engaged DO Location

The location of the engaged DO.

Engaging Entity ID

The identification of the entity that initiated the engagement. Depending on training system implementation, the engaged DO has this information available or not. When engagements with engagement areas are determined locally at the DO, then this information must be provided in this dataset. The "engaging entity ID" can be:

- The "shooter ID", in case of contact, proximity, missile or energy weapon engagements;
- The "fire support target area ID", in case of fire support target area engagements;
- The "minefield ID", in case of minefield engagements;
- The "obstacle ID", in case of engagements with man-made obstacles other than minefields;
- The "CBRNe area ID", in case of CBRNe area engagements;
- The "bridge ID", "swamp ID" or "river ID", in case of engagements with a tactically relevant restricted or impassable part of the terrain;
- The "out of bounds area ID", "no-strobe area ID" or "no-pyro area ID", in case of engagements with an exercise imposed restricted area (this is reporting on an E3 interaction);
- The "administrative area ID", in case of administrative area engagements. This cannot result in a status change;
- The "CSS area ID", in case of engagements with a medical treatment area, repair area, FARP or decontamination area;
- The "medic DO ID", in case of medical treatment by a medic DO;
- The "repair DO ID", in case of repair by a mechanic DO;
- The "EW influence area ID", in case of engagements with an EW influence area; and
- The "O/C ID", in case of an enforced status change or an O/C imitated engagement (this is reporting on an E3 interaction).

Engaging Means

The identification of the means that was used in the engagement. It can be:

- The "ammunition type", in case of contact, proximity, missile, fire support target area, minefield and O/C imitated contact, proximity and missile engagements;
- The "obstacle type", in case of obstacle engagements;
- The "agent type", in case of CBRNe area engagements;
- The "CSS area type", in case of CSS area engagements;

- The “EW influence area type”, in case of EW influence area engagements; and
- The “energy type”, in case of energy weapon and O/C imitated energy weapon engagements.

This parameter is omitted in case of:

- Engagements with man-made obstacles (other than minefields), tactically relevant restricted or impassable parts of the terrain and exercise imposed restricted areas; and
- Medical treatments and repair activities. When however, more detail is required, then this parameter could contain the “medical activity type” or “repair activity type” respectively.

New Status

If applicable for the type of engagement, the value to which the status of the DO is set as a result of the engagement. The statuses are defined in Table A-1, Table A-2, Table A-3, and Table A-4. Note that the engagement can also result in that the DO status is left unchanged.

Engagement Time

The instance in time when the DO is engaged.

A7.4 DO Ammunition Supply Report

Table A-72: Ammunition Supply Reporting Dataset.

Parameter	Purpose	Unit	Max	Resolution	Prio
Engaged DO ID	MONITORING	ID	100,000	-	1
Engaged DO location (x, y, z), plus accuracy indicator	MONITORING	Metres	World coordinate	Centimetre	1
Supplier ID	MONITORING	ID	100,000	-	1
Supply type	MONITORING	Enumeration		-	1
Ammunition type	MONITORING	Enumeration		-	1
Supply quantity	MONITORING	Number	10,000	1	1
Engagement time	MONITORING	Seconds	-	Second	1

Engaged DO ID

The identification of the DO whose ammunition supply is affected.

Engaged DO Location

The location of the engaged DO.

Supplier ID

The identification of the entity that executed the supply. It can be:

- The “CSS area ID”, in case of engagements with a resupply area or FARP; and
- The “Supplier DO ID”, in case of engagements with resupply DOs.

Supply Type

The type of supply activity that was performed. It can be:

- "Take", in case of a resupply activity executed by a resupply DO or an engagement with a CSS area (resupply area or FARP). The "ammunition supply" will be added to the current stock of the DO; and
- "Give", in case of a resupply activity executed by a resupply DO. The "ammunition supply" will be subtracted from the current stock of the DO.

Ammunition Type

The type of ammunition being resupplied.

Supply Quantity

The amount of shells added or subtracted to the ammunition stock of the DO.

Engagement Time

The instance in time when the DO's ammunition supply is changed.

A7.5 DO Activity Report

When a DO is executing an activity, this needs to be reported to EXCON for monitoring and AAR purposes. Although some engagements can be derived from an engagement reporting message (the status of an engaged DO is possibly affected caused by an engagement), some engagements do not hit a target. For example, a soldier firing his weapon in the air or at a random point in the terrain. Such events need to be registered and monitored. These are E4 messages.

There are other categories of DO activities where the shooter probably does not know the set of affected DOs, namely activities that have an area effect (like for example energy weapon engagements) or activities where the shooter fires in an indirect way, often at targets beyond their line of sight (like for example fire support DOs like mortars, howitzers and rocket launching systems). A DO activity report could then be used to determine (centrally in the training system) if any DOs are affected by the activity. Although this is functionally an E1 interaction, the messages for this purpose are likely to make use of the same long range physical interface as the E4 physical interface. For clarity and completeness, the relevant parameters for these activities are included in the DO activity reports, but they are marked as such.

Some player DOs can have the ability to create certain types of engagement area. The datasets to report on the creation of such engagement areas are included in the sections below. However, it is assumed that player DOs will not have the capability to create tactically relevant restricted or impassable parts of the terrain (fixed bridges, swamps, rivers), exercise imposed restricted areas (out of bounds, no-strobe and no-pyro areas), administrative areas, weapon effect modification areas and CSS areas. That is the task of EXCON.

A7.5.1 Contact, Proximity and Missile Engagements

The following dataset (Table A-73) is required for reporting contact and proximity engagements, where the "shooter ID" is the reporting entity:

Table A-73: Contact and Proximity Engagement Reporting Dataset.

Parameter	Purpose	Unit	Max	Resolution	Prio
Shooter ID	MONITORING	ID	100,000	-	1
Shooter location (x, y, z), plus accuracy indicator	(TARGETING) MONITORING	Metres	World coordinate	Centimetre	1
Shooter velocity (vector), plus accuracy indicator	(TARGETING) MONITORING	Metres/sec		Centimetre	1
Weapon type	(TARGETING) MONITORING	Enumeration		-	2
Weapon ID	ANALYSIS	ID	100	-	3
Shooter weapon mode	(TARGETING) MONITORING	Enumeration		-	2
Weapon direction/angle (vector), plus accuracy indicator	(TARGETING) MONITORING			VERY HIGH	4
Ammunition type	(DAMAGE CALCULATION) MONITORING	Enumeration		-	1
Fuse type	(TARGETING) MONITORING	Enumeration		-	2
Fuse settings	(TARGETING) MONITORING			-	2
Engagement range	(DAMAGE CALCULATION) MONITORING	Metres		Metre	1
Reporting time	MONITORING	Seconds		Second	1
Detonation location (x, y, z), plus indicator of accuracy	DAMAGE CALCULATION MONITORING	Metres	World coordinate	Centimetre	1
Effect direction/angle (vector) at the moment of detonation	DAMAGE CALCULATION MONITORING			HIGH	2
Projectile impact velocity (vector), plus accuracy indicator	DAMAGE CALCULATION	Metres/sec		Centimetre	4
Effect volume	DAMAGE CALCULATION MONITORING	Metres		Metre	2
Terrain	TARGETING DAMAGE CALCULATION	Metres		Centimetre	4

Parameter	Purpose	Unit	Max	Resolution	Prio
Atmospheric data	TARGETING				4
Affected DO(s) ID	DAMAGE CALCULATION MONITORING	ID			1
Affected DO(s) location (x, y, z), plus accuracy indicator	TARGETING MONITORING	Metres	World coordinate	Centimetre	1
Affected DO(s) velocity (vector), plus accuracy indicator	TARGETING MONITORING	Metres/sec		Centimetre	1
Time of start of the engagement (trigger time), plus accuracy indicator	TARGETING MONITORING	Seconds		Micro-second	1
Time of end of the engagement (impact time), plus accuracy indicator	TARGETING MONITORING	Seconds		Micro-second	1
Point of impact	DAMAGE CALCULATION	Metres		Centimetre	2

The greyed-out parameters in Table A-73 are required for targeting purposes.

In addition to the dataset for contact and proximity engagements, the following parameters (Table A-74) must be implemented for missile engagements:

Table A-74: Missile Engagement Additional Reporting Dataset.

Parameter	Purpose	Unit	Max	Resolution	Prio
Designator ID	(TARGETING) MONITORING	ID	100,000	-	1
Designator location (x, y, z), plus accuracy indicator	(TARGETING) MONITORING	Metres	World coordinate	Centimetre	1
Designator velocity (vector), plus accuracy indicator	(TARGETING) MONITORING	Metres/sec		Centimetre	2
Duration of flight	(TARGETING)	Seconds		Micro-second	4
Engagement validation	MONITORING	YES/NO			2

A7.5.2 Fire Support Target Area Creation

When player DOs have the capability to create fire support target areas, the following dataset (Table A-75) is required, where the “shooter ID” is the reporting entity.

Table A-75: Fire Support Target Area Creation Dataset.

Parameter	Purpose	Unit	Max	Resolution	Prio
Fire support target area ID	MONITORING	ID	10,000	-	1
Shooter ID	MONITORING	ID	100,000	-	1
Fire support target area location	TARGETING	Metres	World coordinate	Metre	1
Fire support target area shape	TARGETING	Set of points	20	Metre	1
Ammunition type(s)	DAMAGE CALCULATION	Enumeration		-	1
Fuse type(s)	TARGETING	Enumeration		-	2
Fuse settings	TARGETING				2
Number of received salvos	TARGETING	Integer		1	1
Ammunition rounds per received salvo	TARGETING	Rounds/ salvo		1	1
Angle of impact	DAMAGE CALCULATION			-	2
Activation time	TARGETING	Seconds		Second	1
Deactivation time	TARGETING	Seconds		Second	1

A7.5.3 Obstacle Creation

When player DOs have the ability to create obstacles, the following two datasets are required, where a distinction is made between minefields and other man-made obstacles. It is assumed that DOs in the field do not have the capability to remove or deactivate obstacles. For this an O/C or EXCON action is required, at least to validate the DO's activities. DOs can have the capability to create breaches. The "emplacer ID" is the reporting entity.

A7.5.3.1 Minefield Creation

Table A-76: Minefield Creation Reporting Dataset.

Parameter	Purpose	Unit	Max	Resolution	Prio
Minefield ID	MONITORING	ID	10,000	-	1
Minefield type	MONITORING DAMAGE CALCULATION	Enumeration		-	1
Emplacer ID	MONITORING	ID	100,000	-	1
Minefield location	TARGETING	Metres	World coordinate	Centimetre	1
Minefield shape	MONITORING TARGETING	Set of points	20	Centimetre	1

Parameter	Purpose	Unit	Max	Resolution	Prio
Ammunition type(s)	DAMAGE CALCULATION	Category		-	1
Ammunition type density	TARGETING	Mines/m^2		0.01	1
Activation time	TARGETING	Seconds		Second	1

Individual mines and IEDs can be cleared by engineering DOs. For that purpose, the following dataset (Table A-77) is required, where the "operator ID" is the reporting entity.

Table A-77: Mine Clearing Reporting Dataset.

Parameter	Purpose	Unit	Max	Resolution	Prio
Operator ID	MONITORING	ID	100,000	-	1
Mine ID	MONITORING	ID	100,000	-	1
Time of start of the engagement	TARGETING MONITORING	Seconds		Second	1
Time of end of the engagement	TARGETING MONITORING	Seconds		Second	1

A7.5.3.2 Other Obstacle Creation

Table A-78: Obstacle Creation Reporting Dataset.

Parameter	Purpose	Unit	Max	Resolution	Prio
Obstacle ID	MONITORING	ID	10,000	-	1
Obstacle type	DAMAGE CALCULATION MONITORING	Enumeration		-	1
Emplacer ID	MONITORING	ID	100,000	-	1
Obstacle shape	MONITORING TARGETING	Set of points	20	Centimetre	1
Obstacle location	MONITORING TARGETING	Metres	World coordinate	Centimetre	1
Activation time	TARGETING	Seconds		Second	1

A7.5.3.3 Breach Creation

When player DOs have the ability to create breaches through obstacles, the following dataset (Table A-79) is required, where the "breacher ID" is the reporting entity.

Table A-79: Breach Creation Reporting Dataset.

Parameter	Purpose	Unit	Max	Resolution	Prio
Breach ID	MONITORING	ID	10,000	-	1
Obstacle ID	MONITORING	ID	10,000		1
Breach type	DAMAGE CALCULATION MONITORING	Enumeration		-	1
Breach modifier	DAMAGE CALCULATION	Percentage	100	1%	1
Breacher ID	MONITORING	ID	100,000	-	1
Breach shape	MONITORING TARGETING	Set of points	20	Centimetre	1
Breach location	MONITORING TARGETING	Metres	World coordinate	Centimetre	1
Activation time	TARGETING	Seconds		Second	1

A7.5.4 CBRNe Area Creation

When player DOs have the ability to create CBRNe areas, the following dataset (Table A-80) is required, where the "shooter ID" is the reporting entity.

Table A-80: CBRNe Area Creation Reporting Dataset.

Parameter	Purpose	Unit	Max	Resolution	Prio
CBRNe area ID	MONITORING	ID	10,000	-	1
Shooter ID	MONITORING	ID	100,000	-	1
CBRNe area location	TARGETING	Metres	World coordinate	Metre	1
CBRNe area shape	MONITORING TARGETING	Set of points	20	Metre	1
Agent type	DAMAGE CALCULATION	Enumeration		-	1
Agent density	DAMAGE CALCULATION	Ppm or mSv		1	1
Persistence	DAMAGE CALCULATION	YES/NO		-	1
Activation time	TARGETING	Seconds		Second	1

A7.5.5 Combat Service Support Activities

It is assumed that DOs do not have the ability to create CSS areas, but specific DOs can execute medical treatments, repair and resupply activities. Reporting on these activities is covered in Table A-81, Table A-82, and Table A-83 where the "medic DO", "repair DO" and "supplier DO" are the reporting entities.

Table A-81: Medical Activity Reporting Dataset.

Parameter	Purpose	Unit	Max	Resolution	Prio
Medic DO ID	ENGAGING MONITORING	ID	100,000	-	1
Medic DO location (x, y, z), plus accuracy indicator	ENGAGING MONITORING	Metres	World coordinate	Centimetre	1
Medical activity type	EFFECT CALCULATION MONITORING	Enumeration	100	-	1
Engagement time	MONITORING	Seconds		Second	1
Treatment duration	EFFECT CALCULATION MONITORING	Number	43,200 seconds (12 hours)	Second	1
Affected DO ID	ENGAGING MONITORING	ID		-	1
Affected DO location (x, y, z), plus accuracy indicator	ENGAGING MONITORING	Metres	World coordinate	Centimetre	2

For AAR of medical aspects of tactical exercises, it is generally sufficient to collect data regarding time of injury, time of treatment, time of medical transport, time of arriving at a medical facility and the resulting success rates (injured personnel who do not deteriorate or die). This data can be generated based on the current UCATT E4 interface definition, it requires the datasets "DO status report dataset", "DO engagement reporting dataset" and "Medical activity reporting dataset", which contain the following parameters:

- Status of the injured DO;
- Time of medical activity;
- ID of treating medic DO; and
- Result of medical activity.

If, however, more specific medical analysis and AAR is required, then the following parameters need to be sent for each medical engagement event throughout the exercise:

- Vital signs of the DO; and
- Type of medical activity.

In the case where the medical treatment model resides in the injured DO, the injured DO must send this data through E4 to EXCON, while in the case where the model resides in the medical treatment device of the medic, the medical treatment device must send this data through E4 to EXCON.

Table A-82: Repair Activity Reporting Dataset.

Parameter	Purpose	Unit	Max	Resolution	Prio
Repair DO ID	ENGAGING MONITORING	ID	100,000	-	1
Repair DO location (x, y, z), plus accuracy indicator	ENGAGING MONITORING	Metres	World coordinate	Metre	1
Repair activity type	EFFECT CALCULATION MONITORING	Enumeration	100	-	1
Engagement time	MONITORING	Seconds		Second	1
Repair duration	EFFECT CALCULATION MONITORING	Number	43,200 seconds (12 hours)	Second	2
Affected DO ID	ENGAGING MONITORING	ID		-	1
Affected DO location (x, y, z), plus accuracy indicator	ENGAGING MONITORING	Metres	World coordinate	Metre	2

Table A-83: Resupply Activity Reporting Dataset.

Parameter	Purpose	Unit	Max	Resolution	Prio
Supplier DO ID	ENGAGING MONITORING	ID	100,000	-	1
Supplier DO location (x, y, z), plus accuracy indicator	ENGAGING MONITORING	Metres	World coordinate	Centimetre	1
Supply activity type	EFFECT CALCULATION MONITORING	Enumeration	100	-	1
Ammunition type	EFFECT CALCULATION MONITORING	Enumeration		-	1
Supply quantity	EFFECT CALCULATION MONITORING	Number	10,000	1	1
Engagement time	MONITORING	Seconds		Second	1
Supply duration	EFFECT CALCULATION MONITORING	Number	3,600 (1 hour)	Second	2
Affected DO ID	ENGAGING MONITORING	ID		-	1
Affected DO location (x, y, z), plus accuracy indicator	ENGAGING MONITORING	Metres	World coordinate	Centimetre	2

A7.5.6 Electronic Warfare Influence Area Creation

When player DOs have the ability to create EW influence areas, the following dataset (Table A-84) is required, where the "EW carrier ID" is the reporting entity.

Table A-84: EW Influence Area Creation Reporting Dataset.

Parameter	Purpose	Unit	Max	Resolution	Prio
EW influence area ID	MONITORING	ID	10,000	-	1
EW carrier ID	MONITORING	ID	100,000		1
EW influence area type	DAMAGE CALCULATION	Enumeration		-	1
EW influence data	DAMAGE CALCULATION	EW data		-	1
EW influence area freq range: minimum frequency maximum frequency	DAMAGE CALCULATION	MHz		1 MHz	1
EW influence area shape	MONITORING TARGETING	Sphere: metres Cone: metres and degrees for direction and apex		Metre Degree	1
EW influence area location	MONITORING TARGETING	Metres		Metre	1
Activation time	TARGETING	Seconds		Second	1

A7.5.7 Energy Weapon Engagements

The following dataset (Table A-85) is required for reporting energy weapon engagements, where the "shooter ID" is the reporting entity. Like for contact and proximity engagements, the parameters which are only listed for targeting purposes (functionally an E1 interaction), are greyed out.

Table A-85: Energy Weapon Engagement Reporting Dataset.

Parameter	Purpose	Unit	Max	Resolution	Prio
Shooter ID	MONITORING	ID	100,000	-	1
Shooter location (x, y, z), plus accuracy indicator	TARGETING MONITORING	Metres	World coordinate	Centimetre	1
Shooter velocity (vector), plus accuracy indicator	TARGETING MONITORING	Metres/sec		Centimetre	1
Weapon type	MONITORING	Enumeration		-	1
Weapon ID	ANALYSIS	ID	100	-	3

Parameter	Purpose	Unit	Max	Resolution	Prio
Shooter weapon mode	TARGETING MONITORING	Enumeration			2
Weapon direction/angle (vector), plus accuracy indicator	TARGETING			+/- 10% compared to actual weapon	4
Energy type	DAMAGE CALCULATION	Enumeration			1
Energy level	DAMAGE CALCULATION	Enumeration			1
Engagement time	MONITORING	Seconds		1 second	1
Engagement duration	DAMAGE CALCULATION	Seconds		1 second	1
Terrain	TARGETING DAMAGE CALCULATION	Metres		Centimetre	4
Atmospheric data	TARGETING				4
Affected DO(s) ID	DAMAGE CALCULATION	ID			1
Affected DO(s) location (x, y, z), plus accuracy indicator	TARGETING MONITORING	Metres	World coordinate	Centimetre	1
Affected DO(s) velocity (vector), plus accuracy indicator	TARGETING MONITORING	Metres/sec		Centimetre	1
Point of impact	DAMAGE CALCULATION	Metres		Centimetre	2
Affected DO(s) ID	DAMAGE CALCULATION	ID			1
Affected DO(s) location (x, y, z), plus accuracy indicator	TARGETING MONITORING	Metres	World coordinate	Centimetre	1
Affected DO(s) velocity (vector), plus accuracy indicator	TARGETING MONITORING	Metres/sec		Centimetre	1
Point of impact	DAMAGE CALCULATION	Metres		Centimetre	2

A7.5.8 O/C Engagements

O/Cs are a special kind of DO, they can execute specific activities which also needs to be reported to EXCON for monitoring and AAR purposes. There are two categories of O/C specific activities, namely enforced status changes and O/C imitated engagements. In Table A-86, Table A-87, and Table A-88, the "O/C ID" is the reporting entity.

Table A-86: O/C Enforced Status Change Dataset.

Parameter	Purpose	Unit	Max	Resolution	Prio
O/C ID	MONITORING	ID	100,000	-	1
O/C location	MONITORING	Metres	World coordinate	Centimetre	1
Affected DO ID	MONITORING	ID	100,000	-	1
Affected DO location	MONITORING	Metres	World coordinate	Centimetre	1
Reporting time	MONITORING	Seconds		Second	1
Parameter ID	MONITORING	-	-	-	1
Parameter value	MONITORING	Enumeration	-	-	1

Parameter ID

The identification of parameter to be changed, which can be any of:

- DO call sign;
- DO category (e.g., personnel, wheeled, tracked, aircraft);
- DO type;
- DO force ID;
- DO health or operational status (“damage status”);
- DO logistic/supplies state;
- DO location;
- DO association; and
- DO additional status information.

Table A-87: O/C Imitated Contact and Proximity Engagement Reporting Dataset (Including Missiles).

Parameter	Purpose	Unit	Max	Resolution	Prio
O/C ID	MONITORING	ID	100,000	-	1
O/C location (x, y, z), plus accuracy indicator	TARGETING MONITORING	Metres	World coordinate	Centimetre	1
Imitated party ID	MONITORING	Enumeration		-	2
Imitated weapon type	MONITORING	Enumeration		-	2
Weapon direction/angle (vector), plus accuracy indicator	TARGETING			VERY HIGH	4

Parameter	Purpose	Unit	Max	Resolution	Prio
Imitated ammunition type	DAMAGE CALCULATION	Enumeration		-	1
Flight duration	TARGETING	Seconds		Microseconds	4
Engagement range	DAMAGE CALCULATION MONITORING	Metres		Metre	1
Reporting time	MONITORING	Seconds		Second	1
Detonation location (x, y, z), plus indicator of accuracy	DAMAGE CALCULATION	Metres	World coordinate	Centimetre	1
Effect direction/angle (vector) at the moment of detonation	DAMAGE CALCULATION			HIGH	2
Projectile impact velocity (vector), plus accuracy indicator	DAMAGE CALCULATION	Metres/sec		Centimetre	4
Effect volume	DAMAGE CALCULATION	Metres		Metre	2
Terrain	TARGETING DAMAGE CALCULATION	Metres		Centimetre	4
Affected DO(s) ID	DAMAGE CALCULATION	ID		-	1
Affected DO(s) location (x, y, z), plus accuracy indicator	TARGETING MONITORING	Metres	World coordinate	Centimetre	1
Affected DO(s) velocity (vector), plus accuracy indicator	TARGETING MONITORING	Metres/sec		Centimetre	1
Time of start of the engagement, plus accuracy indicator	TARGETING MONITORING	Seconds		Micro-second	1
Time of end of the engagement, plus accuracy indicator	TARGETING MONITORING	Seconds		Micro-second	1
Point of impact	DAMAGE CALCULATION	Metres		Centimetre	2

As with reporting of player DO contact and proximity engagements, the greyed out parameters in the table above are required for targeting purposes.

Table A-88: O/C Imitated Energy Weapon Engagement Reporting Dataset.

Parameter	Purpose	Unit	Max	Resolution	Prio
O/C ID	MONITORING	ID	100,000	-	1
O/C location (x, y, z), plus accuracy indicator	TARGETING MONITORING	Metres	World coordinate	Centimetre	1
Imitated party ID	MONITORING	Enumeration		-	2
Imitated weapon type	MONITORING	Enumeration		-	2
Weapon direction/angle (vector), plus accuracy indicator	TARGETING			VERY HIGH	4
Imitated energy type	DAMAGE CALCULATION	Enumeration		-	1
Imitated energy level	DAMAGE CALCULATION			-	1
Effect volume	DAMAGE CALCULATION	Metres		Metre	1
Activation time	TARGETING MONITORING	Seconds		Second	1
Deactivation time	TARGETING MONITORING	Seconds		Second	1
Engagement time	MONITORING	Seconds		Second	1
Engagement duration	DAMAGE CALCULATION	Seconds		Second	1
Terrain	TARGETING DAMAGE CALCULATION	Metres		Centimetre	4
Atmospheric data	TARGETING			-	4
Affected DO(s) ID	DAMAGE CALCULATION	ID		-	1
Affected DO(s) location (x, y, z), plus accuracy indicator	TARGETING MONITORING	Metres	World coordinate	Centimetre	1
Affected DO(s) velocity (vector), plus accuracy indicator	TARGETING MONITORING	Metres/sec		Centimetre	1
Point of impact	DAMAGE CALCULATION	Metres		Centimetre	2

A7.6 DO Technical System State Report

Through the E2 interface the technical system state of DOs can be changed. The current system state and the results of E2 interactions must be monitored, therefore DOs must be able to report the following dataset:

- Technical status of the training equipment;
- Battery status;
- BIT (built-in test);
- Radio signal strength (when applicable);
- Connectivity of system components (e.g., is the datalink operational?); and
- Cheating signal (e.g., remove a cable).

A8.0 E9: DO ASSOCIATION AND PAIRING

This interface enables the logical linking of objects in the training environment, this includes linking of DOs amongst each other (DO association) and linking equipment that is not modelled as a DO with DOs (equipment pairing).

When a piece of equipment can be used by different DOs during an exercise, equipment pairing enables the training system to monitor which DO possesses what equipment at what moment in time. E9 is a two-way interface: equipment information must be transferred to the DO, so the DO can report what equipment it possesses, and the value of protective equipment can be taken into account. Conversely, DO information must also be transferred to the equipment, so the equipment can incorporate that information in its engagements, for example a rifle can pass the "shooter ID" to a target (Table A-89).

Table A-89: Equipment Pairing Dataset.

Parameter	Unit	Max
DO ID	ID	100,000
Equipment type	Enumeration-	-
Equipment ID	ID	100,000
Pairing type	Enumeration	-
Pairing time	Seconds	-

DO ID

The identification of the (human) DO involved in the equipment pairing.

Equipment Type

The category of the involved equipment, it can be:

- Weapon (which can be further specified into different weapon types);
- Helmet;
- Body armour;

- CBRNe mask;
- CBRNe suit;
- Medical treatment device;
- Repair activity device.

Equipment ID

The identification of the piece of equipment involved in the pairing.

Pairing Type

The type of pairing, which can be:

- "Pair": The piece of equipment identified by the "equipment ID" is linked to the "DO ID";
- "Unpair": The piece of equipment identified by the "equipment ID" is unlinked from the "DO ID".

Pairing Time

The moment in time when the (un)pairing is executed.

Equipment pairing can also be used to control the use of the equipment and disable it to function, based on conditions determined by the DO (e.g., its operational status, ammunition supply or capability level). For example, a heavily wounded soldier is denied to operate a machine gun, because in reality he would not be physically capable. Or after a certain number of shots a weapon will not fire anymore, to prevent simulating an unlimited ammunition supply. Or only a medic is allowed to operate a medical treatment device to prevent that any DO picking up such a device can act like a medic. Therefore, a signal must be sent between the DO and the piece of paired equipment (Table A-90).

Table A-90: Equipment Pairing Control Dataset.

Parameter	Unit	Max
DO ID	ID	100,000
Equipment type	Enumeration-	-
Equipment ID	ID	100,000
Control type	Enumeration	-
Control time	Seconds	-

Control Type

The type of control, which can be:

- "Enable": the "DO ID" is allowed to operate the piece of equipment identified by the "equipment ID";
- "Disable": the "DO ID" is denied to operate the piece of equipment identified by the "equipment ID".

Control Time

The moment in time when the control is executed.

DO association is defined as the situation where two or more DOs are logically grouped in order to, for example, synchronise their position or enable the propagation of effects.

Table A-91: DO Association Dataset.

Parameter	Unit	Max
Contained DO ID	ID	100,000
Containing DO ID	ID	100,000
Association type	Enumeration	-
Pairing time	Seconds	-

Contained DO ID

The identification of the DO which is in or on the "containing DO ID".

Containing DO ID

The identification of the DO which carries or contains the "contained DO ID".

Association Type

The type of association, which can be:

- "Moves in": the "contained DO ID" enters into the "containing DO ID", an association is established;
- "Moves out": the "contained DO ID" leaves the "containing DO ID", an association is removed;
- "Moves on": the "contained DO ID" climbs on the "containing DO ID", an association is established; and
- "Moves off": the "contained DO ID" descends from the "containing DO ID", an association is removed.

Annex B – UCATT NATO ARCHITECTURE FRAMEWORK (NAF)

EXECUTIVE SUMMARY

This report aims to examine and document the current state of practice of Systems Engineering (SE) and architectural artefacts[1] and information, within the UCATT program, and how an architecture standard such as the NATO Architecture Framework version 4 (NAF v4) may be applicable to the program.

According to ISO/IEC/IEEE 42010: "An Architecture is the fundamental concepts or properties of a system in its environment embodied in its elements, relationships, and in the principles of its design and evolution."

The study is based on an analysis that highlights the potential to capture MSG 098/099 UCATT documentation and information in an architectural description, according to NAF v4, by introducing a Model-Based Systems Engineering (MBSE) methodology. Compiled findings indicate that an MBSE methodology, in combination with NAF v4, will improve several key quality aspects of SE artefacts, including aspect such as completeness, unambiguousness, traceability, information management, clarity and understanding. The study also shows that an MBSE approach can enhance the capability to perform SE processes, according to ISO/IEC/IEEE 15288 System and Software Engineering – System Life Cycle Process.

A UCATT Architectural Description can be considered as a deliverable artefact, by itself, which can be used by organisations that develops, procures, maintains or uses live simulation systems. In a larger perspective, a formal architectural description can also facilitate the communication and integration with other SISO standardisation initiatives and Model and Simulation Groups.

The first essential step is to introduce an MBSE approach is to create a Systems Engineering Plan (SEP), covering both how to implement a new methodology as well as how to perform the systems engineering tasks, including processes, methods, resources and information management. The recommendation is to develop the SEP during the initial phase of LSS2.

[1] An aggregated set of information that can be represented as a document, database, diagram, etc.

B1.0 INTRODUCTION

B1.1 Background

The Urban Combat Advanced Training Technology – 1 (UCATT-1) and UCATT-2 working groups focused on defining the UCATT concept and to demonstrate its feasibility and usability. Subsequently, the UCATT-3 working group focused on creating the first UCATT standard along with the associated reference and guidance documents. UCATT-LSS elaborates on the previous work and aims to increase the set of UCATT standard interfaces.

UCATT-LSS Task Group NATO Architectural Framework (TG NAF) is part of the UCATT-4 initiative.

B1.2 TG NAF Objective and Tasks

In the UCATT community there is a need for a structured approach to manage the complexity of creating an integrated and consistent set of standards. The number of standards will increase over time and will evolve to reflect the needs of the community. Architectural frameworks may support this objective; therefore, a task group was initiated (TG NAF) with the aim to examine the potential effects of introducing an architecture framework.

The TG NAF was given the task to evaluate if an Architecture Framework (AF) approach:

- Can increase consistency in information in and between UCATT reports;
- Can, by a systematic approach, capture the interfaces; and
- Can represent UCATT products within a common architecture framework.

The following questions were also given to TG NAF to evaluate by analysis:

- Will an AF increase consistency and quality of UCATT products?
- Will an AF increase UCATT capabilities to perform change and configuration management?
- Can an AF support acquisition organisations to design and acquire systems?

TG NAF was obligated to give successive reports at the UCATT-LSS meetings to:

- Produce out-briefs on progress to the UCATT group; and
- Remittance issues on the TG NAF report.

The TG NAF work was supported in collaboration with TG Architecture, TG E4 and TG E8.

The initial task was to evaluate a UCATT use of NATO Architecture Framework (NAF) v3. Early in the work a draft NAF v4 became available. There is a significant difference in the meta-model between NAF v3 and NAF v4. TG NAF reported a change to focus on the draft NAF v4. In January 2018 NATO released the first issue of NAF v4.

B1.3 An Introduction to the NATO Architecture Framework

The purpose of an enterprise architecture is to optimise, across the enterprise, the often-fragmented legacy processes (both manual and automated) into an integrated environment that is responsive to change and supportive of the delivery of the business strategy.

An Architecture is the fundamental concepts or properties of a system in its environment embodied in its elements, relationships, and in the principles of its design and evolution.

ISO/IEC/IEEE 42010

The architecture description can cover many aspects, including capability, operational, system, technical, performance, services provided, and evolution over time. An architecture description may include views showing various aspects of the system of interest. These views include architectural elements and the relation between the elements as governed by a meta-model.

The NATO Architecture Framework is a specification of an architecture description. Therefore, NAF v4 is not an architecture itself, instead it provides the rules, guidance, and product descriptions for developing, presenting and communicating an architecture. The application of the framework will contribute to the acquisition and fielding of cost-effective, interoperable capabilities and systems. The framework ensures that the architectures developed by NATO and the participating Nations can be compared and related across NATO and National boundaries. NATO common funded programmes are to comply with the NAF v4 to promote systems interoperability.

It is important to appreciate that architecture modelling is a collaborative activity and cannot be undertaken by individuals working in isolation. Various individuals may be responsible for developing models of specific aspects of an enterprise, for a specific purpose, and these individual pieces of work can have some value in answering specific questions. However, the full value of architecture models is only realised when they are collected together within a shared model repository, and more particularly are linked together in a way that recognises common shared elements and relationships.

Architectures can be represented by models and are used to support operational processes by providing an explicit representation of the operational domain. They can be used in analysis, for articulation of issues and requirements, as support to planning, as a means of a design solution, validation, etc. Architecture models can be developed representing all levels of abstraction, from components up to complete enterprises.

Architecture models must be maintained, communicated, and enforced.

The role of an enterprise architecture model is to provide decision support, in the context of the enterprise strategy, for the use of resources (including processes and procedures) in the enterprise. In other words, the architecture model is responsible for defining how resources will be used to support enterprise strategy and benefit the NATO goals and objectives. Enterprise architecture touches every part of the organisation.

Architecture models are to be used as analysis tools to develop new capabilities, structure organisations and to optimise processes and spending. There is an increasing need for international coalition operations (NATO Response Force) and a growing need to deliver end-to-end capability, while delivering more for less and ensuring interoperability. NATO Network Enabled Capability (NNEC) is a key part of meeting this changing need, and enables us to integrate systems, sensors, effectors and hence improve military effectiveness.

B2.0 ACRONYMS AND REFERENCES

B2.1 Acronyms

DODAF	Department of Defense Architecture Framework
IEC	International Electrotechnical Commission

IEEE	Institute of Electrical and Electronics Engineers
ISO	International Organization for Standardization
MODAF	Ministry of Defence Architecture Framework
NAF	NATO Architecture Framework
NATO	North Atlantic Treaty Organisation
NRF	NATO Response Force
SISO	Simulation Interoperability Standards Organization
UCATT	Urban Combat Advanced Training Technology
SE	Systems Engineering
NAF v4	NATO Architecture Framework version 4
SysML	Systems Modelling Language
OMG	Object Management Group
UAD	UCATT Architectural Description
TOGAF	The Open Group Architecture Framework

B2.2 References

http://nafdocs.org.

B2.3 Reference Documents

Reference	Document	Doc nr	Note
[Ref1]	UCATT	TR-MSG-032	UCATT-1 RTO TG 032 Report Published April 2010.
[Ref2]	UCATT	TR-MSG-063	UCATT-2 RTO TG 063 Report
[Ref3]	UCATT	TR-MSG-098	UCATT-3 RTO TG 098 Report
[Ref4]	UCATT	TR-MSG-099	UCATT-3 RTO TG 099 Report
[Ref5]	NATO	NATO Consultation, Command and Control Board under cover of AC/322-D(2007)0048-AS1	NAF v3
[Ref6]	NATO	http://nafdocs.org/	NAF v4 documentation (draft issue)
[Ref7]	ISO/IEC/IEEE	15288:2015 https://www.iso.org/standard/63711.html	2015-05-15

Reference	Document	Doc nr	Note
[Ref8]	NATO	NATO Architecture Capability Team, Consultation, Command and Control Board, January 2018	NAF v4
[Ref9]	Object Management Group (OMG)	OMG System Modelling Language (v1.5) http://www.omgsysml.org/	2017-05-01
[Ref10]	NATO	Science and Technology Organization Annual Report 2015	
[Ref11]	SISO	www.sisostds.org	
[Ref12]	INCOSE	INCOSE System Engineering Handbook	2015
[Ref13]	Royal Institute of Technology, Stockholm	T Huldt, I Stenius. State-of-practice survey of model-based systems engineering. Systems Engineering. 2018;1-12 https://doi.org/10.1002/sys.21466	2018
[Ref14]	IEEE	IEEE 1471, Recommended Practices for Architectural Description of Software-Intensive Systems	

B3.0 METHODOLOGY

The methodology used during the study was based primarily on identifying UCATT artefacts and results produced during earlier program stages (UCATT 1 to 3). Outputs produced during UCATT 4 have been taken into account and partly included in the study.

Analysed artefacts were translated/transformed into relevant structures, information and views according to the NAF v4, based on the OMG Systems Modelling Language™ (SysML®) version 1.5. In parallel, a gap analysis was performed and data added to the architectural framework to illustrate how an integrated information set can enable traceability between the program's different artefacts and standards. In addition, information, structures and views were identified to further enhance the systems engineering process performed by the program and therefore increase the quality of UCATT deliverables.

The methodology included the following steps:

- Identify, collect and study UCATT information and artefacts.
- Perform a reversed systems engineering process, according to ISO/IEC/IEEE 15288 [Ref7] System and Software Engineering – System Life Cycle Process, to convert UCATT information and artefacts to NAF v4 views and information.
- Perform gap analysis to identify and produce the minimum set of architectural information to facilitate traceability between generated NAF v4 views and information, from stakeholder requirements to UCATT standard documents.
- Elaborate on how NAF v4 can support UCATT programmatic aspects.
- Write a report and deliver an Html draft model (readable in a web browser), to visualise an example of a model.

Note: During the execution of TG NAF, a modelling platform was used to compile, analyse and report data according to NAF v4. The platform consisted of the tool Magic Draw, with an associated database. The architectural description compiles information from previous phases of UCATT, the current UCATT phase and additional information produced during analysis. The purpose of added information was to integrate analysed data, in order to be compliant with NAF v4, and to identify potentials using an architecture framework. The architectural description is customised to support the task group and does not claim to be complete nor quality assured by the information owners. Therefore, the information (the architecture model) cannot be used as a valid artefact. The architectural description is published for information purposes only. An Html version is available on the NATO Science connect website. Download the compressed file locally on your computer and then unzip it. Use your browser to access the data.

B4.0 COLLECTED INFORMATION

The main focus, throughout this study, was to gather data produced during previous program phases (UCATT 1 to 3). Furthermore, information produced by other working groups, during UCATT 4, was considered.

Studied UCATT information:

The information can be found on https://scienceconnect.sto.nato.int/spaces/2134/posts:

1) UCATT 032 report: Use Cases and Capability (user?) Requirements Matrix.
2) UCATT 063 report: Architecture description.
3) UCATT 098 report: reference documents for creation of first SISO standards.
4) UCATT 140 E8 work documents and diagrams.
    a) TG E8 documents (until #8 Orlando).
5) UCATT 140 E4 work documents and diagrams.
    a) TG E4 documents (until #8 Orlando).

Studied Architecture Framework information:

1) NAF v3, [Ref5].
2) NAF v4 draft, [Ref6].
3) NAF v4 std, [Ref8].
4) SysML stds, [Ref9].

Studied Systems Engineering processes:

a) System Life Cycle Processes ISO/IEC/IEEE 15288 [Ref7].

B5.0 ESTABLISHMENT OF PRODUCTION ENVIRONMENT

B5.1 Process

In order to create a well-documented and normative approach, the standard ISO/IEC/IEEE 15288 System and Software Engineering – System Life Cycle Process [Ref7] was chosen as the starting point, both for the implementation of the study as well as the structure of the report.

Since the project's artefacts primarily cover technical aspects, the Technical Processes were considered relevant for the execution of the study. In addition to the Technical Processes, a limited number of other processes were analysed, particularly programmatic and configuration aspects, refer to Section B6.0.

B5.2 Architectural Framework

There are several different architectural frameworks available today, for example *Ministry of Defence Architecture Framework (MODAF), NATO Architecture Framework (NAF), The Open Group Architecture Framework (TOGAF).*

Since the UCATT program is performed in the context of NATO, the NAF was the preferred architectural framework. To be future compatible, version 4 of the framework was chosen.

The NAF v4 methodology is based on the TOGAF ™ Architecture Development Method (ADM) with input from other sources such as the MODAF learning portal and systems engineering standards such as ISO/IEC/IEEE 15288 [Ref7] (according to reference http://nafdocs.org/methodology/).

The foundation of the NAF v4 is the NATO Architecture Framework Meta-model. The meta-model defines the relationships between the different components of the framework. The NAF v4 meta-model uses the IEEE STD 1471 [Ref14] as a starting point.

NAF v4 supports the definition of a modelling element creating a traceable architectural description, facilitating an integrated information set. The use of a systematic analysis method like an architecture framework increases the efficiency and quality of systems engineering tasks and to decrease uncertainties and risks (Figure B-1).

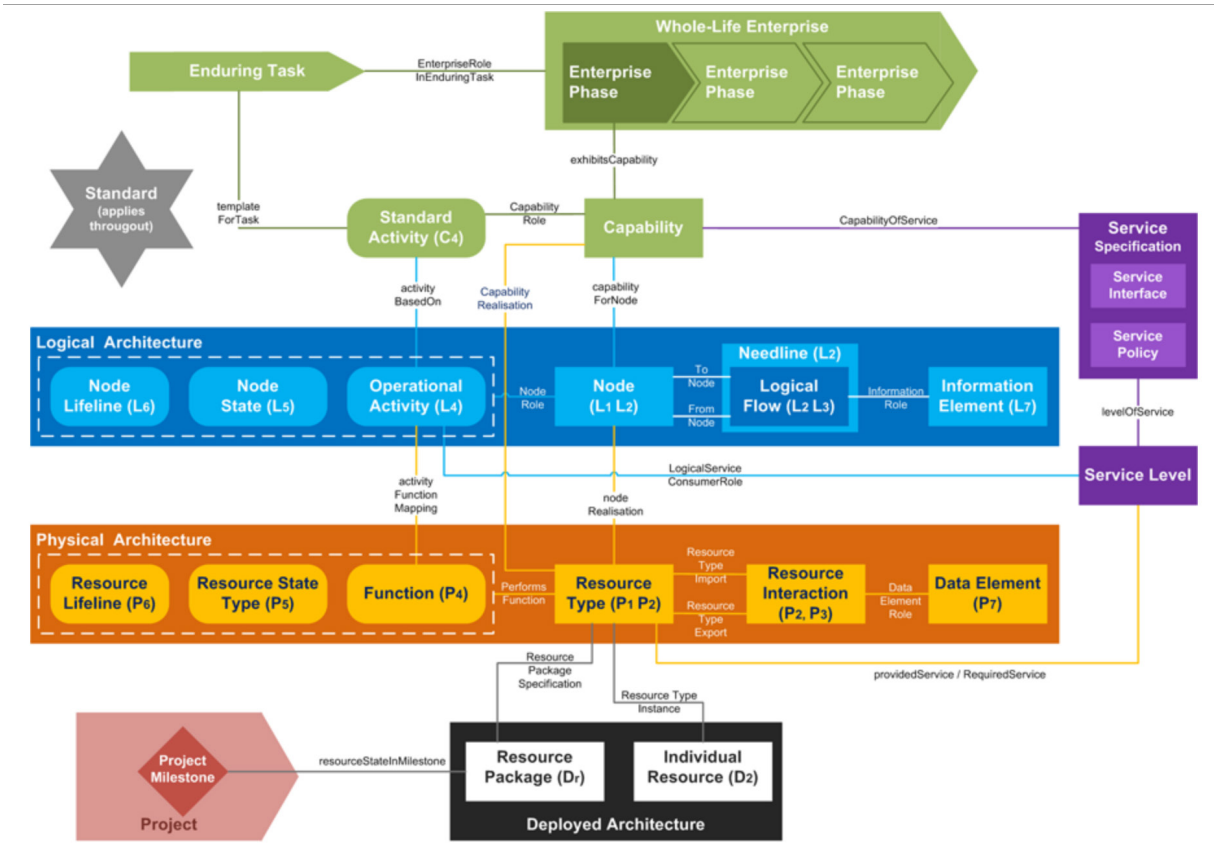


Figure B-1: A Simplified View of NAF v4.

B5.3 Modelling Language

An implementation of the NATO Architecture Framework Meta-model requires a modelling language, which follows the rules of the meta-model. The modelling language chosen for this study is SysML (The Systems Modelling Language), which is considered as the only language to fully support the NAF v4 meta-model.

SysML is a general-purpose modelling language for systems engineering applications. It supports the specification, analysis, design, verification and validation of a broad range of systems and systems-of-systems. SysML was originally developed by an open source specification project and includes an open source license for distribution and use. SysML is defined as an extension of a subset of the Unified Modelling Language (UML) using UML's profile mechanism. The language's extensions were designed to support systems engineering activities. SysML model management constructs support of models, views, and viewpoints. These constructs extend UML's capabilities and are architecturally aligned with IEEE-Std-1471-2000 (IEEE Recommended Practice for Architectural Description of Software Intensive Systems).

B5.4 Tools

A number of tools were considered and evaluated based on the preferred architectural framework and modelling language.

Criteria considered were:

1) Compliancy to standards;
2) Forward compatibility;
3) Availability; and
4) Required learning curve.

The tool Magic Draw© from No Magic© was used throughout this study. Based on the above criteria, Magic Draw was considered as the most applicable tool, of which criteria one (1), compliancy to standards was considered to be of the highest priority to facilitate change in the future.

B6.0 ANALYSIS

B6.1 Tailored System Life Cycle Process(es) ISO/IEC/IEEE 15288

ISO/IEC/IEEE 15288 [Ref7] is a standard about systems and software engineering in the context of system life-cycle processes. The systems considered in the standard are man-made, created and utilised to provide products or services in a defined environment for the benefits of users and other stakeholders. These systems may be configured with one or more of the following elements: hardware, software, data, humans, processes, procedures, facilities, materials and natural occurring entities. As viewed by the user, they are thought of as products or services.

Based on studied information relevant to the ISO/IEC/IEEE 15288 [Ref7] standard, processes were selected and tailored to establish a well-documented and structured report, refer to Section B6.4 to Section B6.6.

B6.2 Adoption of the Architectural Framework

The NAF v4 includes a hierarchical breakdown of views and viewpoints, covering an enterprise architecting perspective of a system or system-of-systems. The framework is extensive and it is assumed that each application of the framework is a tailored set of selected views and information. Available views are identified in Figure B-2. For more detailed information about the standard and views refer to NAF v4 (http://nafdocs.org/).

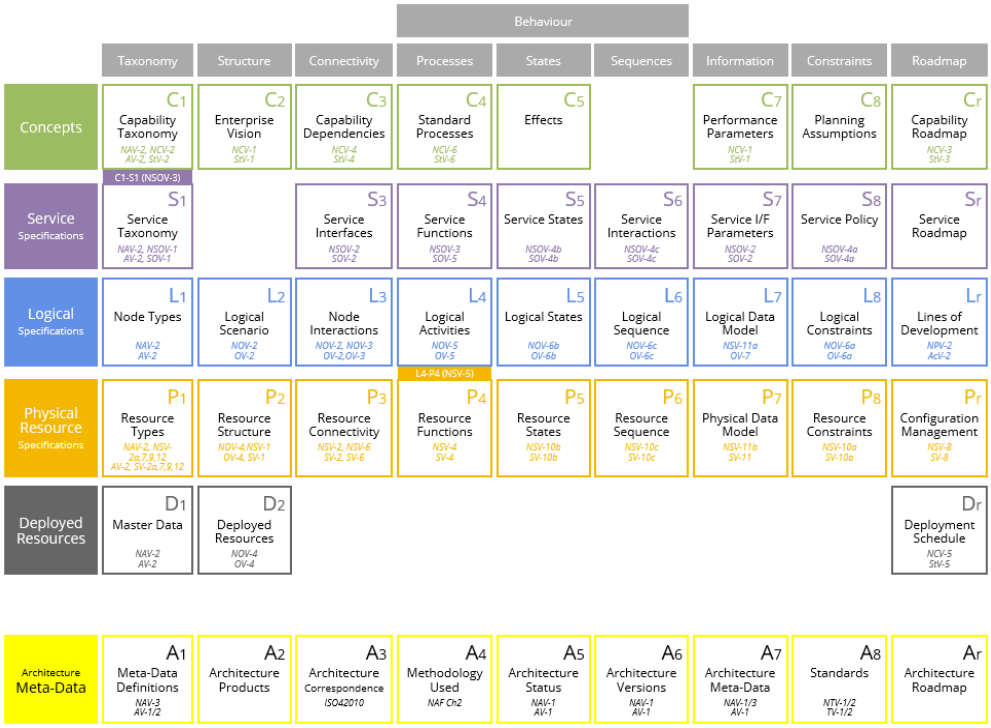


Figure B-2: Type of Available NAF v4 Views.

During this study, UCATT artefacts and information were collected and transformed to NAF v4 views and viewpoints. Additional viewpoints and views were required in order to establish traceability between these elements. The NAF v4 used during this study are highlighted in Figure B-3.

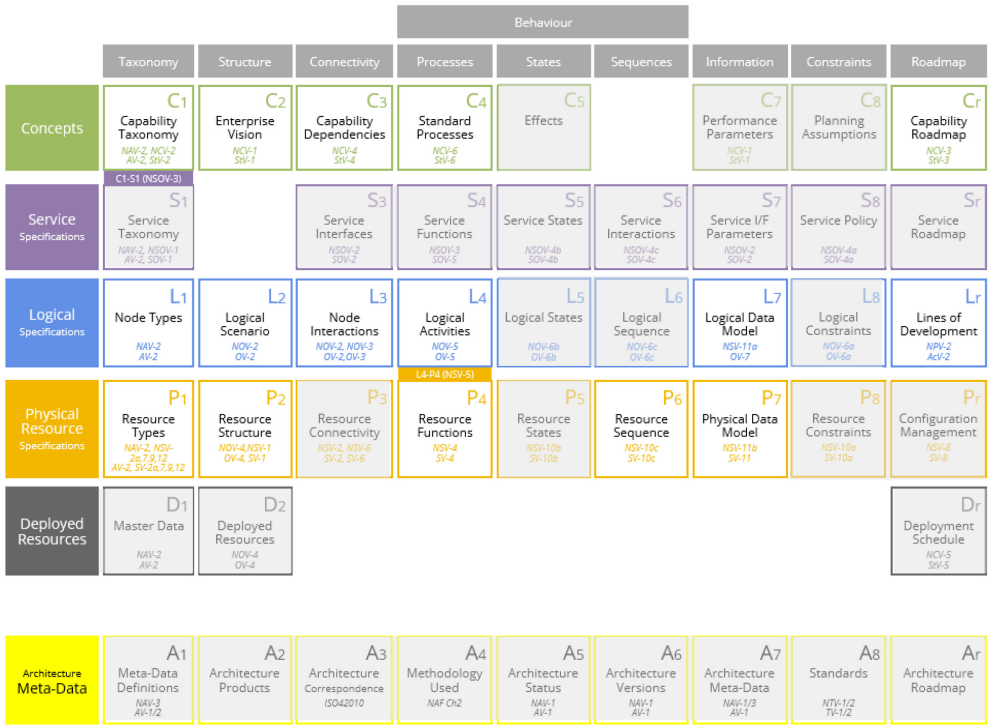


Figure B-3: NAF v4 Views Used During This Study.

B6.3 Agreement Process

Sub-clause 6.1 in ISO/IEC/IEEE 15288 [Ref7] specifies the requirements for the establishment of agreements with organisational entities external and internal to the organisation.

The agreement process consists of the following:

a) Acquisition process – used by organisations for acquiring products or services.

b) Supply process – used by organisations for supplying products and services.

These processes define the activities necessary to establish an agreement between two parties. The supplier (UCATT) enters into an agreement about the delivery of reports and standards from the acquirer (NATO MSG).

The objective is to maintain and improve the UCATT-developed Functional Architecture for Live Urban training systems and identify and prioritise external architecture interfaces to develop/enable interoperability.

B6.4 UCATT Organisational Project Enabling Process

The Science and Technology Organisation (STO) focuses on delivering a superb Program of Work (PoW) to support the objectives of Allies, their partners and NATO as a whole.

Collaboration in NATO S&T context is voluntary; stakeholders participate according to their capabilities, interests and needs.

The stakeholders can be grouped into three categories:

- Those that benefit from S&T as customers, utilising S&T results without being actively involved in S&T development.
- Those designated to execute dedicated S&T programs of various scales, topical portfolios, or funding mechanisms.
- Those that influence requirements or investment decisions in future S&T activities.

MSG UCATT involves approximately ten nations, including a few NATO partner nations, who work in close cooperation to develop live simulation standards.

It is recommended that UCATT produce a Capability Roadmap (Cr) and a Development Schedule (Dr) according to NAF v4 to support NATO STO project enabling processes.

B6.5 UCATT Technical Management Process

The UCATT Architecture will enable joint and coalition military training through interconnected live simulation training systems. The resulting set of standardised live simulation interfaces better positions military users and acquisition organisations to:

- Define requirements.
- Target industrial internal R&D investments.
- Open new tendering opportunities.
- Bring interoperable training to new levels of efficacy.

The first evidence of these benefits is the adoption of the UCATT Laser Engagement interface standard.

B6.6 Technical Process

To facilitate an effective transformation of stakeholder requirements to a product, to sustain this product throughout its life-cycle and to permit consistent reproduction, a set of processes have to be performed. ISO/IEC/IEEE 15288 [Ref7] defines these processes and puts them in a wider business context.

To create a starting point and baseline for the analysis and reporting, technical processes according to ISO/IEC/IEEE 15288 [Ref7] is used, refer to Section B5.0.

UCATT information defines requirements and an architecture of a normative and future system, therefore the emphasis of this study has been on the early stages of the systems engineering life cycle. Other processes covering later systems engineering life-cycle phases may be of interest in future projects within the UCATT program. This will likely increase the potential scope of the architectural framework used. This also applies to the size and scope of the architectural description, as the number of standardised interfaces increases.

B6.6.1 Business or Mission Analysis Process

B6.6.1.1 Analysis of the Standard Process

According to ISO/IEC/IEEE 15288 [Ref7] Section B6.4.1, the purpose of the *Business* or *Mission Analysis Process* is to define the Business or Mission opportunity, characterise the solution space and determine potential solution class(es) that could address a problem or take advantage of an opportunity.

The following relevant UCATT outcomes have been identified, according to ISO/IEC/IEEE 15288 [Ref7] Section B6.4.1.2:

- A – The problem or opportunity space is defined.
- F – Any enabling systems or services needed for business or mission analysis are available.

B6.6.1.2 Analysis of UCATT Artefacts and Information

UCATT's overall mission is to identify and standardise the interfaces that allow interoperability of different systems for live training focusing on the urban environment. The benefits realised through this mission are effective national procurement, training flexibility and conducting international training events.

This is done by architecture and standardised interface development according to objective(s) given by NATO STO in MSG-140 UCATT-LSS.

According to NATO STO TECHNICAL REPORT TR-MSG-099, the continuation of the UCATT activities within MSG-140 UCATT Live Simulation Standards TG shall secure not only a platform for continued work on standardisation within the live simulation community, but also to embed and support the goals already achieved[2].

This report elaborates how to develop and support a UCATT architectural description, in accordance with NAF v4, including development and support of interface descriptions.

B6.6.1.3 Supporting NAF v4 Viewpoints

When analysing previous UCATT reports, missions and capabilities for training were identified which can be transformed into the following NAF v4 views:

- C1 Capability Taxonomy;

[2] NATO STO Technical Report TR-MSG-099, Urban Combat Advanced Training Technology Standards.

- C2 Enterprise Vision; and
- Cr Capability Roadmap.

These views are further elaborated below.

Furthermore, the usage of use case views is a powerful notation to define high-level business objectives and missions. These use cases are not covered by the NAF however supported by SysML, and therefore can be integrated seamlessly into the architecture.

In the UCATT program use cases have been used to address both stakeholder concerns, at a capability level, as well as to describe technical aspects of the architecture and design.

B6.6.1.4 Definition of Use Cases

According to the OMG Systems Modelling Language ™: "The use case diagram describes the usage of a system (subject) by its actors (environment) to achieve a goal, that is realised by the subject providing a set of services to selected actors. The use case can also be viewed as functionality and/or capabilities that are accomplished through the interaction between the subject and its actors."

B6.6.1.5 Evaluation of Use Cases Description Techniques to Support UCATT

To address stakeholder concerns and system objectives, use cases are defined and documented [Report of Task Group 032]. The identified use cases are:

- USE CASE 0: National training on national site.
- USE CASE 1: Live MOUT training – National force on national site (consolidated combined training).
- USE CASE 2: Use other nation's training facility and staff.
- USE CASE 3a: Distributed combined training.
- USE CASE 3b: Combined training in mission area.
- USE CASE 4: Command and staff training for engagements in different mission areas.

These use cases are based on natural language and do not have any graphical representation.

If use cases are used as an extended NAF viewpoint, they can be used as a starting point to analyse required capabilities and stakeholder requirements. The Use Cases are then the focal point to define, allocate and refine main business objectives and requirements. This defines a high level definition of the system of interest using the system and its environment as context for analysis, refer to Figure B-4 and Figure B-5.

It is recommended that use cases are used to illustrate stakeholder needs and concerns and therefore are included in the architectural framework.

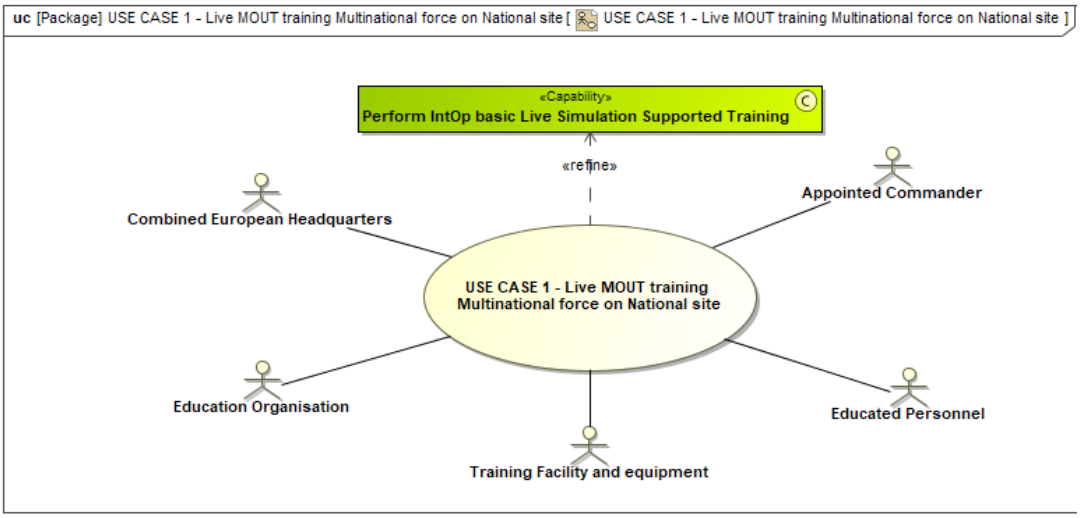


Figure B-4: Example of a Business/Capability Use Case (Use Case 1).

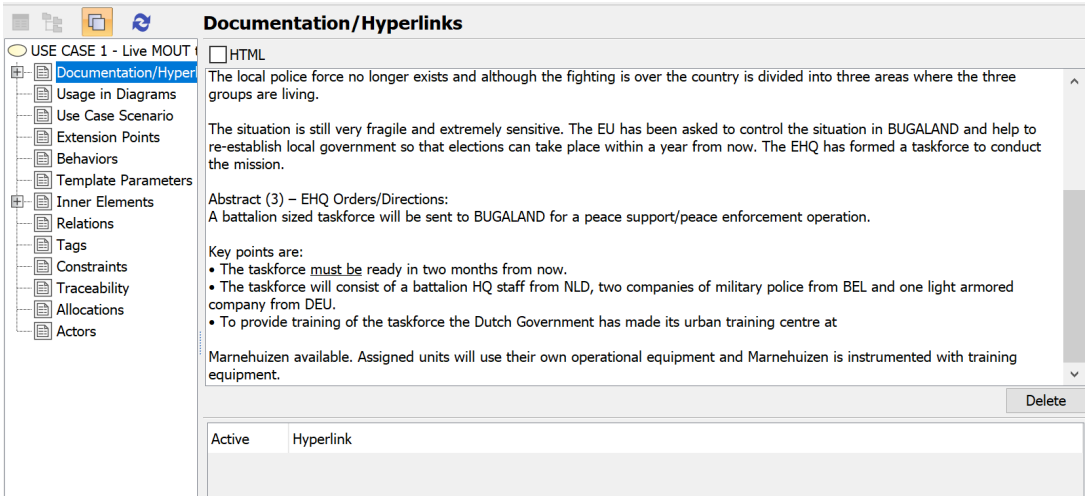


Figure B-5: Example of Embedded Information in a Use Case Class.

B6.6.1.6 Definition of C1 Capability Taxonomy View

According to NAF v4 [http://nafdocs.org/viewpoints/] the C1 view covers capabilities and the hierarchical relationships between them.

*A Capability is defined as the **ability** to execute a specified course of action.*

The C1 view is aimed at defining and structuring a set of applicable capabilities, to outline the main purpose and goal of the system under consideration in an operational context. In previous UCATT reports there are technical capabilities however they are not addressed in this report.

C1 specifies all the capabilities that are referenced throughout one or more architectures – i.e., C1 may provide the definitive list of capabilities for a number of logical and resource architectures. The capabilities may be organised into specialisation hierarchies (taxonomies) and measures of effectiveness may be specified for each capability. Note that measures of effectiveness are inherited down to a capability taxonomy (Figure B-6).

Figure B-6: C1 Capability Taxonomy Key Elements and Their Relationships.

These capabilities can be used as information to baseline current available/fielded capabilities as well as be used as part of a Capability Gap Analysis (CGA). CGA is the determination of capabilities that do not yet exist. The utilisation of NAF v4 view, L4 – Logical Activities (an operational activity mode) is recommended when conducting a CGA. This process and method can be referred as part of a Capability Based Analysis (CBA).

General purpose and usage:

- Identification of existing and required capabilities.
- Source for the derivation of cohesive sets of Key User Requirements.
- Providing reference capabilities for multiple architectures.

B6.6.1.7 Evaluation of View C1 Description Techniques to Support UCATT

During a previous phase of the UCATT program the task group sought to identify the needs of the different countries' training capability requirements, evaluate those requirements and make recommendations on a generic set of capability requirements for urban operations training in the Live, Virtual and Constructive (LVC) domains. In order to carry out this task a Requirements Matrix Sub-Group was established. The output was a Capability Requirements Matrix whose purpose was to identify those components needed to support the training at all levels from team to brigade levels including non-military and Peace Support Operations (PSO).

Although it was initially intended to include all three environments, only the live training environment was completed. The development of the matrix and its subsequent analysis was used to identify common elements, interoperability issues and the standards that could be applicable in conducting urban training. These were then addressed in the functional architecture and interfaces that are described in Section 5 through the definition of a common set of functional training requirements.

The Capability Requirement Matrix is defined as a hierarchical structure, documented in an Excel format, according to Annex F TR-MSG-032. Limited or no effort has been made to manage this information, after its first version. Furthermore, there are no documented traceability from the capabilities to the architecture, design and ultimately the standards produced by UCATT. The consequences are poorly managed capabilities, stakeholder requirements and limited to no opportunities to perform an efficient systems' engineering and management process, including configuration, change and risk management.

The nature of the Capability Requirement Matrix enforces the usage of a combination of capability and requirement structures (refer to Section B6.6.2.12) to fully represent the information and facilitate the traceability to the architectural description. For examples of how to structure capabilities, requirements and traceability refer to Figure B-8, Figure B-9 and Figure B-10.

The general purpose and usage:

- The identification of existing and required capabilities.
- Source for the derivation and traceability of a set of cohesive Key User Requirements.
- Providing reference capabilities for multiple architectures.

Figure B-7 illustrates an example of a C1 view of the UCATT Capability taxonomy structures and Figure B-8 illustrates the traceability between capabilities and stakeholder needs.

It is recommended that the C1 Capability taxonomy view is considered as an option to illustrate capability aspects and to facilitate the Capability Gap Analysis.

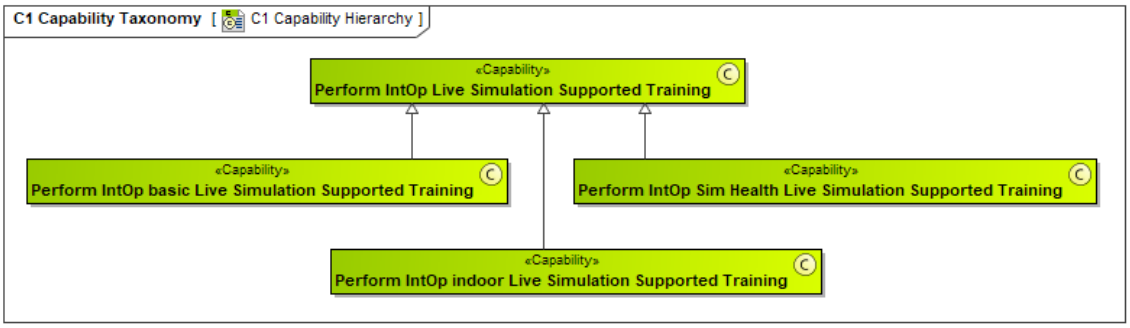


Figure B-7: Example of a Capability Hierarchy.

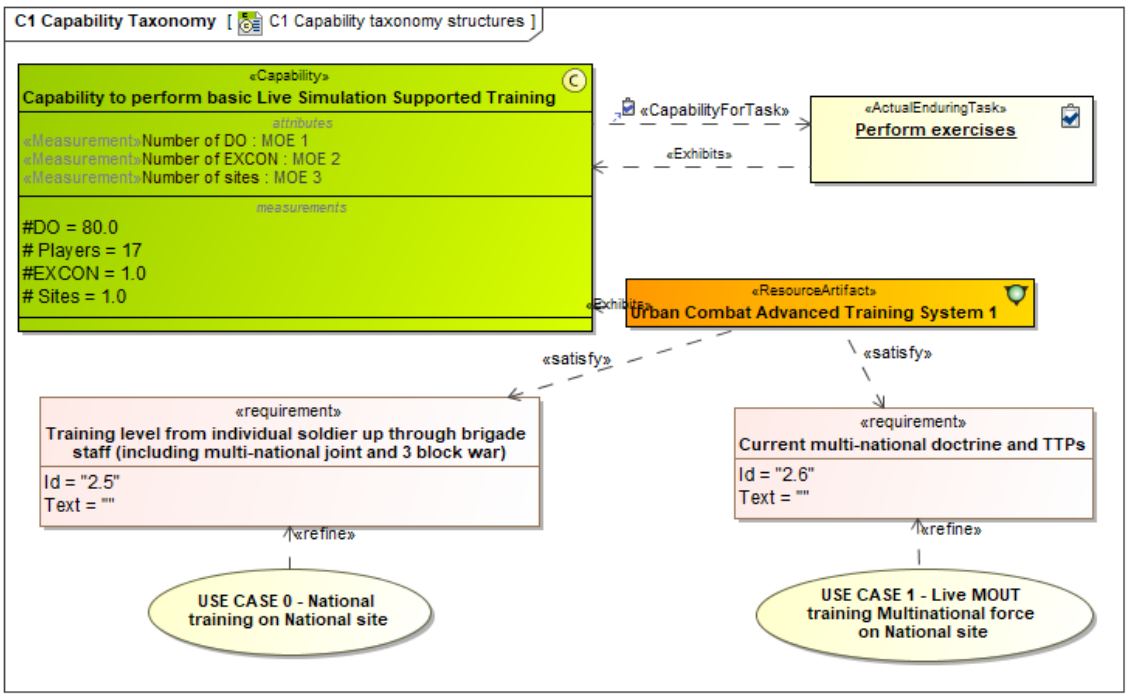


Figure B-8: Example of a C1 View.

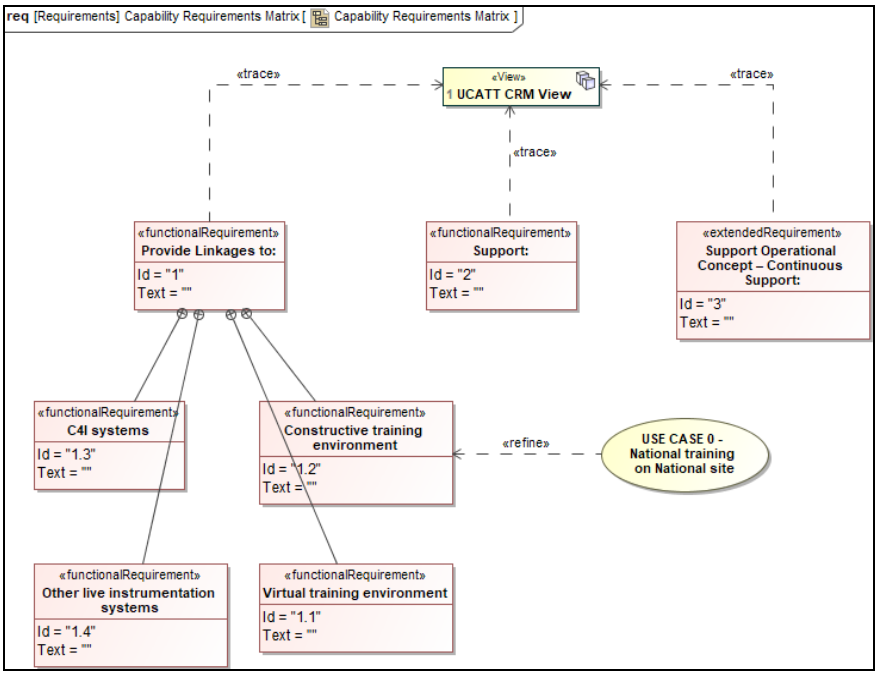


Figure B-9: Example of a Requirement Structure/View.

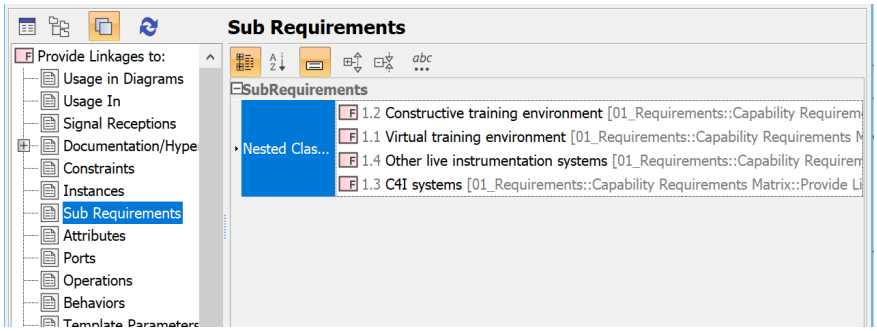


Figure B-10: Example of Embedded Information in a Requirement Class.

B6.6.1.8 Definition of C2 Enterprise Vision View

According to NAF v4 the purpose of a C2 view is to provide a strategic context for the capabilities described in the architecture and to specify the scope for the architecture. The C2 is high-level and describes the vision, goals, enduring tasks and capabilities using terminology that is easily understood by non-technical readers Figure B-11.

General purpose and usage:

- Capture and communication of the strategic vision related to capability evolution.
- Identify the capabilities required to meet the vision and goals.
- Identify the required timelines for the capabilities (as opposed to Cr view which provides a summary of when projects are estimated to deliver capability).
- Identify any enduring tasks the enterprise performs.

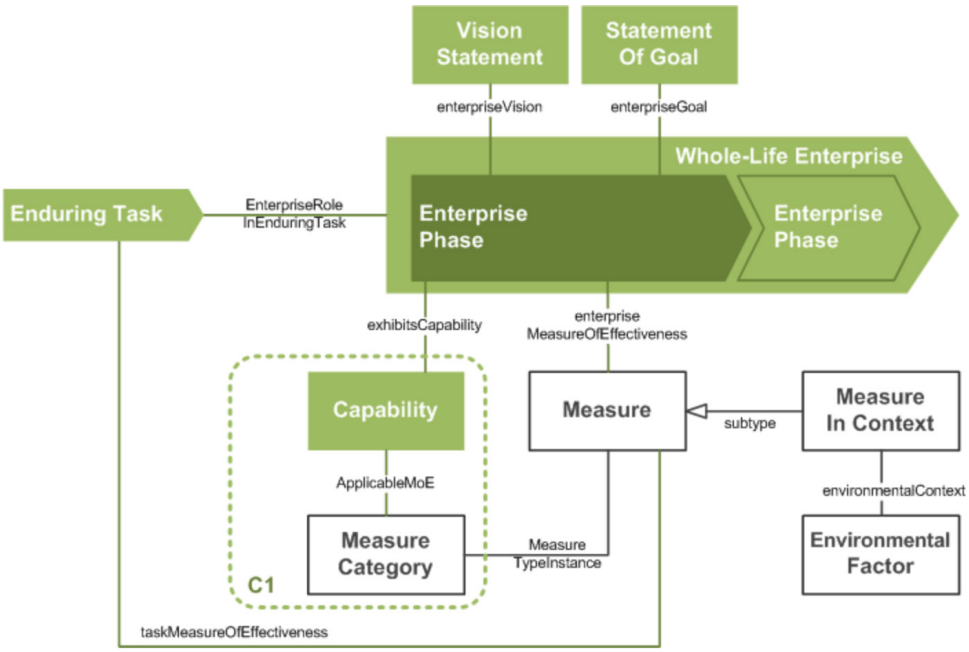


Figure B-11: C2 Enterprise Vision Key Elements and Their Relationships.

B6.6.1.9 Evaluation of View C2 Description Techniques to Support UCATT

The UCATT standardisation program can be defined as a Whole Life Enterprise Phase. In order to capture and communicate UCATT business objectives, vision statements and capabilities can be defined and allocated to the UCATT Whole Life Enterprise Phase. Furthermore, the tasks given by NATO STO to the UCATT Working Group (i.e., MSG 030 aka UCATT 1) can be identified as an Enterprise Phase according to NAF v4, as part of the Whole Life Enterprise. Each enterprise phase, project(s) and milestone(s) can be allocated. Figure B-12 illustrates an example of a C2 view of the UCATT standardisation program.

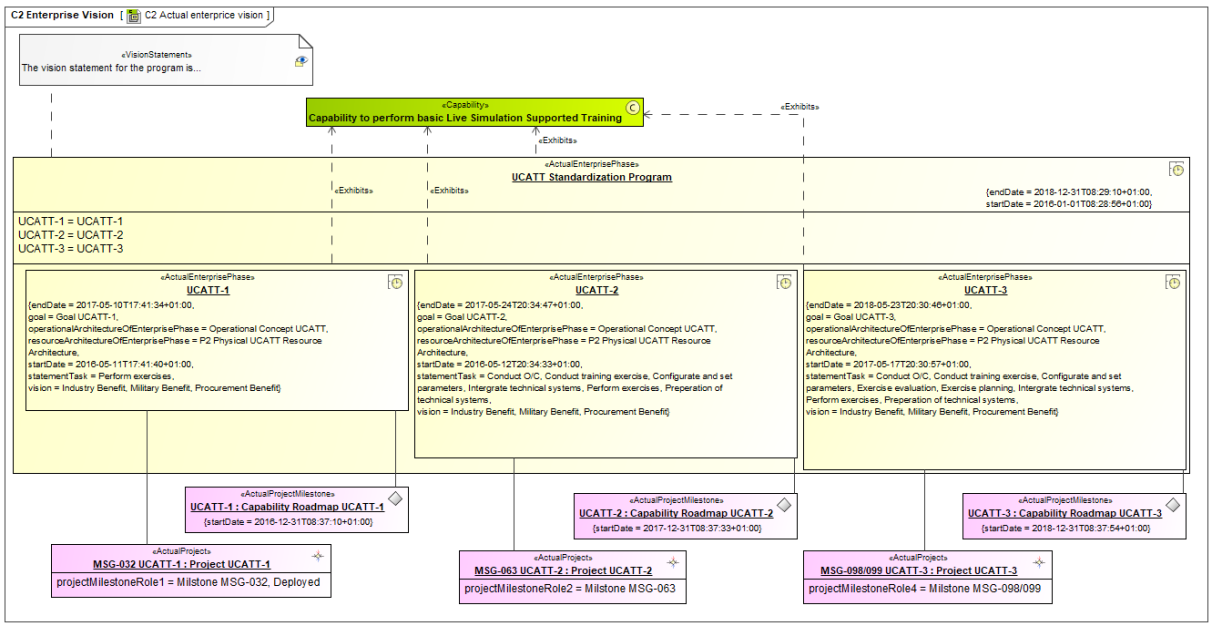


Figure B-12: Example of a C2 View.

It is recommended that the C2 Enterprise vision view is considered as an option to illustrate programmatic aspects and to facilitate the Capability Gap Analysis.

B6.6.1.10 Definition of Cr Capability Roadmap View

According to NAF v4 the purpose of the Cr view is to provide a representation of the actual or estimated availability of capabilities over a period of time (as a consequence of fielded capability configurations).

The Cr view support the capability audit process and similar processes used across different communities of interest by providing a method to identify gaps or duplication in capability provision, as part of the CGA. The view identifies capability increments, which are derived from delivery milestones within acquisition projects (Figure B-13).

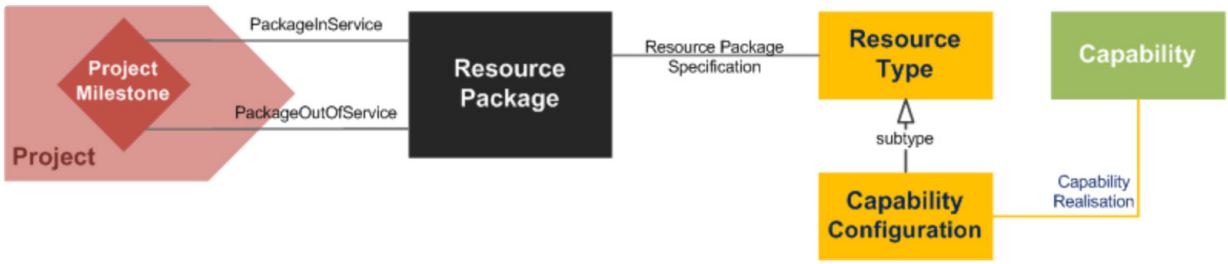


Figure B-13: Cr Key Elements and Their Relationships.

General purpose and usage:

- Capability planning (capability phasing).
- Capability integration planning.
- Capability gap analysis.
- High-level dashboard for acquisition management.

Key elements and their relationships:

- Capability.
- Resource Package.
- Capability Configuration.
- Project.
- Project Milestone.

B6.6.1.11 Evaluation of the Cr View Description Techniques to Support UCATT

The Cr view is presented as a timing chart showing capabilities on the vertical axis and time on the horizontal axis. Active capability configurations are shown as bars against the capabilities they provide, with the start and end of the bars corresponding to the capability configuration coming into and going out of service. Where nothing meets a particular capability at a particular time, whitespace is shown so as to highlight capability gaps. This approach and representation can be used to illustrate potential capabilities the set of available UCATT standard can facilitate. In other words: “If these standards are used as requirements and constraints of the realisation of a training system these capabilities will emerge.”

The Cr provides a representation of the available capability levels at different points in time or during specific periods of time (associated with the Enterprise Phases – refer to Section B6.6.1.8 and Section B6.6.1.9 and is illustrated in Figure B-14 as capabilities enforced by a set of standards. The figure illustrates that the set of standards during the timeframe between 2016 to 2019 enforces the capability to perform basic interoperable Live Simulation and the timeframe between 2019 to 2022 enforces both the capability to perform basic interoperable Live Simulation and indoor interoperable Live Simulation, etc.

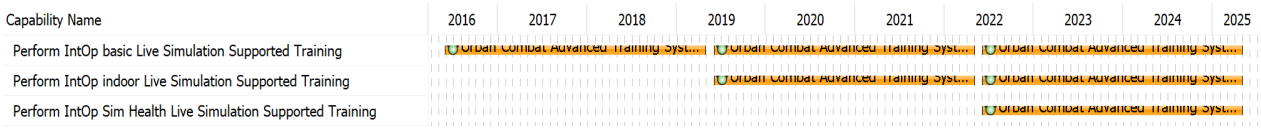


Figure B-14: Example of a Cr, Capability Roadmap.

It is recommended that the Cr Capability Roadmap view is considered as an option to illustrate programmatic aspects and to facilitate the Capability Gap Analysis.

B6.6.1.12 Recommendations

As a result of successful implementation of the business or mission analysis process, the following information will be available for UCATT-LSS:

- Problem and/or opportunity space defined.
- Characterised solution space defined.
- Operational concept defined.
- Candidate solutions defined.
- Traceability between the problem/opportunity and candidate solutions.

It is recommended that UCATT document and firmly establish the business case to be solved by the program, both short and long term. The recommended process is according to Section 6.4.1 in ISO/IEC/IEEE 15288 [Ref7]. This should be performed according to a UCATT MBSE strategy, based on the NAF v4 viewpoints. It is also recommended to perform this process retrospectively for previous UCATT phases, to create a cohesive and complete description.

B6.6.2 Stakeholder Needs and Requirements Definition Process

B6.6.2.1 Analysis of the Standard Process

According to ISO/IEC/IEEE 15288 [Ref7] the purpose of the *Stakeholder Needs and Requirements Definition Process* is to define the stakeholder requirements for a system that can provide the capabilities and services needed by users and other stakeholders in a defined environment. The process aims to analyse and transform these needs into a common set of stakeholder requirements that express the intended interaction the system will have with its operational environment, which are the references against each resulting operational capability or service is validated.

The stakeholder requirements are defined taking into consideration the context of the system of interest with interoperating systems and enabling systems.

B6.6.2.2 Analysis of UCATT Artefacts and Information

No evidence of formal management of stakeholder requirements could be identified throughout the literature study of UCATT artefacts and information. An artefact that expresses high-level requirements was identified in the Capability Requirements Matrix (CRM). The purpose of the CRM is to identify those components needed to support the training at all levels from team to brigade including non-military and Peace Support Operations (PSO). Most of the requirement statements and their related attributes do not meet an appropriate quality level of a well written and managed requirement. Furthermore, the CRM has not undergone configuration control nor been a subject to the verification and closure of derived architecture, design and utterly the standard developed by the UCATT program.

This area is a subject that should be of high priority since well written and managed requirements is one of the key backbones for the justification and quality control of developed products, from the early phases of development to the final validation of the delivered product.

B6.6.2.3 Supporting NAF v4 Viewpoints

A requirement specifies a capability or condition that must (or should) be satisfied. A requirement may specify a function that a system must perform or a performance condition a system must achieve.

There are several views, according to NAF, that can facilitate elicitation and definition of stakeholder requirements however, the standards do not cover traditional requirement structures and representations. NAF v4 should be strengthened with these structures and requirement classes, refer to Sections B6.6.2.11 and Section B6.6.2.12.

The following NAF v4 views can be used to elicit and define the context of stakeholder needs and requirements:

- C1 Capability Taxonomy, refer to Section B6.6.1.6 and Section B6.6.1.7.
- C2 Enterprise Vision, refer to sections Section B6.6.1.8 and Section B6.6.1.9.
- C7 Performance Parameters.
- Cr Capability Roadmap, refer to Section B6.6.1.10 and Section B6.6.1.11.
- S1 Service Taxonomy.
- S4 Service Functions.
- S6 Service Interactions.
- Sr Service Roadmap.

Other supporting views and notations are requirements and use case diagrams, refer to Section B6.6.1.4, Section B6.6.1.5, Section B6.6.2.11 and Section B6.6.2.12.

It is recommended that the UCATT program use the standard SysML for implementing traditional requirement management to facilitate the definition of requirements and structures.

SysML provides modelling constructs to represent text-based requirements and relate them to other modelling elements, as part of the architectural description. The requirements diagram can depict the requirements in graphical, tabular, or tree structure format. A requirement can also appear on other diagrams to show its relationship to other architectural elements. The requirements modelling constructs are intended to provide a bridge between traditional requirement management methods and information to the architectural descriptions.

B6.6.2.4 Definition of C7 Performance Parameters

Creating this type of diagram is a continuation of the definition of capabilities, according to Section B6.6.1.6.

To enable further design and support evaluation of the system operational effect, measurable quantities should be derived from identified capabilities. These capabilities and measurements will constitute the top-level requirements of the system.

The capability requirements (and existing capabilities) are often expressed in terms of measures of effectiveness (MoE). These are high-level metrics used to judge the level of capability. A C7 view lists the MoEs against the capabilities they are applicable to (Figure B-15).

Figure B-15: C7 Performance Parameters Key Elements and Their Relationships.

B6.6.2.5 Evaluation of the C7 View Performance Parameters Description Techniques to Support UCATT

The C7 view is represented as a chart illustrating the definition of measurable properties of a capability. These parameters shall constitute a set of measurable quantities, which a realised capability should be able demonstrate, to be compliant with stakeholder needs and requirements. This set can be seen as verifiable requirement statements that the operational capability configuration should be able to achieve, see Figure B-16. The C7 view can be used to define required performance levels of capabilities validated during a certification of a capability configuration.

If certification programs will be established, it is recommended that the C7 view is considered as a view to define high-level performance requirements.

#	Property Set	Performance Requirement	Measure	Metric
1	Perform IntOp Sim Health Live Simulation Supported Training	#DO	200.0	MOEV 1
2	Perform IntOp Sim Health Live Simulation Supported Training	#EXCON	2.0	MOEV 2
3	Perform IntOp Sim Health Live Simulation Supported Training	#Sites	2.0	MOEV 3
4	Perform IntOp indoor Live Simulation Supported Training	#DO	100.0	MOEV 1
5	Perform IntOp indoor Live Simulation Supported Training	#EXCON	1.0	MOEV 2
6	Perform IntOp indoor Live Simulation Supported Training	#Sites	1.0	MOEV 3
7	Perform IntOp basic Live Simulation Supported Training	#DO	80.0	MOEV 1
8	Perform IntOp basic Live Simulation Supported Training	#Players	17	Integer
9	Perform IntOp basic Live Simulation Supported Training	#EXCON	1.0	MOEV 2
10	Perform IntOp basic Live Simulation Supported Training	#Sites	1.0	MOEV 3

Figure B-16: Example of a Performance Parameters View.

B6.6.2.6 Definition of the NAF v4 Service Viewpoint

The NAF v4 service viewpoint defines an operational and logical Service-Oriented Architecture (SOA).

A SOA is primarily a collection of interrelated services, required or supplied by an organisational or system entity. These services exchange information or material, or combination thereof, between the entities. In order to provide a service, the means and rules of how to connect and perform the service is required.

An SOA is a well-documented and established method of describing functional dependencies between entities, without specifying the technical solution. The method rather focuses on defining how the service is to be executed and the technical and quantitative aspects required to integrate two or more entities in order to exchange the service. The standards developed by UCATT should be limited to defining how different training equipment (entities) should be integrated and how they interact.

Based on this perspective, the SOA methodology should be relevant to logically define and analyse the services to be standardised. An SOA approach has not been used as a method within the UCATT program, therefore no analysis of existing artefacts and information has been made nor reported in this study.

To create a basis for discussion and further planning, a comprehensive definition of relevant views is described below, see Section B6.6.2.7 to B6.6.2.10.

> **Note:** "In NAF v4 terms, a service is an implementation-independent specification of a packaged element of functionality and/or capability. There is potential for confusion between services and capabilities. The key indicator of a service is that it provides a standard interface to consumers. This means that services may be used as "wrappers" for one or more capability in order to provide a standard method of access to the capability. A well-designed service taxonomy provides a set of specifications for capability providers to adhere to."

B6.6.2.7 Definition and Analysis of the S1 Service Taxonomy View

The purpose of an S1 is to provide a governance structure for an SOA. Along with S3 (Service Interfaces), it specifies a standard library of service specifications for an enterprise, which service implementers are expected to conform to.

This standard library can be the focal point to define and specify the need and context of developed standards, without defining the solution or design, therefore constitute objectives and requirements of a standard to be developed and finally verified and published (Figure B-17).

Usage:

- SOA governance.
- Identification of services.
- Service planning.
- Service audit.
- Service gap analysis.
- Providing reference services for architectures.
- Tailoring generic services for specific applications.

Key Elements and Their Relationships:

- Service Specification.
- Service Generalisation.
- Measure Category.
- Measure.

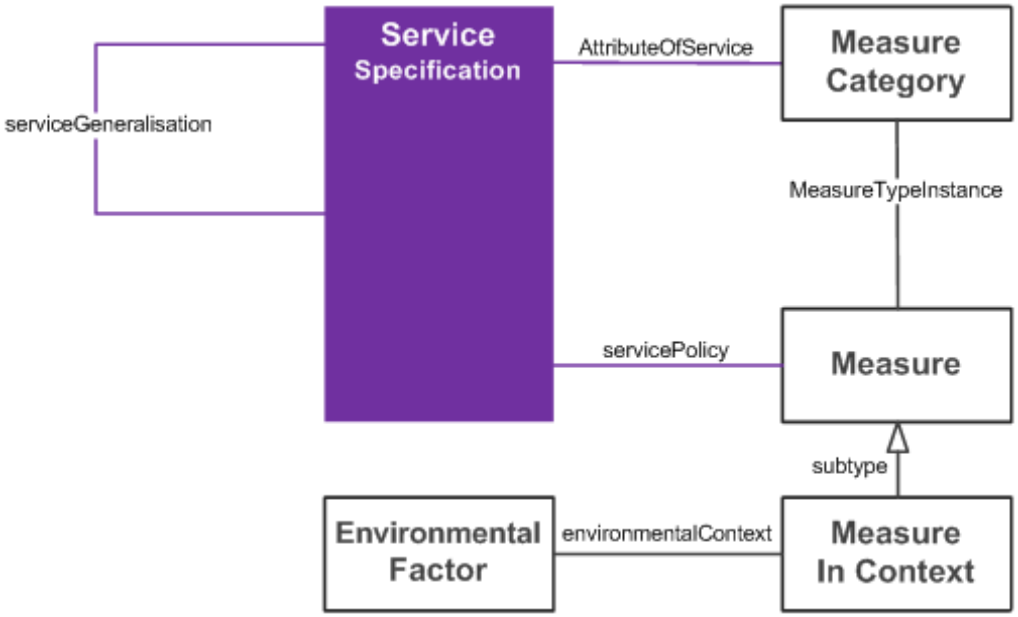


Figure B-17: S1 Service Taxonomy Key Elements and Their Relationships.

B6.6.2.8 Definition and Analysis of the S4 Service Functions View

Creating this type of diagram is a continuation of the definition of services, according to Section B6.6.2.7.

The Service Functions View (S4) defines the behaviour of a service in terms of the functions it is expected to perform.

S4 is the key behavioural specification for services. By defining service functions, structures and flows, according to S4, the diagrams and information specifies a set of functions that a service implementation is expected to perform (Figure B-18).

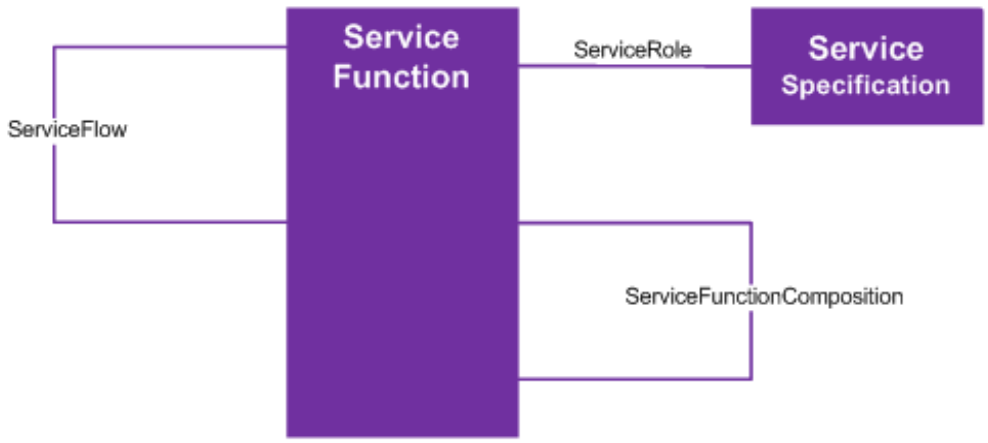


Figure B-18: S4 Service Functions Key Elements and Their Relationships.

B6.6.2.9 Definition and Analysis of the S6 Service Interactions View

Creating this type of diagram is a continuation of the definition of services, according to Section B6.6.2.8.

The purpose of the Service Interactions View (S6) is to specify how a service interacts with external agents, and the sequence and dependencies of those interactions. An S6 product does not specify the sequencing of an orchestrated set of services. Its purpose is to specify the general sequence of interactions that are possible for a given service (Figure B-19).

By defining Service Interaction Views, the rules and constraints of how to execute a service are defined. Furthermore, the sequence is a valid definition of a test case that should be performed in order to certify a product in a UCATT context.

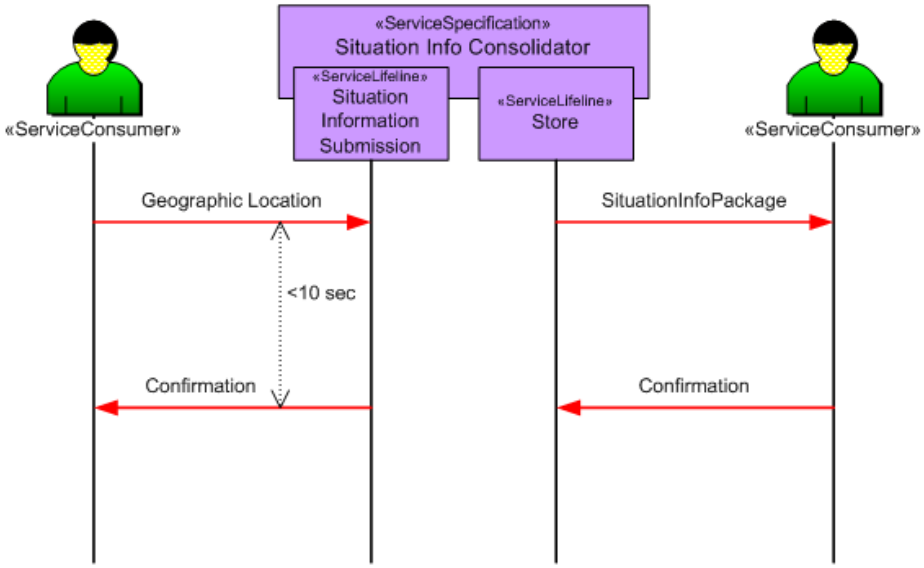


Figure B-19: Detailed View Description S6 Service Interactions.

B6.6.2.10 Definition and Analysis of the Sr Service Roadmap View

The purpose of Sr is to show versions (and version history with dates) of service specifications (Figure B-20). The Sr can support the UCATT program to manage and visualise when a service/standard is planned to be published or when it is intended to be replaced or disposed, defined as project milestones. Furthermore, the services are traceable to its associated capabilities, using the same milestones as in the Cr view indicating which capabilities are supported by implemented services and when, refer to Section B6.6.1.10.

Key Elements and Their Relationships:

- Service Specification.
- Project Milestone.
- Service Level.
- Service Specification Version Succession (relationship).

Figure B-20: Sr Service Roadmap Key Elements and Their Relationships.

B6.6.2.11 Definition of SysML Requirement Diagrams

SysML provides capabilities to represent text-based requirements and relate them to other architectural description entities (modelling elements). The requirements diagram can represent the requirements in graphical, tabular, or hierarchical format, see Figure B-9, Figure B-21 and Figure B-22. A requirement can appear on all other types of diagrams, not only the requirement diagrams, to show its relationship to other architectural description entities. This provides the capability to trace requirements to architectural description entities, creating an integrated and consistent information set. To support this, SysML defines a number of types of relations such as requirement hierarchies, derived requirements, allocation of requirements and the definition of test cases.

Types of basic relationships provided by SysML:

- SysML supports the usage of derived requirements. This relationship relates a derived requirement to its source requirement. This typically involves analysis to determine the multiple derived requirements that support a source requirement.
- To indicate how the requirement is fulfilled, SysML supports the usage of a Satisfy Relation. The Satisfy Relationship describes how a solution satisfies one or more requirements by identifying the system design elements that are intended to satisfy the requirement.
- Since the re-use of requirements is very important in many applications, the SysML standard [Ref9] defines the concept of a master/slave dependency.. The requirement text of the slave requirement is constrained to be the same as the text of the related master requirement. The master and slave requirements do not have the same relations, conditions, states, etcetera, meaning that (for example) the slave requirement can be verified and closed at the same time as the master requirement is still open. The master/slave relationship is indicated by the use of the copy relationship. This is a feature that is of special interest when running a program, which manages multiple realisations and versions of systems that partly utilises the same set of requirements.
- The refined requirement relationship can be used to describe how a model element or set of elements can be used to further refine a requirement. For example, a use case or activity diagram may be used to refine a text-based functional requirement, creating a richer description and therefore enhanced understanding of the requirement.
- The verify relationship defines how a test case or other model element verifies a requirement. In SysML, a test case or other named element can be used as a general mechanism to represent any of the standard verification methods for inspection, analysis, demonstration or test.

#	
1	F 1 Provide Linkages to:
2	F 1.1 Virtual training environment
3	F 1.2 Constructive training environment
4	F 1.3 C4I systems
5	F 1.4 Other live instrumentation systems
6	F 2 Support:
7	F 2.1 Legacy/analogue training units

Figure B-21: Example of a Tabular Requirement View.

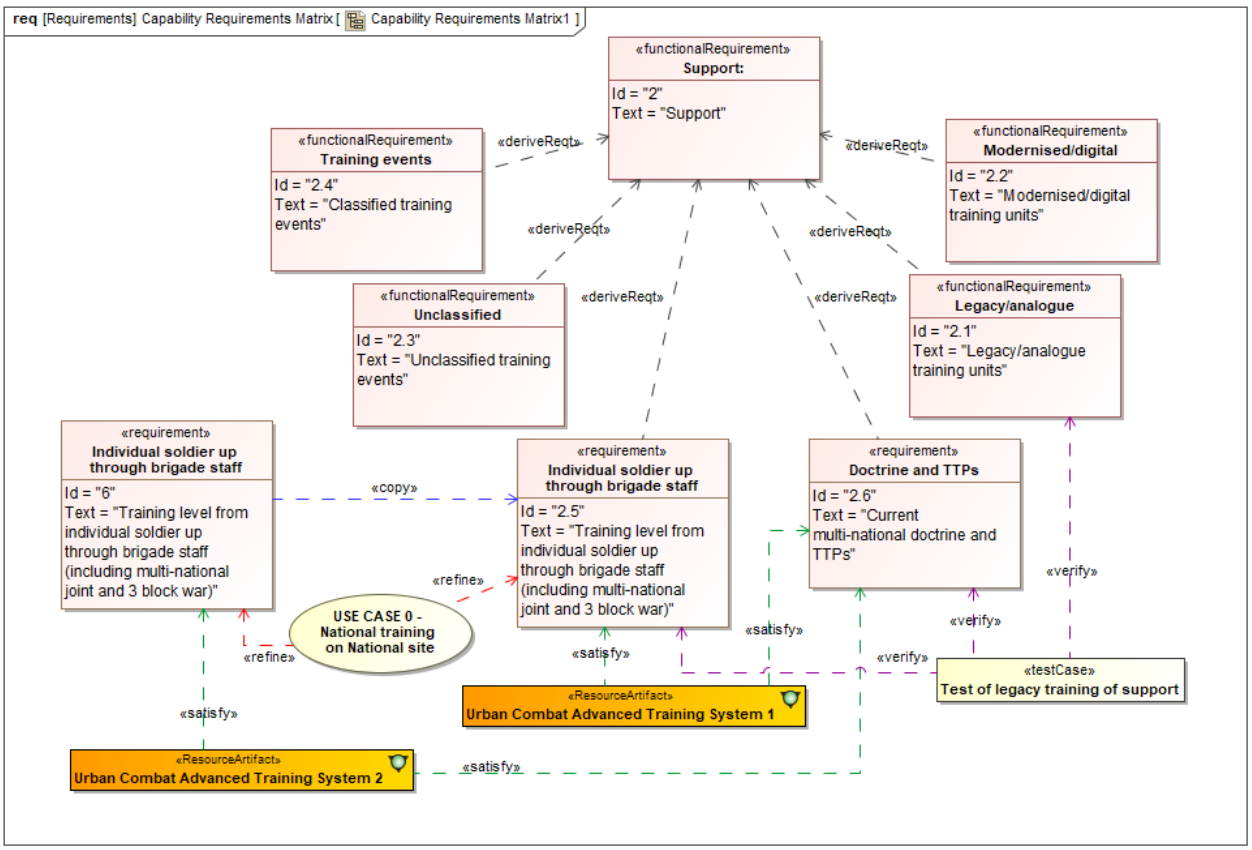


Figure B-22: Example of a Requirement Diagram.

B6.6.2.12 Evaluation of the SysML Requirement Diagrams View Description Techniques to Support UCATT

The only evident requirement artefact developed by UCATT is the Capability Requirements Matrix, refer to Section B6.6.1.7. During UCATT projects, little or no effort to derive, structure or allocate requirements are made, which means that traceability from requirements to system elements and therefore UCATT artefacts is not documented. In other words, there is no basic documentation of performed requirements analysis and architectural design, therefore the traceability from system requirements down to the identified and defined standards and interfaces are undefined.

Certification of products, in a multi-national context, is an important evolutionary step for the UCATT program. The SysML notation supports the definition and specification of test cases. An appropriate usage of these capabilities is a certification program for UCATT-compliant products which can be defined and specified.

It is recommended to perform and document a re-engineering of current status using SysML and NAF v4 to facilitate proper requirement management, re-use and traceability to the UCATT artefacts, and furthermore enhance the definition of a generic set of verification methods and test cases for product certification (in a UCATT context).

B6.6.2.13 Recommendations

As a result of successful implementation of the stakeholders needs and requirements definition process the following information will be available for UCATT-LSS:

- UCATT stakeholders of the system are identified.
- Required characteristics and context of use of capabilities and concepts in the life cycle stages, including operational concepts, are defined.
- Constraints on a system are identified.
- UCATT stakeholder needs are defined.
- UCATT stakeholder needs are prioritised and transformed into clearly defined stakeholder requirements.
- Critical performance measures are defined.
- UCATT stakeholder agreement that their needs and expectations are reflected adequately in the requirements is achieved.
- Any enabling system or services needed for stakeholders needs and requirements are available.
- Traceability of UCATT stakeholders' requirements to UCATT stakeholders and their needs is established.

Stakeholders are recommended, at a minimum, to be categorised into the following:

- Acquirer / Owner.
- User.
- Supplier.
- Builder.

It is recommended that UCATT verify the stakeholders needs and requirements by performing a tailored analysis according to Section 6.4.2.3 in ISO/IEC/IEEE 15288 [Ref7]. This should be performed according to a UCATT MBSE strategy, based on the SysML notation and NAF v4.

B6.6.3 System Requirements Definition Process

B6.6.3.1 Analysis of the Standard Process

The purpose of the *System Requirements Definition Process* is to transform the stakeholder, user-oriented view of desired capabilities and services into a technical-driven view of a solution that could deliver those capabilities and services.

When the process is completed, the following information is generated:

- System constraints and environment.
- System interfaces.
- Required system functions, performances and qualities.
- System Non-functional requirements.
- System design constraints.

The aim of the process is to:

- Ensure that all stakeholder requirements are managed and analysed.
- Define critical properties and metrics of the system.
- Create traceability between stakeholder requirements and needs and system requirements.

B6.6.3.2 Analysis of UCATT Artefacts and Information

The prime input to this part of the study is the standard SISO-GUIDE-003-00-2016, Guide for UCATT Live Simulation Standards and Architecture. The standard covers aspects such as:

- Functional Architecture.
- Internal and External Interfaces.
- Interface Definitions.
- Physical Architecture.
- Physical Interfaces.
- Functional allocation.
- Design constraint/guidelines (OSI 7 Layer Model).

The standard is a guide and defines a logical definition of a UCATT Live Simulation system, aimed at providing joint and combined military training through the ability to interconnect live simulation training systems, otherwise known as Combat Training Centres (CTCs). CTCs contain a multitude of interfaces over which data is sent and received before, during and after an exercise. The standard identifies interfaces needed to be standardised, to achieve full interoperability.

The standard does not cover other important aspects of the system and its operational context which is vital for the systems engineering process and the design of the system. Furthermore, the standard does not trace back to stakeholder requirements and expectations, nor does it identify the use cases and capabilities. This creates limited capabilities to perform verification and validation of produced artefacts and information to perform efficient program and configuration management.

One outcome of this approach is that only a few individuals can make a relevant interpretation and evaluation of the standards. This will have a negative effect on the development of new standards making it difficult to introduce new resources into the program and the consequence is that the program is dependent on a few individuals. The spread and use of standards can also be limited to the organisations and companies involved in the process of developing the standards, which counteract one of the main objectives of the standards in the first place.

Other documents considered as inputs to the study was the STO Technical Report TR-MSG-098 Urban Combat Advanced Training Technology Architecture. This report also covers aspects such as:

- Use cases.
- Capabilities.
- Stakeholder requirements.
- Logical operational node entities (e.g., Dynamic Object, Observer/Controller etcetera).
- High-level processes and tasks.

Since the information is baselined at the time of the reporting date, less confidence in the accuracy of the information can be made at this point. One of the benefits of having an integrated architectural description is the enhanced capability to perform an engineering change process and to support efficient configuration management.

B6.6.3.3 Supporting NAF v4 Viewpoints

The Stakeholder Needs and Requirements Process (refer to Section B6.6.2), defines the focal point of creating a description of the logical system architecture of the system to be realised, with associated system requirements and constraints. A major output is to identify the operational context and concept of operation to identify external dependencies and interfaces.

The purpose is to define, analyse and compile relevant system requirements that satisfy stakeholders' needs as well as fulfilling technical constraints and predicted operating environments.

There are several views, according to NAF v4, that can facilitate elicitation and definition of a logical architectural description and system requirement however, the standard does not cover traditional requirement structures and representations. NAF v4 should be strengthened with these structures and requirement classes, refer to Section B6.6.2.11 and B6.6.2.12.

The following NAF view can be used to elicit and define the context of stakeholder requirements:

- S1 Service Taxonomy, refer to Section B6.6.2.7.
- S4 Service Functions, refer to Section B6.6.2.8.
- S6 Service Interactions, refer to Section B6.6.2.9.
- Sr Service Roadmap, refer to Section B6.6.2.10.
- L1 – Node Types.
- L2 – Logical Scenario.
- L3 – Node Interactions.
- L4 – Logical Activities.

- L7 – Logical Data Model.
- Lr – Lines of Development.

Other supporting views and notations are requirement and use case diagrams, refer to Sections B6.6.1.4, B6.6.1.5, B6.6.2.11 and B6.6.2.12.

B6.6.3.4 Definition of the L1 Node Types View

According to NAF v4 (http://nafdocs.org/), an L1 view specifies the types of logical nodes used in the architecture.

These nodes are logical representations of entities, used in the logical architecture that should perform something that is desired or required by the stakeholder. The logical nodes are the required operational entities that are required to fulfil stated capabilities, refer to Sections B6.6.2.6 and B6.6.1.7. They are not necessarily a representation of the solution, rather a definition/entity used to perform system analysis and to structure and document requirements. A logical node is normally a representation of what an organisation can or have to perform, consisting of a combination of methods, personnel and equipment used. Nodes can be organised into a hierarchical structure of subtype-supertype.

To be able to express the level of performance, Measures of Performance (MoP) should be defined. These MoP's are dependent of what the logical node is required to perform as well as the environments in which the logical node is required to operate. The operational aspects are considered in the L4 view, Logical Activities, refer to Section B6.6.3.11.

The primary output is the definition of user requirements, operational planning and high-level systems requirements.

An L1 can either be shown as a diagram that traces nodes to capabilities, also showing required MoP, or as a table (Figure B-23).

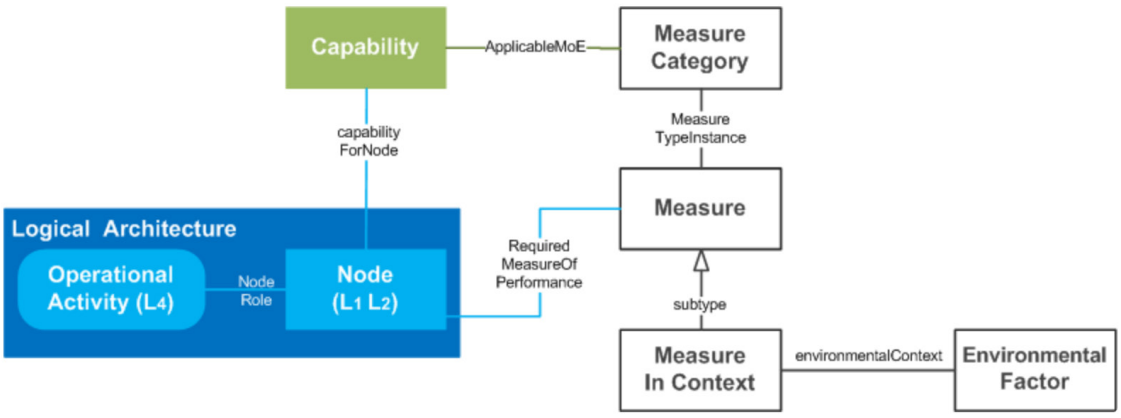


Figure B-23: L1 Node Types Key Elements and Their Relationships.

B6.6.3.5 Evaluation of the L1 Node Types View Description Techniques to Support UCATT

The L1 node type view enable the capability to create logical structures (see Figure B-25) and to document interfaces (see Figure B-27), rules, constraints and patterns (see Figure B-26) to determine how to apply

these logical elements in an operational context (see Figure B-24). The goal is to create a definition as perceived from an operational perspective and not from a solution-oriented viewpoint. The L1 view should manifest a design-agnostic architecture that can support a long-term approach to standard development and system design.

Current architectural descriptions have a solution-oriented approach, constraining the flexibility in the design trade space in the future. Furthermore, current documentation lacks well defined requirements, critical performance measures, properties and constraints, decreasing the capability to verify and validate the design.

It is recommended to create a logical structure that reflects an operational and design-agnostic architecture of the system, at a high level to ensure traceability to stakeholder needs as well as to identify key aspects of the system, such as operational performers, interfaces, performance measures, patterns and constraints.

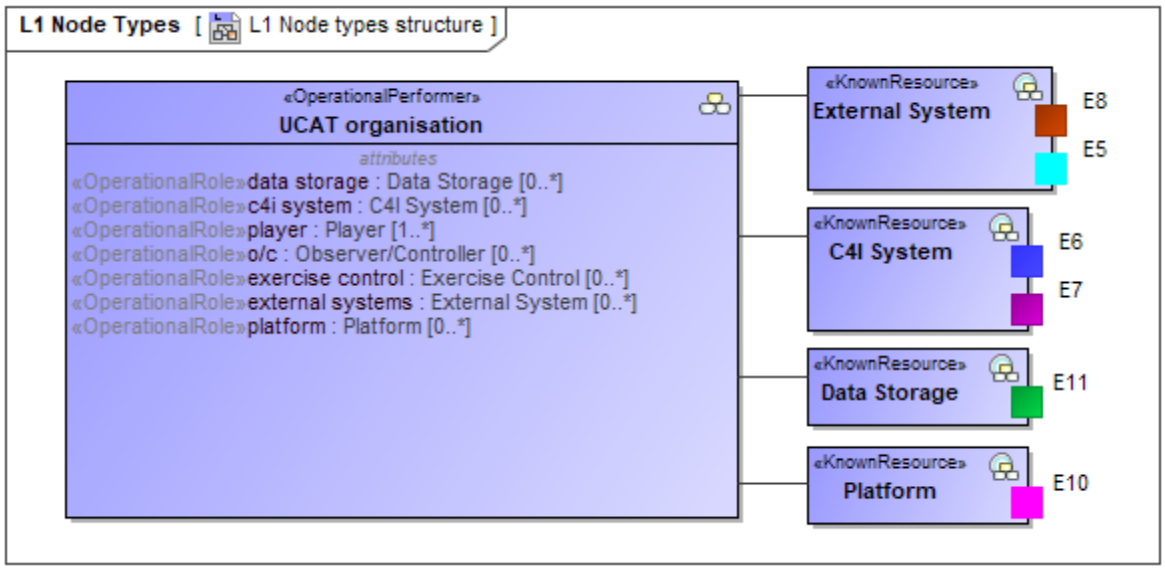


Figure B-24: Example of a Logical System Context with Exposed External Interfaces.

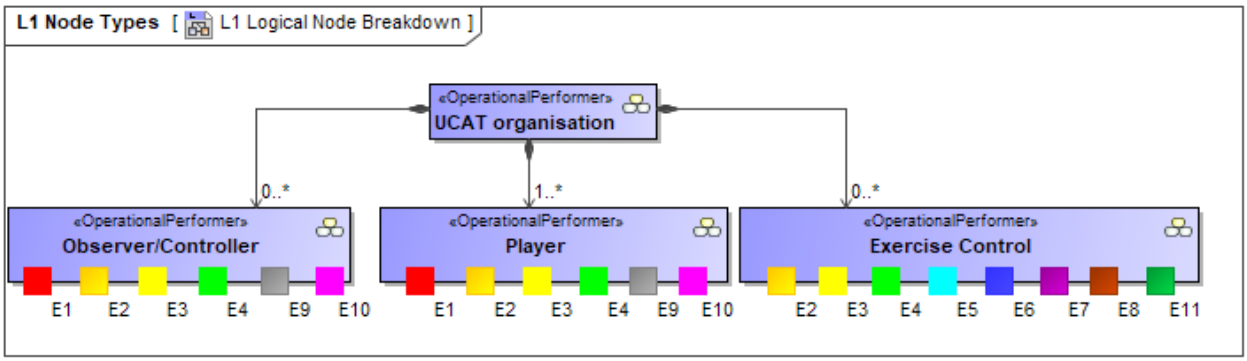


Figure B-25: Example of a Logical Breakdown of the System, with Exposed Interfaces.

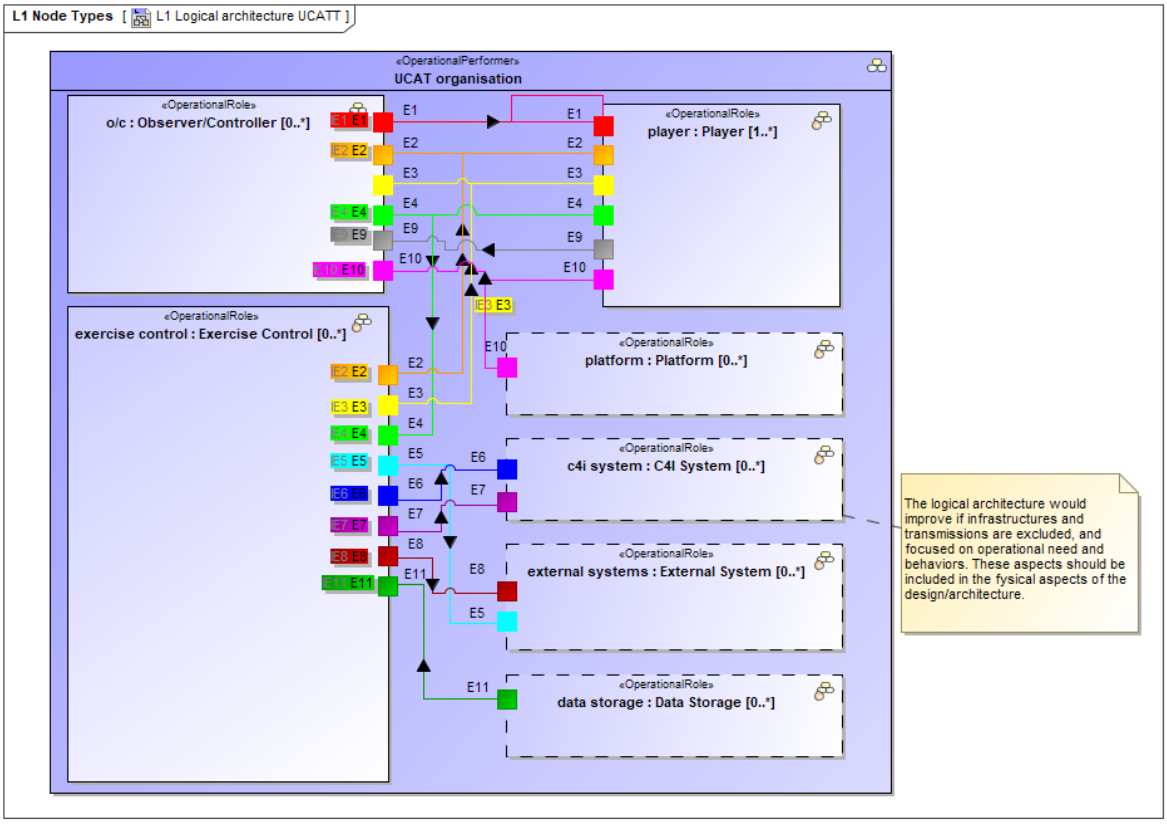


Figure B-26: Example of a Logical Architectural Pattern, with Exposed Interfaces and Information.

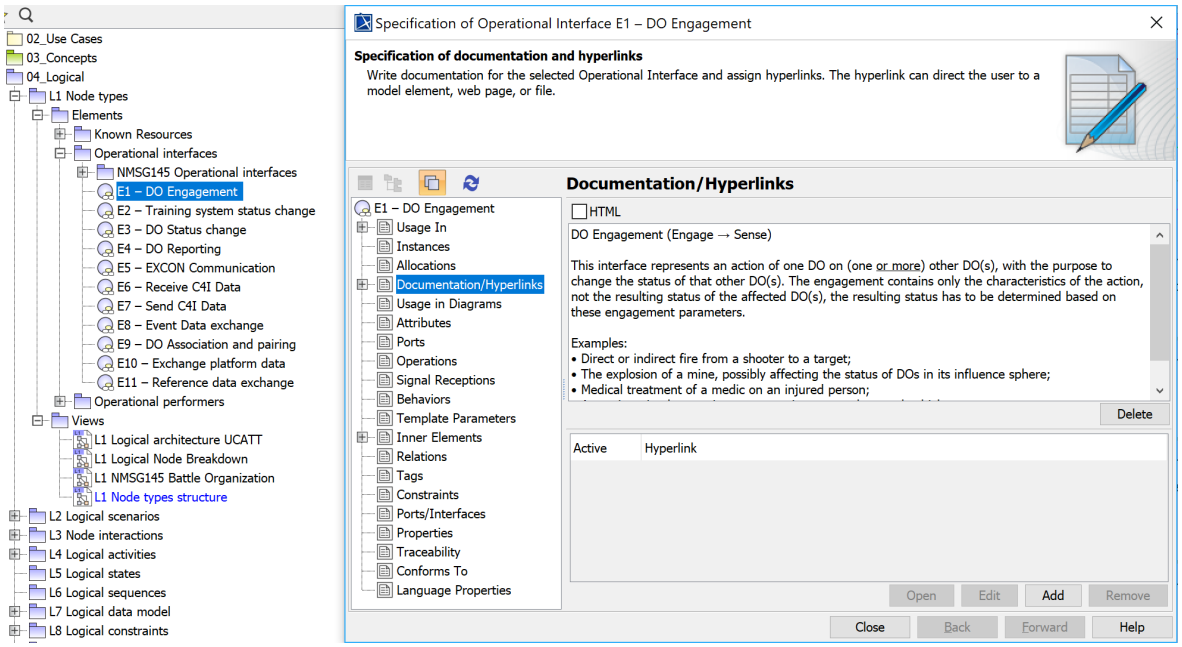


Figure B-27: Example of a Definition of an Operational Information Object (Interface Definitions).

B6.6.3.6 Definition of the L2 Logical Scenario View

According to NAF v4 (http://nafdocs.org/), the L2 Logical Scenario view shows, at a high level, the interactions between logical nodes and places them in the context of location(s) (Figure B-28).

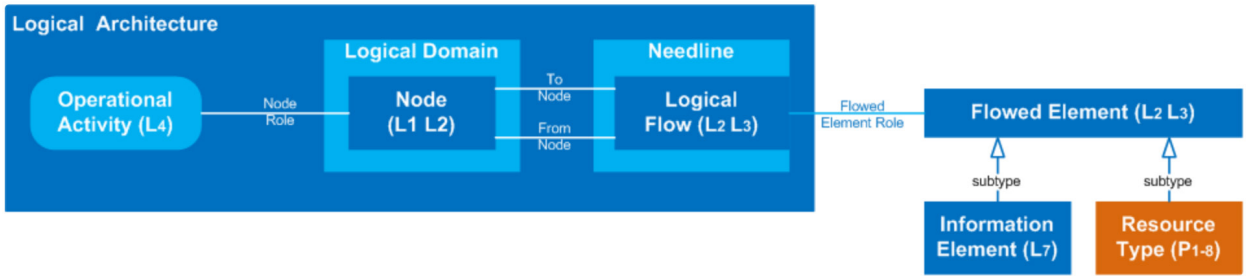


Figure B-28: L2 Logical Scenario Key Elements and Their Relationships.

The L2 view is intended to be a logical model and therefore strive to be solution independent to create a baseline of information that does not constrain the design of the system and to create a set of information that can be reused during the evolutionary steps of the organisation and products.

The primary purpose of the L2 View is to specify nodes in relation to each other, refer to Sections B6.6.3.4 and B6.6.3.5. This view primarily expresses the relationships between defined logical nodes. These can be expressed as flows of materiel, human resource or energy. The context is usually expressed in terms of the information that flows between the nodes. The analysis is based upon a given scenario and is used to define high-level requirements of flows between nodes to achieve specified capabilities.

The primary output is the definition of operational concepts, elaboration of capability requirements, definition of collaboration needs, associating capability with a location, problem space definition, operational planning and supply chain analysis.

B6.6.3.7 Evaluation of the L2 Logical Scenario View Description Techniques to Support UCATT

The L2 Logical Scenario view enable the capability to define, at a high level, the interactions between logical nodes and places them in the context of location(s) (Figure B-29). These operational configurations shall follow the rules and patterns defined in the L1 view, refer to Section B6.6.3.5.

Several configurations can be defined expressing different operational capabilities and missions, supporting the business and requirement process, express stakeholder needs and to define and evaluate system requirements and constraints. These configurations can also be used to define verification and validation concepts of the system.

To ensure that current architecture definition supports stated stakeholder needs, it is recommended to create operational concepts that reflects defined use cases (refer to Section B6.6.1.6). Furthermore, it is recommended to create concepts appropriately to verify and certify realised operational systems.

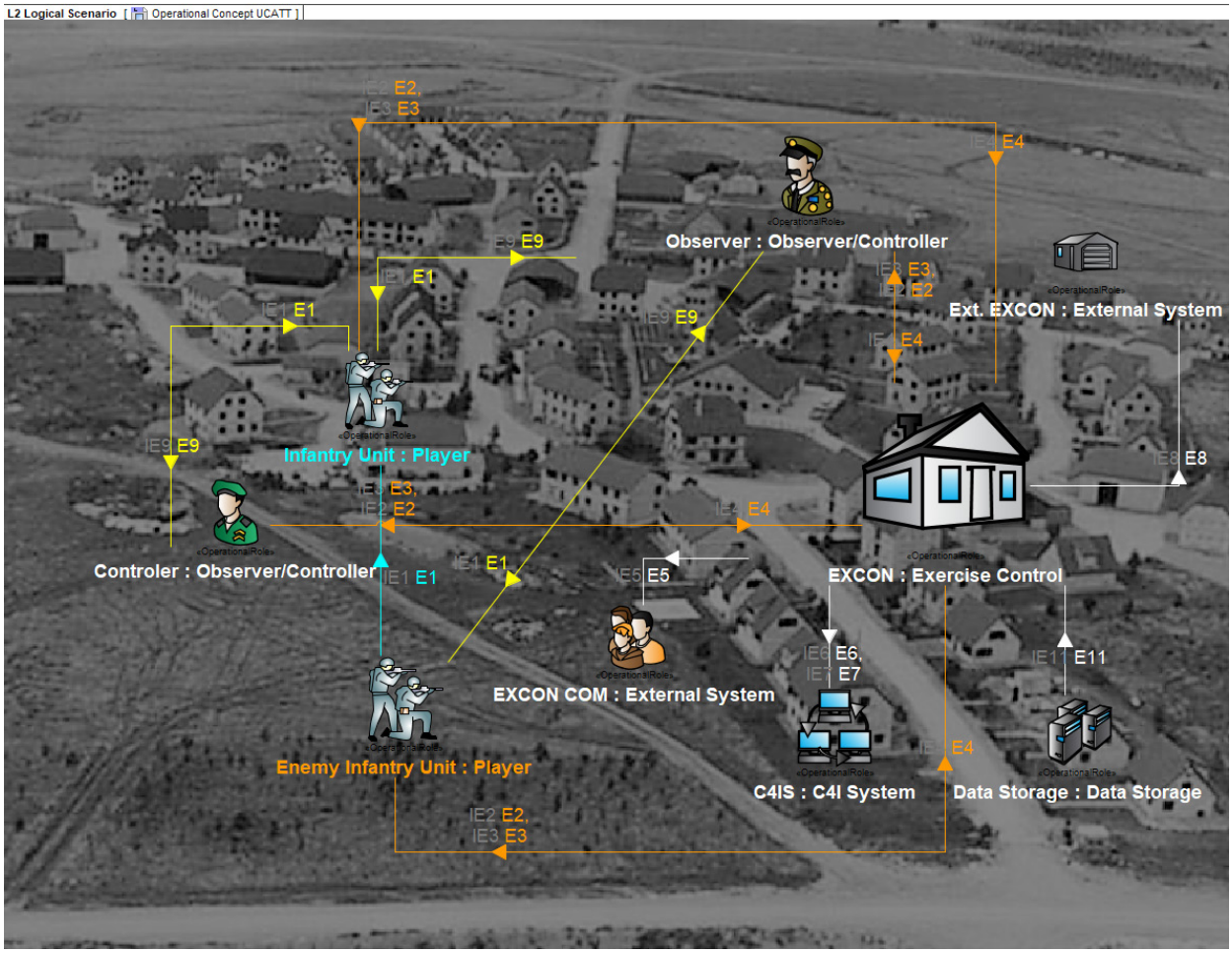


Figure B-29: Example of a Logical Scenario Description.

B6.6.3.8 Definition of the L3 Node Interactions View

According to NAF v4 (http://nafdocs.org/), the L3 Node Interactions view addresses operational information exchanges between nodes. This view creates a detailed definition of the flows (information, materiel, energy and human resources) addressed in the L2 Logical Scenario, refer to Sections B6.6.3.6 and B6.6.3.7. The major output is a definition of the information exchanges required to support interoperability aspect of the system (Figure B-30).

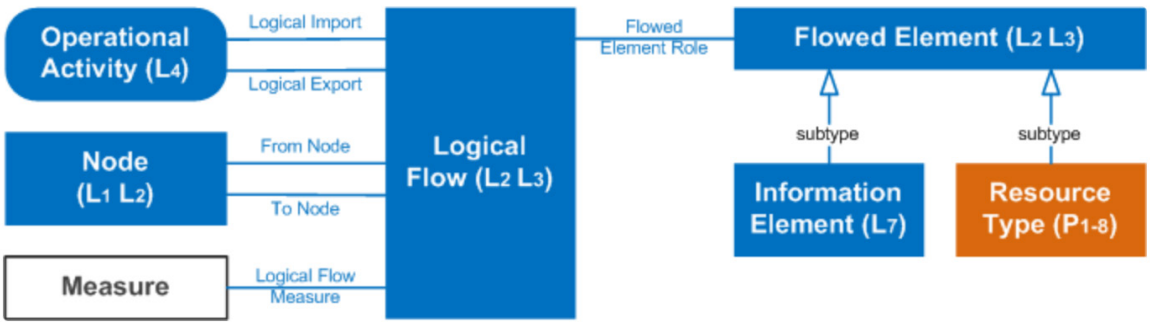


Figure B-30: L3 Node Interactions Key Elements and Their Relationships.

The primary outputs are definition of operational concepts, elaboration of capability requirements, definition of collaboration needs, associating capability with a location, problem space definition, operational planning, supply chain analysis and security models.

B6.6.3.9 Evaluation of the L3 Node Interactions View Description Techniques to Support UCATT

The L3 Node Interactions view enable the capability to define operational information exchanges between nodes and furthermore, identify related operational activities (see Figure B-31) defined in the L4 view (refer to Section B6.6.3.10). These operational exchanges are according to the operational configurations defined in the L2 view (refer to Section B6.6.3.7) or the patterns according to the L1 view (refer to Section B6.6.3.5) (Figure B-31).

By using a professional enterprise architectural tool, interactions are derived from other views, primarily the L1 and L2 view.

To ensure a consistent and percipient architectural description, it is recommended to use a professional tool.

#	Exchange ID	Operational Exchange Item	Sending Role	Sending Operational Performer	Receiving Role	Receiving Operational Performer	Producing Operational Activity	Consuming Operational Activity
1	OE25	IE1 E1	o/c : 04_Logical::L1 Node typ...	Observer/Controller	player : 04_Logical::L1 Node t...	Player	Engage	Sense
2	OE25	IE1 E1	Controler : 04_Logical::L1 No...	Observer/Controller	Infantry Unit : 04_Logical::L1 ...	Player	Engage	Sense
3	OE25	IE1 E1	Observer : 04_Logical::L1 No...	Observer/Controller	Infantry Unit : 04_Logical::L1 ...	Player	Engage	Sense
4	OE25	IE1 E1	Observer : 04_Logical::L1 No...	Observer/Controller	Enemy Infantry Unit : 04_Log...	Player	Engage	Sense
5	OE42	IE1 E1		Player		Player	Engage	Sense
6	OE42	IE1 E1	Enemy Infantry Unit : 04_Log...	Player	Infantry Unit : 04_Logical::L1 ...	Player	Engage	Sense
7	OE26	IE2 E2	exercise control : 04_Logical::...	Exercise Control	player : 04_Logical::L1 Node t...	Player	Control System Status	Sense
8	OE26	IE2 E2	EXCON : 04_Logical::L1 Node...	Exercise Control	Enemy Infantry Unit : 04_Log...	Player	Control System Status	Sense
9	OE26	IE2 E2	EXCON : 04_Logical::L1 Node...	Exercise Control	Infantry Unit : 04_Logical::L1 ...	Player	Control System Status	Sense
10	OE36	IE2 E2	exercise control : 04_Logical::...	Exercise Control	o/c : 04_Logical::L1 Node typ...	Observer/Controller	Control System Status	Sense
11	OE36	IE2 E2	EXCON : 04_Logical::L1 Node...	Exercise Control	Controler : 04_Logical::L1 No...	Observer/Controller	Control System Status	Sense
12	OE36	IE2 E2	EXCON : 04_Logical::L1 Node...	Exercise Control	Observer : 04_Logical::L1 No...	Observer/Controller	Control System Status	Sense
13	OE27	IE3 E3	exercise control : 04_Logical::...	Exercise Control	player : 04_Logical::L1 Node t...	Player	Control Dynamic Object Status	Sense
14	OE27	IE3 E3	EXCON : 04_Logical::L1 Node...	Exercise Control	Enemy Infantry Unit : 04_Log...	Player	Control Dynamic Object Status	Sense
15	OE27	IE3 E3	EXCON : 04_Logical::L1 Node...	Exercise Control	Infantry Unit : 04_Logical::L1 ...	Player	Control Dynamic Object Status	Sense
16	OE34	IE3 E3	exercise control : 04_Logical::...	Exercise Control	o/c : 04_Logical::L1 Node typ...	Observer/Controller	Control Dynamic Object Status	Sense

Figure B-31: Example of a Node Interactions.

B6.6.3.10 Definition of the L4 Logical Activities View

According to NAF v4 (http://nafdocs.org/), the L4 Operational Activity Model describes the operations that are normally conducted in the course of achieving a mission or a business goal. The view aims to create a normative description of required operational activities to perform the objectives for the organisation. The analysis should also address and describe the logical order of activities and associated flows, input and output, both internal to the scope of the architecture as well as external (Figure B-32).

According to NAF v4 (http://nafdocs.org/), L4 describes the operational processes and activities that are being conducted within the mission or scenario. L4 can be used to:

- Clearly delineate lines of responsibility for activities when coupled with L2 – Logical Scenario;
- Uncover unnecessary operational activity redundancy;
- Make decisions about streamlining, combining, or omitting activities;
- Define or flag issues, opportunities, or operational activities and their interactions (information flows among the activities) that need to be scrutinised further; and
- Provide a necessary foundation for depicting activity sequencing and timing in L8 – Logical Constraints, L5 – Logical States, and L6 – Logical Sequence.

An operational activity should strive to be on a high level and not be specific of how it is carried out. This is addressed later in the solution space of the system, refer to Section B6.6.4.

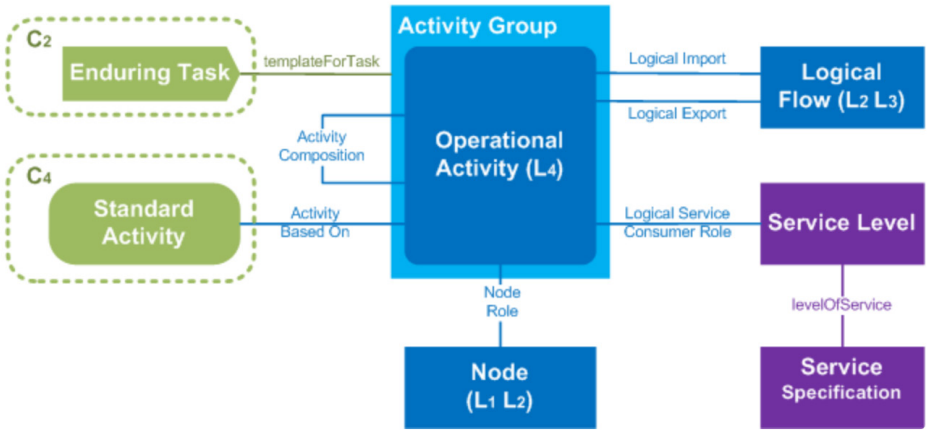


Figure B-32: L4 Logical Activities Key Elements and Their Relationships.

B6.6.3.11 Evaluation of the L4 Logical Activities View Description Techniques to Support UCATT

One key aspect to define the problem space, mission objectives and constraints of a capability configuration is the definition of an operational context. A vetted definition will support the development of qualitative interoperable standards. Architectural methodologies facilitate the definition of a formal and quality assured operational concept.

The main elements that should be investigated and understood are:

- Operational objectives.
- Operational training services being delivered.
- Concepts to achieve operational objectives. (e.g., the tasks and responsibilities of the various parties involved).
- Organisational and program strategies.

The L4 Logical Activities view enable the capability to describe the operations that are normally conducted in the course of achieving a mission or a business goal. It describes operational activities, input and output flows between activities and to or from activities that are outside the scope of the architecture. For example, the system functions defined in the UCATT Functional Architecture, as depicted both in Figure B-33 and Figure B-34, can be captured in a NAF L4 Logical Activities view as depicted in Figure B-35.The L4 view is a vital analysis of how an organisation will act in order to fulfil its mission objectives, both as required by external interfaces as well as current law, doctrines and procedures. Further analysis will define to what level the system shall support these activities therefore, the L4 view is a vital prerequisite to the definition of well-structured and balanced systems requirements.

Current architectural artefacts contain limited operational information and is not structured in a comprehensive manner, creating uncertainties of operational requirements and context. Preferably, the identified use cases should be analysed and documented.

To document interoperable aspects of the system as well as to facilitate full traceability, from stakeholder requirements to the design, it is recommended to perform a more formal operational analysis, covering critical interfaces and operational procedures and rules. To focus and constrain the analysis defined, use cases should be revised to create a more complete set of use cases required to capture all appropriate states and modes.

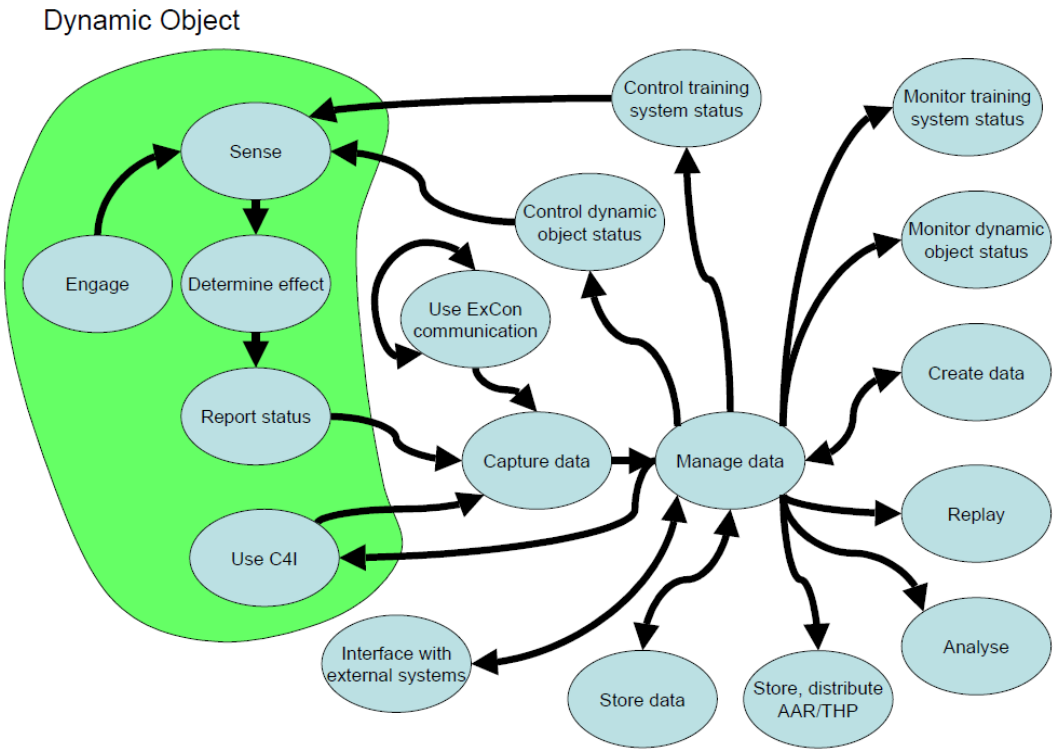


Figure B-33: The System Functions of a Dynamic Object According to TR-MSG-032.

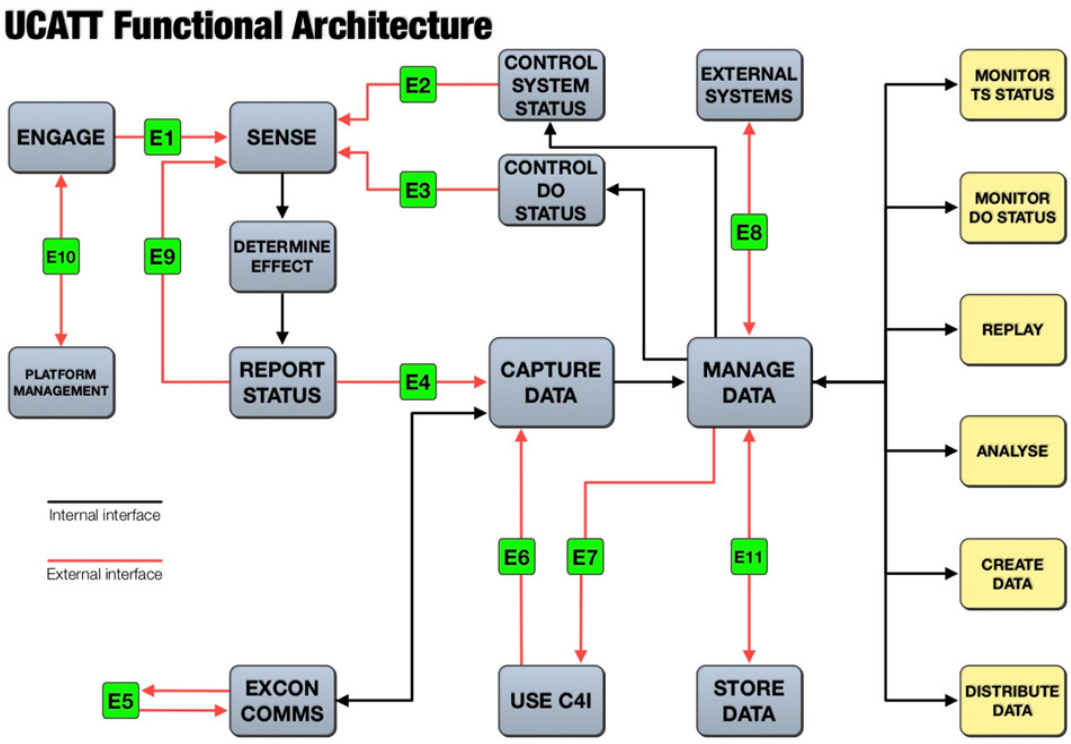


Figure B-34: UCATT Functional Architecture According to SISO-GUIDE-003-00-2016.

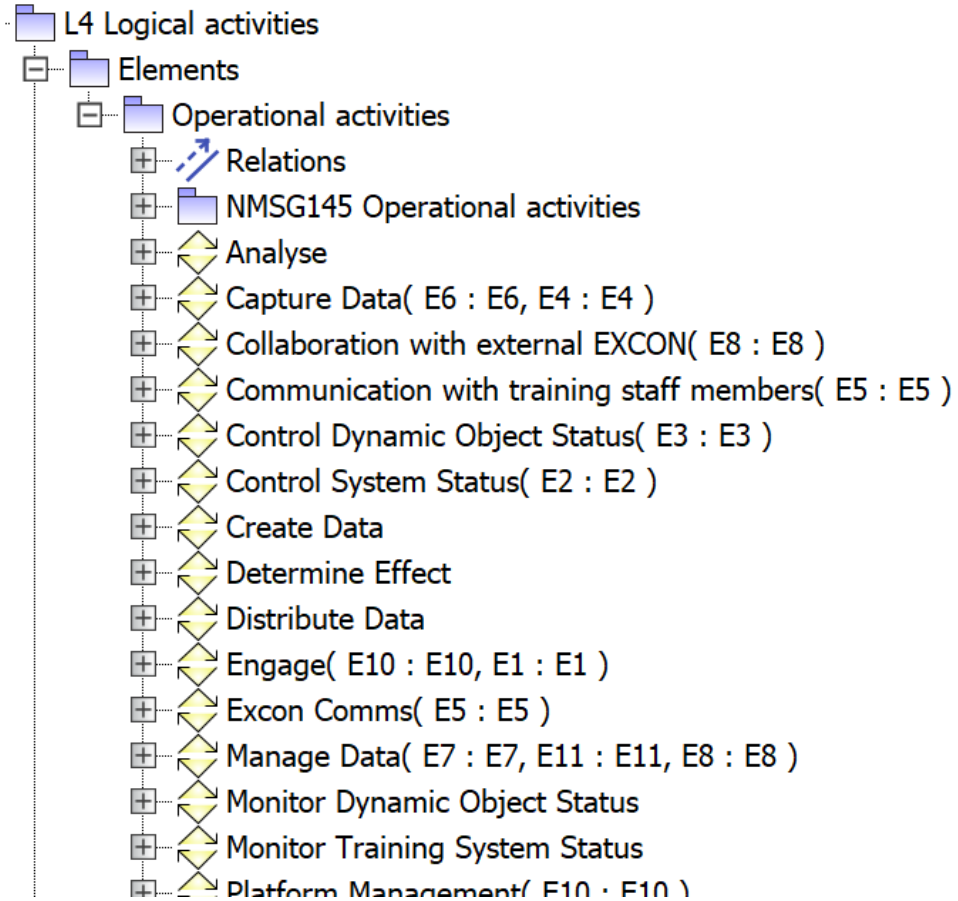


Figure B-35: Example of Definitions of System Functions with Exposed Interfaces.

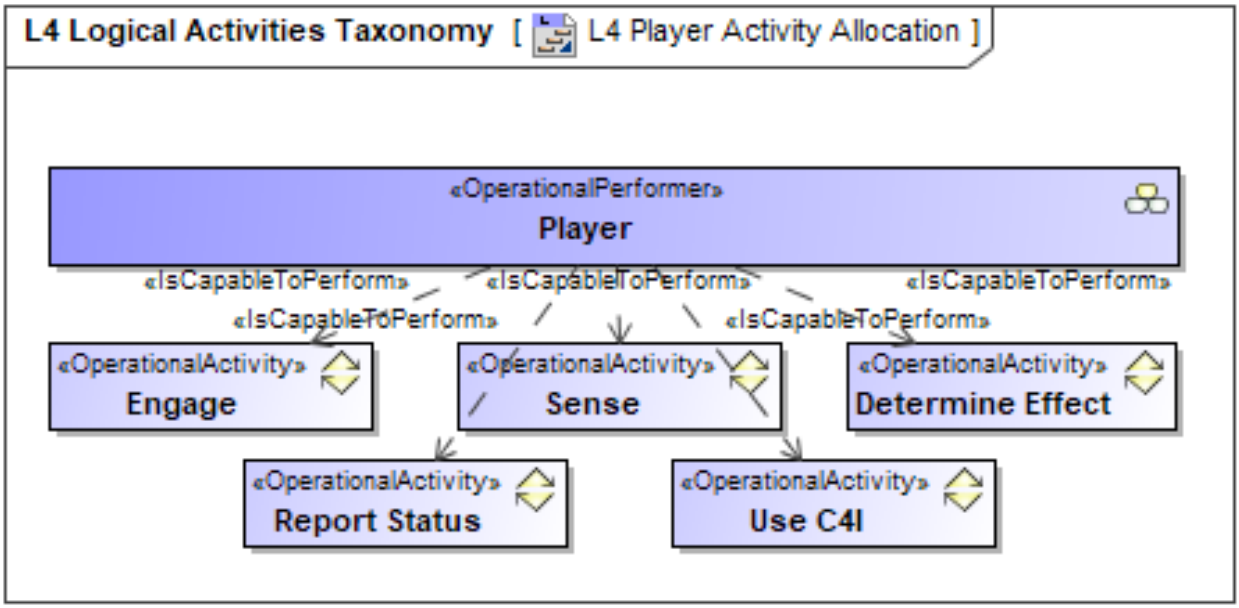


Figure B-36: Example of Allocation of System Functions to an Operational Performer.

B6.6.3.12 Definition of the L7 Logical Data Model View

According to NAF v4 (http://nafdocs.org/), the L7 Logical Data Model view addresses the information perspective on an operational architecture (Figure B-37). In software engineering, an entity-relationship model is commonly formed to represent things that a business needs to remember in order to perform business processes. Consequently, the entity-relationship model becomes an abstract data model that defines a data or information structure which can be implemented in a database, typically a relational database.

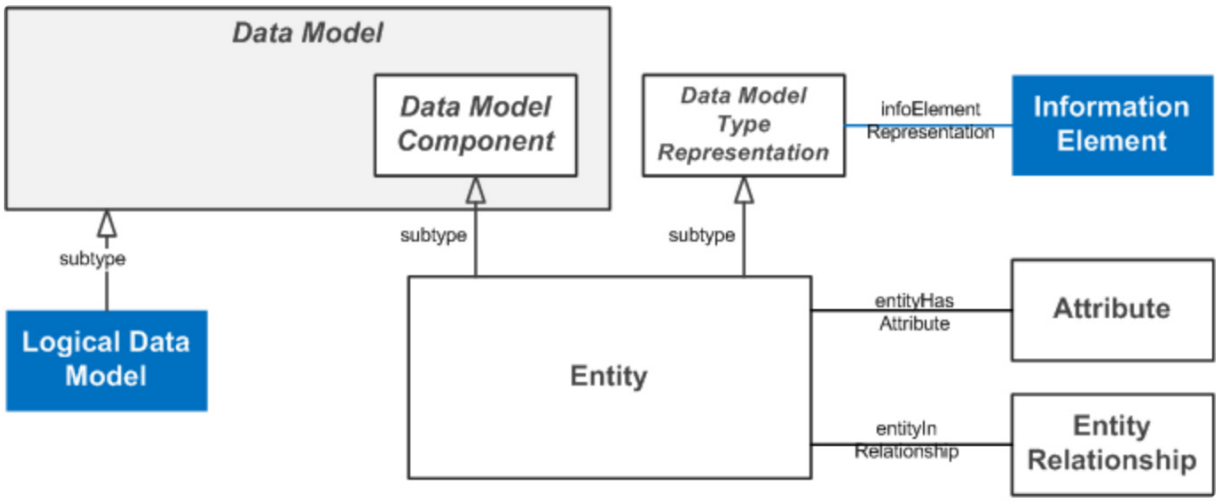


Figure B-37: L7 Logical Data Model Key Elements and Their Relationships.

The L7 is a type of entity-relationship model that describes interrelated things of interest in a specific domain of knowledge. A basic entity-relationship model is composed of entity types (which classify the things of interest) and specifies relationships that can exist between instances of those entity types. The L7 represents a logical model of the information used and exchanged by the organisation, when performing its activities in order to reach business or mission goals. Therefore, the L7 expresses the definitions, relations and rules that applies to the information (for example to be compliant with laws and doctrines) and not necessarily the design and implementation of the realised system.

The main objective of the L7 view is to describe the information that is associated with the information exchanges of the architecture. As a consequence, the entity-relationship model includes information items, their attributes or characteristics, and their inter-relationships. The primary output is the business information requirements and structural business process rules of the Information architecture.

B6.6.3.13 Evaluation of the L7 Logical Data Model View Description Techniques to Support UCATT

The L7 Logical Data Model view enables the capability to describe the information perspective on an operational architecture. The L7 view facilitates the capability to create information models expressing rules and definitions of information items, their attributes or characteristics, and their inter-relationships (Figure B-38). The L7 view is an analysis, vital to define exposed systems interfaces. These information elements are an important part to define services according to Sections B6.6.2.7, B6.6.2.8, B6.6.2.9 and B6.6.2.10 supported by the technical system and therefore a prerequisite to exposed technical interfaces which is part of the UCATT standard suite.

Current architectural artefacts contain a limited information definition/model and is not structured in a comprehensive manner, creating uncertainties of operational requirements and context.

To decrease uncertainties, it is recommended that a more comprehensive analysis is performed and documented, such as an entity-relationship model of information exchanged in exposed interfaces.

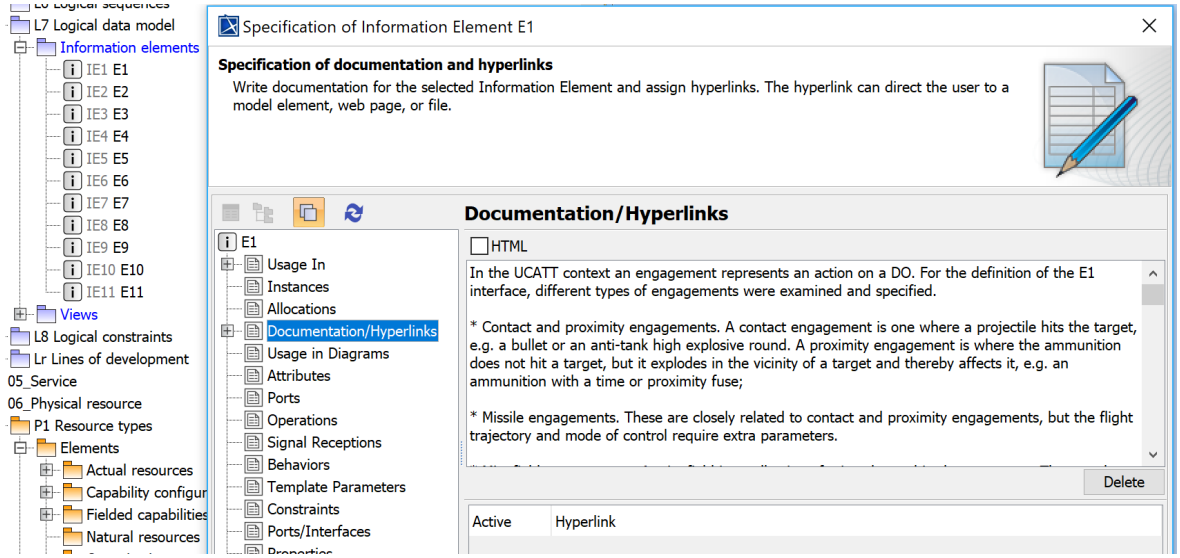


Figure B-38: Example of Embedded Information in an Information Element Class.

B6.6.3.14 Definition of the Lr Lines of Development View

According to NAF v4 (http://nafdocs.org/), the Lr view specifies the logical threads (lines of development) for a set of projects and programs (Figure B-39). The status of each line of development can be shown at the various milestones in projects or programs. The Lr view is a type of bar chart that illustrates the schedule to deploy lines of development. This diagram lists the lines of development on the vertical axis, and time intervals on the horizontal axis. The width of the horizontal bars in the graph show the duration of each line of development and illustrates the start and finish dates and major milestones to be achieved by the program.

The Lr view is primarily intended to support the management of multiple projects or programs including the management of dependencies between projects and the integration of all the lines of development. The aim is to properly plan and manage projects and programs to deliver required system configurations and products and to align deliveries with the capability phase planning, according to the Cr Capability Phasing view, refer to Sections B6.6.1.10 and B6.6.1.11.

The primary output is portfolio management through Life Management Planning (TLMP), project management and control.

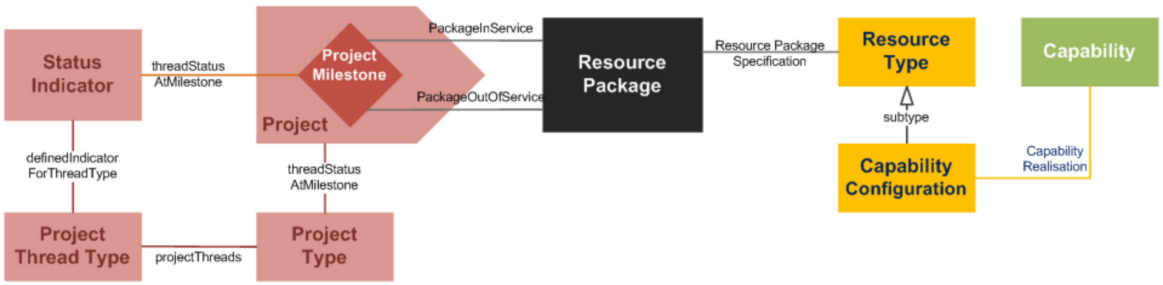


Figure B-39: Lr Lines of Development Key Elements and Their Relationships.

B6.6.3.15 Evaluation of the Lr Lines of Development View Description Techniques to Support UCATT

The Lr Lines of Development view enables the capability to describe the logical threads (lines of development) for a set of projects and programs. The status of each of these threads can be shown at the various milestones in the projects or programs.

The Lr view facilitates the capability to create information models expressing planning and control aspects of a project or program in the form of GANTT-charts (see Figure B-40). These views are traced to other model objects creating an integrated planning and monitoring capability of the evolution of the project or program (see Figure B-41 and Figure B-42). This will enhance the process to plan, monitor and finally to report the progress and status of performed efforts.

To increase planning, monitoring and reporting, it is suggested to perform basic planning according to NAF v4 based upon the Lr view.

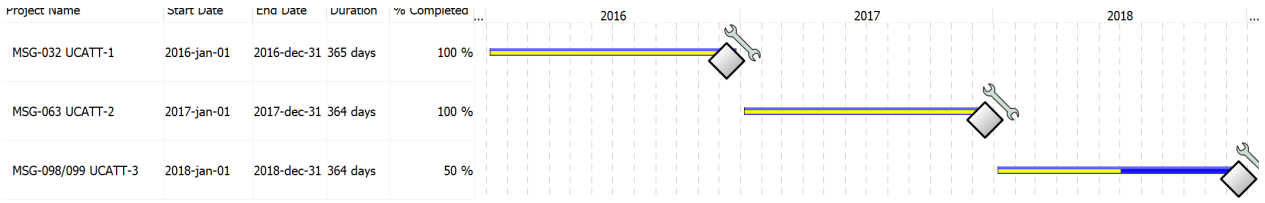


Figure B-40: Example of a Lines of Development View.

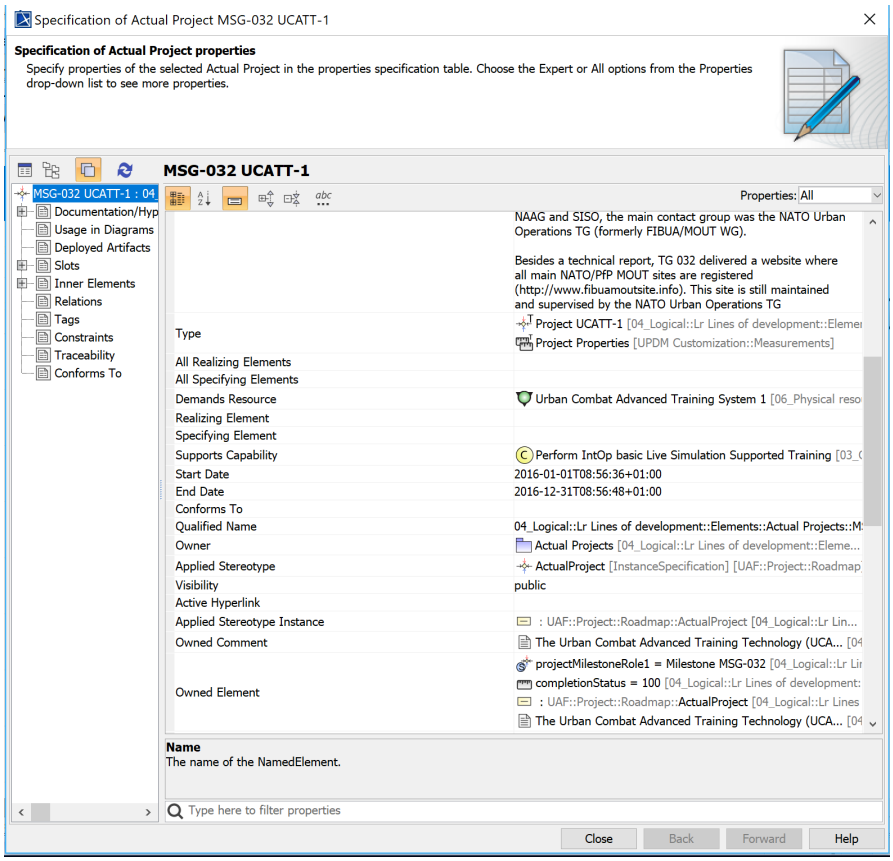


Figure B-41: Example of Embedded Information in an Actual Project Class.

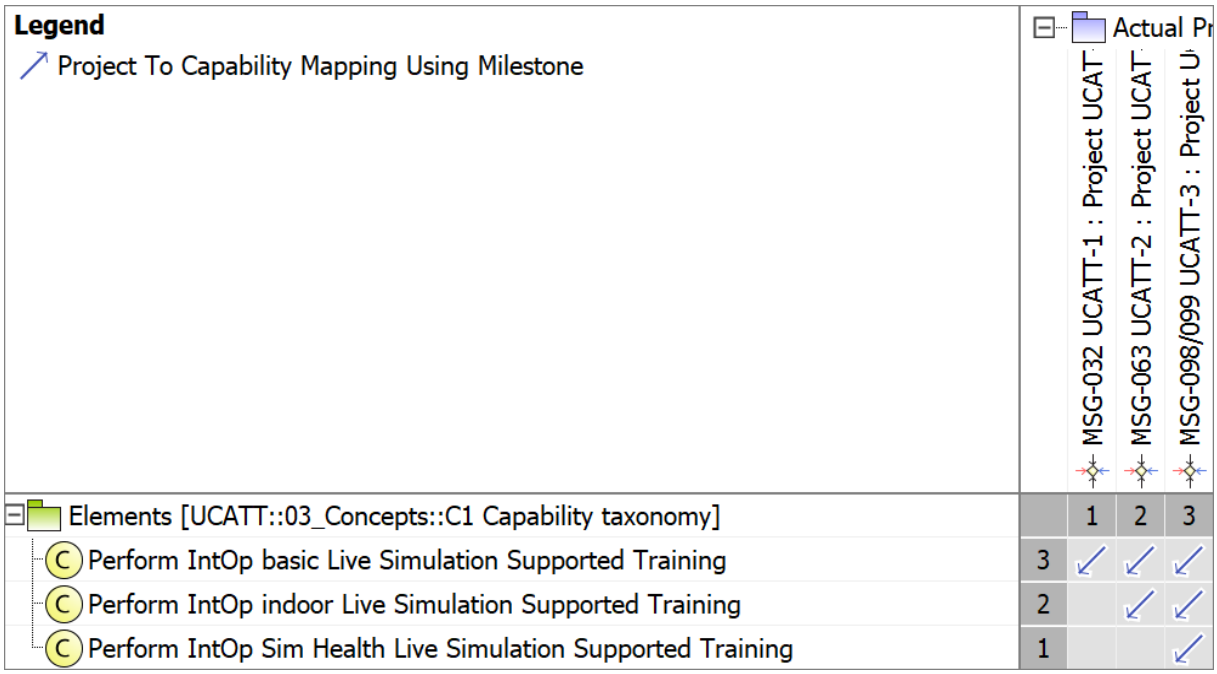


Figure B-42: Example of a Programme to Capability Mapping (Lr) View.

B6.6.3.16 Recommendations

As a result of a successful implementation of the system requirements definition process the following information will be available for UCATT-LSS:

- Operational context, constraints and environment are defined.
- Key external and internal logical interfaces are defined.
- Design-agnostic system functions, performances and qualities are defined.
- Design-agnostic non-functional requirements are defined.
- Required system design constraints are defined.
- Line of development is defined and monitored.

The aim of the process is to:

- Ensure that all stakeholder requirements are managed and analysed and allocated to the logical architecture.
- Critical properties and metrics of the system are defined.
- Stakeholder requirements are traceable to system requirements.

It is recommended that UCATT establish a logical architectural description according to a tailored version of the System requirements definition process according to ISO/IEC/IEEE 15288 [Ref7]. This should be performed according to an UCATT MBSE strategy, based on the SysML[3] notation and NAF v4.

[3] http://www.omgsysml.org/.

B6.6.4 Architecture Definition Process

B6.6.4.1 Analysis of the Standard Process

The purpose of the *architecture definition process* is to generate systems architecture alternatives, to select one or many alternatives that frame stakeholder concerns and meet system requirements, and to express these in a set of consistent views. The process facilitates and interacts with the business or mission analysis, stakeholder needs and requirements and stakeholder requirements definition process. The iterations and the recursive behaviour it creates, a common understanding of the nature of the problem to be solved and a corresponding and realistic design-agnostic solution are defined and negotiated.

The implantation of standards, such as UCATT artefacts, spans over several designs, applied by different organisations. The architecture serves to make these compatible and interoperable across its system life cycle and organisations, therefore a design-agnostic system definition creates the platform to enhance both program management as well as system development, configuration and integration.

When the process is completed, the following information is generated (examples):

- Architecture viewpoints are developed.
- Concepts, properties, characteristics, behaviours, functions, or constraints are allocated to the architecture.
- System elements and their interfaces are identified.
- Architecture candidates are assessed.
- Alignment and traceability of the architecture and requirements and design characteristics is achieved.

The aim of the process is to (examples):

- Create a foundation to identify stakeholders and their concerns.
- Understand and evaluate emerging properties at system level, as a consequence of its system elements.
- Facilitate technical reviews, decision and trade-offs.
- Ensure that all stakeholder requirements are managed and analysed.

B6.6.4.2 Analysis of UCATT Artefacts and Information

Refer to Section B6.6.3.2 Analysis of UCATT Artefacts and Information.

B6.6.4.3 Supporting NAF v4 Viewpoints

The *Architecture Definition Process* defines the focal point of creating a description of the system architecture of the system to be realised, with associated system requirements and constraints. A major output is to identify the system context and concept of design and to identify external dependencies and interfaces. The purpose is to define, analyse and compile architectural descriptions that are pertinent to the logical architecture and compliant to defined system requirements and satisfies stakeholder's needs as well as technical constraints and predicted operating environments.

There are several views, according to NAF v4, that can facilitate elicitation and definition of an architectural description. The following NAF v4 view can be used to define and illustrate a system architecture:

- P1 Resource Types.
- P2 Resource Structure.
- P4 Resource Functions.
- P6 Resource Sequence.
- P7 Physical Data Model.

B6.6.4.4 Definition of the P1 Resource Types View

According to NAF v4 (http://nafdocs.org/), the P1 view specifies the types of resources, technology and competences required for the architecture (Figure B-43). It can also be used to specify properties of resources. The P1 view defines the set of reusable definitions of resources that is, or can be, used to define a physical architecture of a system. UCATT currently has created a draft physical architecture (see Figure B-44) and has mapped functional interfaces, denoted by "Ex", to one or more physical interfaces, denoted by "Ix" (see Figure B-45). The recourse is typically structured as a hierarchical package structure. It is commonly structured depending on the type of resource or lines of responsibilities, or a combination thereof, see Figure B-46. These definitions are used to define the physical architecture of the system well as be the analytical point to define the properties of the resource, such as its requirements, interfaces and constraints. The definition of a resource is broad, in the context of the P1. A resource can, for example, be products (both S/W and H/W), humans (persons, roles and competencies), technologies (both existing and emerging), ports/interfaces, etcetera. Technologies and competences can also be set against a timeline indicating when they are expected to be in use.

The primary output is identifying resource taxonomies, forecasting technology readiness against time, HR trends analysis, recruitment planning, planning technology insertion, input to options analysis, definition of performance characteristics, and identification of non-functional requirements.

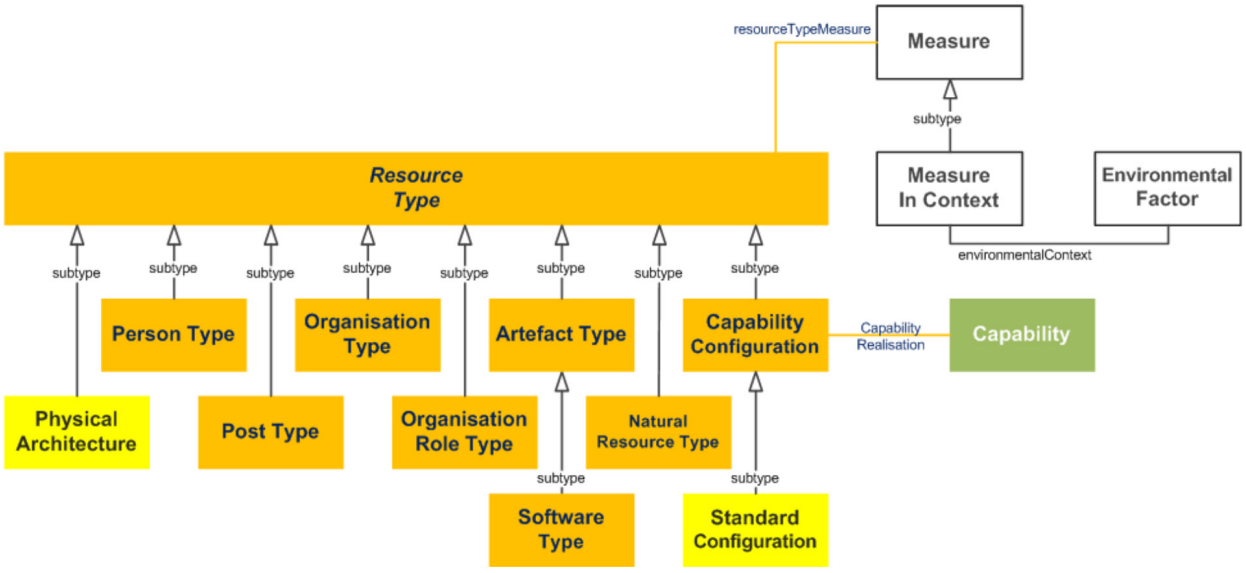


Figure B-43: P1 Resource Types Key Elements and Their Relationships.

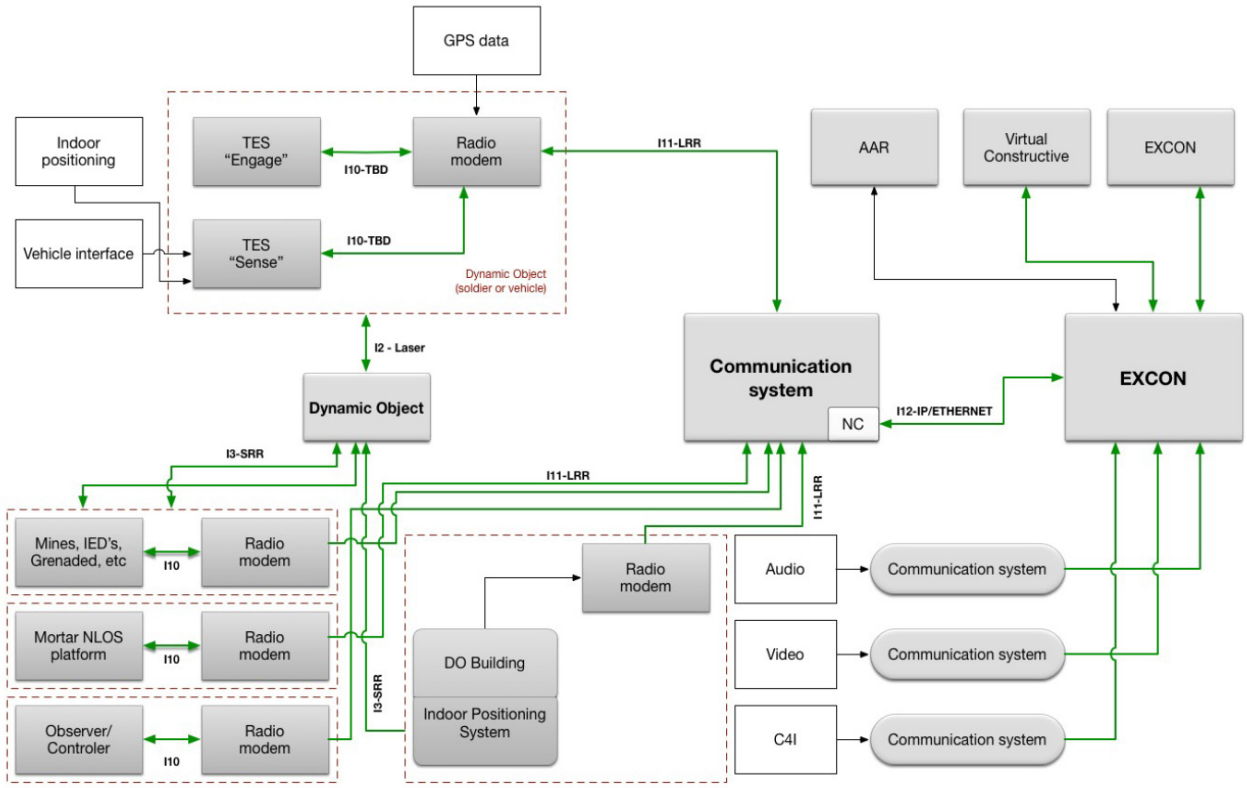


Figure B-44: Physical Architecture According to SISO-GUIDE-003-00-2016.

		E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12
I1	Long range radio DO to DO	X											
I2	Laser	X	X	X									
I3	Short range radio	X											
I4	IR- Short Range												
I5	Reserved												
I6	Reserved												
I7	Reserved												
I8	EXCON to EXCON								X				
I9	Fire Control unit interface												
I10	Serial interface between TES and Radio modem		X	X	X								
I11	Long Range Radio – DO / EXCON		X	X	X								
I12	Ethernet – NC to EXCON				X								

Figure B-45: Functional to Physical Matrix According to SISO-GUIDE-003-00-2016.

B6.6.4.5 Evaluation of the P1 Resource Types View Description Techniques to Support UCATT

The P1 Resource Types view enables the capability to specify the types of resources (see Figure B-46), technology and competences required for the architecture. It can also be used to specify properties of resources. The P1 view enables the capability to create physical structures (see Figure B-47) and to define

interfaces (see Figure B-49), rules, constraints and design patterns (see Figure B-48) and how to apply these system elements in a system context (see Figure B-24). The goal is to create a definition as perceived from a technical perspective and not from an operational-oriented viewpoint. Therefore, the P1 view should manifest an as-design or to-be-design architecture that can support an approach to standards development and system design.

Current architectural descriptions have a solution-oriented approach. The current documentation lacks well defined requirements, critical performance measures, properties and constraints, therefore decreasing the capability to evaluate and verify the design of a system and to certify different applications of the standards.

It is recommended to create a physical structure that reflects the requirements, rules and patterns of a system, at a high level to ensure traceability to the logical aspects of the system as well as to other key aspects of the system, such as system recourses, interfaces, performance measures, patterns and constraints.

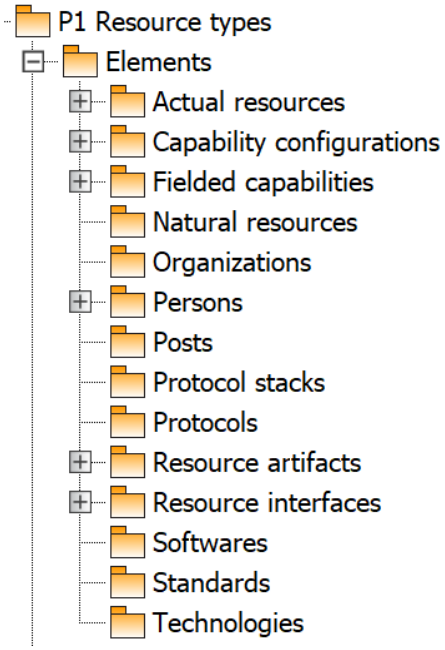


Figure B-46: Example of Recourse Types Used in a Resource Types View.

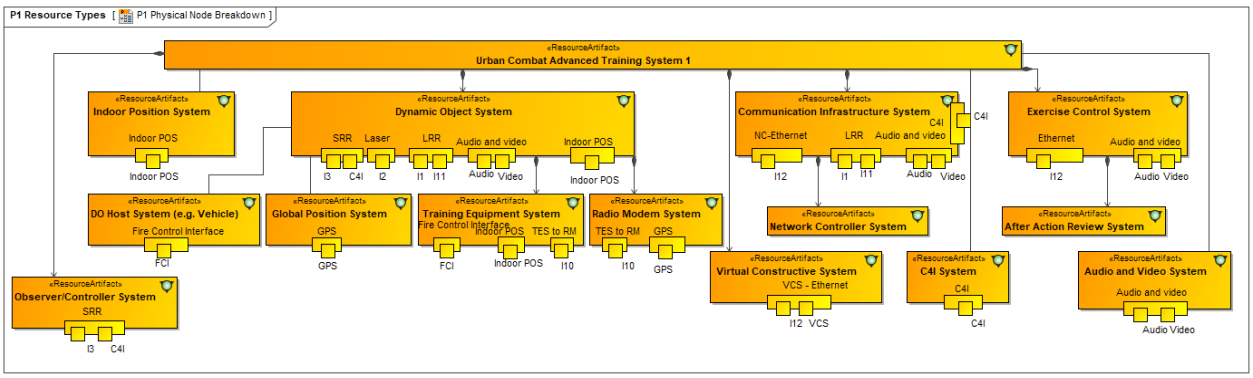


Figure B-47: Example of a Resource Types Hierarchical View.

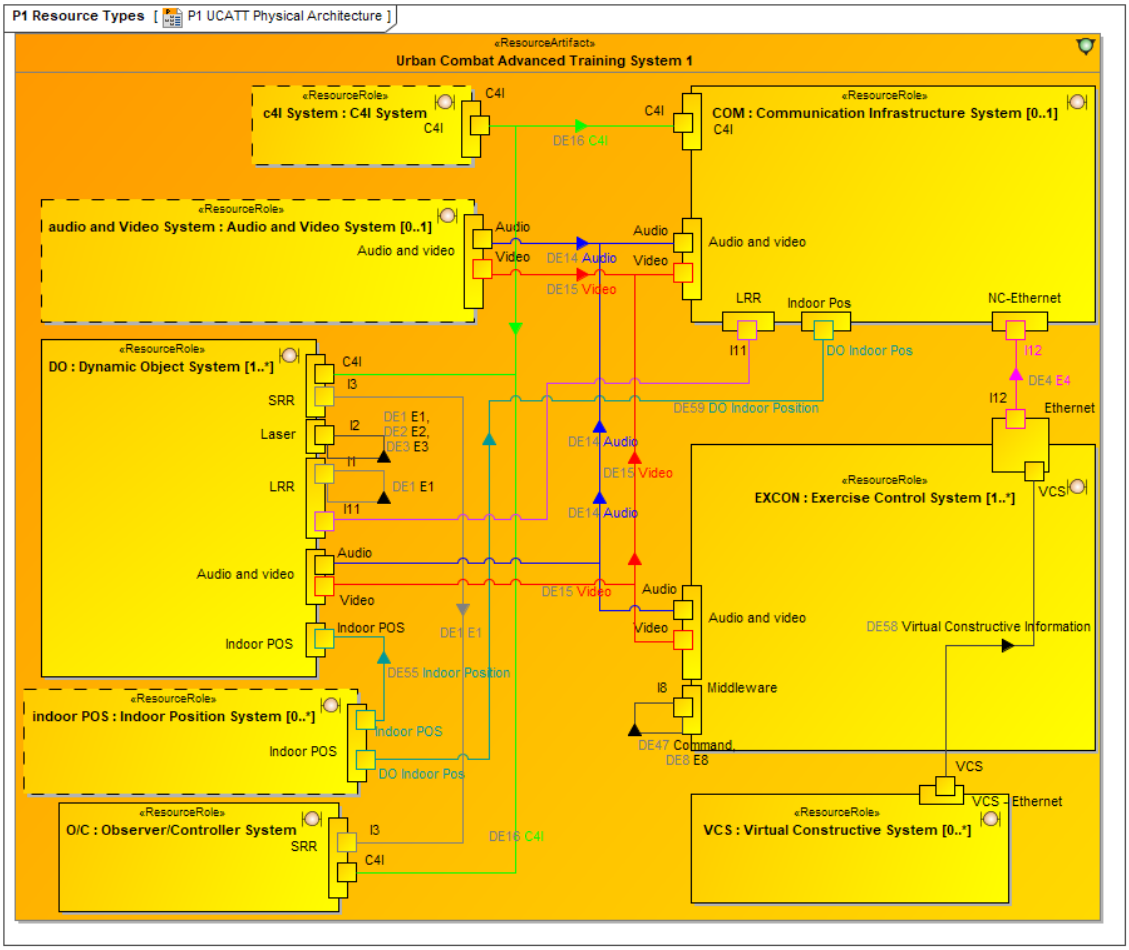


Figure B-48: Example of a Resource Types Physical View.

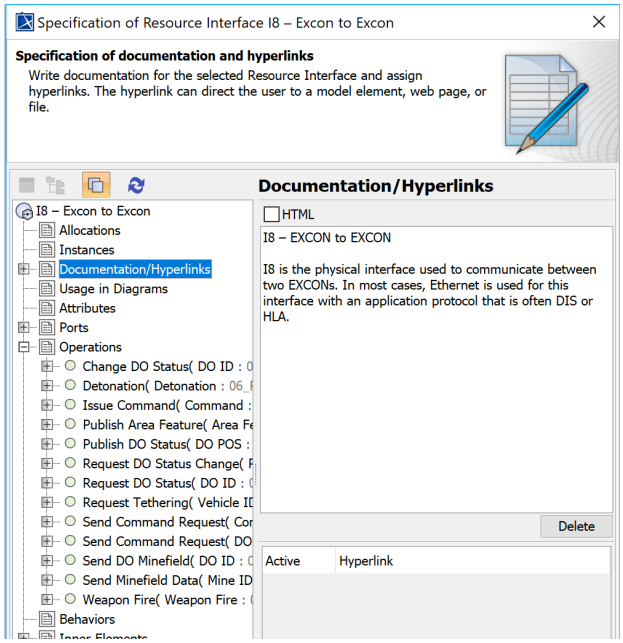


Figure B-49: Example of Properties of a Resource Interface.

B6.6.4.6 Definition of the P2 Resource Structure View

According to NAF v4 (http://nafdocs.org/), the P2 Resource Structure view addresses the composition and (high-level) interaction of resources. The P2 view defines system resources/components and their inter-relationships required to realise the logical aspects of the system as well as its associated requirements, as defined in the logical architecture description, refer to Section B6.6.3 (Figure B-50). The P2 view can represent an emerging and new solution or an existing solution or a combination thereof. Furthermore, separate views defining alternative solutions can be made. This facilitates, for example, trade-off studies and gap analysis, commonly used at early system life-cycle stages.

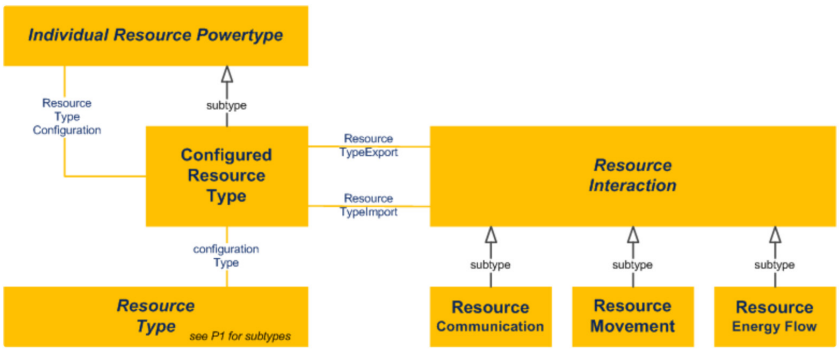


Figure B-50: P2 Resource Structure Key Elements and Their Relationships.

Since P1 defines a broad definition of what a resource can be, the P2 view also can be used to specify organisational structures, and also identify how human resources interact with each other and with systems. (Figure B-51). One of the main objectives of the P2 view is to provide a simplified representation of a pathway or network and interactions between resources that are of interest to the architect These interactions can be further specified in the P3 Resource Connectivity view.

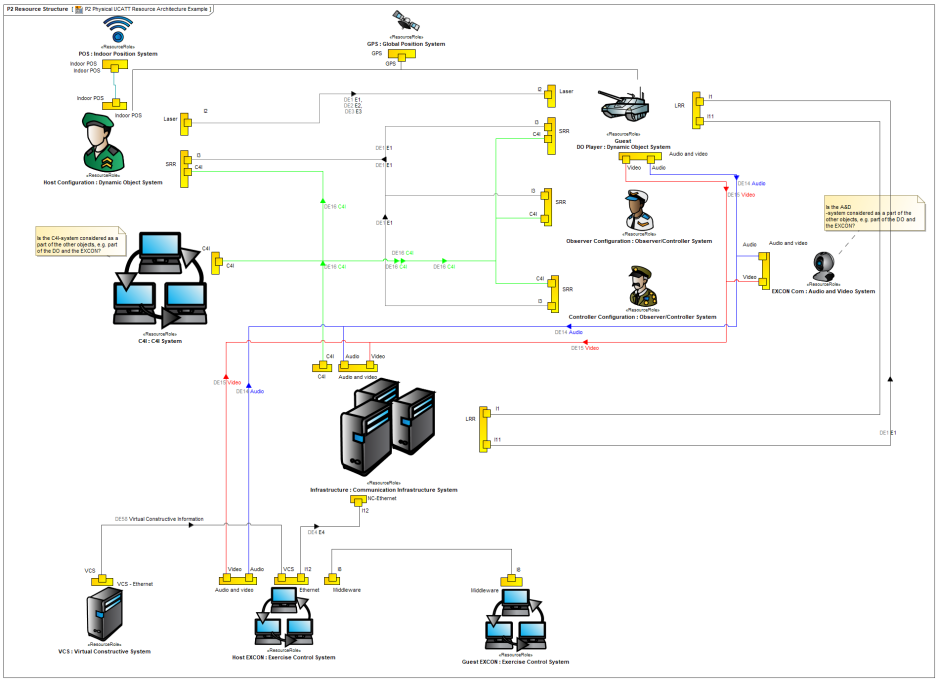


Figure B-51: Example of a Resource Structure Configuration View.

This study does not cover the P3 view, however, important P3 aspects are covered by the P2 example below, see Figure B-52. It is possible to represent the resource structure as a hierarchy, often as a set of organised P2-diagrams, decomposed to any level of system decomposition. This decomposition could for example be used to identify an operational configuration, used by an operational node, of personnel and physical assets (e.g., platforms) and to decompose these assets to its composite parts. As a consequence, a logical entity in a L2 view will probably have a physical representation in the resource structure.

Exchange ID	Exchange Name	Interface ID	Resource Exchange Item	Sending Role	Sending System Resource	Sending Port	Receiving Role	Receiving System Resource	Receiving Port
RI50	flow for E4	R98	E4	Ethernet	IP/Ethernet Port	I12	NC-Ethernet	Network Controller System	I12
RI54	flow for Command	R94	Command		Communication Middleware	I8		Communication Middleware	I8
RI49	flow for Virtual Constructive Information	R100	Virtual Constructive Information	VCS - Ethernet	IP/Ethernet Port	VCS	Ethernet	IP/Ethernet Port	VCS
RI52	flow for DO Indoor Position	R99	DO Indoor Position	Indoor POS	Indoor Positioning Port	DO Indoor Pos	Indoor Pos	Indoor Positioning Port	DO Indoor Pos
RI38	flow for C4I	R50	C4I	C4I	C4I Port	C4I	C4I	C4I Port	C4I
RI55	flow for E8	R94	E8		Communication Middleware	I8		Communication Middleware	I8
RI39	flow for Audio	R51	Audio	Audio and video	Audio and Video Port	Audio	Audio and video	Audio and Video Port	Audio
RI46	flow for E1	R57	E1 E2 E3		Optical Laser Port	I2		Optical Laser Port	I2
RI44	flow for E1	R58	E1		Long Range Radio Port	I1		Long Range Radio Port	I1
RI43	flow for C4I	R56	C4I	C4I	C4I Port	C4I	SRR	Short Range Radio Port	C4I

Figure B-52: Example of a P3 Resource Connectivity View.

The primary outputs are definition of system concepts, definition of system options, human – system interactions, typical organisation structures, interface requirements capture, capability integration planning, system integration management and operational planning (capability configuration definition).

B6.6.4.7 Evaluation of the P2 Resource Structure View Description Techniques to Support UCATT

The P2 Resource Structure view enables the capability to address the composition and interaction of resources. These system configurations shall follow the rules and patterns defined in the P1 view, see Section B6.6.4.5. Several configurations can be defined expressing different system configurations, representing different operational contexts, capabilities and stakeholder needs and requirements. These configurations can also be used to define verification concepts of the system.

To ensure that current architecture definition supports stated stakeholder needs, it is recommended to create system concepts that reflects defined use cases and operational logical aspects and requirements (see Section B6.6.3). Furthermore, it is recommended to create descriptions, appropriate to verify and certify realised system configurations.

B6.6.4.8 Definition of the P4 Resource Functions View

According to NAF v4 (http://nafdocs.org/), the P4 Resource Functions view addresses resource (human and non-human) functions – i.e., the activities performed by system resources (Figure B-53). The P4 view represents the implementation-specific realisations of the operational activities specified in the L4 Logical Activities view and is therefore the counterpart to the Activity Model (L4) of the operational view The view defines required function and their sequential order as well as their properties, such as input and output, constraints and performance requirements. The view also facilitates the allocation of functions to resources that should be able to perform the functions.

By performing a well-executed analysis according to P4, it is possible to develop a clear description of the necessary data flows that are input (consumed) by and output (produced) by each resource. This is vital to specify interoperable solutions. It will also increase the quality of the produced artefact, such as interface specifications, by ensuring that the functional connectivity is complete (i.e., that a resource's required inputs are all satisfied).

The functional decomposition of the system should reflect the technology readiness level and technological risks and uncertainties, therefore reaching an appropriate level of detail. The primary outputs are description of task workflow, identification of functional system requirements, functional decomposition of systems, identify human interactions, and system functions.

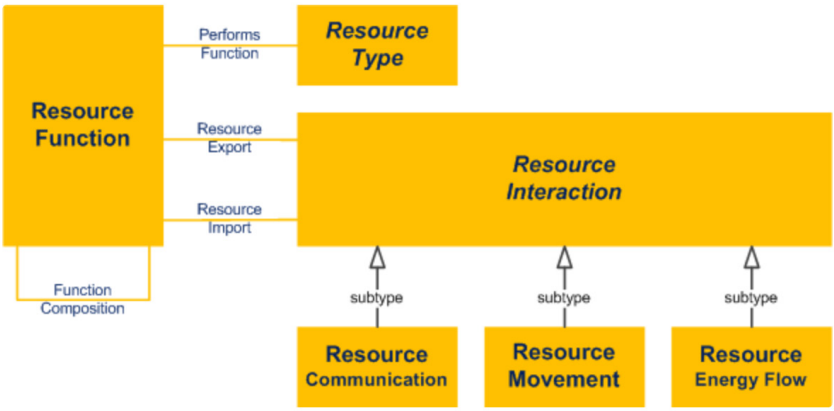


Figure B-53: P4 Resource Functions Key Elements and Their Relationships.

To be able to trace functionality to operational activities and service functions a L4-P4 view can be used. According to NAF v4 (http://nafdocs.org/), the L4-P4 Function to Operational Activity / Service Function view can illustrate the mapping of functions to operational activities or service functions by the linkage between resource functions described in the P4 view and operational activities specified in the L4 view, refer to Sections B6.6.3.10 and B6.6.3.11. It also can illustrate the traceability between resource functions from the P4 view and the service functions defined in the S4 view, refer to Section B6.6.2.8, thus supporting a service-oriented approach. During requirements definition, L4-P4 plays a particularly important role in tracing the architectural elements associated with system requirements to those associated with user requirements.

The primary outputs are tracing functional system requirements to user requirements, tracing solution options to requirements and identification of functional gaps and overlaps.

B6.6.4.9 Evaluation of the P4 Resource Functions View Description Techniques to Support UCATT

The P4 Resource Functions view enables the capability to address resource (human and non-human) functions – i.e., the activities performed by resources. It describes functions, input and output flows between activities and to or from functions that are outside the scope of the architecture. The P4 view also enables the capability to create process descriptions expressing the functional aspect of a system as well as to allocate these functions to system elements/resources. The P4 view is a vital analysis of how a system will perform in order to fulfil its objectives, both as required by external interfaces as well as allocated system requirements and constraints. The P4 view is a vital prerequisite to the definition of a well-structured and balanced system.

Current architectural artefacts contain limited functional information and is not structured in a comprehensive manner, creating uncertainties of system requirements and context.

To document interoperable aspect of the system as well as to facilitate full traceability from stakeholder requirements to the design, it is recommended to perform a formal functional analysis. The functional analysis should cover at least definitions of critical interfaces (part of the UCATT standard suite).

B6.6.4.10 Definition of the P6 Resource Sequence View

According to NAF v4 (http://nafdocs.org/), the P6 Resource Sequence view provides a time-ordered examination of the interactions between resources (Figure B-54). The P6 view is commonly a sequence diagram illustrating a required sequence of actions in order to perform a task, in a particular scenario or situation. A scenario can, for example, be the execution of a service or operational activity, based upon previous functional analysis, refer to Sections B6.6.4.6 and B6.6.4.8. The diagram can be seen as a detailed definition of how a resource shall interact with its environment and applied rules of conduct. P6 products are vital artefacts to be able to define the next level of detail from system level to the definition of the solution, to an appropriate level of detail.

The primary outputs are analysis of resource events impacting operation, behavioural analysis, identification of non-functional system requirements.

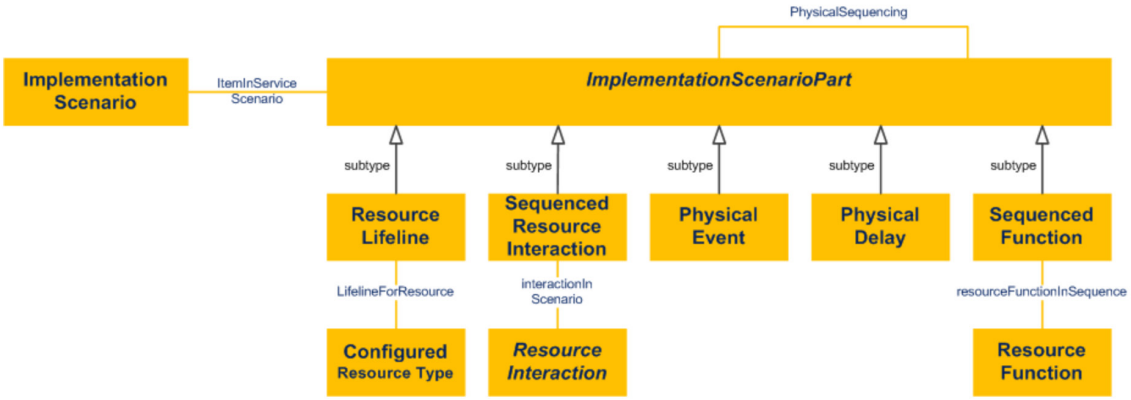


Figure B-54: P6 Resource Sequence Key Elements and Their Relationships.

B6.6.4.11 Evaluation of the P6 Resource Sequence View Description Techniques to Support UCATT

The P6 Resource Sequence view provides a time-ordered examination of the interactions between resources. These are usually depicted as event-trace diagrams and will have an accompanying description that defines

the particular scenario or situation. The P6 view is powerful to identify patterns and requirements allocated to resource interfaces (see Figure B-58), applicable both for the specification and verification thereof (see Figure B-56). Use case diagrams are one prerequisite to P6 views/diagrams (see Figure B-55 and Figure B-57), identifying critical players, interfaces and objectives for an identified situation or scenario.

The P6 view is a vital analysis of how a system element shall interact in order to fulfil its objectives, both as required by external interfaces as well as allocated system requirements and constraints. The P6 view is a vital prerequisite to the definition of an interoperable system.

Sequence diagrams are currently only used by the task group developing the E8 interface.

To document interoperable aspects of the system as well as to define appropriate test and certification procedures, it is recommended to perform a formal sequence analysis. The sequence analysis should cover at least critical interfaces (part of the UCATT standard suite).

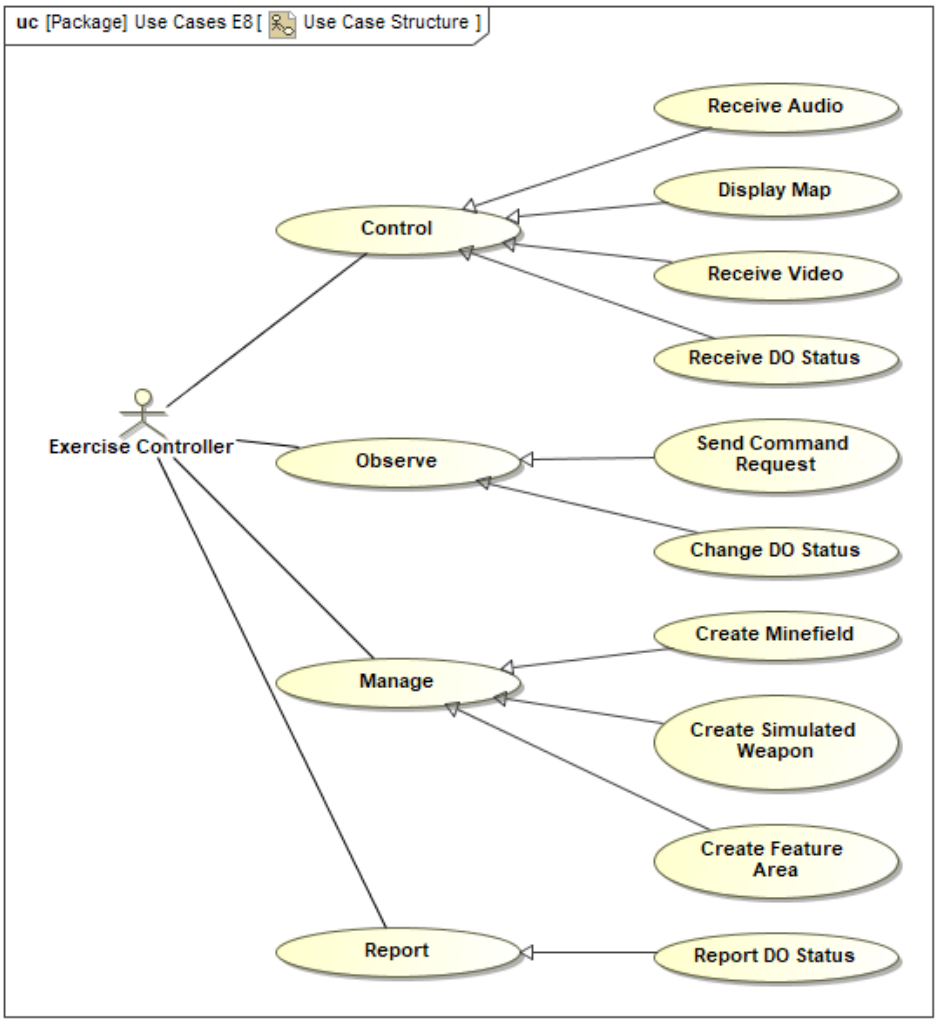


Figure B-55: Example of a Technical Use Case Hierarchical View.

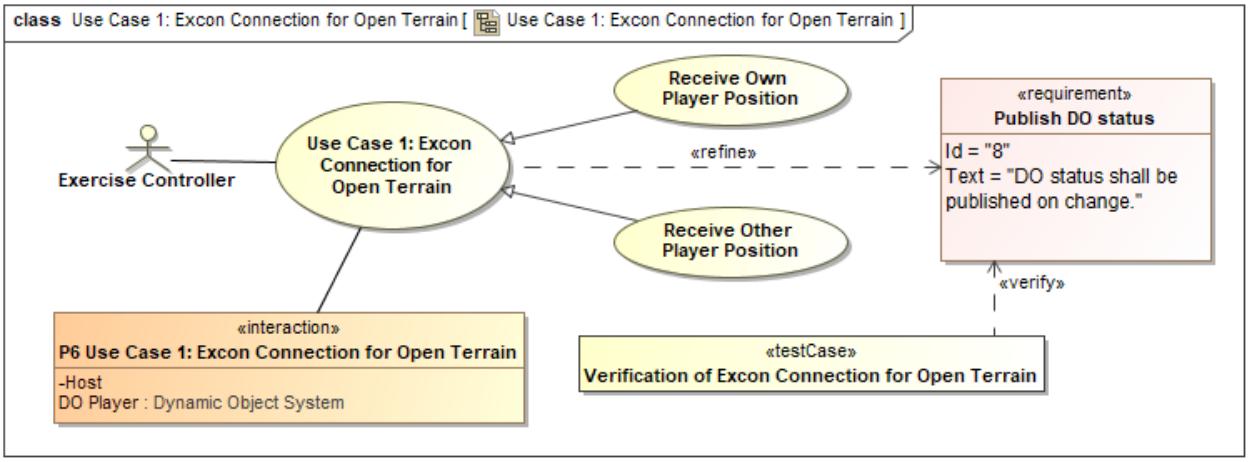


Figure B-56: Example of a Technical Use Case View with Associated Sequence Diagram (<<interaction>>) Requirement and Test Case.

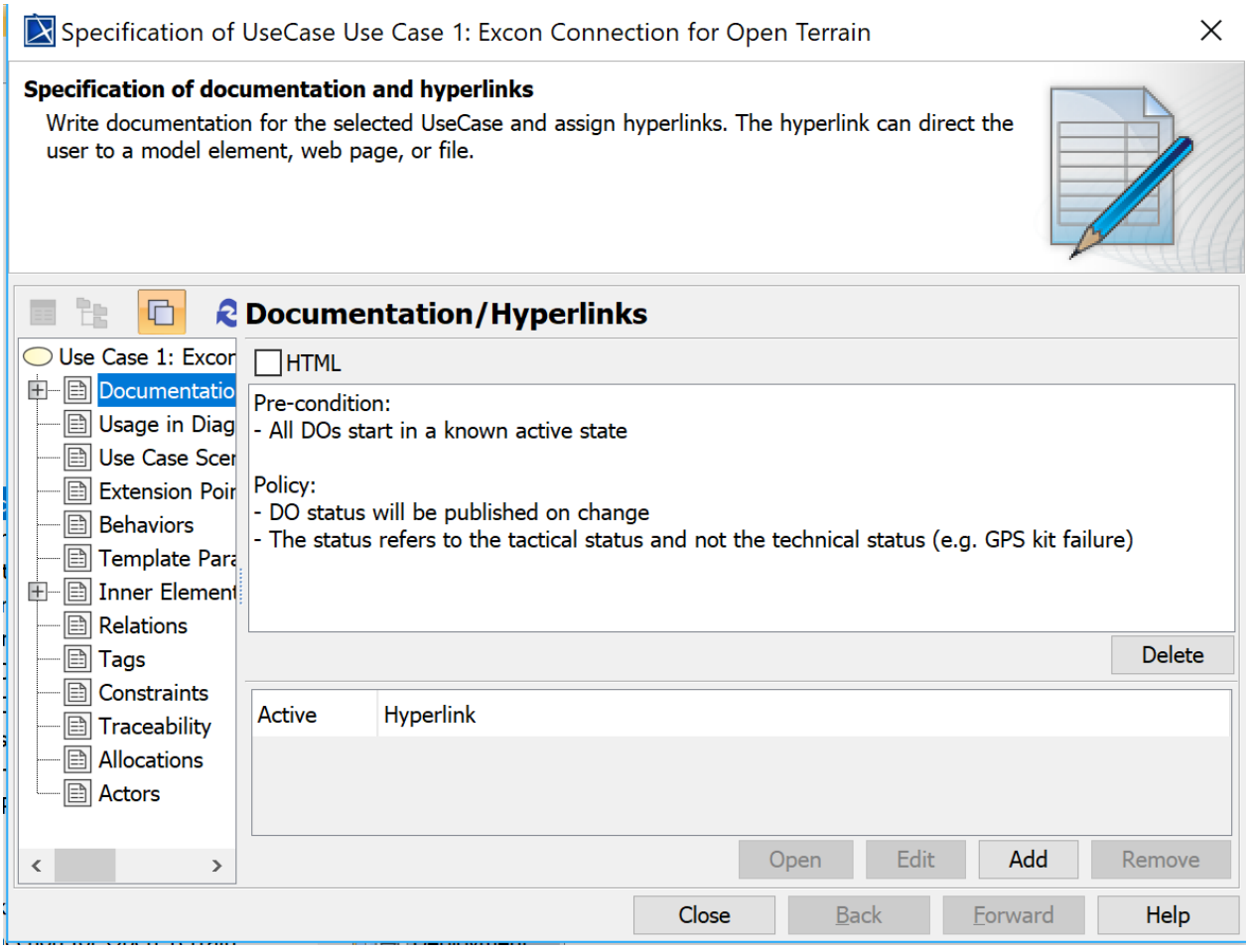


Figure B-57: Example of Embedded Information in a Use Case Class.

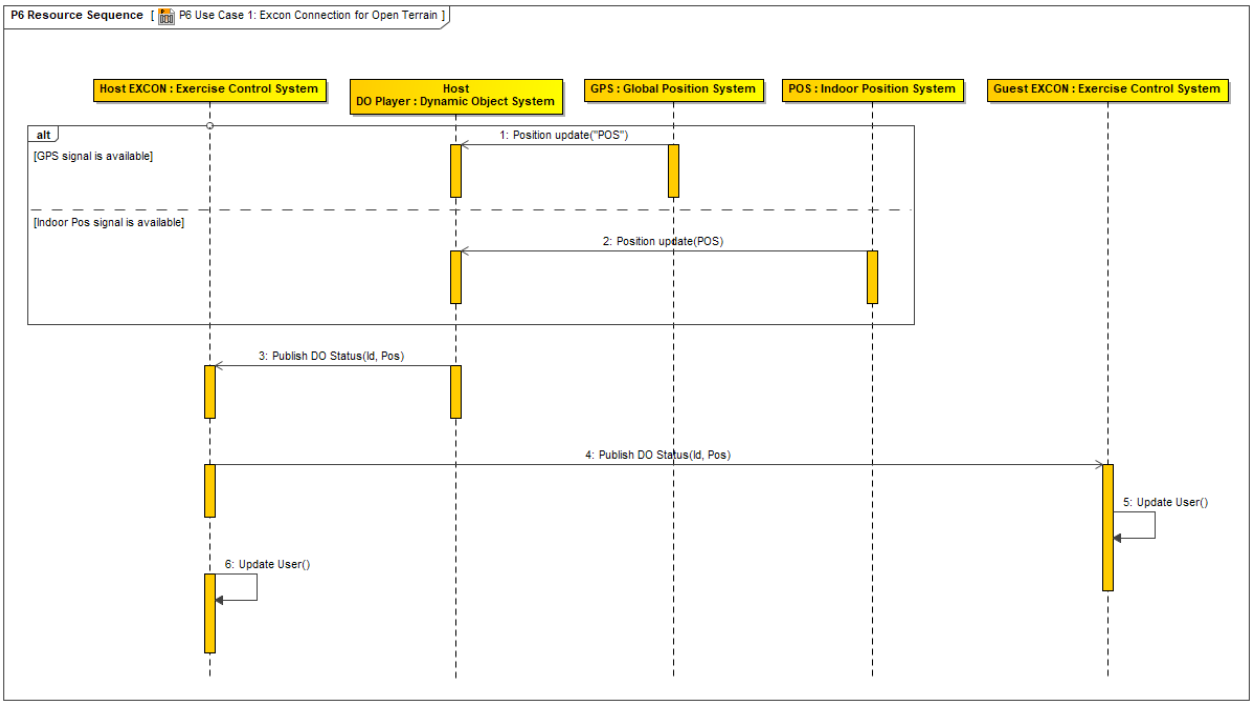


Figure B-58: Example of a Resource Sequence View.

B6.6.4.12 Definition of the P7 Physical Data Model View

According to NAF v4 (http://nafdocs.org/), the P7 Physical Data Model view defines the structure of data used by the resources in the architecture (Figure B-59). The P7 view defines how the L7 views transformed and should be implemented, refer to Sections B6.6.3.12 and B6.6.3.13. The view defines the rules and structures to be implemented than the realised solution.

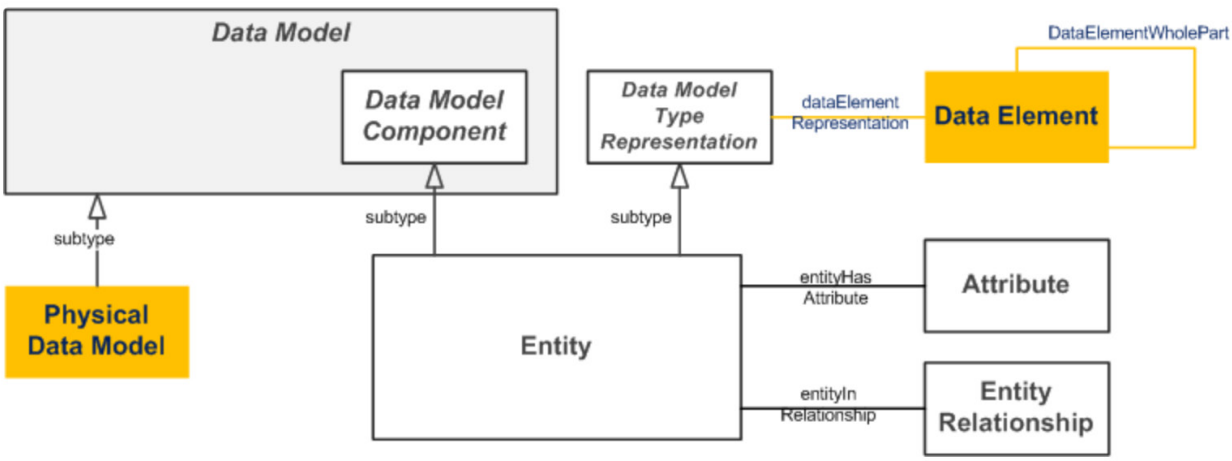


Figure B-59: P7 Physical Data Model Key Elements and Their Relationships.

B6.6.4.13 Evaluation of the P7 Physical Data Model View Description Techniques to Support UCATT

The P7 Physical Data Model view enables the capability to define the structure of data used by the resources in the architecture (Figure B-60). The P7 view facilitates the capability to create information models expressing rules and definitions of information items, their attributes or characteristics, and their inter-relationships (Figure B-60). The P7 view is a vital analysis to analyse and define exposed system interfaces which is part of the UCATT standard suite.

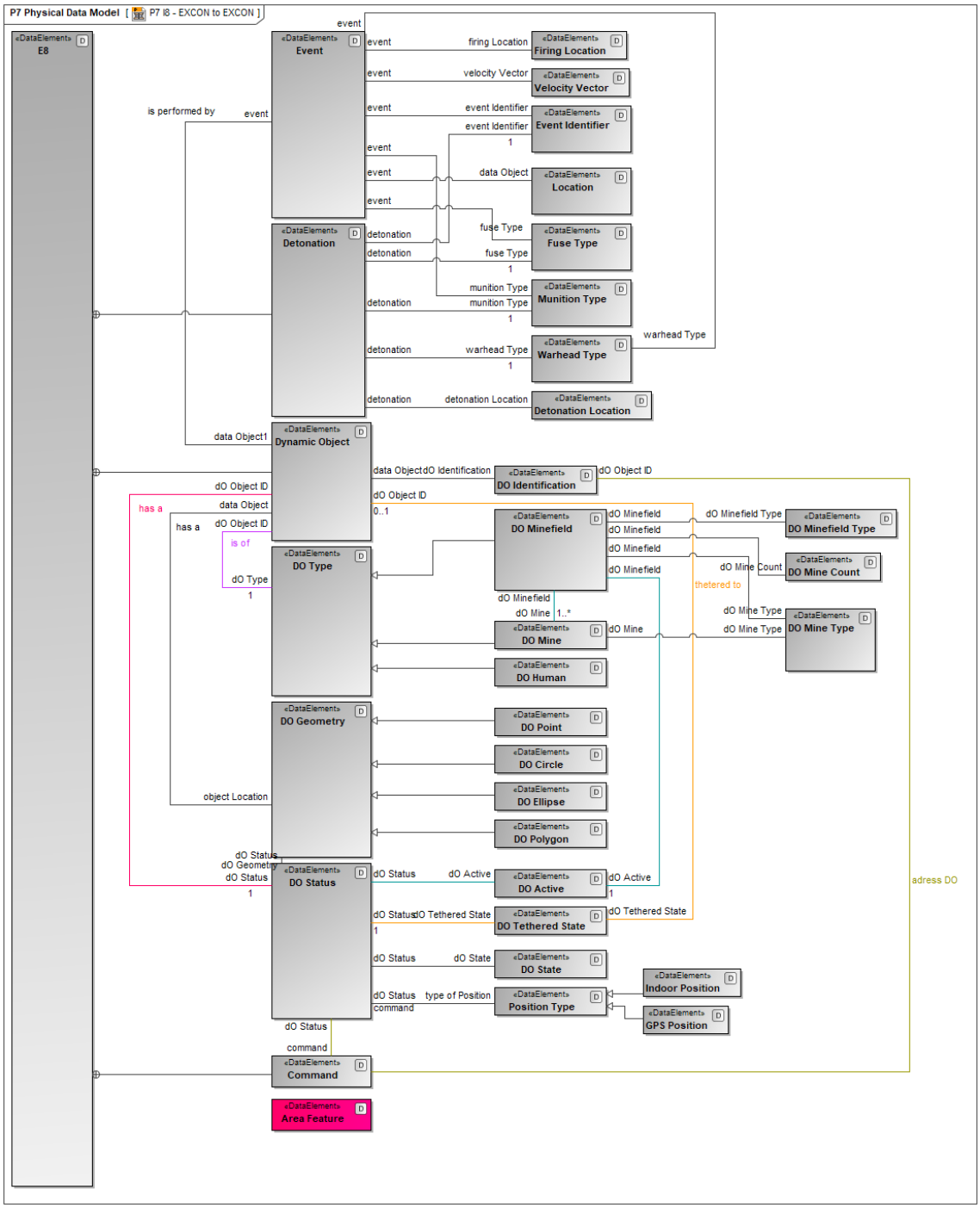


Figure B-60: Example of a Physical Data Model (Interface E8).

Current architectural artefacts contain a limited information definition/model and is not structured in a comprehensive manner, creating uncertainties of system requirements and context.

To decrease uncertainties, it is recommended that a more comprehensive analysis is performed and documented, such as an entity-relationship model of information exchanged in exposed interfaces.

B6.6.4.14 Recommendations

As a result of successful implementation of the Architecture Definition Process the following information will be available for UCATT-LSS:

- Architectural viewpoints are defined expressing the realisation of a capability configuration striving to achieve system requirements.
- System requirements are traceable to the physical architecture and design requirements.
- Concepts, properties, characteristics, behaviours, functions, or constraints are defined and allocated to the realisation of the capability configuration.
- Key system elements and their interfaces are identified and defined.
- Alignment and traceability of the architecture and requirements and design characteristics is defined.

Furthermore, the information can support the process to:

- Create a foundation to identify stakeholders and their concerns.
- Assess candidate architectures.
- Understand and evaluate emerging properties at a system level, as a consequence of its system elements.
- Facilitate technical reviews, decision and trade-offs.
- Ensure that all stakeholder requirements are managed and analysed.

It is recommended that UCATT establish a logical architectural description according to a tailored version of the Architecture definition process according to ISO/IEC/IEEE 15288 [Ref7]. This should be performed according to an UCATT MBSE strategy, based on the SysML notation and NAF v4.

B6.6.5 Design Definition Process

B6.6.5.1 Analysis of the Standard Process

According to ISO/IEC/IEEE 15288 [Ref7] the purpose of the process is to provide sufficient detailed data and information about the system and its element to enable the implementation consistent to the architectural entities as defined in models and views of the system architecture (see Section B6.6.4).

This process is assumed to be performed by the organisations using developed UCATT standards.

B6.6.5.2 Analysis of UCATT Artefacts and Information

This information is assumed to be produced by the organisations using developed UCATT standards.

B6.6.5.3 Supporting NAF v4 Viewpoints

In general, this process can be supported by the same views as for the architecture process (refer to Section B6.6.4). If performed recursively, from system level throughout all lower levels, it is possible to establish and maintain a consistent and traceable architectural description.

B6.6.6 System Analysis Process

B6.6.6.1 Analysis of the Standard Process

According to ISO/IEC/IEEE 15288 [Ref7] the purpose of the process is to provide rigorous basis of data and information for technical understanding to aid decision-making across the life cycle.

During the execution of a project or program, technical planning should be performed through a Systems Engineering Plan (SEP) and related Systems Engineering Milestone Schedule and Systems Engineering Detailed Schedule. As a foundation for planning and systems development, a life cycle and development model should be defined, see ISO/IEC/IEEE 15288 [Ref7] and INCOSE System Engineering Handbook [Ref12].

Based on the collective knowledge of the system at hand analysis, technical reviews and decisions will be performed throughout the life-cycle of the system, from front-end to end-of-life analysis. Performed planning should strive to define the production of required artefacts used during the performed System Analysis Process.

The architectural description can support this process by creating qualitative views and viewpoints according to the stakeholder concerns and milestone or review objectives.

B6.6.6.2 Analysis of UCATT Artefacts and Information

No planning artefacts has been identified during this study; however, information might be available for the technical management of the program.

B6.6.6.3 Supporting NAF v4 Viewpoints

The System Analysis Process collects and processes technical data and information to support, for example, analysis, decisions and reviews according to stakeholder concerns. According to NAF v4 [Ref6], the methodology applied when using NAF v4 is currently under development. It is likely to be based on the TOGAF™ Architecture Development Method (ADM) with input from other sources such as the MODAF learning portal and systems engineering standards such as ISO15288. There is a need to select and develop both planning aspects as well as define milestones and reviews. Furthermore, other concerns should be defined in order to establish proper views and viewpoints to be developed in order to support the System Analysis Process.

NAF v4 defines a set of views and viewpoints without references to stakeholder concerns, applicable preferred development methodology or life-cycle model. To enforce the definition of stakeholder concerns and relations to architectural views and viewpoints, architecture meta-data can be defined using the view A1 to A8 (not part of this study), see [Ref6]. These views are under development and therefore no clear application guidance is available.

Different views and viewpoints can be combined in order to plan the execution of a project or program, at a high level. The following NAF v4 view can be used to define and illustrate a planning aspect:

- Cr – Capability Roadmap (refer to Section B6.6.1.10).
- Sr – Service Roadmap (refer to Section B6.6.1.10).
- Lr Lines of Development (refer to Section B6.6.3.14).
- Pr – Configuration Management (not part of this study).
- Dr – Deployment Schedule (not part of this study).
- Ar – Architecture Roadmap (not part of this study).

B6.6.7 Implementation Process

According to ISO/IEC/IEEE 15288 [Ref7] the purpose of the process is to realise a specified system element.

This process is assumed to be performed by the organisations using developed UCATT standards.

If NAF v4 views are tailored and used during this process, it is possible to establish and maintain a consistent and traceable architectural description, using the architectural description developed by UCATT as a baseline. **The architectural description developed by UCATT can conform to a valuable artefact, delivered by the program.**

B6.6.8 Integration Process

According to ISO/IEC/IEEE 15288 [Ref7] the purpose of the process is to synthesize a set of system elements (product or service) that satisfies system requirements, architecture and design.

This process is assumed to be performed by the organisations using developed UCATT standards.

If NAF v4 views are tailored and used during this process, it is possible to establish and maintain a consistent and traceable architectural description, using the architectural description developed by UCATT as a baseline. **The architectural description developed by UCATT can conform to a valuable artefact, delivered by the program.**

B6.6.9 Verification Process

According to ISO/IEC/IEEE 15288 [Ref7] the purpose of the process is to provide objective evidence that a system or a system element fulfils its specified requirements and characteristics.

This process is assumed to be performed by the organisations using developed UCATT standards.

If NAF v4 views are tailored and used during this process, it is possible to establish and maintain a consistent and traceable architectural description, using the architectural description developed by UCATT as a baseline. **The architectural description developed by UCATT can conform to a valuable artefact, delivered by the program. If the UCATT architectural description reflects both operational as well as high-level system aspects, the artefact can be used to support the verification or certification of configured operational system.**

B6.6.10 Transition Process

According to ISO/IEC/IEEE 15288 [Ref7] the purpose of the process is to establish a capability for a system to provide services specified by the stakeholder requirements in the operational environment.

This process is assumed to be performed by the organisations using developed UCATT standards.

If NAF v4 views are tailored and used during this process, it is possible to establish and maintain a consistent and traceable architectural description, using the architectural description developed by UCATT as a baseline. **The architectural description developed by UCATT can conform to a valuable artefact, delivered by the program.**

B6.6.11 Validation Process

According to ISO/IEC/IEEE 15288 [Ref7] the purpose of the process is to provide objective evidence that the system, when in use, fulfils its business or mission objectives and stakeholder requirements, achieving its intended use in its intended environment.

This process is assumed to be performed by the organisations using developed UCATT standards.

If NAF v4 views are tailored and used during this process, it is possible to establish and maintain a consistent and traceable architectural description, using the architectural description developed by UCATT as a baseline. **The architectural description developed by UCATT can conform to a valuable artefact, delivered by the program. If the UCATT architectural description reflects both operational as well as high-level system aspects the artefact can be used to support the verification or certification of configured operational system.**

B6.6.12 Operation Process

According to ISO/IEC/IEEE 15288 [Ref7] the purpose of the process is to use the system to deliver its services.

This process is assumed to be performed by the organisations using developed UCATT standards.

B6.6.13 Maintenance Process

According to ISO/IEC/IEEE 15288 [Ref7] the purpose of the process is to sustain the capability to provide services.

This process is assumed to be performed by the organisations using developed UCATT standards. The architectural description can support the evaluation and process to maintain UCATT artefacts and standards.

B6.6.14 Disposal Process

According to ISO/IEC/IEEE 15288 [Ref7] the purpose of the process is to end the existence of a system element or system for a specified intended use, appropriately handle replaced or retired elements, and to properly attend to critical disposal needs.

This process is assumed to be performed by the organisations using developed UCATT standards. The architectural description can support the evaluation and process to dispose UCATT artefacts and standards.

B7.0 BENEFITS

This section covers the short, medium- and long-term benefits of using the ISO/IEEE 15288, NAF v4 and SysML to support the development of UCATT standard documents and artefacts by introducing formal systems engineering procedures, methods and information.

B7.1 Short-Term Benefits

The UCATT Architectural Description (UAD) can facilitate the process to analyse and prioritise stakeholder needs and requirements by creating a structured and comprehensive model that traces the need to a potential solution. The UAD enables an evidence-based analysis to a level of granularity appropriate to the scenario in question and provide a platform on which to prioritise issues and make well-grounded decisions.

The following are examples of some short-term benefits:

- Make it possible for the MSG UCATT to provide guidance for a common architecture for the live simulation community.
- Initial support for capability planning.
- Guidance to revise and update reference architectures, to create consistent and coherent standards.
- Formal methods to enhance the quality review process when developing technical standards.

B7.2 Medium-Term Benefits

The UAD can improve efficiency and effectiveness to develop standards to support interoperability in the live simulation domain. Furthermore, it aids in the evolutionary development of interface standards, based on capability planning and life cycle management of developed standards.

The following are examples of some medium-term benefits:

- Make it possible for the UCATT-LSS to provide guidance for a common architecture with another simulation community.
- Identify the next interface standard to develop.
- Maintain a coherent set of standards.
- Improved ability to share architectural information.
- Increased probability to create compatible live simulation training components.

B7.3 Long-Term Benefits

ISO/IEC/IEEE 15288 [Ref7] is an international standard that defines a set of processes and activities, based on best practices, to manage the life-cycle of systems for the benefit of customers, suppliers and stakeholders. Furthermore, the standard also facilitates a common platform to run and integrate projects and programs, throughout a common way of working.

The NATO Architecture Framework (NAF) creates a formal method and language to perform system engineering and design, in the way of an architecture, facilitating the communication, integration and collaboration of distributed or disrupted organisations.

The following are examples of some long-term benefits:

- By using ISO 15288 and NAF v4 standards, the capability to reach out and integrate UCATT-standards with other standard initiatives will be enhanced.
- Make it possible for the NATO STO to provide guidance for a common architecture for the LVC simulation community.
- By utilising ISO 15288 there is a common ground (platform) to work.
- By utilising NAF v4, there is a common ground to create compatible architectures.
- Supports the development of operational concepts for training and exercises.
- Supports the development of procedures to plan, execute and evaluate training and exercises.
- Supports the alignment of live simulation standards for Urban and Rural environments.

If the UAD is considered a deliverable artefact, organisations involved in the realisation of live simulation systems can utilise it to improve communication and to reduce programmatic and technical uncertainties, through mutual and standardised architecture descriptions.

For example, the following tasks are supported:

- Integration across platforms.
- Development of requirement specifications.
- Capability gap analysis.
- Verification and validation of requirements.
- Traceability between components of the system.
- Cause and effect analysis.

B8.0 CONSIDERATIONS

In preparation for the next MSG UCATT task (MSG174), formal processes, methods and description techniques should be considered to perform and document Systems Engineering (SE) and architecture tasks, a.k.a. Model-Based Systems Engineering (MBSE). In order to introduce the MBSE approach, the principles of ISO 15288 [Ref7] along with the methods and description techniques according to NAF v4 [Ref8] and SysML [Ref9] should be applied. Refer to Section B6.0 for a tailored version applicable to the MSG UCATT.

B8.1 Architecture Development Method

The development and sustainment of an UAD will require a continuous and cyclical process that requires constant support according to an Architecture Development Method (ADM). It's recommended to choose an ADM that is:

- Proven in use on an applicable level;
- Sustained by a robust organisation;
- Accepted by participating knowledge resources, and
- Considered as a de-facto standard by a majority of the stakeholders.

The ADM defined by NAF v4 is proposed to be the baseline for future UCATT AD development.

While using the ADM, the UAD is developed and reflects the decisions and their implications at particular points in time. Each new task assigned to MSG UCATT, will further evolve the UAD with architecture assets encompassing all MSG UCATT standards.

The first iteration of an ADM includes capturing legacy data as well as supporting the development of new standards.

B8.2 Systems Engineering Management

In an early stage of the next phase an SE Strategy should be produced and agreed.

The Strategy should focus on enabling SE support functions by establishing a team comprised of SE team leader(s) and SE team members. Team members are comprised of editors of the UAD who supports task groups during their SE activities.

Example of SE team tasks to be performed;

- Plan[4], enable and implement MBSE to support MSG UCATT.
- Perform basic MBSE-training of MSG UCATT members.
- Re-engineering of previous MSG UCATT products and deliverables (e.g., E1, E4, E8) in accordance with NAF v4.
- Document performed task(s) within Task Groups and other SE activities in accordance with NAF v4.
- Ensure that required data and documentation is provided to Task Groups and other SE activities.
- Conduct quality assessment regarding traceability, format, structure and consistency.
- Support configuration control.

B8.3 MBSE Knowledge Management for MSG UCATT

It is important that the SE team focus on key aspects when introducing the MBSE approach, in order to facilitate an efficient implementation. These aspects are:

- Cultural;
- Availability of skills; and
- MBSE learning curve.

B8.3.1 Cultural

The MBSE approach will have an impact on how the systems engineering process is performed, which can cause initial friction. This friction can be reduced by setting common processes and vocabulary. One step is to agree upon the usage of common SE standards, such as ISO/IEC/IEEE 15288 [Ref7]. Furthermore, it is essential that the new way of work is well defined, communicated and agreed by the organisation at all levels.

B8.3.2 Availability of Skills

It is important to ensure long-term access to skills and resources. These resources shall support task groups to document and manage architectural information and artefacts. This role is defined as an SE editor.

B8.3.3 MBSE Learning Curve

Some basic training is required to enable task groups to participate and understand how to contribute to the UAD as well as to understand the output. The best way to perform training, in this context, is to have a short introduction followed by on-the-job-training, facilitated by an SE team editor.

The SE strategy should address how these aspects shall be managed. It should also define the scope of systems engineering, how (processes and methods) to perform SE and the application of the architectural framework (input and output). Finally, the strategy should be transformed to a plan, balanced according to the task groups needs and development of MSG UCATT deliverables.

[4] a.k.a. SE-strategy in guidance of ISO/IEC/IEEE 24748-4.

B8.4 Architecture Development Roadmap

This section is a suggestion of the first iteration of an architecture development roadmap indicating prioritised views to support the systems engineering process.

Columns are core engineering processes according to ISO/IEC/IEEE 15288 [Ref7]. Rows are views according to NAF v4 with the extension of SysML diagrams (requirement diagrams and use cases). Each view is evaluated based on its capability to support processes identified in Section B6.0. The capability is defined on three levels, which are as follows:

1) Views to be implemented in the first step/evolution of the UAD.
2) Views to be evaluated then implemented in the next step/evolution of the UAD.
3) Views to be considered to be implemented in the future of MSG UCATT. However, these views are still of importance to create a well-documented and consistent UAD.

This prioritisation is the first iteration and should be further elaborated in the Systems Engineering Strategy and finalised in the Systems Engineering Plan.

Table B-1: Prioritisation of the Usage of Views.

Reference to Process / Reference to View/Method	7.6.1 Business or Mission Analysis	7.6.2 Stakeholder Needs and Requirements Definition	7.6.3 System Requirements Definition	7.6.4 Architecture Definition	7.6.5 Design Definition	7.6.6 System Analysis
C1 Capability Taxonomy	1	1				
C2 Enterprise Vision	1	1				
C7 Performance Parameters		1				
Cr Capability Roadmap	2	2				2
SysML Use Cases		1	1			
S1 Service Taxonomy		3	3			
S4 Service Functions		3	3			
S6 Service Interactions		3	3			
Sr Service Roadmap		3	3			3
SysML requirement diagrams		1	1			
L1 Node Types			1			
L2 Logical Scenario			1			
L3 Node Interactions			1			
L4 Logical Activities			2			
L7 Logical Data Model			1			
Lr Lines of Development			2			2
P1 Resource Types				1	2	

Reference to Process / Reference to View/Method	7.6.1 Business or Mission Analysis	7.6.2 Stakeholder Needs and Requirements Definition	7.6.3 System Requirements Definition	7.6.4 Architecture Definition	7.6.5 Design Definition	7.6.6 System Analysis
P2 Resource Structure				1	2	
P4 Resource Functions				1	2	
P6 Resource Sequence				1	2	
P7 Physical Data Model				1	2	
Pr Configuration Management						2
Dr Deployment Schedule						3
Ar Architecture Roadmap						2

B9.0 CONCLUSIONS

An enhanced MBSE capability, using the ISO/IEEE 15288, NAF v4 and SysML, is predicted to support the development and to increase the quality of UCATT standard documents and artefacts, by introducing formal systems engineering procedures, methods and information. If these standards are used during the development of UCATT standards, a UCATT Architectural Description (UAD) based on NAF v4 will be produced. This architectural description can be considered a deliverable artefact, by itself, which can be used by organisations that develops, procures, maintains or uses live simulation systems.

Formal methods will increase the performance of definition, analysis and reviews of standards to ensure that the information is:

- Complete;
- Consistent;
- Connected; and
- Traceable.

Furthermore, these methods and procedures enhance the capabilities to communicate stakeholder and architectural aspects of the system of interest and to perform configuration control.

An introduction of formal processes, methods and description techniques to perform and document SE and architectural tasks will contribute as follows:

Key Benefits

a) Facilitate alignment of MSG UCATT work by using unified SE processes and methods.

b) Support MSG UCATT decisions and technical reviews.

c) Facilitate the introduction of new members in regard to system design, behaviour and characteristics.

d) Support traceability from stakeholder requirements to MSG UCATT deliverables, such as interface standards, guidance and reference documents.

Other Benefits

a) Support the verification of stakeholder requirements.

b) Support the definition of certification plans and specifications.

c) Improve the capability to communicate MSG UCATT products.

d) Support life cycle management of MSG UCATT products, such as configuration management and information sustainment.

A recent survey indicates that 50 – 75 % of the respondents (with SE knowledge) noted some improvement or a significant improvement across almost all systems engineering tasks, by introducing an MBSE approach. The survey evaluated the maturity and status of the implementation of MBSE within industry, academia, and governments.

B10.0 RECOMMENDATIONS

Formal processes, methods and description techniques are used to perform and document Systems Engineering (SE) and architecture tasks, a.k.a. Model-Based Systems Engineering (MBSE).

The first essential step is to introduce an MBSE approach to create a Systems Engineering Plan (SEP), to increase efficiency and reduce risk. The plan should cover how to implement a new methodology as well as how to perform the systems engineering tasks, including processes, methods, resources and information management.

The recommendation is to develop a tailored SEP, refer to Section B9.4, during the initial phase of MSG-174 (UCATT LSS2), to execute an efficient systems engineering process.

Appendix B-1: FUTURE CANADIAN ARMY INTEGRATED TRAINING ENVIRONMENT (F-CITE) SYSTEM ARCHITECTURE REPORT

John KENT
Canadian Army Doctrine and Training Centre (CADTC) G5

This appendix is futuristic in application and will only apply to illustrate the Canadian Army's Training Systems Enterprise Architecture.

The intent when producing the F-CITE System Architecture Report was to provide the Canadian Army's Training authority with a means to model the pan-Army training system in a consistent, coherent and structured manner in order to set the conditions for its successful evolution, transformation and effective management.

The model is intended for diversified senior and executive management level audiences with no modelling and simulation expertise.

(Note to Reader: This appendix is being published in its original format.)

Future Canadian Army Integrated Training Environment (F-CITE) System Architecture Report

John Kent
QINETIQ/16/00081 v1.1
31 January 2017

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Executive Summary

The Future Canadian Army (CA) Integrated Training Environment (F-CITE) is a key element within the Canadian Army Simulation Strategy. This report has been written to inform future projects that will deliver F-CITE capability as well as planned projects such as the Land Vehicle Crew Training System (LV CTS). The work was informed by consulting the CA training community with inputs from Joint, Maritime and Air stakeholders. The Office of Primary Interest (OPI) for F-CITE is Canadian Army Doctrine and Training Centre (CADTC) Chief of Staff (COS).

The vision for F-CITE is an agile and adaptable System-of-Systems training capability that accelerates the acquisition by the CA of the competences required for future operations. F-CITE will use coherent enterprise-wide Live, Virtual and Constructive simulations, blended to meet varying training needs in which networked training can be conducted on a routine basis. F-CITE will be enabled by an open service-oriented approach that reduces the total cost of ownership through-life. F-CITE is intended to be scalable and extensible, backwards-compatible with current and planned training systems, and interoperable with Joint, Interagency, Multinational and Public training partners.

Several options for F-CITE have been developed. The minimal option brings F-CITE benefits to Virtual and Constructive Force Generation Bases. Other options progressively extend the capability to Live training, all Regular Army training sites, and finally to Reserve Force bases. The options are underpinned by a National Simulation Centre (NSC) that provides cross-cutting support and resources. The work has developed a Statement of Capability Deficiency (SoCD) for F-CITE and proposed High Level Mandatory Requirements (HLMRs) that address the shortfalls. The HLMRs address all layers of the required F-CITE architecture, namely business, training, information, applications, hardware and infrastructure.

F-CITE has many risks in common with other programmes delivering technically complex capability, but poses some additional risks because of its wide scope, new ways of doing business and transformational nature. These risks will be challenging to address. However, they do not mean that the CA should abandon the F-CITE concept. Instead, F-CITE should be viewed as a managed plan, driven by clearly stated training outcomes, that allows the CA to better respond to the uncertainties of a rapidly changing world. The alternative is a set of piecemeal changes to the existing training capability, driven for example by inevitable technology push, that make it increasingly unwieldy and unresponsive to changing training demands.

The key next steps for F-CITE are as follows:

1. Continue definition of the F-CITE concept, and in particular refine the F-CITE target architecture to a further level of detail;
2. Update the Army Systems Approach to Training (ASAT) to provide guidance on the use of blended simulation and networked training in the context of the Managed Readiness Plan;
3. Analyse the F-CITE options and select a preferred option for further refinement (e.g., in terms of governance and networking requirements);
4. Given the results of the ASAT update and F-CITE option analysis, attribute the required F-CITE roles and functions to CA organisations;
5. Refine the initial F-CITE personnel and cost considerations, supported by appropriate risk-reduction research.

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1 Introduction

1.1 Background

1.1.1 Future Canadian Army Integrated Training Environment

The Future Canadian Army Integrated Training Environment (F-CITE) is a key element within the Canadian Army Simulation Strategy (CASS) [1] which is itself consistent with Canadian Army Order (CAO) 28-01, Canadian Army (CA) simulation policy [2], . The broad intent expressed in CASS is that F-CITE will connect Live, Virtual and Constructive (LVC) simulation systems for the purpose of conducting distributed combined arms, and joint exercises, spanning multiple provinces and times zones, as well as linking to other Canadian Army Forces (CAF) assets.

The Office of Primary Interest (OPI) for F-CITE is the Canadian Army Doctrine and Training Centre (CADTC) Chief of Staff (COS).

1.2 Aim of report

The aim of this report is to describe a technical architecture for F-CITE.

1.3 Purpose of report

This system architecture report is primarily aimed at F-CITE stakeholders in the CA, in particular those responsible for planning future simulation projects (training-related or otherwise). It is also relevant to stakeholders in the wider CAF, notably those in the Royal Canadian Navy (RCN) and Royal Canadian Air Force (RCAF) developing maritime and air simulation capabilities that may in future interoperate with F-CITE.

This report is intended to help stakeholders answer the following questions:

1. What is the scope of F-CITE?
2. How is simulation-based training delivered in the F-CITE era?
3. What is the capability gap between what F-CITE promises and the actual capabilities of current and planned systems?
4. What could be done to bridge the capability gap?
5. What impacts does F-CITE have on extant CA training organisations and processes?
6. What are the wider implications of F-CITE, e.g., in terms of personnel?
7. What are the potential costs and risks of F-CITE?

As a result of answering these questions, stakeholders will be better able to plan and focus the F-CITE programme.

1.4 Objectives and content of report

This report presents:

1. The target F-CITE technical architecture, i.e., the desired future state for CA training (in Section 2);
2. F-CITE acquisition options, to support cost-benefit analysis (in Section 3);

3. An assessment of the impact of F-CITE on CA personnel (in Section 4);
4. A preliminary analysis of F-CITE against Personnel and Leadership; Research & Development, and Operational Research; Infrastructure, Environment, and Organisation; Concepts and Doctrine; Information Management and Technology; Equipment and Support; and Generate (PRICIE+G) criteria (in Section 5);
5. An assessment of F-CITE cost drivers (in Section 6);
6. A Statement of Capability Deficiency (SoCD) for F-CITE that considers portions of the architecture to be delivered by currently planned CA simulation projects (in Section 7);
7. Draft High Level Mandatory Requirements (HLMRs) for an F-CITE project, to provide any portions of the F-CITE technical architecture not likely to be delivered by currently planned CA simulation projects (in Section 8);
8. F-CITE-related risks (in Section 9);
9. Proposed Research and Development (R&D) topics (in Section 10).

This report assumes some knowledge of relevant CA operational concepts, current CA approaches to simulation-based training, CA training levels and progressions, the existing CA simulation 'fleet' and training and simulation governance processes as characterised in the CASS [1] and CAO-28-01 [2].

1.5 The baseline for F-CITE

1.5.1 Baseline CA training capability

F-CITE will be a System of Systems that will include some existing and planned CA training systems. The key existing systems that form the baseline from which F-CITE could be developed are summarised in Table 1 1. The table also identifies the Functional Centres of Excellence (FCoE) that currently govern the systems, namely:

1. CADTC, the FCoE that has pan-CA authority for simulation governance and CA simulation projects yet to be delivered;
2. Canadian Manoeuvre Training Centre (CMTC), the FCoE for Live (L) simulation and operational authority for currently fielded L simulations;
3. Combat Training Centre (CTC), the FCoE for Virtual (V) simulation and operational authority for currently fielded V simulations;
4. Canadian Army Simulation Centre (CASC), the FCoE for Constructive (C) simulation and operational authority for currently fielded C simulations

Table 1-1. Baseline CA training capability.

Role	System	FCoE	Number / location
Combined & Staff Training	Joint Conflict and Tactical Simulation (JCATS).	CASC	Numerous, at CASC, Divisional Simulation Centres (DSC) and schools.
	Virtual Battlespace (VBS).	CASC	Numerous locations.
	ABACUS.	CASC	CASC.

Role	System	FCoE	Number / location
Armoured Crew Training	Interim Crew Gunnery Simulator (ICGS).	CTC	80
	Leopard Driver Station Simulator (LDSS).	CTC	2
	Leopard 2 Gunnery Skills Trainer (LGST).	CTC	18
Mounted Forces	Weapon Effects Simulation (WES), which consists of the Direct Fire Weapon Effects Simulator (DFWES) and the Area Weapon Effects Simulator (AWES).	CMTC	Wainwright.
Dismounted Soldier	WES Dismounted Company Suites (DCS).	CMTC	13 held between CMTC and Wainwright.
	WES static ranges: Urban Operations Training System (UOTS).	CADTC	Edmonton, Gagetown, Petawawa, Shilo, Valcartier and Wainwright.
	Small Arms Trainer (SAT).	CTC	158
	Indirect Fire Trainer (IFT).	CTC	25
	Interim FOO/FAC Simulator (IFFS).	CTC	5 static, 3 portable.

Some of these systems (e.g., WES) are themselves complex Systems of Systems. The table omits obsolete systems that are in divestment, as well as simulations (e.g., OneSAF) that are used for experimentation rather than training. It also omits range Targetry capability and existing middleware and Exercise Management Systems (EMS) such as the Virtual Command and Control Interface (VCCI).

In addition to these in-service training systems, the Army Capability Development Programme includes projects that are planned to replace or update existing training capability. From the perspective of F-CITE, relevant projects include:

1. Land Vehicle Crew Training System (LV CTS), which is expected to integrate LGST and replace LDSS and ICGS, and is planned to be delivered to Edmonton, Gagetown, Petawawa, Shilo and Valcartier;
2. WES Midlife Upgrade (WES MU);
3. Unit Weapon Training System (UWTS) for dismounted and crew served weapons, that will modernise SAT and IFT.

These projects are not explicitly funded to deliver F-CITE functionality. However, if appropriately designed, they could provide supporting components and services and may also de-risk technologies or approaches relevant to F-CITE. Note that because their projects have yet to deliver, LV CTS, WES MU and UWTS do not yet form part of the Baseline CA training capability.

CA training takes place at numerous sites across Canada's ten provinces and three territories,

including Force Generating Bases (FGBs), Divisional Simulation Centres (DSCs) and Divisional Training Centres (DTCs). The CA FGBs are at Edmonton, Shilo, Petawawa, Valcartier and Gagetown. Kingston is a CAF-level FGB. Two of the FGBs host FCoEs (Kingston is home to CADTC and CASC while Gagetown is home to CTC). Wainwright hosts CMTC but is not itself a FGB.

From an F-CITE perspective, the deduction here is that CA training sites vary significantly in terms of the types of training audience and training services they support. They do not represent a single integration target for F-CITE and as a result integration may need to address multiple case-specific technical challenges.

1.5.2 CA Command and Control capability

The primary Command and Control (C2) system that must be stimulated by F-CITE in training is the Land Command Support System (LCSS). LCSS is a System of Systems that has three main branches:

1. Tactical Communications (TacComms): radio and fibre optics;
2. Tactical Networks (TacNet): routers, servers, clients and crypto boxes;
3. Tactical Command and Control Information System (TacC2IS): a family of applications and their interfaces for operators, sensors and weapons.

LCSS enables command and effects control, provides an integrated set of tools to be used with HQ processes, integrates Intelligence Surveillance Reconnaissance (ISR) sensor feeds to shooter links, is joint and coalition interoperable.

LCSS is used at the strategic, operational and tactical levels, and successive releases (e.g., the planned Topaz upgrade) are in general pushing increased LCSS capability to lower tactical levels. LCSS also includes High Assurance Gateways (HAGs) that support interoperability with DND / Other Government Departments (OGD) or international (multi-eye) networks.

In general, F-CITE will be required to incorporate changes to C2 systems such as LCSS, including the adoption of new systems and upgrades or patches to existing systems. The timing of such C2 system changes cannot be controlled by F-CITE (or even by DND in the case of coalition-sourced C2 systems) which must react to them in order to ensure that they are appropriately represented within training.

1.6 Architecture approach

1.6.1 Architectural framework

This work uses wherever possible the architecture notation and conventions defined by the Department of National Defence and Canadian Forces (DND/CF) Architectural Framework (DNDAF) [3]. Readers are referred to the DNDAF reference for further information. In summary, however, DNDAF is based on the concept of multiple ‘views’ that each present different types of information about an enterprise, covering aspects such as operational activities, system functions, information, technology and security. This architecture report includes DNDAF views recommended for the Project Identification Phase and Option Analysis Phase, as well as additional artefacts (e.g., SoCD and HLMRs) that support F-CITE acquisition, as indicated in Figure 1-1.

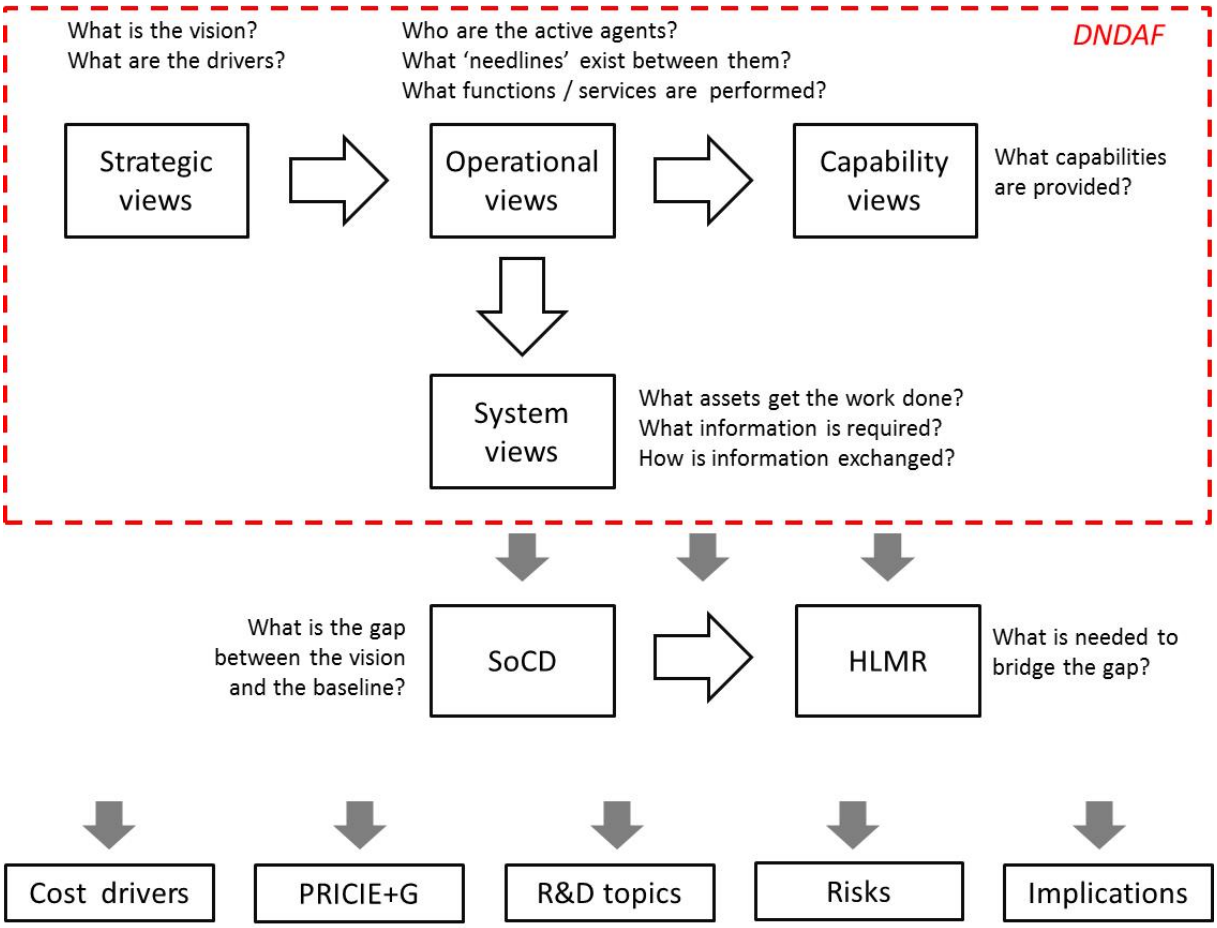


Figure 1-1 Architecture artefacts.

1.6.2 Functions versus services

In accordance with CASS, F-CITE has been designed as a system of systems in which the delivery and re-use of services replaces traditional 'stove-piped' solutions. It therefore follows that the F-CITE functional model must identify the full gamut of services associated with a training capability, including training delivery as well as the operation, sustainment and enhancement of the training environment and its constituent systems.

DNDAF does not include dedicated service-oriented views, but the DNDAF documentation identifies the views that should be used when a capability has a service-oriented architecture. Accordingly, this report presents (in Section 2.5) a 'service taxonomy' that is analogous to a traditional 'functional decomposition'.

2 F-CITE system architecture (target)

2.1 Overview

This section documents the F-CITE target system architecture using appropriate DNDAF views. Specifically:

1. Section 2.2 presents F-CITE Common Views – purpose, scope, assumptions, timelines, effort and cost, security classification and integrated data dictionary;

2. Section 2.3 presents F-CITE Strategic Views – the drivers and vision;
3. Section 2.4 presents F-CITE Operational Views – operational activities, user roles, their interactions during exercise set-up and execution and the concepts of simulation blends and networked training;
4. Section 2.5 presents the F-CITE Service Taxonomy – the 'how' of F-CITE in terms of the services it provides;
5. Section 2.6 presents the F-CITE Capability Taxonomy – the enterprise goals and benefits that are delivered by F-CITE;
6. Section 2.7 presents the F-CITE Strategic Information Model ;
7. Section 2.8 presents F-CITE system views – a set of use cases illustrating the ways in which F-CITE can be used to support different types of training;
8. Section 2.9 discusses F-CITE standards.

2.2 F-CITE overview and summary Information

2.2.1 Purpose of the F-CITE architecture

The F-CITE architecture is intended to provide a single point of truth that characterises the F-CITE capability, in order to underpin future acquisition and delivery of training and education capabilities.

2.2.2 Scope of F-CITE

F-CITE will directly support the range of training types provided by the existing and planned CA simulation baseline (as per Section 1.5.1), from training levels 1 to 7 as follows:

1. L1 – individual;
2. L2 – section;
3. L3 – sub-sub-unit;
4. L4 – sub-unit, no enablers;
5. L5 – combined arms sub-unit with enablers;
6. L6 – unit;
7. L7 – formation.

F-CITE has a CA-centric focus as shown in Figure 2-1. F-CITE can facilitate CA interoperability with Joint, Interagency, Multinational and Public (JIMP) training systems via gateways to CAF-level facilities such as the Canadian Forces Warfare Centre (CFWC). However, F-CITE is not itself responsible for providing connectivity or managing JIMP exercises.

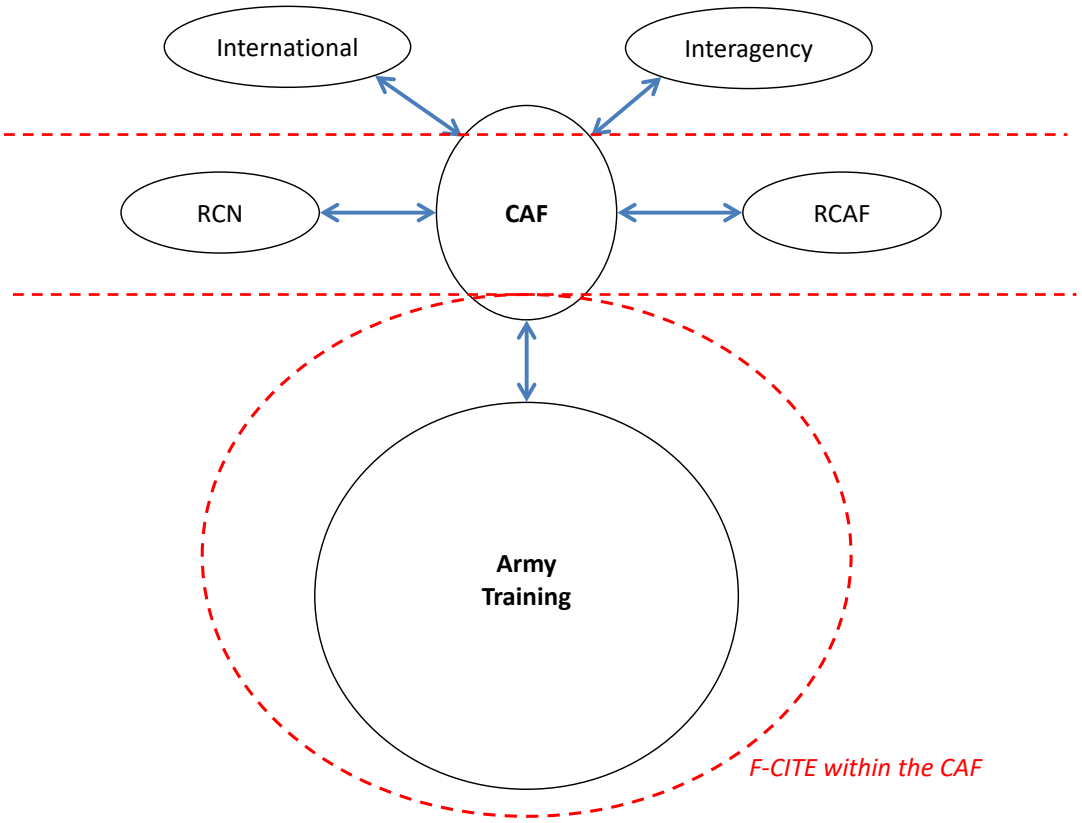


Figure 2-1 The scope of F-CITE within the CAF.

2.2.3 Assumptions

Assumptions identify factors outside the control of the F-CITE programme but which could influence it in some way. Changes to stated assumptions may therefore require changes to affected aspects of the F-CITE architecture. The following assumptions have been identified to date:

1. CA policy drivers (as listed in Section 2.3.1) remain extant;
2. Future CAF defence strategy and missions remain broadly similar to current roles and missions assigned, accepting that they will evolve in response to new requirements, threats and government policy;
3. Current CA training levels and throughput requirements remain broadly similar to today, set within an overarching Managed Readiness Plan (MRP) defined by the CA;
4. Current CA training organisations (including CADTC, CTC, CMTC and CASC) and structures remain extant;
5. F-CITE will primarily be delivered at existing CA training sites, and (with the exception of a possible deployable capability) will not fundamentally change the CA's 'training footprint';
6. Current Training projects (including LV CTS and WES MU) are delivered, and may be fitted for (but not necessarily with) F-CITE;

7. The Canadian Forces Experimentation Network (CFXNet) may provide the connectivity required to support F-CITE and further investigation of this capability is warranted. However, there may still be a connectivity shortfall that will need to be addressed by enabling F-CITE projects;
8. CA continues the adoption of the Decisive Action Training Environment (DATE) as a basis for developing relevant, scalable and flexible scenarios.

2.2.4 F-CITE timelines

The F-CITE programme has started with this study (initiated by the Army Capability Development Board) that delivered this report. Capability delivery milestones have yet to be defined.

2.2.5 Effort and Cost

The effort and cost of F-CITE have not yet been formally quantified. However, Section 5 discusses potential F-CITE cost-drivers.

2.2.6 Security classification and caveat

The overall F-CITE capability will operate at multiple levels of security reflecting the varying systems, data, training tasks and participants in supported training events. Some exercises may operate multiple security domains, e.g., when coalition forces are involved.

The overall existence of the F-CITE programme is unclassified.

2.2.7 F-CITE Integrated Data Dictionary

The terminology used within this report is intended to be fully consistent with that defined within the Army Systems Approach to Training (ASAT) [4]. Table 2-1 presents the F-CITE Integrated Data Dictionary, which identifies additional terminology that has a specific meaning within this report. Acronyms used within the report are presented in Section 12.

Table 2-1. F-CITE integrated data dictionary.

Term	Meaning	Comments
Event	Generic term for the training exercises, experiments, mission planning and rehearsal, operational analysis potentially supported by F-CITE.	Preferred to ‘exercise’ since this constrains the scope of F-CITE to a single M&S application.
Networked	An event in which multiple sites participate simultaneously in the same event via long-haul communications.	Preferred to ‘distributed’ which can also mean training delivered independently at unconnected remote sites (as opposed to a centralised school).
Reach-back	The situation where F-CITE users access centrally provided services.	E.g., when users at a remote site use central staff to handle some aspects of an exercise.

Term	Meaning	Comments
Service	An implementation independent specification of a packaged element of training and education functionality.	A service approach provides a consistent framework for dealing with organisations, people, processes and materiel.
Simulation blend	Two or more different types of simulation (L, V or C) used in the same training event.[5]	E.g., when a live training area has synthetic feeds or participants.

2.3 F-CITE drivers and vision

2.3.1 F-CITE drivers

F-CITE is influenced by numerous policy drivers. Some of the key drivers are summarised in Table 2-2. The table omits description of the CA governance structures and battle rhythm pertinent to F-CITE, instead focussing on drivers that can be viewed as functional or non-functional requirements for F-CITE.

Table 2-2. F-CITE policy drivers.

Driver	Key points
DND / CF Capstone Modeling and Simulation (M&S) Strategy.	"*Institutionalized, standards-based and integrated M&S capabilities used by the DND / CF to enable the warfighter and to support command and decision making across the DND and CF*". [5]
Commander Canadian Army (CCA) Vision.	"*A common architecture that supports / enables all five applications for simulation[6].* *Dissolves barriers between our legacy and future Live / Virtual / Constructive (L / V / C) simulation solutions and integrates seamlessly with targeted joint / multinational environments* *An end to 'stove-piped', standalone systems, enabling and encouraging the efficient re-use of resources.* *Where applicable, the CA retains full Intellectual Property (IP) and usage rights to M&S assets that it has paid to develop.*" [1]

[5] The term 'blended training' is used to refer to the use of different training media (including simulation) across successive events within a training progression.

[6] The five applications of simulation are defined within CASS as follows: (i) Training and Education; (ii) Operations and Planning; (iii) Concept Development and Experimentation (CD&E); (iv) R&D; (v) Acquisition and Life-Cycle Management.

Driver	Key points
CASS Guiding principles.	The CASS requires simulation to be: • Effective; • Efficient; • Accessible, both in terms of geographical location and alignment with the Managed Readiness Plan (MRP); • Coherent.
CASS Benefits realisation.	The CASS identifies the following benefits to be realised from the effective use of simulation: • Enhances the learning process; • Enhances / augments training when conditions are impractical or restricted; • Improves the effectiveness of pre-deployment training; • Provides resource savings; • Decreases the environmental Impact; The functionality and connectivity provided by F-CITE should further magnify these benefits.
CAO 28-01.	Simulation is part of a progressive training program. It is only through the accurate recording and analysis of utilisation that the simulation capability may be managed and developed effectively. The Canadian M&S Standards Profile (CMSP) [6] will be adhered to. Proprietary standards will be avoided. Before a model is embedded into a simulation, its 'correctness' and limitations must be understood.

2.3.2 F-CITE vision

The proposed F-CITE vision is as follows:

> F-CITE is an agile and adaptable System-of-Systems training capability accelerating the acquisition by the CA of the competences required for likely operational environments, using enterprise-wide blended Live, Virtual and Constructive simulation, enabled by a robust, open, networked, modular, scalable service-oriented approach engineered to reduce the total cost of ownership through-life, and to facilitate interoperability with Joint training partners.

Achieving the F-CITE vision delivers multiple benefits to the CA. These are covered in detail in Section 2.6, but in summary include training that is more accessible, interoperable, flexible, coherent, secure, efficient, responsive and assured.

2.4 F-CITE operational views

2.4.1 F-CITE as a training capability

The operational activities of the F-CITE training capability are fully consistent with ASAT [4]. Accordingly, F-CITE is a capability that, given operational requirements and forces to be trained, has the effect of producing:

1. Trained forces;
2. Validation data (training records) describing the forces being trained;
3. Evaluation data concerning the performance of F-CITE itself.

Figure 2-2 shows the ASAT-compliant training activities conducted by F-CITE, as well as additional management activities specific to F-CITE itself. The activities shown are summarised in Sections 2.4.2 and 2.4.3 respectively, and developed in more detail throughout the subsequent presentation of the architecture.

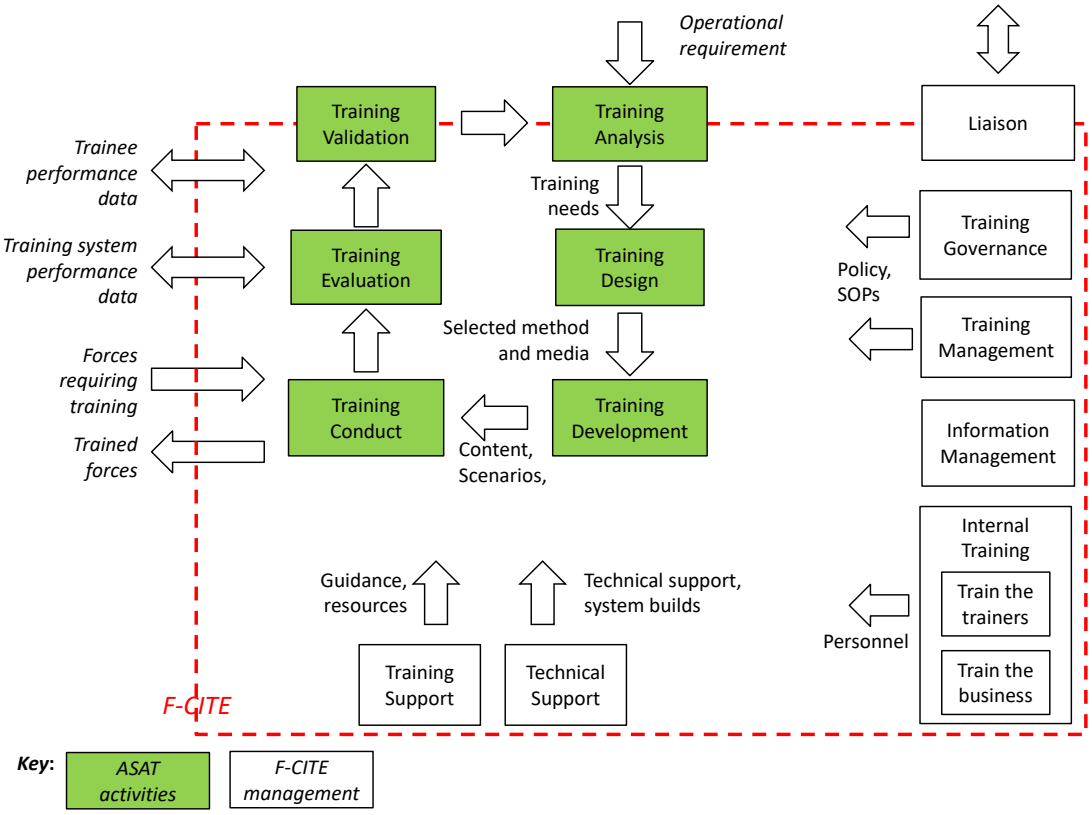


Figure 2-2. F-CITE operational activities.

2.4.2 F-CITE training activities

The ASAT-derived F-CITE training activities are as follows:

1. Training analysis. Determination of training tasks and the required performance standards. This activity straddles the F-CITE boundary, reflecting the fact that some training requirements may be defined externally to F-CITE;

2. Training design. Selection of appropriate training methods and media, typically from a 'toolbox' of existing F-CITE services (the toolbox concept is described in more detail in Section 2.5). In some cases, the design process may recommend that existing media be reconfigured to support a specific event;
3. Training development. Creation of training content, which can be generic, trainee-specific or event-specific. Development activities will wherever possible reuse and tailor previously developed content (e.g., 'off-the-shelf' scenarios and ORBATs). Technical reconfiguration of systems and services also falls within the development activity;
4. Training conduct. The delivery of the training itself in specific events or sequences of events tied together into an overall training campaign;
5. Training evaluation. Assessing the performance of a) the trainees and b) the F-CITE capability itself;
6. Training validation. Assessing the impact of F-CITE-delivered training on the operational performance of the trained forces.

2.4.3 F-CITE management activities:

In addition to generic ASAT training activities, F-CITE supports the following self-management activities:

1. Training governance. This activity is set within the wider CA training governance context and includes creating policy and procedures specific to F-CITE itself;
2. Training management. The planning, organizing, coordinating and controlling of other F-CITE activities including training delivery as well as supporting technical functions;
3. Liaison. Interaction with the wider CA and CAF at micro (e.g., event scheduling) and macro (e.g., role of F-CITE) levels;
4. Training support. Support by training Subject Matter Experts (SMEs) to F-CITE sites and users, (e.g., advice on the content required to meet specific training objectives);
5. Simulation support. Support by technical SMEs to F-CITE technical users (e.g., advice to SYSCON regarding system configuration);
6. Information management. This activity covers the diverse range of functions required to ensure that F-CITE users can easily and consistently create, retrieve and update the many different types of data relevant to F-CITE;
7. Internal training. The training of F-CITE users ('train the trainers') and business staff to help them fully realise F-CITE benefits.

2.4.4 Organisational attribution of F-CITE operational activities

The F-CITE activities defined here will need to be attributed (in terms of Authority, Accountability and Responsibility) to specific organisations within the CA. Such attribution cannot be determined from a purely architectural perspective, and is not therefore attempted in this report.

However, for planning purposes, this work has assumed that existing FCoE responsibilities for F-CITE governance and LVC delivery will broadly be retained by CADTC, CMTC, CTC and CASC respectively. Additionally, the phrase 'F-CITE National Simulation Centre' (NSC) is used to refer to an eventual organisation that provides cross-cutting support including:

1. Provision of a cadre of personnel acting as SMEs for F-CITE training services (e.g., event design or conduct). These would advise or could be deployed to F-CITE sites that lack dedicated personnel;
2. Training support (e.g., in terms of exercise design and conduct);
3. Technical support (e.g., in terms of simulation usage);
4. System and information repository services.

2.4.5 F-CITE operational user roles

This section identifies key operational user roles associated with F-CITE-based training activities. This set, presented in Table 2-3, includes key roles identified within ASAT. These roles represent functionally distinct 'hats', and it is possible that in some cases (especially at lower training levels) specific individuals could fulfil multiple roles. The interactions between these roles are covered in subsequent sections.

Table 2-3. Operational user roles within F-CITE

Role	Description
Evaluator	Military staff who evaluate the performance of the force being trained (e.g., in an After Action Review (AAR), or the performance of the training capability itself.
Exercise planning	The dedicated training staff who establish an exercise, led by the Officer Scheduling the Exercise (OSE).
Exercise Control (EXCON)	The dedicated training staff who are responsible for directing an exercise to ensure that it meets its training objective. These include the Officer Conducting the Exercise (OCE), who issues exercise and administrative instructions and Exercise Director (Ex Dir) who is responsible for training the Primary Training Audience (PTA).
Higher Controllers (HICON)	Role-players that provide a representation of the superior HQ of the force being trained. E.g., for a company-sized training audience, the HICON would represent a Battlegroup HQ.
Lower Controllers (LOCON)	Role players that provide a representation of forces, if any, that are subordinate to the force being trained.
Observer Controller Trainer (OCT)	Trainer staff who directly interact with the training audience, both to observe their performance, to provide coaching and in the worst case to intervene to ensure that safety processes are followed. OCTs are logically separate from evaluators since they should ideally be perceived by the trainees as 'friendly force' teachers rather than scorers.
Opposing Force (OPFOR)	Role players, that following EXCON direction, represent the force opposing the force being trained.
Role players	Generic term for an exercise participant whose function is to play the role of an individual that a trainee would encounter operationally. HICON and LOCON are two key categories of role player. Role players may be either serving staff or contractors with appropriate military knowledge and credibility. In many exercises at higher training levels, role players will be used to represent participants such as JIMP partners and neutral forces.
System Control (SYSCON)	Technically focussed staff who operate exercise systems while an exercise is running.

Trainees	The PTA, i.e., the forces being trained during an exercise or participants in individual training. In some cases, serving role players may also receive training value (e.g., practicing operational procedures) but such secondary training is not reflected in formal exercise TOs.
Instructors	Staff who instruct students during individual training (as opposed to collective training events).

Section 4 assesses the wider F-CITE personnel requirement, including support staff not explicitly identified by ASAT.

2.4.6 Generic exercise set-up interactions

Exercise set-up under F-CITE is broadly similar to current practices, but modified to reflect the increased emphasis on composition and configuration from an underlying toolbox of services, and the need for all sites to be consistent with overarching F-CITE practice (e.g., in terms of using consistent exercise constructs).

The approach is illustrated in Figure 2-3, which shows in high-level terms the interactions between different F-CITE organisations during the set-up of an exercise. The underlying systems and interfaces that support these logical interactions are separately described in Section 2.8.

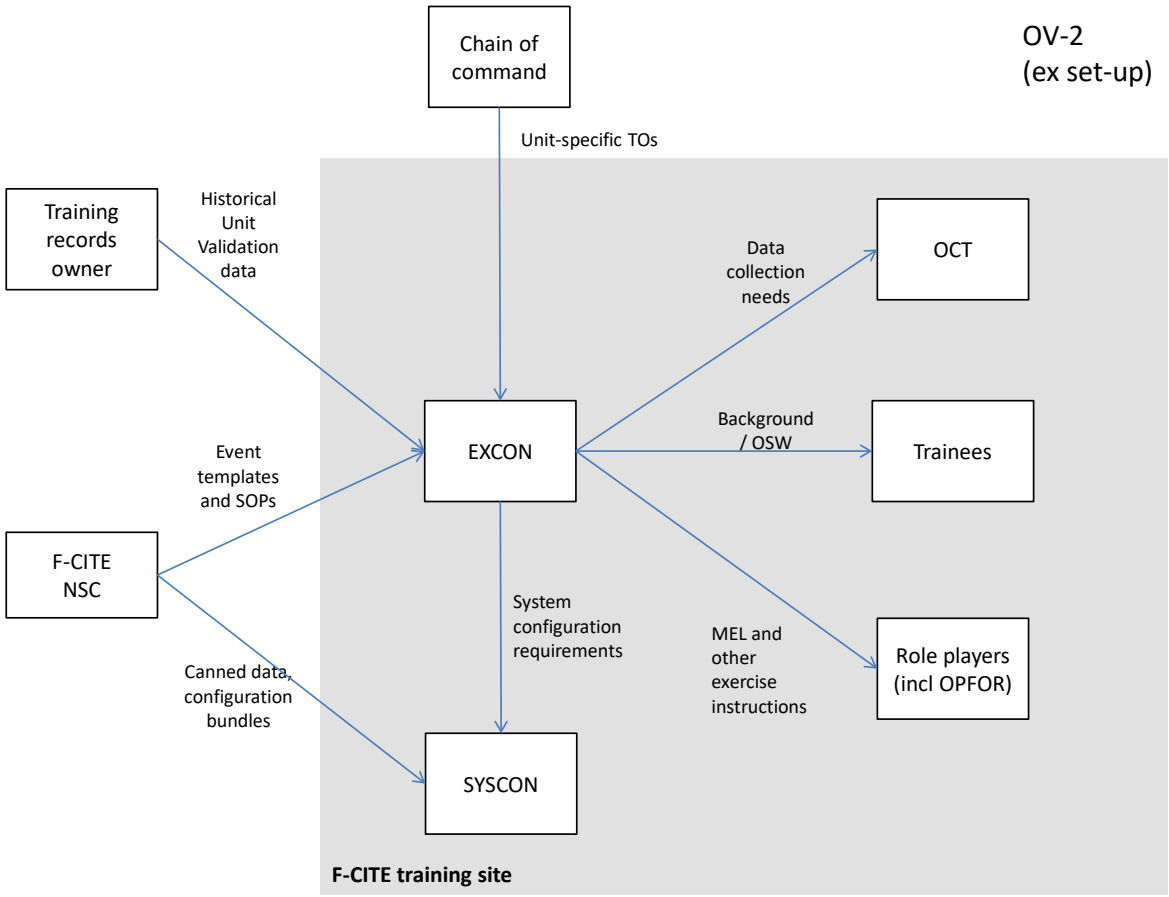


Figure 2-3. F-CITE exercise set-up.

The key aspects are as follows:

1. The overall exercise construct is derived from event templates supplied to the

training site by the relevant F-CITE FCoE, tailored if necessary to reflect unit-specific TOs supplied by the chain of command and taking account of the unit's past performance;

2. If, during exercise planning, EXCON determines that a standard exercise construct does not precisely meet the needs of the trainees, then an existing construct can be quickly reconfigured to do so. Such reconfiguration may require support from an FCoE with respect to changes at the procedural and / or technical level;
3. Once the preferred construct has been chosen by EXCON, then appropriate direction is issued to the wider set of exercise participants, including the trainees themselves, SYSCON, observers and role players.

Clearly, the majority of F-CITE exercises will re-use pre-defined exercise configurations 'off the shelf', but F-CITE will facilitate the effective dynamic development of novel training packages without having to reengineer the underlying systems.

2.4.6.1 Generic exercise execution

F-CITE exercise execution is illustrated in Figure 2-4 in terms of the organisations involved and their primary interactions.

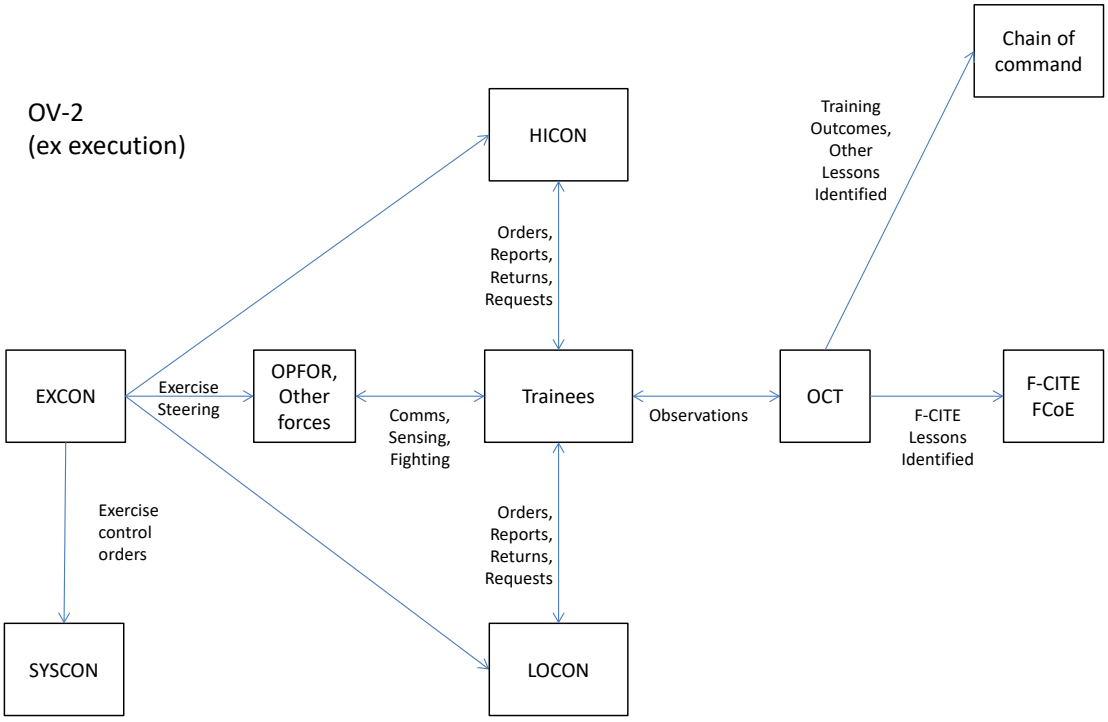


Figure 2-4. F-CITE exercise execution.

The overall construct is again broadly similar to current exercise practices. EXCON is responsible for ensuring that the exercise meets the training objectives and can use HICON, LOCON and OPFOR as 'levers' to change the challenges and tempo experienced by the trainees. HICON task the trainees, who in turn may task LOCON representing subordinate forces. Also of note is the recording of training outcomes and lessons identified, either to identify that the force being trained has completed (or not) the training to the desired standard or to identify ways in which exercise processes themselves could be improved.

The specific interactions and organisations involved will vary considerably depending on the type and roles of the training audience, the type of simulation (L, V or C) and the training level. By way of example, a section or sub-sub-unit (CT levels 2 and 3 respectively) undergoing Live training using WES are unlikely to have LOCON and will be physically present in real terrain (as are the OPFOR). In contrast, a BG undergoing a Level 6 Command Post Exercise (CPX) will primarily interact with the battlespace via LOCON and may lack direct visibility of the battlespace (except perhaps for ISR feeds).

Adoption of suitably consistent processes is a fundamental enabler of the F-CITE aspiration to increase connectivity between different sites. In contrast, use of arbitrarily different approaches at different sites increases the technical barriers to their successful interoperability.

2.4.6.2 F-CITE simulation blends and networked training

The set-up and execution interactions presented above cover the case when F-CITE is used at a single training site. However, F-CITE is also expected to be used in a networked mode, involving trainees at multiple sites dynamically connected in the same event using long-haul communications capability, and operating (i.e., sensing, moving and fighting) in a shared synthetic battlespace.

Figure 2-5 shows the key interactions that occur during the execution phase of a networked event in terms of the trainees, the underlying simulation and EXCON / SYSCON.

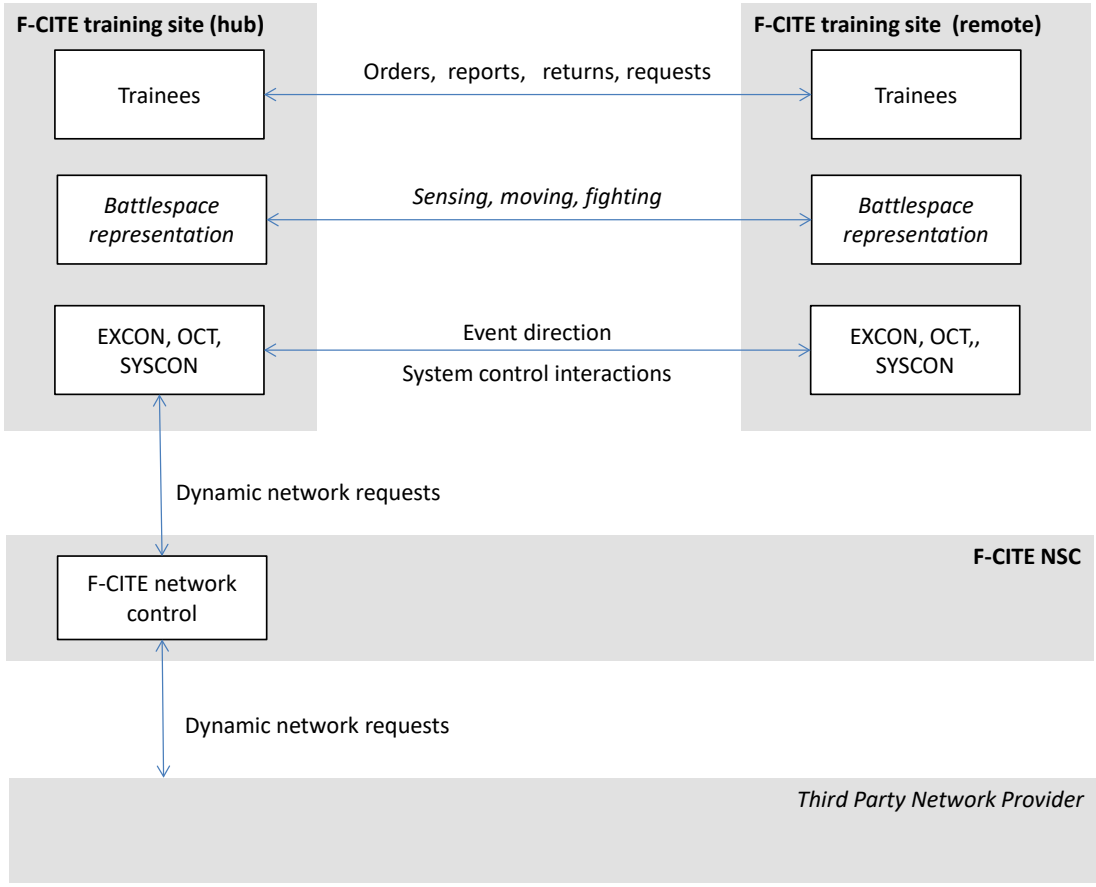


Figure 2-5. F-CITE networked training

In this example, one of the sites is designated as the hub and thus leads the overall event. Other sites are remote, and will follow direction from the hub, e.g., with respect to starting and stopping

play. Networking can also be used to provide a reach-back capability, e.g., where trainees at a remote site access services provided by the F-CITE NSC.

When an event simultaneously involves two different types of simulation, the result is a type of simulation blend. One example is the case where Live training is enhanced by Virtual inputs to represent information, effects, platforms or forces that for whatever reason cannot be present or generated in the Live training area. The Virtual inputs can be presented via C2 systems, emulations of operational ISR video-downlink terminals[7], or, potentially AR technology so that trainees can observe synthetic fall-of-shot overlaid on real terrain. The simulation blend can occur at a single site (e.g., with the Virtual simulation hosted in a Live site's EXCON) or networked across multiple sites.

Networked events will in general all exhibit the interactions shown in Figure 2-5. However, at the system level, there can be considerable variation. These technical permutations are considered in more detail in Section 2.8.

Key observations that emerge from consideration of networking are as follows:

1. The inter-site connectivity mechanism must provide logically separate channels for the different organizations involved, even when a single physical bearer has sufficiently high bandwidth for the overall inter-site traffic. Such separation is necessary to ensure that the trainees cannot access EXCON discussion (or even maliciously influence the simulation-level traffic) and that peaks in one channel (e.g., an unscheduled EXCON VTC) do not degrade other network traffic that can affect training outcomes;
2. Some F-CITE functionality (in this case an underlying long-haul network) may be provided by third-parties who cannot be directly controlled by F-CITE; Use of these third party services means that F-CITE does not have to directly implement all of its own long-haul infrastructure (thus reducing implementation costs) but creates a risk that essential services may not be fully accessible on demand;
3. The F-CITE NSC will play an important role in facilitating and mediating inter-site networking, e.g., negotiating with a third party network provider if it becomes apparent that increased bandwidth is required.

Without a centralised F-CITE NSC the onus will be on individual sites to manage the networking issues themselves, leading to duplicated effort and inconsistent approaches.

2.5 F-CITE service taxonomy

2.5.1 F-CITE services taxonomy overview

Figure 2-6 shows the proposed F-CITE service taxonomy, which is structured into the following discrete but interrelated layers:

1. F-CITE business services;
2. F-CITE training services;
3. F-CITE information services;
4. F-CITE application services;
5. F-CITE hardware services;

[7] Sometimes referred to as 'synthetic wrap'.

6. F-CITE infrastructure.

This mix provides a consistent framework for considering the various organisational, personnel, process and materiel services that will together constitute F-CITE. As will be described below, novel ways of thinking about composable training capability are essential if F-CITE is to avoid recreating the vertically stove-piped nature of existing training capability (where in the worst case, each capability independently implements every layer of the entire 'stack').

This layered service approach is also consistent with emerging concepts in other international partners, notably the Training and Education Architecture (Land) (T&EA(L)) being developed by the UK Ministry of Defence.

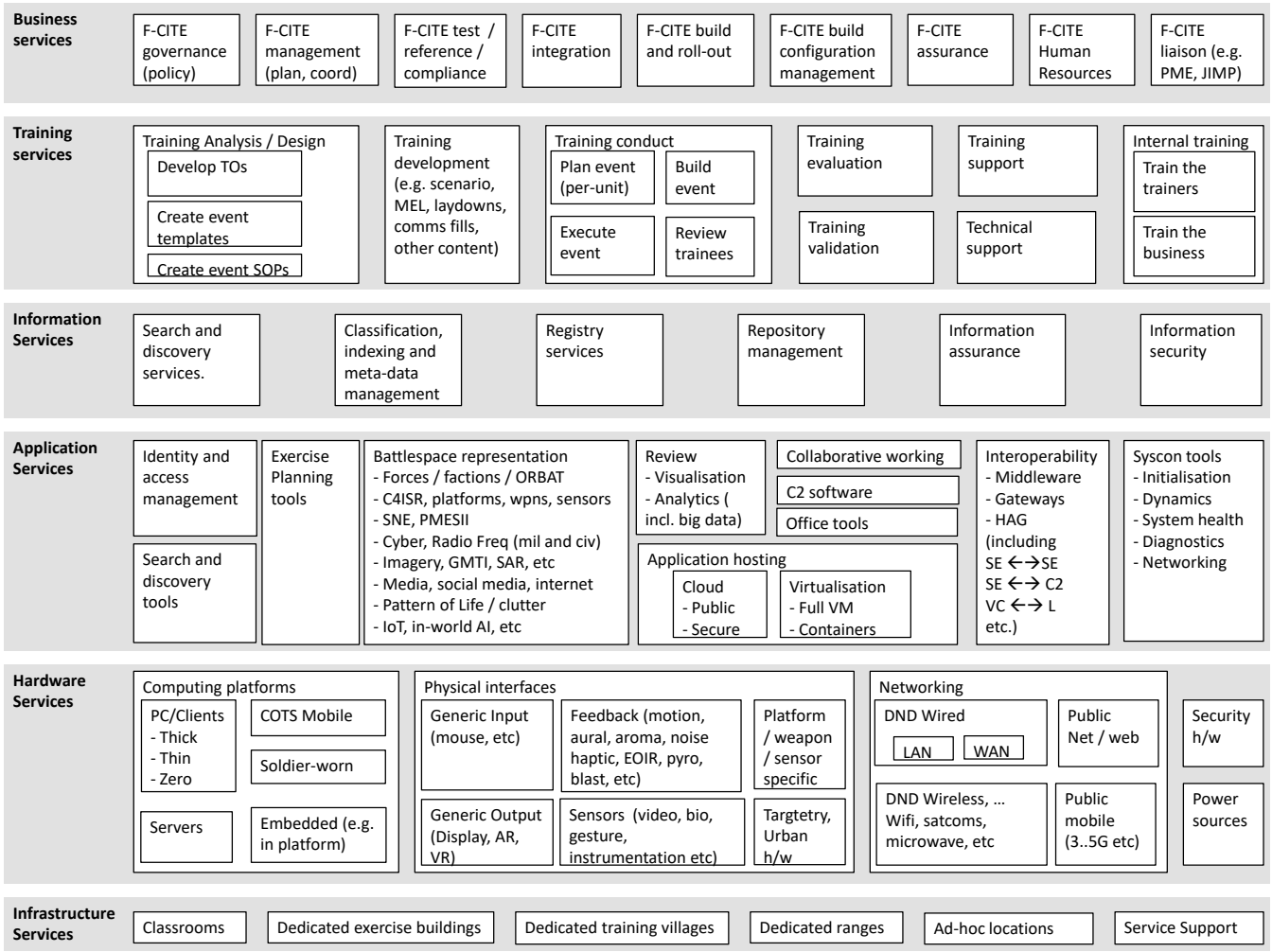


Figure 2-6. F-CITE service taxonomy

Taken together, the services constitute a toolbox of shared, open and reusable elements that can be used to compose various training capabilities. For example, a high-fidelity vehicle simulator (e.g., for use at CTC) could be composed of services taken from the application, hardware and information layers. Some of the same services (e.g., image generators and vehicle models) could then be used to create a lower fidelity desktop trainer for the same vehicle (e.g., for use at CASC). Both types of simulator could use a common AAR tool, and common representations of the battlespace (e.g., in terms of terrain, forces and factions).

Maximum flexibility can be achieved when the services are loosely coupled, such that individual services do not come with 'strings attached' that tie them to specific supporting layers. For example, it should ideally be possible to move software applications (such as simulations) that are currently hosted on local servers to an external secure cloud provider. This allows different simulation systems to share supporting computing resources, avoiding the need for each to acquire, maintain and refresh its own local servers.

Clearly, there will always be constraints on just how decoupled specific services can be. For example, a high fidelity vehicle simulation may require real vehicle controls supported by a dedicated vehicle model rather than a generic simulation. However, such special cases should become the exception rather than the rule as the service-based approach is more widely adopted.

2.5.2 Business services

Although many aspects of F-CITE will be designed during capability acquisition, the F-CITE concept places considerable emphasis on the flexible post-acquisition development of new capability (such as the integration of a new, standards-compliant C2 system). This aspiration is to be achieved by a process of service composition and configuration, as opposed to technical customization and re-engineering of the underlying systems.

Unfortunately, the desired capability will not simply compose itself. The uppermost layer of the service taxonomy therefore includes a set of business services that proactively enable the agility and adaptability required by F-CITE. These services will be delivered by a range of actors including the pan-CA F-CITE FCoE (notionally CADTC), the F-CITE NSC and even appropriately contracted industry partners.

Several distinct business services are shown, but their overall objectives are to manage training. This involves:

1. Defining and policing F-CITE policy;
2. Orchestrating (rather than control in a traditional top-down sense) F-CITE activities, enabling bottom-up initiatives driven by F-CITE FCoEs and other F-CITE users;
3. Providing an F-CITE integration capability that creates known 'good' builds for deployment to F-CITE sites;
4. Controlling the overall F-CITE toolbox, in particular to ensure that participants use consistent builds of the constituent systems, and that the release of new builds is synchronised with other changes. Such configuration management is critical to the F-CITE aspiration to facilitate ad-hoc connectivity and interoperability between different sites. The intent is not to force all F-CITE users to use a single 'one-size-fits-all' build, but instead to avoid basic barriers to interoperability, such as different sites using different and incompatible versions of interoperability middleware;

5. Providing an F-CITE test and reference capability that allows service providers to confirm that their offerings are consistent with F-CITE policy (and potentially to award services an 'F-CITE-approved' sticker);
6. Collecting Lessons Identified, and thus providing an evidence base for future changes to the F-CITE capability itself (these lessons are distinct from those relating to the trainees, e.g., comments on operational practices).

These business services do not directly deliver training, but are an essential enabler of the overall F-CITE vision. They must be appropriately supported, funded and resourced. Without them, there is a risk that F-CITE will become yet another inflexible stovepipe, or that the toolbox approach will lead to anarchy rather than coherence. They are also a mechanism for stating and policing F-CITE rules, e.g., so that users who intentionally use non-compliant systems may forfeit some types of technical support.

2.5.3 Training services

Services in this layer relate directly to the management and provision of learning and training. They cover the entire ASAT training / exercise lifecycle. The basic processes will in general appear similar to those conducted today, although F-CITE places greater emphasis on aligning processes across different types of training environment (except where there are intrinsic differences between L, V and C). Such alignment is necessary to facilitate interoperability and the effective use of shared resources.

One feature of note is the internal training required by F-CITE. This includes the standard 'train the trainers' as well a 'train the business'. The later captures the need to train appropriate staff in the management and use of F-CITE itself, e.g., the processes required to create new capability from the service toolbox, or update the existing toolbox.

2.5.4 Information services

F-CITE will require a large and diverse array of information types to support its various functions. The full set data types of is covered in Section 2.7, but includes training records, scenarios, trainee performance data, F-CITE performance data and F-CITE configuration management. F-CITE data will in general be edited by tools that reside in the Application Services layer (covered below), exploiting the use of standardized data formats to separate content from specific editing tools. Such separation is necessary to reduce the extent to which the CA is locked-in via proprietary formats to a narrow set of tools or service providers.

However, several distinct services are required at the overall information level. These relate to:

1. Information assurance: managing risks related to the use, processing, storage, and transmission of information or data;
2. Information security: defending information from unauthorized access, use, disclosure, disruption, modification, perusal, inspection, recording or destruction;
3. Information repository management for data that is owned and held by F-CITE itself (including back-up for recovery from data loss and archiving for long-term persistence);
4. Information registry functions for data needed by F-CITE but that for whatever reason is owned or held externally;
5. Universal information search and discovery mechanisms for F-CITE users;
6. Data classification and meta-data management.

The overall intent is to provide a Single Information Environment (SIE) for F-CITE users, such that users can search for, query and retrieve information from across the entire F-CITE enterprise. Subsequent access to such data may still be constrained (e.g., so that trainees cannot edit their own scores) but it is critical that F-CITE does not in itself create new information silos. Information collected during training may also support non-training functions such as R&D, as described in Annex B.

2.5.5 Application services

This layer covers the wide range of software required by F-CITE users, including the simulations themselves (described here as battlespace representation), exercise management tools, collaborative working (e.g., between EXCON staff at networked sites) and interoperability middleware and gateways. Some of the simulation software will appear similar to current capability. However, there is anticipated to be greater use of Artificial Intelligence (AI) based capability, e.g., to create synthetic teammates or role-players. AI could potentially be used to create assistants for OCTs or instructors (e.g., to monitor trainees and alert a human OCT when events of note occur).

The layer also includes application hosting software, including virtualisation and container approaches that insulate end-user-software from the underlying 'compute' hardware[8]. Such hosting can drive resource utilisation efficiencies by allowing multiple users to share common computation resources, rather than acquire their own separate duplicated hardware which is perhaps only 50% utilised.

Many of the systems and technologies that support services in this layer will evolve extremely rapidly during F-CITE timescales. It is therefore particularly important to prevent long-term contractual lock-in to software technologies that rapidly become obsolete and / or lose vendor support. Increased ownership by CAF of the relevant IP may reduce dependence on third parties in some cases, but it will be impossible in general for the CAF to fully own IP across the massive array of technologies concerned, especially the lower-level enablers. IP ownership by the CAF would also incur commercial and management overheads.

2.5.6 Hardware services

The hardware service layer includes

1. The physical 'compute' devices that support F-CITE, ranging from conventional PCs and servers, to mobile technology, to various zero or thin clients[9];
2. Physical interface devices, whether traditional keyboard and mouse, simulator controls, motion platforms, and innovative display and sensor devices;
3. Networking, whether wired or wireless, or DND-owned or public;
4. Power sources (e.g., for soldier-worn WES applications);
5. Specialised security hardware (e.g., so-called data diodes).

[8] Virtualisation involves running, on a single server, multiple Virtual Machines (VMs) that each host user-facing software. The number of VMs can be easily scaled to meet demand, and the underlying hardware shared between many different users. Containers are a form of lightweight VM that support increased tailoring of resources to specific users.

[9] Zero clients are stripped-down computers that only allow users to access data held elsewhere. They hold no local data or software licenses when disconnected from the network. Thin clients offer basic PC functionality, but access applications from the network. Both types allow the use of less powerful (and thus more affordable) client machines by exporting the heavy lifting to the servers. They also simplify security by ensuring that no classified data is held locally.

As with application software, the underlying systems are evolving rapidly with year-on-year improvements in key areas such as storage and image generation. Use of appropriate application hosting services (as described in Section 2.5.5) can help prevent CA users from being locked into obsolete hardware. However, there will always be a requirement for some dedicated local hardware – e.g., PCs with high-end Graphics Processing Units (GPUs) for real-time image generation in high-fidelity vehicle simulators. Furthermore, some remote F-CITE sites may lack the connectivity required to access cloud-hosted applications. The extent to which application hosting approaches can be exploited by F-CITE will therefore be partially driven by external programmes that deliver long-haul connectivity, and as these programmes improve connectivity, 'local vs. cloud' decisions may need to be re-assessed.

As ever, there is no single 'correct' machine performance specification, and it will remain necessary to consider the performance required on a case-by-case basis. Planned technology refresh points provide decision points where the choice between local and cloud hosted services can be re-assessed.

Assessment of the minimum system specification required must also take account of future systems (notably C2 systems) that may be used in the training requirement. For example, an upgrade to a C2 system requiring higher-performance hardware could cause problems if training environments had assumed that a lower-performance machine was all that was required to host the C2 systems, and had locked themselves into the long-term provision of hardware that would suddenly be of insufficient specification to support credible training.

Finally, ongoing commercially-driven improvements to hardware capability mean that entirely new and massively disruptive capabilities may emerge within F-CITE timescales.

2.5.7 Infrastructure services

This layer has been included for completeness, to emphasize that F-CITE will, as at present, be tied to real-world physical locations, including schools, ranges, and unit sites.

However, F-CITE may offer better utilisation of physical infrastructure by allowing distinct training communities to share underlying facilities. For example, transitioning some aspects of simulation capability to the cloud (as is routine in CAF education) could avoid the need for two separate desktop simulation systems to duplicate commodity PC hardware in separate classrooms. Cloud-hosting could reduce the number of distinct classrooms required but equally it requires careful scheduling to maximise bookings and avoid contention on the shared hardware. Dealing with resource contention could be problematic if the different classroom users were not under the same chain of command.

2.6 F-CITE capability taxonomy

The service taxonomy presented in Section 2.5 describes the 'how' of F-CITE in terms of the functionality it provides. In contrast, the F-CITE capability taxonomy presented in Table 2-4 articulates the enterprise goals that will be delivered by F-CITE (the 'why'), or, in other words, the effects that F-CITE will deliver to the CA.

Table 2-4. F-CITE capability taxonomy.

#	Capability	Description.
1	**Accessible training**	
1.1	Training at fixed sites	F-CITE is available at a wide variety of Regular and Reserve Force sites.
1.2	Networked	F-CITE allows different sites to be networked together to augment per-site training and / or reduce travel.
1.3	Deployable	F-CITE can be deployed to ad-hoc sites (including operational areas) for distributed and / or networked training.
1.4	Available	F-CITE minimizes training time lost due to system failures and procedural 'friction'.
2	**Interoperable training**	
2.1	Internal CA interoperability	F-CITE's own components operate together seamlessly.
2.2	JIMP training	F-CITE, via Joint enablers, allows CA forces to train seamlessly with non-CA partners.
3	**Flexible training**	
3.1	Blended simulation	F-CITE provides post-acquisition flexibility by providing a toolbox of mutually supportive but loosely coupled services, from which new simulation capability can be blended on demand.
3.2	Targeted fidelity	F-CITE targets simulation fidelity[10] at specific training needs.
4	**Coherent training**	
4.1	Common, open services	F-CITE provides coherent standards-based tools and processes across training and education progressions to reduce arbitrary differences between the different supporting systems.
4.2	Single Information Environment	F-CITE provides uniform mechanisms for F-CITE users to discover, retrieve and update data.
4.3	Configuration control	F-CITE ensures that different users and sites use consistent, supported versions of its services and systems.
4.4	Test and reference	F-CITE allows service providers to confirm that their offerings are in fact F-CITE compliant.

[10] There is no single correct answer to the question 'how much fidelity is enough?' If fidelity is set too high, it can distract novices and / or create unnecessary expense. If set too low, it can reduce the credibility of the training environment, or lead to negative training.

#	Capability	Description.
5	**Secure training**	
5.1	Multi-level secure training	F-CITE allows training to represent operational security requirements, including multi-level secure networks in a single training event.
5.2	Hardened training	F-CITE is itself hardened against cyber and other threats (e.g., malicious changes to training data or denial of service attacks on networked capability).
6	**Efficient training**	
6.1	Control diversity	F-CITE reduces the Total Cost of Ownership (TCO) by minimizing unnecessary diversity in its services, while allowing for the intrinsic differences between L, V and C.
6.2	Efficient use of resources	F-CITE encourages more efficient use of resources by increasing their sharing and / or reuse across training. The sharing includes staff that support common training functions as well as systems and components.
7	**Responsive training**	
7.1	Respond to changing training requirements	F-CITE can respond to changes to training requirements (e.g., as new threats emerge) and as demand changes (e.g., an operational surge).
7.2	Respond to generational change	F-CITE can respond to the human dimension including impacts of ‘generation Z’ and training-the-trainers issues.
7.3	Respond to technology change	F-CITE can exploit emerging technologies as well as supporting system capacity growth, system upgrades and obsolescence management.
8	**Assured training**	
8.1	Training evaluation	F-CITE provides the evidence to support assessment of whether training is effective (trainees meet the prescribed standards) and efficient (methods, materials and resource expenditures are optimized).
8.3	Training validation	F-CITE supports assessment of whether training has adequately prepared soldiers to perform operational tasks or attain professional competencies.

This capability taxonomy is used as a basis for deriving the SoCD (in Section 4) and HLMRs (in Section 8). Specifically, given the capability requirements stated here, the SoCD describe the accessibility of the current and planned simulation fleet, and the HLMR describes how to address the gap.

2.7 F-CITE strategic information model

The strategic information model identifies in high-level terms the types of data required by F-CITE. The precise data formats will be defined at a later stage, as will the organisations responsible for generating and maintaining them.

Table 2-5. F-CITE strategic information

Data	Description	Comment
Policy and SOPs		
F-CITE Training policy	Covering general principles, including internal governance relationships where necessary.	
Overarching F-CITE training SOPs	SOPs that apply to all F-CITE users irrespective of whether they are L, V or C.	
FCoE-specific training SOPs	SOPs specific to L, V or C training.	
TOs / tasks	TOs originate from outside F-CITE, but will be internally mapped to training activities across L, V and C.	
Train-the-trainers courseware	Covering both 'how-to-train-using F-CITE' and 'how-to-operate the F-CITE business services'.	Ideally implemented using CAF Campus or similar CA education portals.
Encyclopaedic data		
Scenario background data	Derived from generic sources including DATE, but also including mission or location-specific data as required. Includes Geo data and forces and factions.	'Real' country data (as opposed to generic DATE) will be required for mission preparation, and L training will often require real terrain data for the training area.
Synthetic Environment (SE) assets.	The software models that underlie Virtual and Constructive simulation.	Assets may be created by industry and will often be unclassified. Some will allow post-acquisition scripting by trained military staff.
SE asset performance data	Equipment performance and vulnerability data for SE assets.	The data that brings the assets to life. May be classified if necessary, and copies may be modified on a per-event basis to better meet training objectives.
Event templates		
Event template	Many different templates will exist, corresponding to the different levels and types of training, and different training tasks. They include but are not limited to network diagrams, scenario contents, MELs, C2 application deployments and data collection plans.	Individual and collective battle task standards.

Data	Description	Comment
Per-event set-up data		
Unit-specific event pack	The result of taking an exercise template and then populating it with data specific to the unit being trained.	For repeating routine exercises, the population process should be largely 'mechanical'.
System data fills	The data that must be loaded into systems before they are used by trainees. Includes C2 message history and crypto as well as traditional simulation ORBATs.	For C2 systems, such data could include database contents, faked historical message traffic and operational pictures. Without such data, C2 systems will be unnaturally empty.
Per-event dynamic data		
Simulation ground truth	Data recording objects, activities and events in the underlying battlespace.	Provides AARs with the underlying evidence for what happened during an exercise.
Trainee-level data	Data (including voice traffic) generated by the trainees as they go about their business.	Shows observers what the trainees thought was happening. May also be a useful source of canned data for subsequent exercises.
Observational data	Data generated by observers, e.g., to bookmark events of interest for AAR and dynamically update trainee records.	Used to develop AARs and inform assessment of the trainees performance.
Per-Event AAR data		
Exercise AAR data pack	The products that support AAR.	Includes replays of events, force-on-force graphs and videos of the trainees.
Exercise take-home pack	Subsets of AAR data issued to particular participants for later referral.	May be identical to the AAR data pack. However, for combined arms exercises, technical data of interest to a specific arm may be irrelevant to other participants, and therefore omitted.
Persistent training records		
Trainee performance data	Data that centrally records the training outcomes of F-CITE events including the standard achieved by the trainees.	Ideally, training records will provide sufficient detail for trainers to tailor exercises to address the strengths and weaknesses of the trainees demonstrated in prior exercises. Non-training F-CITE users will need their own local equivalents.

Data	Description	Comment
Lessons identified from training	Observations made during training that may inform development or refinement of operational doctrine or SOPs.	E.g., where trainers realise over time that a particular SOP could be streamlined, or that there is a systemic weakness with respect to a particular threat.
F-CITE operational data		
F-CITE configuration notes	Records that document the services and systems (including their versions) currently supported within F-CITE.	Critical to ensure controlled use of the F-CITE toolbox.
F-CITE performance data	Data that records the performance of F-CITE itself against predefined performance metrics.	E.g., to allow CA to determine whether service providers are meeting availability targets.
F-CITE lessons identified	Records of the practical experiences of F-CITE users that inform F-CITE operations or subsequent improvements.	E.g., where users identify a change to a SOP that improves resource utilisation.
F-CITE meta data	Descriptions of the structure and / or content of other F-CITE data sets.	Supports information management activities such as indexing and search. Some meta-data can be taken from simulation standards, but this will not be possible for data not covered by standards (e.g., training records and F-CITE performance data).

2.8 F-CITE use cases

2.8.1 F-CITE use case overview

F-CITE will support many different types of training. Some possible use cases include the following:

System View (SV) 1 diagrams show key systems and their interfaces. Because F-CITE is a complex system of systems that can support many different types of training, multiple SV-1s are used here, corresponding to likely F-CITE use cases:

1. A single F-CITE site conducting Virtual or Constructive training;
2. A single F-CITE site conducting Live training supported by a local synthetic capability;
3. Multi-site permutations of LVC integration;
4. F-CITE as a part of a Joint Simulation Network;
5. F-CITE components supporting individual training.

These use cases are described in more detail in the following paragraphs (some in a purely textual form). Other use cases may be identified as the F-CITE architecture is further matured.

2.8.2 F-CITE Virtual / Constructive training

Figure 2-7 shows the system structure of a generic F-CITE training site conducting Virtual or Constructive training.

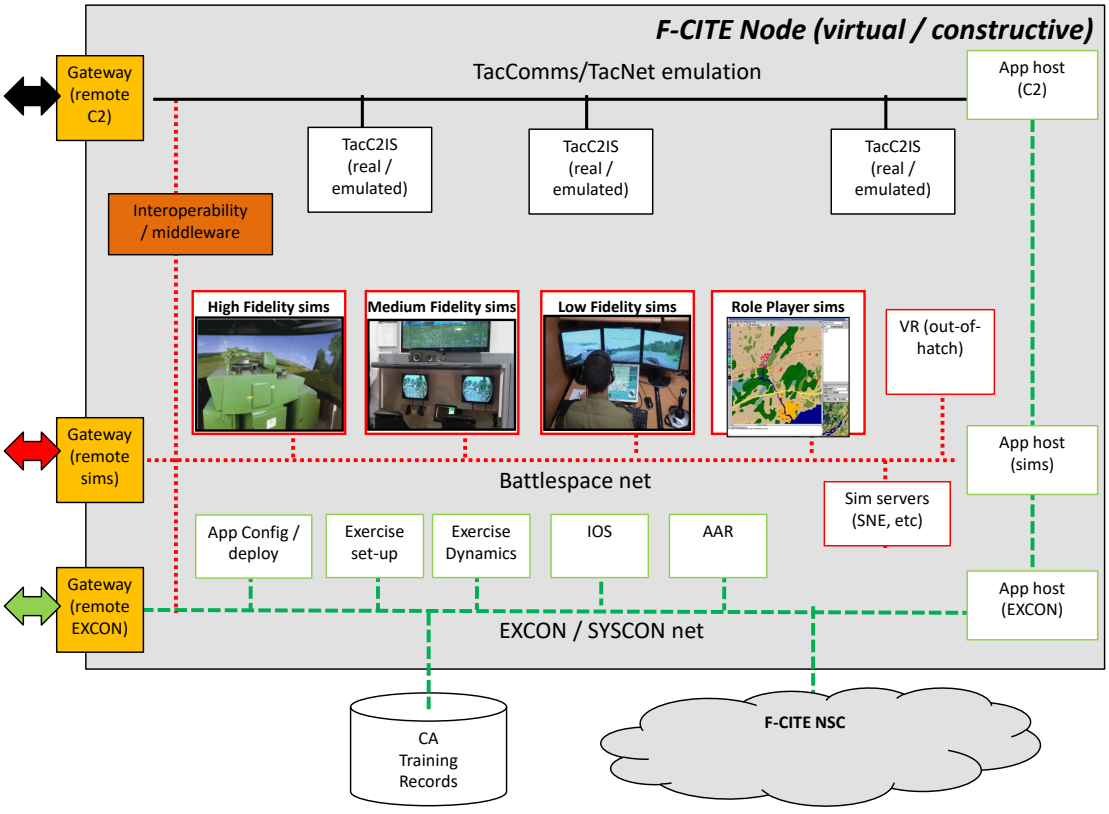


Figure 2-7 Generic F-CITE node SV-1

In many ways, this is broadly similar to existing training systems in that it includes simulators of varying fidelity, real or emulated TacC2IS, Instructor Operator Stations (IOS), and AAR. It also runs multiple logical networks, including C2 and Battlespace nets that are used by trainees and an EXCON / SYSCON net that is used by the trainers. The C2 network can be internally partitioned to support multiple logically distinct voice and data nets, potentially at different levels of classification.

However, F-CITE differs from conventional capability in the following ways:

1. Each F-CITE site can be flexibly configured to support either Virtual or Constructive training by selecting appropriate permutations of simulations and simulators from the overall F-CITE toolbox (as is the intent for LV CTS). The overall degree of flexibility will be constrained largely by the physical infrastructure available rather than technical limitations;
2. Applications (e.g., simulations and EXCON tools) are virtualised wherever possible, and the host virtual machines are run on dedicated application servers. Three logically distinct servers are shown, corresponding to C2, simulation and EXCON / SYSCON respectively. Use of virtualisation in conjunction with thin (or zero) clients means that many tasks can be supported by relatively low specification commodity client hardware. Virtualisation can also reduce the security overhead of exercises, in particular the need to 'wipe' the hard drives of the client machines;
3. EXCON tools include an application configuration and deployment tool. This is used as a central facility to deploy the applications required by a specific event to the relevant servers and clients across the facility. The applications are taken as required from the F-CITE NSC. Centralising this function reduces the SYSCON manpower overhead by reducing the need to physically visit and initialise many different PCs before trainers or trainees can use them;
4. The site has gateways to remote C2 systems. These gateways allow trainees to interact with those at other sites (e.g., a Bde HQ in a virtual site commanding trainees in a live training area) or for the site to act in a HICON / LOCON role with others. If appropriate HAGs are used, the site can connect to trainees operating in a different security domain;
5. The site has gateways to remote simulation systems. These gateways allow trainees at the different sites to operate in the same synthetic battlespace. They also allow a virtual / constructive site to provide a simulation blend capability to live training areas. However, they may also raise potential 'fair-fight' issues if different models or terrains are used at the different sites;
6. The site has gateways to remote EXCON systems that support inter-site networked training.

2.8.3 F-CITE Live training

WES is the foundation on which live training is built. The F-CITE systems approach to simulation integration will allow WES to be used as part of larger, more comprehensive simulation blends, as illustrated conceptually in Figure 2-8.

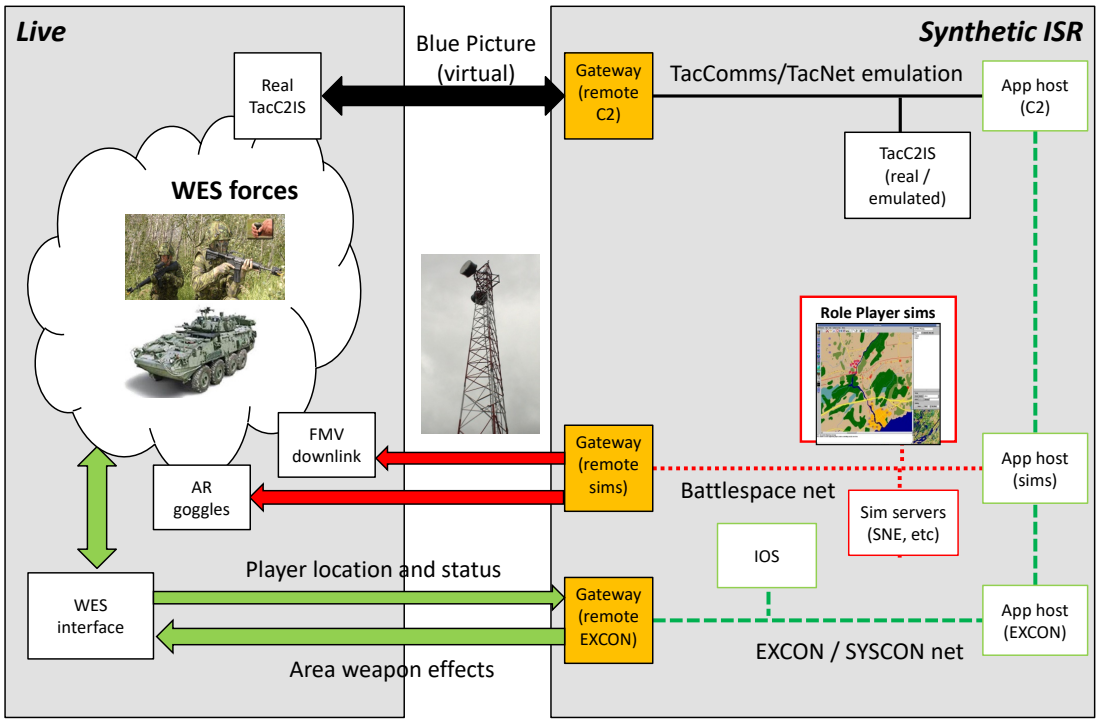


Figure 2-8. Simulation blended training in F-CITE

The configuration shown can be seen as an extension to the WES EXCON function:

1. Location and status information is read from WES equipment and passed (via the EXCON net) into an F-CITE virtual battlespace representation;
2. Synthetic representations of the Live forces are integrated with the locations of existing virtual forces, which may include friendly flanking units or OPFOR units in the deep battle;
3. Blue force tracking information for the virtual blue forces is passed to the WES players via their real TacC2IS;
4. Simulated ISR feeds including Full Motion Video (FMV) can be passed to WES forces by real or emulated downlink terminals;
5. Augmented Reality (AR) devices (e.g., goggles or modified binoculars) can be used to display synthetic entities (e.g., a fast jet) or events (e.g., fall of shot) to some live players.

This capability allows the WES players to benefit from training in a much larger terrain area than can be provided by the real-world training area, which will be particularly important for dispersed operations. The players can also benefit from interacting with assets (such as ISR systems, or Joint platforms) that for whatever reason are not available in a purely live exercise.

Some of the live / synthetic interactions will require careful management or synchronisation by EXCON, in particular the case where live forces (e.g., an OPFOR unit) enter the live area having advanced toward it virtually.

2.8.3.1 Multi-site permutations of LVC integration

In the simulation blend example just shown, the Virtual environment is hosted as part of the EXCON function of a Live training area (e.g., at CMTC). However, the interoperability gateways allow full LVC integration for multiple distinct sites (assuming appropriate long-haul connectivity). Permutations made possible by this networked systems approach include the following, where the '+' symbol indicates inter-site networking:

1. L, V or C: individual sites operating non-networked training;
2. LV: A live site with a collocated virtual element;
3. L+V: e.g., a WES site connected to a LV CTS site;
4. V+V: two interconnected LV CTS sites;
5. L+C or V+C: e.g., a WES site or LV CTS site connected to a C site.

The actual set to be supported by F-CITE should be determined from consideration of the training requirement rather than from purely technical considerations.

2.8.3.2 F-CITE networking

Whether or not a training site can join an F-CITE network depends on the site's long-haul connectivity, which must provide sufficiently high bandwidth and low latency to handle dynamic exercise interactions. Such connectivity may also need to be secure, depending on the types of data used in an exercise. Secure long-haul networking is therefore a key enabler for F-CITE. However, not all of the networking required needs to be provided by F-CITE itself. In particular, F-CITE could use secure Joint networks as bearers for CA-specific training connectivity, assuming that such networks had available bandwidth when required by F-CITE. In this context, it is important to realise that a networked F-CITE exercise could place extremely high demands on the underlying bearer, especially if voluminous simulation and C2 data is exchanged between the sites.

Sites that lack appropriate connectivity could still participate in F-CITE if they had access to a deployable mobile F-CITE kit (the F-CITE equivalent of 'Sim-in-box'), e.g., hardware pre-loaded with the appropriate applications and data. A mobile F-CITE kit could still take advantage of novel F-CITE services even if it could not access the F-CITE cloud. For example, the mobile F-CITE kit could include servers running virtualised applications accessed by trainees using low-footprint, low-cost thin/zero clients. Such a kit would reduce the need for local system administration skills, at the cost of only supporting a narrower range of training tasks than available via the cloud. Mobile kits could also support JIMP training (discussed below) or be used by CA units deployed outside Canada.

2.8.3.3 F-CITE as a part of a joint simulation network

The system views presented here all relate to training in a purely CA context. However, F-CITE's interoperability capabilities (in terms of the standards, middleware and gateways) potentially allow it to participate in wider JIMP training networks involving elements of the RCN, CA, RCAF and Combined Joint Operations Command (CJOC). Some illustrative use cases are as follows:

1. Networked joint training for combinations of the RCN, CA, RCAF and CJOC ('big J' training);
2. Single service training in a rich joint context for one of the RCN, CA, RCAF and CJOC, where the others are essentially role-players rather than trainees ('little j' training). In this sense, the CA, using F-CITE as the underlying mechanism,

could either be the training recipient of the joint context or the provider (e.g., to CJOC) of the Land component of the joint context;

3. Bilateral training between the RCN, CA, RCAF without a rich joint context (e.g., for networked Air / Land Integration (ALI) training involving CA FOO/FACs and RCAF aircrew).

These permutations, which are not mutually exclusive, are illustrated in Figure 2-9.

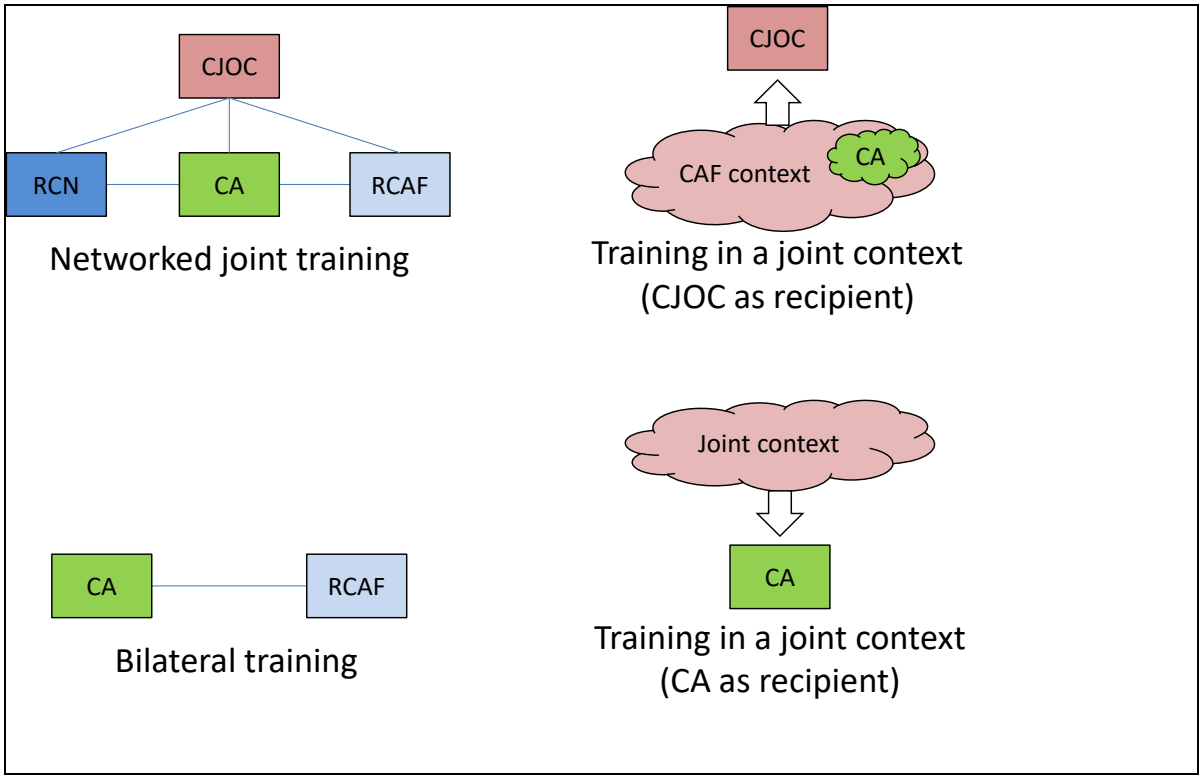


Figure 2-9. Permutations of joint training

The extent to which F-CITE should support one or more of these options is a Joint-level decision. Furthermore, their full implementation would require Joint funding and resources. However, although F-CITE does not have a mandate to support Joint training, its architecture gives F-CITE sufficient technical agility and adaptability to participate if required (and if funded).

2.8.4 F-CITE components supporting individual training

Although F-CITE is primarily intended to support collective training, specific F-CITE components could also support aspects of individual training. The prime example is F-CITE simulators being used by LV CTS as part-task turret trainers, e.g., by gunnery students transitioning from Computer Based Training (CBT) media to full-scale crew training. Using the same simulator components provides the trainees with a smoother training progression and avoids duplication of systems. F-CITE application and hardware services could also host CBT classrooms, ideally in a way that is complementary with education initiatives such as CAFCampus.

However, F-CITE collective training scenarios (as opposed to simulators) are unlikely to be directly reused without modification, primarily because individual training (especially for technical tasks) does not require the rich tactical context of collective training. Instead of using identical scenarios, the CA should instead aim to ensure that scenarios for use with individuals (e.g., in LV CTS) and collectives are both based on common DATE-derived elements.

2.9 F-CITE standards

Numerous existing standards are potentially applicable to F-CITE, ranging from the simulation interoperability standards referenced in the CMSP to building codes for infrastructure. The specific standards will be identified as the F-CITE architecture is further matured. The intent is to facilitate interoperability and avoid lock-in to proprietary approaches. Areas where standards are found to be lacking are those where F-CITE acquisition will need to take greater care, e.g., to obtain Interface Control Documents (ICDs) for technical interfaces for which agreed standards do not exist.

3 F-CITE options for analysis

3.1 Overview

This Section presents several F-CITE options for analysis. Specifically, the following options have been identified, in order of increasing capability, services provided and users supported:

1. Option 1: Maintain the status quo (the 'do nothing' option from a F-CITE perspective);
2. Option 2a: F-CITE delivered at all CA FGBs plus Kingston;
3. Option 2b: F-CITE delivered at all CA FGBs plus Kingston and CMTC;
4. Option 3a: F-CITE delivered at all CA training sites;
5. Option 3b: F-CITE delivered at all CA training sites plus Reserve Forces.

As will be explained in Section 6, cost benefit analysis of the options is outside the scope of the current work, and this study has not therefore attempted to select a preferred option. This analysis is not exhaustive and may need to be further developed to take account of the extant situation at the time a preferred option is selected.

3.2 F-CITE option 1: maintain status Quo

3.2.1 Option 1 overview

This option involves the continued delivery of current and planned capability (and is thus not zero-cost), without attempting to move it toward the F-CITE target architecture. This could involve completely abandoning the F-CITE concept, or alternatively, deferring consideration for several years.

3.2.2 Option 1 advantages

The advantages of this option are as follows:

1. The CA training community can focus on its immediate challenges rather the need for reconfiguring itself to prepare for F-CITE;
2. Funding earmarked for F-CITE acquisition activities can be reallocated for other priorities.
3. The CA training community can adopt a 'wait and see' policy until the impact of ongoing Defence reviews is more clearly understood.

3.2.3 Option 1 disadvantages

The disadvantages of this option are as follows:

1. Cancelling F-CITE does not avoid the need to train the CA for future operational environments, or to react to a changing world. The wider CA is thus left with training that will be increasingly irrelevant and unwieldy, and vulnerable to 'shocks';
2. The costs and inefficiencies identified by the SoCD will remain, and in fact increase in relative severity should CA training face increased demand pressure or reduced funding;
3. Implementing planned projects without taking F-CITE concepts and goals into account will nourish current stovepipes and develop new ones. The inefficiencies due to stovepiping will still need to be addressed by future training transformation projects.

3.3 F-CITE Option 2a: F-CITE delivered at all CA FGBs plus Kingston

3.3.1 Option 2a overview

This option involves delivering F-CITE capability to all CA FGBs (as defined in Section 1.5) plus Kingston and making the supporting organisational and process changes. This option in effect applies F-CITE to the VC subset of collective training but not does lead to fundamental transformation of Live training. This is because CMTC – the Live FCoE – is not a FGB and because the non-CMTC Live training capabilities available at the FGBs (e.g., via WES DCS) are insufficient to provide the required Live FCoE-level support to F-CITE. Option 2a therefore implicitly creates a two-tier training capability:

1. F-CITE-compliant V and C FGBs;
2. Everything else.

3.3.2 Option 2a advantages

The advantages of this option are as follows:

1. The CA is more ready to train the future CA, at least in the V and C subset of simulation;
2. The CA simulation fleet is partially rationalised and simplified, allowing the realisation of some F-CITE benefits in terms of sustainment and life-cycle efficiencies;
3. The CA has a more coherent technical architecture for V and C which simplifies integration of new operational capability;
4. The CA has access to increased levels of networked training;
5. V+C integration is supported.

3.3.3 Option 2a disadvantages

The disadvantages of this option are as follows:

1. F-CITE benefits are restricted to Regular Force V and C trainees at a limited set of FGBs but not L, in effect creating a two-tier training capability;
2. F-CITE itself cannot fully support the CA's managed readiness plan;
3. The CA incurs costs to make the fundamental underlying changes required to deliver F-CITE services, but relatively few sites realise any benefits. The costs incurred may therefore be considered disproportionate to the benefits;
4. The two-tier training capability means that the V and C FCoEs now operate different processes to non-F-CITE V and C sites, making it harder for the FCoEs to disseminate best practice;
5. Access to training is not substantially improved for the non-FGB sites;
6. Because CMTC is excluded, fully networked LVC integration is not possible.

3.4 F-CITE option 2b: F-CITE delivered at all CA FGBs plus Kingston and CMTC

3.4.1 Option 2b overview

This option is broadly similar to Option 2a, except that by bringing CMTC into the fold, F-CITE provides a complete LVC capability. However, although the two-tier effect remains (given that not all CA training sites are F-CITE compliant), Option 2b in general provides a better return on investment than Option 2a.

3.4.2 Option 2b advantages

The advantages of this option are as follows (over and above those of Option 2a):

1. The CA can provide networked LVC training for the future CA, albeit at a small number of sites;
2. Full LVC integration is available, albeit at a small number of sites;
3. Greater rationalisation, simplification and coherence is achieved than with Option 2a, given that some Live capability is now covered.

3.4.3 Option 2b disadvantages

The disadvantages of this option are as follows (over and above those of Option 2a):

1. F-CITE benefits are restricted to Regular Force trainees at FGBs only;
2. The discrepancies between training practices at FCoE and non-FCoE sites now extend to Live training as well.

3.5 F-CITE option 3a: F-CITE delivered at all CA training sites

3.5.1 Option 3a overview

This Option ensures that F-CITE is available at all regular CA training sites, not just FGBs and FCoEs, and therefore provides a better return on investment than Options 2a or 2b. However, Option 3a is dependent on a centralised F-CITE NSC and sufficient network connectivity for the sites involved.

3.5.2 Option 3a advantages

The advantages of this option are as follows:

1. Networked, integrated LVC training is widely available to all Regular Forces;
2. Training sites can adopt a coherent set of processes and policies which offer a smoother training progression for trainees and reduce the overall 'train the trainer' burden;
3. Significant life-cycle efficiencies can be realised through coherent sustainment, maintenance and upgrade and the coordinated sharing of centralised resources (e.g., cloud-hosted services);
4. Integration of operational platforms and C2 systems is simplified because there are fewer special cases to handle;
5. Other JIMP training capabilities can more readily integrate with CA training because it provides internally consistent services and processes.

3.5.3 Option 3a disadvantages

The disadvantages of this option are as follows:

1. F-CITE benefits are not available at Reserve Force bases;
2. The large number of sites involved increase the challenges associated with rolling out F-CITE capability, and the likelihood of having to deal with site-specific special-cases;
3. Additional long-haul networking and infrastructure improvements may be required for sites if they are to achieve full F-CITE functionality;
4. Some sites may lack the local expertise (e.g., trainers and SYSCON) to fully realise all F-CITE benefits, even given a centralised F-CITE NSC.

3.6 F-CITE Option 3b: F-CITE delivered at all CA training sites plus Reserve Forces

3.6.1 Option 3b overview

This Option brings the advantages of F-CITE to the widest possible CA training audience (i.e., Regular Forces plus Reserve Forces in a multitude of Canadian cities). It thus extends the benefits of F-CITE compared with Option 3a (just as Option 2b extends the benefits of Option 2a) but also creates some specific additional challenges.

3.6.2 Option 3b advantages

The advantages of this option are as follows (over and above those of Option 3a):

1. The Reserves Forces can participate as equals in CA training with Regular Forces;
2. There is substantially improved access to training for Reserve Forces;
3. The entire CA training community shares consistent services, offering the greatest life-cycle efficiencies.

3.6.3 Option 3b disadvantages

The disadvantages of this option are as follows (over and above those of Option 3a):

1. Greater demands on long-haul networking and local infrastructure;
2. Greater demands on the F-CITE NSC to offset local weakness and resource limitations.
3. Increased security challenges, notably for Reserve Forces based in armouries rather than secure garrisons.

Some of these disadvantages could be partially offset by the use of a mobile F-CITE capability that would reduce the need for a permanent F-CITE presence at each reserve base.

3.7 F-CITE option discussion

These options provide analysts with a small set of options that have clearly distinguishable advantages and disadvantages. This site-based approach to defining options is considered to be easier to understand than options based on providing different levels of F-CITE services (e.g., comparing F-CITE based on cloud-hosting to F-CITE based on conventional computing).

The options also provide a possible phased approach to F-CITE implementation. In particular, Option 2a (or 2b) could be viewed as an F-CITE Initial Operating Capability, followed by Option 3a (or 3b) as a Full Operating Capability (FOC).

4 F-CITE personnel assessment

4.1 Overview

This Section considers the F-CITE personnel requirement in terms of staff roles, staff numbers and the possible split between military or civilian staff.

4.2 F-CITE staff roles

As an ASAT-compliant training system, F-CITE will require many of the same staff roles as found in current collective training. However, some of the novel aspects of F-CITE (e.g., networked blended training supported by a NSC) will require correspondingly novel staff roles.Table 4-1 presents a preliminary assessment of the F-CITE personnel requirement, broken down in terms of the functional staff roles associated with the distinct layers of the F-CITE service taxonomy. The roles were identified by a two stage process:

1. ASAT documentation [4] was reviewed to discover the various types of training capability user, which were added to the Table as a starting point;
2. The F-CITE service taxonomy was then examined. For each of the main functional areas in the different service layers (e.g., governance and management in Business services), additional staff roles were added where these were not already covered by ASAT. These new roles are identified in the table with the prefix 'F-CITE'.

At this point in the F-CITE programme, it is not possible to define the detailed job-titles associated with the identified staff areas. For example, the table identifies that staff will be required to support F-CITE configuration management. In practice, this staff area would probably require a senior responsible officer (in this case an overarching F-CITE configuration manager, presumably located at the NSC) supported by junior officers, technical and administrative / clerical staff, as well as local configuration management officers and clerical staff at key F-CITE locations (e.g., FCoEs / FGBs). Similar staffing patterns are likely to be required for many of the staff areas, and are covered in the Table by the generic term 'personnel' in the absence of an ASAT-defined job label.

Table 4-1. F-CITE staff roles

Service layer	Staff roles
Business services	F-CITE governance personnel. F-CITE operations planning and coordination personnel. F-CITE forward planning personnel. F-CITE strategy development personnel. F-CITE strategy realisation personnel. F-CITE assurance and compliance personnel. F-CITE NSC management personnel. F-CITE build, configuration and deployment management personnel. F-CITE Human Resources (HR) management personnel. F-CITE contractual / commercial management personnel. F-CITE financial management personnel.
Training services	Training Authority (TA). Training Requirements Advisor (RA). Professional Development Needs Analysis (PDNA) personnel. Training Development Officer (TDO). Instructional Systems Design (ISD) personnel. Occupational Analysis (OA) personnel. Training content development personnel (e.g., course designers, course authors and scenario writers for individual and collective training). Training operations personnel (i.e., OSE, OCE, OCT, HICON and LOCON, as per Table 2-3). Qualification Standard (QS) personnel.

Service layer	Staff roles
Information services	F-CITE information management / exploitation personnel. F-CITE registry / repository management personnel. F-CITE Information assurance personnel. F-CITE Information / cyber security personnel.
Application services	F-CITE simulation software personnel. F-CITE EMS / SYSCON personnel. F-CITE middleware personnel. F-CITE general software personnel (e.g., Office and Collaborative working tools). F-CITE cloud personnel. F-CITE big data / analytics personnel.
Hardware services	F-CITE computer systems engineering personnel. F-CITE computer network engineering personnel (for local and long-haul networks). F-CITE simulator support engineering personnel.
Infrastructure services	F-CITE facility management and maintenance personnel. F-CITE range management personnel (as per current Live training). F-CITE Service Support personnel.

Although the training services layer is well covered by ASAT, the majority of the staff roles in the other service layers are not explicitly identified by ASAT. At first sight, this might appear to suggest that F-CITE will create a massive new staffing burden for the CA in terms of the types of staff required. However, although some of the F-CITE staff roles (e.g., associated with the NSC) are genuinely new, many are already present within existing training establishments in areas not explicitly described by ASAT (e.g., computer or network engineers, or facility management staff).

4.3 Numbers of F-CITE staff

The actual numbers of staff required depend critically on the F-CITE option that is selected, and thus cannot be accurately determined at this early stage. Broadly speaking however, the successive options (1, 2a, 2b, 3a and 3b) require successively increasing numbers of staff, primarily because of the increasing numbers of F-CITE sites associated with each (i.e., 3b has the largest staffing requirement, all other things being equal).

Using the existing CA training staffing establishment as a baseline, it is possible to make the following observations:

1. F-CITE will require a greater number of staff in overarching business and information services, primarily to plan, coordinate and manage the more flexible training offered by F-CITE;
2. F-CITE will likely require similar numbers of training staff in areas that are trainee-facing (e.g., OCTs, HICON and LOCON) or that are specified by ASAT (e.g., TA, RA and TDO);

3. There may be reductions in the numbers of staff associated with development of training content because of the increased re-use of such material enabled by F-CITE;
4. The NSC concept should see a reduction of the numbers of technical staff required at distinct F-CITE sites, albeit with a corresponding increase at the NSC itself to provide virtual support and reach-back;
5. The coherence offered by F-CITE should reduce the range of different technical skills required by support staff to support the training systems, which may in turn offer a reduction in the overall number of staff;
6. F-CITE may reduce the overall number of per-site technical staff required in application and hardware services (e.g., by using centralised cloud-based application hosting staff to replace local software support staff). However, F-CITE will require new technical skills not already present in the CA (e.g., to manage the cloud itself). These skills will not be required at all F-CITE sites, ideally being localised to the NSC;
7. F-CITE is unlikely to significantly reduce the numbers of staff associated with physical infrastructure services, e.g., those associated with building and range maintenance.

These observations describe F-CITE operating at steady state. There may be temporary staffing increases during the period of transition to F-CITE (e.g., as new F-CITE services are run in parallel with existing capability).

It is worth noting that the staff reduction benefits provided by the NSC scale commensurately with the overall number of F-CITE sites, such that options 3a and 3b (which have the most remote sites that require technical support) make the NSC most cost-effective when considered in purely staffing terms. Without an NSC, options 3a and 3b might in fact be prohibitively expensive because of the need for local technical staff at each site.

4.4 Sources of staff

The question of whether specific F-CITE roles can be civilianised (sourced by contractors or civil servants) or must be filled by serving military staff is important, since it defines the irreducible minimum of military staff required to operate F-CITE, which in turn drives the CA's staffing burden.

Reasons for needing serving military staff in specific roles include the following:

1. Provision of (or supporting) the training capability's Chain of Command (CoC);
2. Conduct of tasks that require military-held qualifications (e.g., some weapon firing);
3. Possessing up-to-date knowledge of current operational experience and lessons identified;
4. Providing military credibility in certain trainee-facing roles;
5. Fulfilling the CA's Duty of Care requirements, especially for younger or vulnerable soldiers at the lower CT levels;
6. Maintaining the CA's 'intelligent customer' status in key technical or commercial areas;
7. Building the 'seedcorn' for future training contractors, e.g., trainee-facing role-players who are recruited from a pool of ex-military staff.

Given these reasons, the greatest requirement for serving military staff will be in the training services layer. Business services will require serving military staff in key governance, management, assurance and liaison roles. However, with the exception of CoC responsibilities for the functions concerned, there does not appear to be a compelling requirement for military staff in the other service layers.

This (admittedly simple) reasoning suggests that for many functions, the F-CITE staffing burden could, all other things being equal, be exported to civilian organisations (contractors and civil servants). However, it also suggests that it is unlikely that the entirety of F-CITE (including its military governance) could be outsourced to a purely civilian service provider.

5 Preliminary F-CITE PRICIE+G analysis

5.1 Overview

This section presents a preliminary PRICIE+G analysis for F-CITE. The intent at this stage is to identify key conditions for the successful adoption of F-CITE, not to generate the substantive PRICIE+G content required by a formal Capability Development Record (CDR).

The conditions identified are outlined below under the PRICIE+G headings (the problems that may arise if these conditions are not met are considered separately as risks in Section 9). The Section concludes by considering key next steps for achieving these conditions.

5.2 PRICIE+G analysis

5.2.1 P – Personnel and Leadership

1. The CA is able to recruit and retain sufficient numbers of Suitably Qualified and Experienced Personnel (SQEP) to fill the personnel roles identified in Section 4, and provide appropriate long-term professional development for the specialists required.

5.2.2 R – Research & Development, and Operational Research

1. The CA is able to initiate the research required to reduce the risk associated with novel aspects of F-CITE (suggested research activities are identified in Section 10);
2. Research outcomes can be successfully exploited by industry delivering F-CITE services or solutions.

5.2.3 I – Infrastructure, Environment, and Organisation

1. The CA is able to organisationally transform to provide the overarching management and governance functions required by F-CITE;
2. The required F-CITE roles and functions can be attributed to CA organisations (existing or perhaps newly formed). The attribution takes account of cross-cutting services and resources (e.g., the support provided by the F-CITE NSC and the F-CITE SIE) that will be shared by L, V and C FCoEs.
3. The CA's fixed physical infrastructure is suitable for F-CITE systems (e.g., in terms of power supplies and security) and has sufficient room for the numbers of systems required (e.g., for new simulators);

4. Suitable DND-wide enabling capabilities (e.g., secure long-haul networks) are available for use when required by F-CITE and satisfy F-CITE's measures of effectiveness and performance requirements (as yet to be specified).

5.2.4 C – Concepts and Doctrine

1. ASAT is updated to provide guidance on the use of blended LVC simulation and networked training in the context of the Managed Readiness Plan, thus ensuring that F-CITE development is training-led rather than technology driven;
2. F-CITE's management processes can dynamically flex and optimise resources (physical and virtual) as required between different elements of the overall F-CITE capability to manage peaks and troughs in demand, reducing the extent to which specific resources are idle or overworked;
3. Different F-CITE users can sufficiently align their processes to enable component re-use across sites and inter-site connectivity;
4. The CA is able to operate an informed and unified configuration management process across the entire F-CITE capability.

5.2.5 I – Information Management and Technology

1. The CA can collect sufficient, accurate F-CITE performance data to inform in-year dynamic resource load balancing of physical and virtual resources;
2. The CA can provide F-CITE with an accurate future demand signal (e.g., numbers of troops and units to be trained) to allow F-CITE management to plan and allocate the future resources required;
3. Industry implements DND-mandated open standards for use in systems intended for use in F-CITE.

5.2.6 E – Equipment and Support

1. F-CITE capability development coherently adopts and integrates systems and services across the entire capability rather than perpetuating existing equipment silos;
2. The CA conducts whole-fleet management of simulators and other equipment to ensure optimal resource utilisation across the entire capability;
3. F-CITE support contracts provide through-life capability management, including the ability to upgrade technologies and processes without contractual lock-in;
4. Flexible support contracts enable rather than constrain the flexible training provided by F-CITE;
5. F-CITE support contracts are service-oriented, with Service Level Agreements (SLAs) and Key Performance Indicators (KPIs) that relate to desired training outcomes (e.g., numbers of troops successfully trained) than mere training inputs (e.g., numbers of simulators available);
6. Industry solution providers can be incentivised to accept the novel arrangements required by F-CITE, including service provision rather than equipment supply.

5.2.7 G – Generate (PD initiatives, IT initiatives, CT initiatives)

1. CA trainers are themselves trained to fully realise the benefits of the novel training methods and media provided by F-CITE and are up to date with respect to best-practice training approaches.

5.3 Other issues

5.3.1 F-CITE use cases

The F-CITE use cases presented in Section 2.8 illustrate how F-CITE can support many different types of training. However, they need to be endorsed from a training-led perspective (so that they represent real end-user requirements) before detailed technical design takes place. The networking required to support F-CITE governance and training management must also be determined.

This need for endorsement is particularly important because the levels of integration and connectivity required will be major cost-drivers for F-CITE, and 'connect everything' is an overly simplistic answer.

5.3.2 F-CITE support for a CA-wide NSC

This work has suggested the creation of an F-CITE NSC that provides support relating to both training and simulation. Such a centre could in principle form the basis of a NSC for the entire CA. The responsibilities of the NSC could include:

1. Identifying M&S standards and best practice, and engaging with the standards development communities in NATO and Simulation Interoperability Standards Organization (SISO);
2. Management and technical accreditation of a set of sharable M&S tools (the battlespace representation services with the F-CITE toolbox);
3. Hosting appropriate working groups;
4. Coordination with non-F-CITE parties, including the industry suppliers of M&S capability;
5. Providing M&S-related training and education;
6. Integration, test and reference facilities;
7. Running communication campaigns (e.g., to raise awareness of new M&S approaches); and
8. Technical support for M&S users, ranging from help-desk functions to provision of M&S SMEs.

Clearly, the F-CITE MSC should not duplicate related roles (e.g., MSCO) or functions (e.g., the proposed Synthetic Environment Resource Repository (SERR)). Development of the proposed F-CITE NSC into a CA NSC must therefore be coordinated across the CAF.

5.3.3 Provision of shared resources

Use of cross-cutting organisations (e.g., the F-CITE NSC) and shared resources (e.g., cloud solutions) to avoid local duplication is key to driving efficiencies in F-CITE. However, the provision of shared services and resources will require tighter integration of the requirements of

the individual contributory projects, and greater alignment of the overall project lifecycles. The shared resources must be developed top-down, and will not emerge naturally from the current stovepiped approach.

5.3.4 F-CITE support for joint and international training

F-CITE does not itself provide a Joint or international capability, although the architecture is consistent with its use in these contexts. However, the fundamental uncertainty here is the extent, from the CA perspective, of the Joint training requirement that needs to be supported. This requirement should logically follow from the CA's operational interoperability needs, determined at the CAF level and then agreed by the CA.

5.3.5 F-CITE support for non-training applications

Because of its adaptable toolbox approach, F-CITE is well-placed to support the non-training applications of simulation, namely:

1. Operations and Planning;
2. Concept Development and Experimentation (CD&E);
3. R&D;
4. Acquisition and Life-Cycle Management.

Annex B provides more information about how F-CITE can be used in each of these roles.

5.4 Key next steps

The key next steps for F-CITE are as follows:

1. Continue definition of the F-CITE concept, and in particular refine the F-CITE target architecture to a further level of detail;
2. Update ASAT to provide guidance on the use of blended simulation and networked training in the context of the Managed Readiness Plan;
3. Analyse the F-CITE options and select a preferred option for further refinement (e.g., in terms of governance and networking requirements);
4. Given the results of the ASAT update and F-CITE option analysis, attribute the required F-CITE roles and functions to CA organisations;
5. Refine the initial personnel and cost assessments developed in the current work.

6 F-CITE cost drivers

6.1 Overview

This Section presents a preliminary analysis of F-CITE cost drivers and cost variations. The intent is to inform the development (in separate work) of a formal cost model that will support cost-benefit analysis of F-CITE and its implementation options, and generation of a Rough Order of Magnitude (ROM) cost.

6.2 Costing process

Costing F-CITE is challenging because it is not a simple new build that replaces an existing capability whose known costs can be used as a comparator. Instead, F-CITE is a transformational process that will gradually evolve a set of currently disparate capabilities toward a desired future state (as defined by the F-CITE target architecture). It will also build on other separately funded programmes (notably LV CTS) and re-use existing infrastructure.

In the absence of a standard cost model that can be repurposed to support analysis of F-CITE costs, the F-CITE service taxonomy has been therefore used as a basis for identifying potential F-CITE costs, and the factors that may influence them.

6.3 F-CITE cost breakdown

6.3.1 Business, training and information services

These layers are considered together because they have the same primary direct cost: the costs of the personnel that deliver the services they define, and to a lesser extent the associated organisational overheads. The assessment of the numbers of personnel required by F-CITE when operating at steady state (presented in Section 4.3) therefore provides a basis for assessing the changes to the today's staffing costs baseline. In summary:

1. The numbers of staff in trainee-facing (and other ASAT-defined) roles are likely to remain broadly similar to today's, so the associated staff costs to F-CITE should also be broadly similar;
2. F-CITE will require additional staff in its business and information service layers, which represents a relative increase in personnel costs. However, because these are centralised management functions, the numbers of staff concerned should be relatively small;
3. F-CITE should see reductions in the overall numbers of technical support staff required (and their associated costs) due to more centralised support for a less technically diverse set of systems. There may be similar benefits in terms of the staff costs associated with course and scenario development.

These observations are broadly applicable to all of the identified F-CITE options, with the caveat that staff numbers (and therefore costs) for ASAT-required personnel may scale linearly with the number of bases supported. It is also noted that decisions concerning the split between military and civilian staff (as discussed in Section 4.4) will influence whether some staff costs must be directly funded by the CA or can in effect be exported into service contracts.

6.3.2 Application and hardware services

The primary driver for costs at the application and hardware service layers are the software and hardware that supports these layers. Viewed in traditional terms, the costs are therefore directly dependent upon the numbers of systems required. These in turn break down into general purpose commodity IT systems (such as office software and commodity PCs) and training-specific systems such as simulators and battlespace representations.

In traditional terms, there would be an initial cost of acquisition for these systems, with through-life support and servicing costs, and intermittent technology insertion, refresh and disposal costs. Through-life costs are clearly higher for training-specific rather than commodity systems, since training-specific systems have a much smaller market to fund their overall development. It is not

yet clear whether consumer-driven development of new technologies (such as augmented reality or virtual reality) will offer significantly cheaper alternatives to today's simulators, or whether they will remain expensive relative to commodity hardware. However, it is probable that, even given anticipated improvements in computing, training approaches that require high-fidelity simulation will remain more expensive than lower-fidelity equivalents.

Several aspects of the F-CITE approach allow for cost savings relative to the traditional approach of purchasing dedicated software and hardware:

1. Greater coherence of data and systems across L, V and C training, and F-CITE-wide configuration management, reduces unnecessary technical diversity, which in turn reduces licensing, support and other through-life costs;
2. Use of cloud-based approaches (as discussed in Section 2.5) allows disparate users at multiple sites to share common underlying computing resources rather than purchasing local hardware. Cloud approaches also work to reduce the number of local system managers (and thus reduce staff costs);
3. Use of the service-oriented approach reduces the overall number of systems directly purchased by DND. Instead, the DND buys a service, and the service provider is responsible for acquiring, operating and refreshing the underlying equipment required. Clearly, the actual savings offered by this approach depends critically on whether service providers can spread the equipment costs over a wide range of distinct customers. One good example is the use by F-CITE of DND-wide long-haul bearers as opposed to dedicated training networks;

Combining these possibilities allow for some extremely cost-effective solutions, e.g., use of a centralised cloud-based simulation service, available on a 'pay-as-you-go' basis to regular users, with pre-planned surge-pricing to meet short term peaks or urgent operational needs. However, creating such mechanisms requires CA-wide adoption of the relevant F-CITE concepts, and could raise challenges for traditional acquisition processes.

6.4 Cost variations

The brief assessment has identified some ways in which the F-CITE approach can lead to cost savings relative to today's solutions. However, there are still several areas of uncertainty that will impact the actual cost of F-CITE. These include but are not limited to:

1. The contribution of other programmes such as LV CTS;
2. The extent to which the NSC can reduce staffing or systems costs at its remote supported sites;
3. The DND's appetite for innovative service-oriented approaches;
4. The actual levels of inter-site interconnectivity required by distinct F-CITE sites (which drives the requirement for secure high-bandwidth bearers);
5. The levels of simulation fidelity required to meet future CA training objectives;

7 Statement of Capability Deficiency

7.1 Overview

This Section presents a Statement of Capability Deficiency (SoCD) that describes the shortfall between the current CA simulation baseline (as identified in Section 1.5.1) and the proposed FCITE capability.

The SoCD is structured as a set of high-level deficiencies with respect to the F-CITE capability taxonomy presented in Section 2.6 (i.e., deficiencies with respect to accessible training, interoperable training and flexible training). More detailed impact statements are provided as required, broken down by the types of service affected (i.e., business, training, information, applications, hardware and infrastructure), as defined within the F-CITE service taxonomy (Section 2.5).

7.2 The F-CITE SoCD

7.2.1 SoCD table

The SoCD is presented in Table 7-1.

Table 7-1. F-CITE SoCD

#	Required capability	Overall deficiency	Service-level impact
1	**Accessible training**		
1.1	Training at fixed sites	Simulation capability is not available at all Regular and Reserve Force bases.	**Training services**: Significant travel costs and / or missed training opportunities. **Infrastructure services**: Reduced access to simulation away from secure garrisons (e.g., at Reserve Force armouries).
1.2	Networked	Networked training is not routinely conducted by the CA.	**Business services**: There is a lack of suitably qualified and experienced networked training SMEs. **Training services**: The networked events that do occur are typically large Joint events or experiments that are organised and run on an ad hoc basis. **Information services**: No routinely available templates (e.g., EXCON structures and processes) for networked events. **Application services**: Few tools to support exercise management of networked events (e.g., synchronisation and distributed AAR). **Hardware services**: The CA has not yet established the long-haul connectivity required to support large numbers of networked exercises on a routine basis.

#	Required capability	Overall deficiency	Service-level impact
1.3	Deployable	Simulations cannot be readily deployed to arbitrary locations.	**Training services**: Limits on the use of distributed simulation-based training by forces that cannot access training sites. **Application services**: Limited ability to provide simulation-based Operations and Planning support to deployed forces.
1.4	Available	Availability of training systems, and the associated metrics, are defined and contracted on a per-system basis.	**Business services**: There are no centralised pan-CA mechanisms for specifying and managing simulation availability requirements.
2	**Interoperable training**		
2.1	Internal CA interoperability	Although constituent simulations are often standards-based, the wider variations between the overall training systems complicate connecting them to support networked training and / or blended simulation.	**Training services**: Use of different C2 representations[11] at different sites complicates interactions between staff (affecting trainers and trainees) in networked and blended events. **Application services**: Variations in representation increases the number of special cases that must be handled by interoperability middleware, thus making the middleware itself harder to deploy, maintain and upgrade.
2.2	JIMP training	There is no routine training interoperability with non-CA simulation systems.	**Training services**: Representation of JIMP context and missions are largely limited to those that can be represented 'in-house' by the CA.

[11] Including the use of real C2 systems, emulation of real systems, representation by low-fidelity substitutes (e.g., phone rather than military radio), or not represented at all.

#	Required capability	Overall deficiency	Service-level impact
3	**Flexible training**		
3.1	Blended simulation.	Systems are specified and designed from a stand-alone perspective. Construction of simulation blends must be handled on an ad-hoc basis.	**Business services**: The ASAT currently does not provide guidance on the use of blended simulation. **Training services**: There are significant gaps across the levels of collective training in the types of LVC blend that can be constructed from available simulations. This issue is discussed in more detail in Section 7.2.2.
3.2	Targeted fidelity	The fidelity of specific simulation systems is primarily set at the time of acquisition.	**Training services**: The fidelity available across different stages of the training progression is fixed by the capabilities of the supporting systems. Varying the fidelity to meet different training needs requires changing the overall progression or engineering modifications to the underlying system, neither of which can be easily achieved at short notice.
4	**Coherent training**		
4.1	Common, open services	The overall capability provided by the CA simulation baseline has been delivered by multiple distinct projects, each with distinct stakeholders and requirements. Capability development therefore occurs in largely independent project-sized ‘chunks’.	**Business services**: Hard to coordinate capability development activities across multiple projects, thus perpetuating the existing silos. **Application services**: Use of multiple local copies of applications complicates CA-wide version control and other configuration management tasks. **Hardware services**: Each system acquires and manages its own hardware, making it hard for the CA to achieve economies of scale in acquisition and sustainment.

#	Required capability	Overall deficiency	Service-level impact
4.2	Single Information Environment	The CA's training information environment is highly fragmented, with distinct organisations (including the FCoEs) and sites maintaining independent data silos.	**Business services**: Limited scope for using data from training events to influence future training (e.g., so that trainers can tailor training to address previously identified performance shortfalls). **Training services**: The costs of creating training content are increased because users are forced to redevelop it rather than search for and re-use or tailor data created elsewhere. **Information services**: No universal search mechanisms that allow pan-CA access to training data. Non-training users cannot easily access data (e.g., to find and retrieve data sets for R&D). **Application services**: Trainers or performance assessors cannot take advantage of novel 'big-data' analytic techniques, e.g., to detect overall trends in trainee or training system performance.
4.3	Configuration control	The CA has no central configuration management of its simulation fleet, and multiple versions of some systems are in use.	**Training services**: Trainees and trainers experience arbitrary differences in user interfaces and functionality, reducing the smoothness of the training progression. **Information services**: No centralised description of the real configuration baseline (at the level of systems and versions in use). **Application services**: Integration of third party systems (such as C2 systems) is more complex, since in the worst case each version of a system creates distinct integration challenges.

#	Required capability	Overall deficiency	Service-level impact
4.4	Test and reference	The CA has no centralised test and reference capability.	**Business services**: There is no centralised authority to indicate that specific systems are 'F-CITE-compliant' or 'F-CITE ready'. This affects in-current and planned systems, as well as offerings proposed by industry. **Information services**: Integration lessons cannot easily be shared between different projects. **Application services**: Each system constitutes a separate integration challenge when third party systems are introduced.
5	**Secure training**		
5.1	Multi-level secure training	Training cannot comprehensively and consistently represent multi-level secure operations and systems.	**Application services**: Variations between sites (notably in C2 system representation) complicate or prevent realistic representation of operational multi-level security, especially for interactions between trainees at different sites. **Infrastructure services**: Sites vary in their ability to support secure training, notably Reserve Force based away from secure garrisons.
5.2	Hardened training	The CA simulation capability relies on wider DND/CAF infosec and cyber defences.	**Training services**: Novel approaches to networked or distributed training could expose CA simulation to new cyber vulnerabilities. These could include malicious exposure or changes to training data, as well as denial of service attacks on training capability. **Application services**: Future use of multi-tenant cloud-based application hosting increases the cyber risk to training.

6	**Efficient training**		
6.1	Control diversity	The CA simulation baseline is stovepiped (even within the L, V and C categories), creating significant challenges for the overall life-cycle management.	**Business services**: Sustainment and maintainability services are hard to coordinate and consolidate, leading to variations in availability and reliability. The fragmented nature of the baseline increases the complexity of the evolution toward consistent F-CITE training processes because there is no single clean starting point **Training services**: Use of different systems introduces significant 'fair-fight' problems for networked training (e.g., due to varying platform vulnerability and non-correlated imagery and terrain) and EXCON synchronisation. The variations at best reduce the credibility of the training environment to trainees, at worst prevent meaningful training. **Application services**: The overall technical architecture exhibits multiple distinct solutions to common problems and unnecessary per-site variations (e.g., in C2 usage, representation and emulation). Upgrades to capability (e.g., introduction of a new C2 system) therefore involve multiple distinct technical challenges, which may perpetuate the existence of the stovepipes. Middleware systems essential for technical interoperability are made more complex because they need a larger number of 'plugs' to the end-point systems.

6.2	Efficient use of resources	The stovepiped nature of the CA simulation baseline presents top-down resource management and makes it harder to achieve economies of scale.	**Business services**: Management functions are distributed between multiple organisations making it hard to centrally plan and coordinate. Some important functions (e.g., configuration management) are not addressed centrally. **Training services**: Variations in processes between systems increases the range of skills and knowledge required by trainers and complicates top-down management and deployment of human resources. **Information services**: There is no organisation equivalent to the F-CITE NSC that provides consistent support to the Live, Virtual and Constructive simulation communities. **Application services**: Sustainment costs are increased because of the need to support multiple versions of systems, notably when they require different underlying computer operating systems and databases. **Hardware services**: Not all hardware is fully utilised.
7	**Responsive training**		
7.1	Respond to changing training requirements	The majority of the simulations currently in use were developed to support force-on-force kinetic operations, and lack some of the features required to train CA for future operational environments.	**Information services**: Current simulations do not reflect the future operational battlespace, e.g., with respect to cyber threats, the complexity of the Radio Frequency (RF) environment and long-term cause-and-effect relationships associated with information operations.

7.2	Respond to generational change	Simulation-based training generally uses traditional tried-and-tested learning strategies, and instructors (and content developers) are often serving CA regulars who themselves graduated from courses they now teach within.	**Training services**: Hard to adopt novel training or learning strategies (e.g., self-paced and adaptive learning, long duration 'campaign' style training events that allow complex cause-and-effect relationships to be played out). **Application services**: Lack of a 'social' aspect to training, e.g., to support collaborative social-media style working by widely dispersed participants in networked events. **Hardware services**: Trainees cannot readily access training using their own devices.
7.3	Respond to technology change	Opportunities to adopt new technologies are mainly limited to per-project planned upgrades and technology refresh activities.	**Business services**: Hard to align technology refresh and other mid-life upgrade activities to introduce CA-wide consistency. **Training services**: Delays in the adoption of new techniques and media, which typically evolve faster than acquisition timescales. **Application services**: Under-utilisation of technologies (e.g., virtualisation) that reduce the system management burden on SYSCON staff. **Hardware services**: CA training lags behind current commercial approaches (e.g., use of mobile devices and cloud-based application hosting).
8	**Assured Training**		
8.1	Training evaluation	Training evaluation is conducted on a per-system basis.	**Training services**: ASAT does not define how evaluation should be performed for networked and / or blended training capabilities.
8.3	Training validation	Training validation is conducted on a per-system basis.	**Training services**: ASAT does not define how validation should be performed for networked and / or blended training capabilities.

7.2.2 The LVC simulation coverage deficiency

This Section amplifies the LVC coverage deficiency identified as item 3.1 in the SoCD table.

Although F-CITE has aspirations to provide LVC integration, the degree of integration possible at each level of training is constrained by the range of L, V and C systems actually available at each level. For example, Virtual training is not currently conducted at Level 4 or above. LVC integration is therefore not possible above Level 4, without using existing Virtual systems in training roles for which they were not intended.

The coverage of the different training levels by current and planned simulations is shown in Figure 7-1. The figure breaks down Virtual simulation into its Mounted and Dismounted variants (designated V(m) and V(d) respectively). For completeness, the figure also distinguishes between Live simulation and training that involves live fire (e.g., based on targetry systems). The planned simulations (e.g., LV CTS) are included to show that the capability deficiency will persist even when they are implemented, and thus remain a problem that must be addressed by F-CITE.

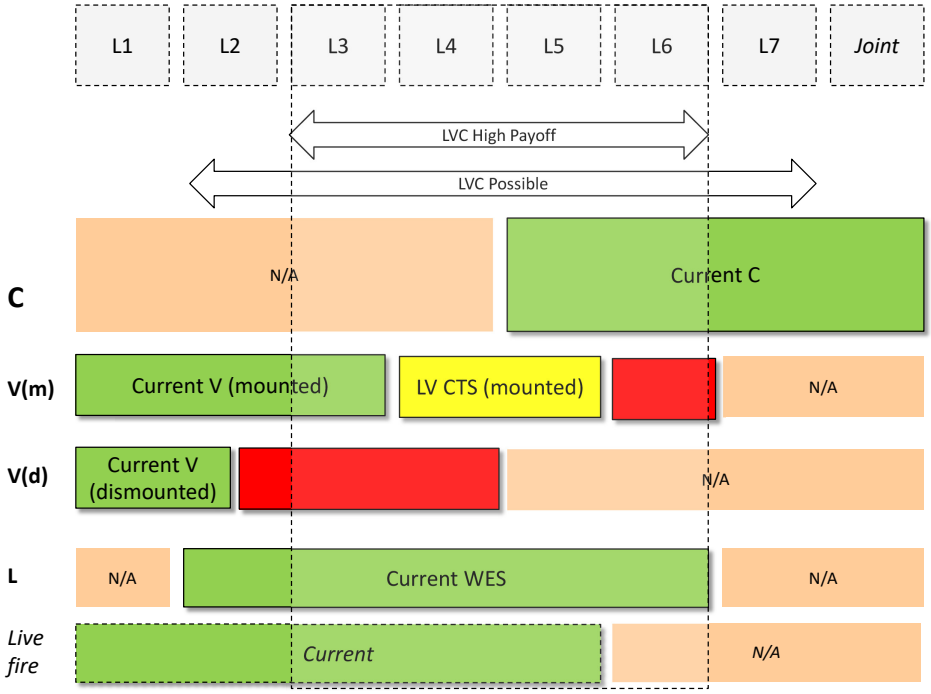


Figure 7-1. LVC vs. current and planned training systems

As can be seen, even taking planned systems into account, and discounting training levels where LVC is not appropriate (e.g., L1), LVC coverage gaps will remain depending on the types of force being trained and the level of the training. Full LVC integration will only be possible for mounted forces training at L5 unless additional capabilities are provided.

8 High Level Mandatory Requirements

8.1 Overview

This Section presents the High Level Mandatory Requirements (HLMR) developed during the current work. The HLMRs together address the F-CITE SoCD. They are presented in terms of the layers of the F-CITE service taxonomy.

Table 8-1. F-CITE HLMRs

Seq	Service layer / HLMR	Comment
	Business	
1	F-CITE requires an empowered, authoritative organisation to centrally command and control F-CITE business services within CADTC.	The organisation will use an overarching F-CITE roadmap to inform capability development and scheduling.
2	F-CITE requires an F-CITE NSC to provide training and technical support to F-CITE organisations, sites and users.	
3	F-CITE requires a controlled configuration baseline of systems and software that can be centrally managed by the F-CITE NSC. New systems and software must undergo appropriate accreditation checks (e.g., for standards compliance) at a standardized test and reference facility before they can be added to the configuration baseline. The F-CITE NSC will prioritise support for baselined systems over non-baselined equivalents.	This baseline constitutes the F-CITE 'toolbox' from which simulation blends can be constructed and deployed. The intent is not to force all users to use a single type of simulation, but to better understand and manage the overall set of systems that together constitute F-CITE. Some organisations and users (e.g., R&D) may have the expertise to use non-baselined systems, but they may forfeit NSC support if they do so.
4	F-CITE requires sufficiently qualified and experienced personnel to carry out F-CITE tasks, including F-CITE business management as well as training.	The specific mix of military and contractors remains to be determined.
	Training	
5	F-CITE requires ASAT to be updated to provide guidance on the use of networked training and simulation blends. The result of the update should be an integrated framework for needs analysis that ensures coherent use of simulation across training progressions and by external equipment programmes.	ASAT remains sound and viable overall, but the update is considered necessary to reduce the silo-effect that can occur when changes to training are considered in isolation.
6	F-CITE requires training capability that can be used in networked events and blended simulation. The capability should be available at fixed sites for Regular and Reserve Forces and deployable as needed to support operational use.	

Seq	Service layer / HLMR	Comment
7	F-CITE requires supporting education that prepares users to fully exploit F-CITE's novel training and business management approaches.	Instructors whose approaches are based on their own historical experience will not necessarily fully understand how best to use novel approaches and technologies.
	Information	
8	F-CITE requires a secure Single Information Environment such that users can create, search for, query, retrieve, update and archive information from across the entire F-CITE enterprise. The F-CITE SIE will support training management, exercise management and F-CITE business management functions. F-CITE information will also be available to external users (subject to appropriate access controls) such as operational commanders (e.g., to inspect training records) and R&D staff (e.g., to assess trends over time). In cases where data used by F-CITE has non-F-CITE custodians, the SIE shall act as a registry (rather than a repository) that provides appropriate links to external sources.	The information held within the F-CITE SIE may itself be distributed over multiple physical servers and cloud solutions. However, the physical location should generally be transparent to F-CITE users. Access to the F-CITE SIE may depend on users having access to appropriate network bearers and interfaces.
	Application	
9	F-CITE requires that blended or networked training events provide trainees with a single credible synthetic representation of likely battlespace with correlated terrain, imagery and effects to ensure a 'fair fight'. Wherever possible, the same underlying representation will support multiple types and levels of training, accepting that different trainees require types and fidelities of stimulation specific to their mission and function.	A given battlespace representation may consist of multiple networked simulation engines that model distinct aspects of the real world (e.g., weapon effects, cyber and weather), with appropriate standards-based interfaces and interoperability mechanisms to stimulate each other and other software used in exercises.
10	F-CITE requires consistent exercise management tools for use in blended and networked exercises and that are coherent to the full extent practical across L, V and C simulation and different levels of training.	Different types of training will clearly have varying exercise management processes, but arbitrary variations should be eliminated so that EXCON and SYSCON staff from different environments can work together effectively.

Seq	Service layer / HLMR	Comment
11	F-CITE requires coherent representation and stimulation of fielded C2 systems and other operational equipment used by trainees.	
12	F-CITE requires its constituent systems to be sufficiently interoperable to support networked training and blended simulation with Canadian Joint and International capabilities.	The interoperability will be achieved by a combination of open interfaces (ideally standards based) and appropriate middleware.
	Hardware	
13	F-CITE requires sufficient long-haul network bearer capability to routinely support networked exercises, with surge capacity available given appropriate warning. The bearers must be secure and have sufficiently high bandwidth and low latency to support C2, simulation, EXCON and other interaction across all stages of the training and exercise lifecycle.	F-CITE may exploit non-CA networks such as CFXNet, which has a long track record of delivering permanently allocated long-haul connectivity. However, although CFXNet is well positioned to support F-CITE requirements, the actual connectivity required has yet to be formally stated and agreed.
	Infrastructure	
14	F-CITE requires critical simulation and support systems to be properly housed in appropriate secure facilities.	This requirement will influence the extent to which F-CITE can be exploited by Reserve Forces.

9 F-CITE Risks

9.1 Overview

This Section considers risks associated with F-CITE.

9.2 Risk identification

Risks were initially identified by taking the PRICIE+G conditions for success identified in Section 5, and then considering the factors that might cause them not to be met. Additional risks were added by working through the F-CITE HLMRs and finally the wider architecture, looking for additional potential problems not already identified. The resultant risks, which are presented in Annex A, relate to factors that are broadly within the control of the F-CITE programme, not wider risks to the overall DND (e.g., the assumptions in Section 2.2.3).

The risks are categorised according to the phase of the F-CITE lifecycle they relate to, and their type of impact (operational cost, technical, programme or training delivered). They are grouped according to the PRICIE+G criteria, with an additional ‘general’ category to cover overarching risks.A comprehensive risk mitigation plan has not been developed during the current work, although the R&D proposed in Section 10 will reduce some of the risks (primarily technical).Risk assessment

F-CITE has many types of risks in common with other programmes delivering technically complex capability in the face of a changing world. However, because of its wide scope and transformational nature, F-CITE poses novel organisational and doctrinal challenges to the wider CA training community, and in this sense is more risky than the development of a new type of simulator, for example.

The greatest risk to CA training, however, may result from attempting to rigidly maintain an increasingly unwieldy status quo in the face of considerable external change drivers, rather than introducing the proactive change management and flexible evolution offered by F-CITE.

10 Research activities

10.1 Overview

This Section identifies some candidate subjects for R&D, Operational Analysis and Experimentation aimed at informing or de-risking the continued development of F-CITE. The set of subjects is not exhaustive and is expected to be extended as the F-CITE architecture is matured and as risk mitigation activities are identified

10.2 Requirements-led Joint interoperability

As described in Section 2.8.3.3, F-CITE could participate in a joint Canadian simulation network to support training in tasks (e.g., ALI) that are inherently joint. However, although F-CITE will provide agile and adaptable technical interfaces to support interoperability, the actual connectivity required has not been formally stated. This makes it hard to determine which F-CITE centres should be involved, and whether F-CITE (or some other party) should be the lead or subordinate in specific events.

Work is therefore required to identify and confirm, top-down, the interoperability requirement for F-CITE. The requirement should be derived from the CA’s operational needs, identifying

interactions with the RCN, CA and RCAF that need to be reflected in training. The interoperability requirement should be endorsed by all parties concerned as basis for achieving pan-CAF technical interoperability and coherence.

10.3 F-CITE measures of effectiveness

The F-CITE enterprise goals presented in Section 2.6 are currently stated qualitatively rather than quantitatively. Although they provide aspirational guidance for the development of F-CITE, they do not form hard targets (e.g., for the goal of improving accessibility of training, how much accessibility is actually required).

Work is therefore required, to determine candidate Measures of Effectiveness (and their associated metrics and performance requirements) for each of the F-CITE enterprise goals. This will make clear what needs to be measured and why, and the return on investment of meeting specific enterprise goals.

10.4 Cost effectiveness of networked training

A fundamental question that informs discussion of F-CITE connectivity is the trade-off between:

1. The benefits delivered by networked training (e.g., reduced travel costs and easier access to combined arms enablers);
2. The organisational and other overheads of networked training (e.g., complex scheduling, network requirements, more complex EXCON / SYSCON functions and increased exercise friction)

Intuitively, a networked exercise involving two sub-unit sized teams under the same chain of command should be easier to organize and run than an event involving multiple remote parties with different chains of command and a wider set of training objectives. However, the actual break-even point where the costs of networking exceed the benefits is not believed to have been formally quantified.

Work is therefore required to develop an evidence-based understanding of the costs and benefits of networked training, to support decision-making about the types and levels of networking that F-CITE should support.

10.5 Technology risk-reduction and roadmapping

Implementation of the F-CITE architecture relies on several technologies that are maturing rapidly but which are relatively untested in the military training environment. As a result, it can be difficult to determine their effective Technology Readiness Levels (TRLs), or how rapidly they will mature. Examples of such technologies include:

1. Cloud-based provision of training services;
2. Augmented reality;
3. Internet of things;
4. Simulation of cyber (e.g., RF in Live);
5. Use of Artificial Intelligence (AI) in computer-generated forces.

Work is required to better understand the TRLs of the technologies that support F-CITE. Technology roadmapping is also recommended to understand when specific technologies can be phased in, in support of an overarching F-CITE capability roadmap.

11 References / Bibliography

[1] Canadian Army Simulation Strategy, Army Simulation Authority, Version 2.0, July 2015

[2] CAO 28-01, Canadian Army Simulation Policy, Nov 2015

[3] DND/CF Architecture Framework Version 1.8.1, OTT_TUNN-#298730, 25 January 2013

[4] Training for Land Operations, B-GL-300-008/FP-001, 2014-06-04

[5] DND/CF Capstone Modelling and Simulation Strategy, 1901-1-1 (CO CFWC) – February 2013.

[6] Canadian Army Modelling and Simulation Standards Profile, 24 March 2014.

12 Abbreviations and acronyms

AI	Artificial Intelligence
ALI	Air / Land Integration
AR	Augmented Reality
ASA	Army Simulation Authority
ATA	Army Training Authority
AWES	Area Weapon Effects Simulator
C	Constructive
CA	Canadian Army
CADTC	Canadian Army Doctrine and Training Centre
CAF	Canadian Armed Forces
CALWC	Canadian Army Land Warfare Centre
CAO	Canadian Army Order
Cap Dev	Capability Development
CASC	Canadian Army Simulation Centre
CA Sim SG	CA Simulation Steering Group
CA Sim WG	CA Simulation Working Group
CASS	CA Simulation Strategy
CapV	Capability View
CBT	Computer Based Training
CCA	Commander Canadian Army
CD&E	Concept Development and Experimentation
CDS	Chief of the Defence Staff
CDR	Capability Development Record
CF	Canadian Forces
CFB	Canadian Forces Base
CFD	Chief of Force Development
CFDS	Canada First Defence Strategy
CFWC	Canadian Forces Warfare Centre
CFXNet	Canadian Forces Experimentation Network
CoC	Chain of Command
CJOC	Combined Joint Operations Command
CMSP	Canadian M&S Standards Profile
CMTC	Canadian Manoeuvre Training Centre
COA	Course Of Action

COS	Chief Of Staff
CPX	Command Post Exercise
CR	Canadian Ranger
CT	Collective Training
CTC	Combat Training Centre
CV	Common View
DATE	Decisive Action Training Environment
DCS	Dismounted Company Suite
DCSEM	Director Combat Support Equipment Management
DEA	Director of Enterprise Architecture
DFWES	Direct Fire Weapon Effects Simulator
DGLEPM	Director General Land Equipment Project Management
DLR	Director Land Requirements
DND	Department of National Defence
DNDAF	DND and CF Architectural Framework
DND/CF	DND/Canadian Forces
DRDC	Defence Research and Development Canada
DSC	Divisional Simulation Centre
DTC	Divisional Training Centre
EA	Enterprise Architecture
ECS	Environmental Chiefs of Staff
EMS	Exercise Management System
Ex Dir	Exercise Director
FAC	Forward Air Controller
F-CITE	Future Canadian Army Integrated Training Environment
FCOE	Functional Centre of Excellence
FD	Force Development
FD CoP	Force Development Community of Practice
FGB	Force Generating Base
FMV	Full Motion Video
FO	Flag Officer
FOC	Full Operating Capability
FOO	Forward Observation Officer
GPU	Graphics Processing Unit
GO	General Officer
HAG	High Assurance Gateway
HLMR	High Level Mandatory Requirement
HR	Human Resources
ICD	Interface Control Document
IFFS	Interim FOO/FAC Simulator
IFT	Indirect Fire Trainer
IOC	Initial Operating Capability
IOS	Instructor Operator Station
IP	Intellectual Property
ISD	Instructional Systems Design
ISR	Intelligence Surveillance Reconnaissance
IT	Individual Training
IV	Information View
L	Live
LAV	Light Armoured Vehicle
LCGT	LAV Crew Gunnery Trainer
LDSS	Leopard Driver Station Simulator

LGST	Leopard 2 Gunnery Skills Trainer
LoE	Lines of Effort
LVC	Live Virtual Constructive
JCATS	Joint Conflict and Tactical Simulation
JIMP	Joint, Interagency, Multinational and Public
KPI	Key Performance Indicator
KSA	Knowledge, Skills and Attitudes
LVC	Live Virtual Constructive
M&S	Modelling and Simulation
MR	MAPLE RESOLVE
MRP	Managed Readiness Plan
MSCO	M&S Coordination Office
MSSG	M&S Steering Group
MU	Midlife Upgrade
NSC	National Simulation Centre
O&M	Operations and Maintenance
OA	Occupational Analysis
OCT	Observer Controller Trainer
OGD	Other Government Departments
OPI	Office of Primary Interest
OPP	Operational Planning Process
OPRED	Operational Readiness
OV	Operational View
PAD	Project Approval Directive
PCF	Primary Combat Function
PD	Professional Development
PME	Professional Military Education
PoC	Point of Contact
PoP	Point of Presence
PRICIE+G	Personnel and Leadership; Research & Development, and Operational Research; Infrastructure, Environment, and Organisation; Concepts and Doctrine; Information Management and Technology; Equipment and Support; and Generate
PTA	Primary Training Audience
QS	Qualification Standard
R&D	Research and Development
RA	Requirements Advisor
RCAF	Royal Canadian Air Force
RCN	Royal Canadian Navy
RF	Radio Frequency
ROM	Rough Order of Magnitude
SAT	Small Arms Trainer
SecV	Security View
SE	Synthetic Environment
SERR	Synthetic Environment Resource Repository
SEWG	Synthetic Environment Working Group
SIE	Single Information Environment
SISO	Simulation Interoperability Standards Organization
SLA	Service Level Agreement
SME	Subject Matter Expert
SOA	Service Oriented Architecture

SoCD	Statement of Capability Deficiency
SQEP	Suitably Qualified and Experienced Personnel
StratV	Strategic View
SV	System View
TA	Training Authority
TacC2IS	Tactical Command and Control Information System
TacComms	Tactical Communications
TacNet	Tactical Networks
TCO	Total Cost of Ownership
T&EA(L)	Training and Education Architecture (Land)
TNA	Training Needs Analysis
TO	Training Objective
Trg Sp (Sim)	Training Support (Simulation)
TRL	Technology Readiness Level
TV	Technical View
UWTS	Unit Weapon Training System
UOR	Unforecasted Operational Requirement
UOTS	Urban Operations Training System
UR	UNIFIED RESOLVE
V	Virtual
VBS	Virtual Battlespace
VCCI	Virtual Command and Control Interface
VCDS	Vice Chief of the Defence Staff
WES	Weapon Effects Simulation
WES MU	WES Midlife Upgrade

A F-CITE Risks

Seq	Risk descriptor	Type	Phase	Comment
	General			
A1	F-CITE-based training does not in fact prepare forces for operations.	Operational	In-service	
A2	F-CITE cannot meet unexpected training demands.	Training	In-service	E.g., surges or mission rehearsal.
A3	F-CITE itself becomes an inflexible stove-pipe that does not support interoperability with other CA or JIMP training and education systems.	Technical	Definition, Implementation	
A4	The F-CITE service taxonomy does not all identify all of the services that will eventually be required.	Technical, Cost	Definition, Implementation.	
A5	It is not possible to centrally fund the cross-cutting services required by the individual projects that benefit from F-CITE.	Cost	Programme	
A6	F-CITE becomes a ‘one-size-fits-all’ straightjacket rather than a flexible framework.	Technical, Cost	In-service	E.g., with respect to simulation fidelity.
A7	F-CITE cannot fully support the full range of simulation applications beyond its core training role.	Technical	In-service	E.g., usage by DRDC.
	Personnel and Leadership			
B1	It is not possible to recruit and retain SQEP to meet the F-CITE staffing requirement.	Training	In-service	

Seq	Risk descriptor	Type	Phase	Comment
B2	Existing Army trainers do not have the Knowledge, Skills and Attitudes (KSA) required to use the novel training features provided by F-CITE, or to develop appropriate training content.	Training	In-service	Some of the new ways of working introduced by F-CITE have no precedent in existing CA training capabilities.
	Research & Development, and Operational Research			
C1	It is not possible to initiate or exploit de-risking research associated with novel aspects of F-CITE.	Programme	Implementation	
	Infrastructure, Environment, and Organisation			
D1	F-CITE functionality cannot be cleanly attributed to specific CA training organisations.	Programme	Implementation, In-service	Especially for cross-cutting services relevant to all of the L, V and C FCoEs.
D2	F-CITE operations require CA restructuring that cannot be achieved.	Programme	In-service	
D3	F-CITE cannot be hosted in the CA's current or planned physical infrastructure.			
D4	Appropriate third party enablers are not available when required by F-CITE.	Training	In-service	E.g., secure, high-bandwidth long-haul bearers.
	Concepts and Doctrine			
E1	It is not possible to agree to a set of use-cases that clearly define the range of training supported by F-CITE.	Programme	Definition	

Seq	Risk descriptor	Type	Phase	Comment
E2	The desired F-CITE capability is not clearly articulated in RFPs and Concept of Employment.	Programme	Definition, Implementation	
E3	It is not possible in practice to exploit the technical flexibility offered by F-CITE to achieve optimised resource utilisation.	Technical	In-service	E.g., because there is insufficient prior warning of changes in demand, or because of procedural inflexibility.
E4	The CA is not able to provide comprehensive configuration management of F-CITE systems, leading to duplicated effort and inconsistent approaches across the range of F-CITE users.	Technical, Cost	In-service	
	Information Management and Technology			
F1	It is not possible to specify or police the criteria that define whether specific systems are F-CITE compliant.	Technical	Implementation	
F2	It is not possible to collect the demand and performance information required to allow timely, optimal use of F-CITE resources.	Technical	In-service	
F3	Commercial approaches lead to long-term lock-in to obsolete technologies.	Technical	Programme, In-service	
F4	Novel technologies required by F-CITE are insufficiently mature to support robust in-service use.	Technical	In-service	

Seq	Risk descriptor	Type	Phase	Comment
F5	F-CITE fails to correctly adopt appropriate M&S standards and protocols.	Technical, Cost	Implementation	
F6	Some aspects of F-CITE are not covered by M&S standards and protocols, leading to non-standard or even proprietary solutions.	Technical, Cost	Implementation	
F7	F-CITE information management cannot prevent corruption, disclosure or modification of F-CITE data.	Technical	In-service	Either internally (e.g., trainees modifying their scores) or externally (e.g., revelation of sensitive personnel or unit data).
F8	F-CITE, as a networked system, is vulnerable to cyber threats.	Technical	In-service	E.g., denial of service attacks and hacking.
	Equipment and Support			
G1	Systems and services remain segregated into distinct silos rather than forming an open, flexible toolbox of training capabilities.	Programme	Implementation, In-service	E.g., because it is not possible to redistribute funding between programmes.
G2	It is not possible to establish or operate an NSC with the capabilities required by F-CITE.	Programme	Implementation, In-service	
G3	It is not possible to deploy F-CITE capability to the full range of sites required.	Technical, cost	Implementation	This risk primarily impacts options 3a and 3b.
G4	The desired service-based approach cannot be achieved due to its contractual and commercial complexity.	Programme	Implementation	

Seq	Risk descriptor	Type	Phase	Comment
G5	Industry is not capable of or willing to offer the innovative services and solutions required by F-CITE.	Programme	Implementation	
G6	It is not possible to define appropriate SLAs and KPIs for the flexible F-CITE services required.	Cost	Definition, Implementation	
G7	F-CITE services and procedures are too complex or unwieldy to use in practice.	Training, Cost	In-service	
G8	It is not possible to sufficiently align scenarios, exercise management tools and processes to support networked training between disparate F-CITE sites.	Training, Technical, Cost	Implementation	
	Generate			
H1	Trainers and instructors are not able to make best use of the novel methods and media provided by F-CITE.	Training	In-service	E.g., because they remain wedded to traditional approaches that are perceived as tried and tested.

B F-CITE support for non-training applications

B.1 Operations and planning

Two potential applications of simulation in support of operations and planning are Course of Action (COA) development and Mission Rehearsal (MR).

COA development primarily focusses on the battlespace representation aspects of the overall simulation capability, typically running models faster than real time so that outcomes of plans can be explored before the plans become formal orders. Simulations used in a COA development role must satisfy the following criteria:

1. If the models are to be run faster than real time, they must be sufficiently automated that human-in-the-loop control is not required. Minimum human intervention may also be necessary of the simulations are being used in an operational HQ;
2. The algorithms within the models must be open, so that analysts can confirm that they are accurate representations of the real-world (and therefore that the COA outcomes can be trusted). This contrasts to the situation in training, where the algorithms may be hidden but accepted because they 'look right' to military Subject Matter Experts (SMEs).

In contrast, MR starts when an operational order has been developed. The intent is for the participants to experience their part in the overall mission, not to train the participants in the skills required to conduct the mission. The primary variation from training is therefore that all of the non-player forces and factions must precisely follow the COA that the order assumes they will follow, rather than exhibiting unexpected free-play.

Mission Rehearsal or COA Development versions of F-CITE could be delivered as specialised versions of the F-CITE mobile kit, containing constructive or virtual simulations that meet the criteria listed above.

B.2 Concept development and experimentation

The primary outcome of an experiment is a paper report that answers the question that the experiment was established to answer. Used in the CD&E role, simulation provides the evidential data that will inform the findings of the experiment.

Experiments can often be based on an exercise-like construct, where the trainees are replaced by experimental subjects, EXCON by the experiment director and observers by scientific analysts. It will therefore often be possible for an existing F-CITE exercise template to be used as starting point for developing an experiment. Almost by definition, however, an experiment will require non-standard changes, for example a novel communications plan, or the addition of a simulation that models a new aspect of the battlespace (e.g., a higher-fidelity representation of the complex RF spectrum of a technologically advanced urban environment).

Because of the wide variation between the goals of different experiments, it will probably not be feasible for F-CITE to offer a generic 'experiment in a can'. Experimental use of components not supported by the F-CITE NSC may also require experimenters to be more technically self-sufficient than conventional F-CITE users.

B.3 Research and development

From an F-CITE architectural perspective, there is little difference between the use of F-CITE tools in an R&D role to their use in a military-led experiment. The points made in the discussion concerning F-CITE-based experimentation therefore largely apply to R&D as well.

However, as an alternative to conducting experiment-like R&D activities, R&D researchers might instead collect and analyse existing exercise data, e.g., examining 'real' message logs to explore how soldiers use C2 chat systems. This highlights the importance of:

1. Persistent, post-exercise storage and archiving of exercise data;
2. The 'single information environment' concept, containing search and discovery tools so that analysts can explore F-CITE repositories to see if relevant data already exists.

One issue that must be addressed is the extent to which F-CITE should itself fund the long-term storage of data to support R&D, or provide 'big data' analysis tools as standard components of the baseline toolbox.

B.4 Acquisition and life-cycle management

Simulations have at least two distinct roles in Acquisition and Life-Cycle Management:

1. Operational analysis and evaluation of different acquisition options (e.g., simulating proposed vehicle designs when selecting between competing bids);
2. Concept development-style events during requirements elicitation (e.g., so that stakeholders can visualise the appearance or behaviour of a proposed system).

As with the other non-training applications, these roles may utilise existing F-CITE components in non-standard ways not supported by the F-CITE NSC

Annex C – E4-I10 STANDARD DEVELOPMENT

C1.0 INTRODUCTION AND BACKGROUND

C1.1 HANDOFF FROM UCATT-3

During UCATT-3, the E4 interface (DO Reporting), TES to Modem Interface (I10) was the next interface prioritised by the Architecture Task Group (TG). As much of the ground work for the E4 functional interface specification had been done in UCATT-3, the group was able to start immediately by examining existing interfaces used by the participating organisations to get an overview of how this interface was designed in the past.

C1.2 APPROACH

The starting point for the interface discussion was the data set given by the architecture group MSG-098. This database defined all the expected data for the E4 interface. It is expected that the E4-I10 data set would be a sub-system of E8. This conclusion occurs from the use case where two ranges are connected to one EXCON and the main range connection is E4-I10. Introduced for a coalition exercise is an E8 connection.

The E4-I10 TG identified the main properties of the electrical interface as:

- Able to provide near-real time data transfer speeds; and
- Able to provide power to Tactical Engagement Simulation System (TESS) or Instrumentation System Player Unit (PU) devices.

The approach of the UCATT group in order to define the Player Unit-TESS Interface is similar to the one of UCATT-3 (see Figure C-1).

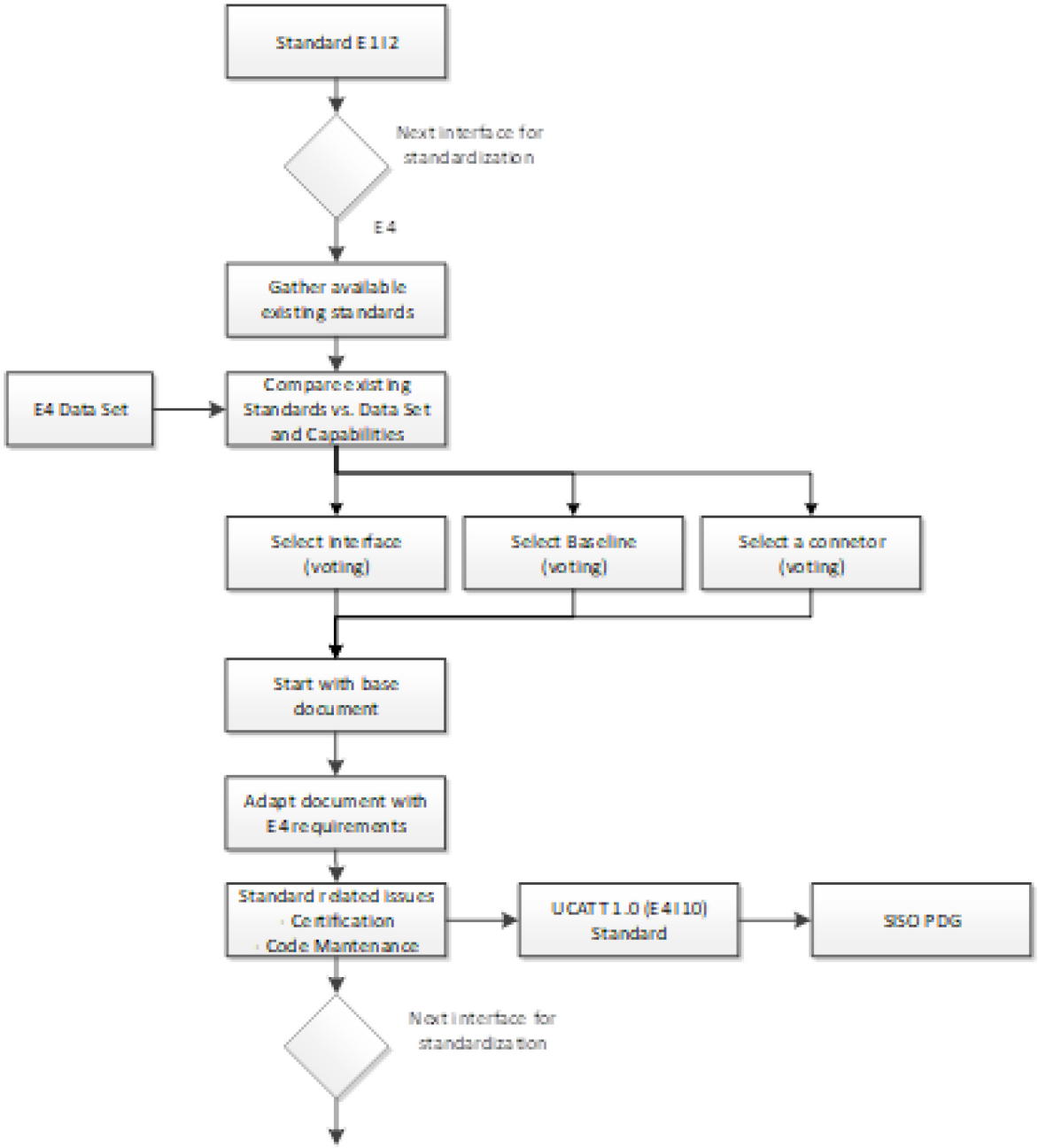


Figure C-1: Flow of Work TG E4.

The TG identified the following tasks for the development process:

1) Gather data on existing and potential (future) interfaces and standards applicable to those interfaces:
   a) Physical (e.g., CAN, RF, RS232, RS485, USB, etc.);
   b) Protocol;
   c) Installed base; and
   d) Longevity (e.g., installed base, underpinning standards, etc.).

2) Define datasets (i.e. inputs driving E4 outputs):
   a) E1 (i.e., laser, virtual, geo-pairing, etc.);
   b) E2;
   c) E3 (i.e., commonality of E3 and E4 implementation); and
   d) E9.
3) Define common data structure use cases (EXCON, O/C, etc);
4) Defined Output to Architecture Group (outline down-select criteria);
5) Short-listing to define candidate baseline:
   a) Down-select;
   b) Review with Architecture Group.
6) Define E4 Interface:
   a) E4 Content;
   b) E4 Certification/Validation;
   c) E4 Formalised as SISO Draft Standard; and
   d) E4 Intern3al Review (E4, UCATT) and Release to SISO.

C1.3 INTERFACE

C1.3.1 Centralised/Decentralised System

a) The Definition of "where" in a CTC the I10 interface takes place is important to timeline, as the output needs to address both near term interoperability and be sufficiently robust to address future systems.

b) The group discussed different existing TES/Radio/GPS configurations to get a common opinion on the position of the interface (Figure C-2).

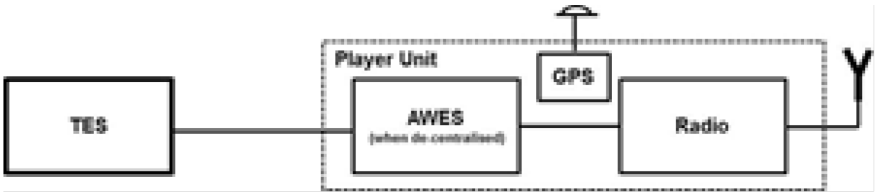
c) The discussion also considered the details of the different implementations and selected the most likely solution.

The implementation (Centralised or Decentralised) of weapon effect simulations (e.g., minefield, artillery, CBRN, etc.) was also reviewed by looking at the E1 and E3 engagement Use Cases.

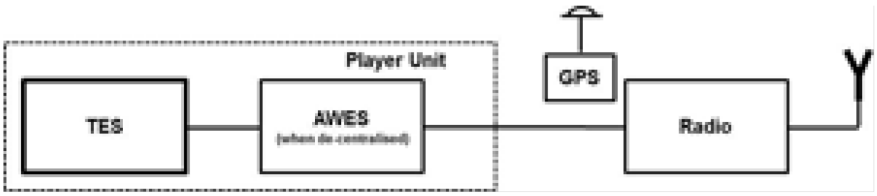
- Decentralised:
  - Communications system data rate is less of a constraint.
- Centralised:
  - Communications system data rate is an important consideration (requiring low latency data transfer).
  - Smart Munitions (allowing for a munition to change targeted entities during flyout).
  - Effects of an Urban Structure (such as a wall) effectively modifying munition effect on a platform.

The implementation of centralised or decentralised weapon effect simulations is not required to be addressed in near term, as if the Player Unit solution either includes AWES simulation or is a simple data pipe then the E4I10 interface does not carry that AWES evaluation detail (just the outcome). When AWES functional block is located in the TES then the ICD needs to reflect centralised or decentralised model.

Centralised Evaluation.



Decentralised Evaluation, with Smart Player Unit (AWES Performed in the PU).



Decentralised Evaluation, with Simple Pipe (AWES Performed in the TES).

Figure C-2: Different PU-TESS Setups.

E1, E3 rationale, from the perspective of Geo-Pairing and Artillery there are a number of functional implementations (See Figure C-3).

Looking at the different implementations, the group decided to have a PU including GPS and AWES calculation (Figure C-4).

For AWES and given the physical architecture, the data flow of E3 is across the TES/PU interface.

Minefield simulation is a general case where the engagement assessment is continuous (compared to artillery, which has a defined impact time).

C1.3.2 Ex-I10 Data Set

- The data to be exchan9ged in this standard is defined in the UCATT-3 MSG-98 “E4 Data Types” document.
- Early on, the Ex-I10 TG concluded that “E4-I10” is actually “Ex-I10” (E2 – E4) – the group found that the “I10” physical interface has applications outside of the “E4” functional interface, and has renamed it to reflect this observation.
- E4-I12 will be defined implicitly from I10, plus IP interface elements similar to E8.

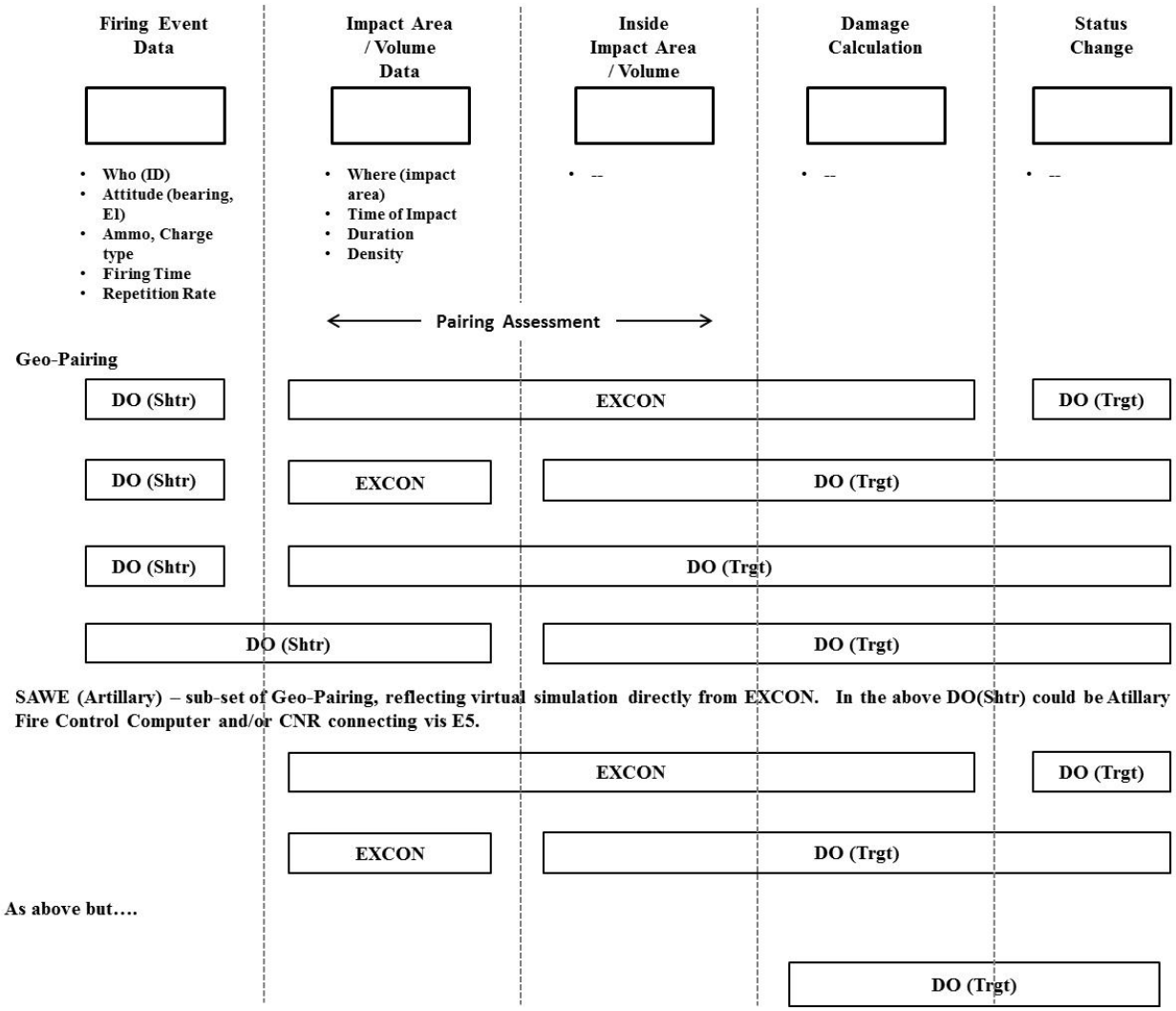


Figure C-3: AWES Functional Implementations.

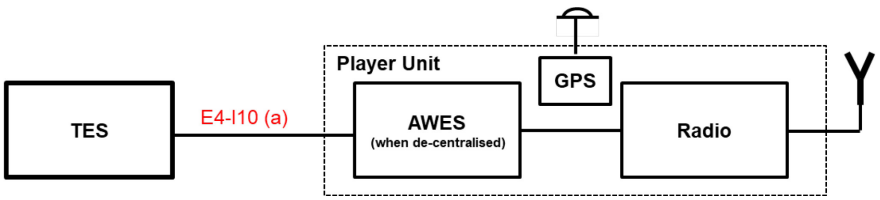


Figure C-4: Selected PU-TESS Setup.

- Review comment on the MSG-98 Data Types is captured in the document "150708 UCATT3 MSG-098 Report – FINAL (including E4-I10 comments 151125).doc", containing review comments/clarifications from the E4-I10 TG.
- **Methodology for conducting Area Weapon Effects:** During a review of the E3 definition, the UCATT Architecture Group agreed to pass dynamic object data (e.g. minefield) from EXCON to Dynamic Object. E3 was only passing outcome, and now passes either outcome or data for later evaluation. There are four "engagement" types as illustrated below:

1) Device sends a signal to a physical entity (e.g. mine simulation device to TESS); the output of which is communicated via E3.
2) Virtual minefield created in EXCON and distributed (E3) as a virtual DO and stored and evaluated in other entity(s). The use case is a minefield communicated to EXCON and decentralised evaluation conducted in the TESS as they traverse the range; as the TESS infringes on the virtual minefield the TESS performs an evaluation of the mine engagement.
3) Virtual minefield created at EXCON. Primary threat evaluation in EXCON and entity(s) are notified that they are under threat of minefield / mine explosion and DO in field evaluates outcome with respect to their protection factors (e.g. armoured, mine-clearing). This case is relevant as information is available in the field that is not (i.e. for latency reasons) available in the EXCON (e.g. entity evaluating virtual artillery and uses prone/standing as part of the evaluation, or location inside fortifications as part of evaluation).
4) Virtual minefield created at EXCON. Primary threat evaluation is performed at the EXCON with the engagement outcome for entity(s) assessed at the EXCON. The resulting status is sent to entity(s) via E3. In this case the EXCON has all necessary (field) information to provide realistic assessment; i.e., the limitations of the third use case are not limitations here.

- Allocation of Functional to Physical implementations: Player Unit or TESS perform the following functions (through the E2 and E3 interfaces):
  - Evaluation of weapon effects.
  - Communication of situational / context information to the soldier and vehicle crew (such as changes in health status).
  - Building instrumentation passing collateral effects, and the TESS target performing final evaluation (taking into account target position, such as lying or standing).
- **ExI10 must cater to non-U-LEIS systems:** The ICD allows for non-U-LEIS implementations. For example, if US Multiple Integrated Laser Engagement System (MILES) equipment is used, the Hit Location is of a lower fidelity than U-LEIS. However, the MILES Hit location can still be expressed via the ExI10 standard.
  - The “Capture Data” and “Manage Data” functions in the UCATT Functional Architecture will be supplied with DO information via E4.
- **E4-I10 scope:** E4-I10 will transfer data related to the following tasks:
  - Status Reporting (DO → EXCON).
  - Engagement (one DO to another via the Instrumentation System).
  - E4-I12 is a direct outcome of E4-I10. For the near term interoperability objective this allows the following (see Figure C-5, which is Figure 10 from the MSG-98 report).

The definition of the Data Layer for the Ex-I10 interface was developed using the definition of the categories of the TESS to Instrumentation System (IS) ICD messages in Table C-1. These messages are a summary of current and future data payloads.

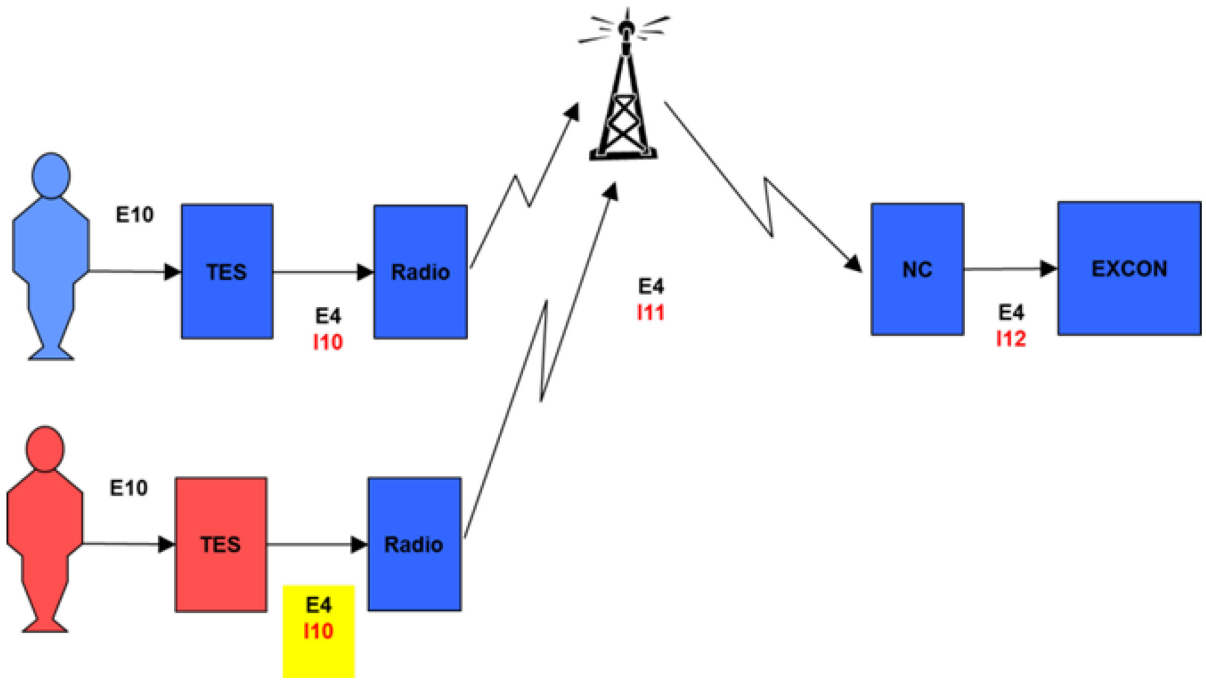


Figure C-5: Physical Interfaces of E4.

Table C-1: Categories of The Data Exchange Between TESS and IS.

Connected Device	Data (from TESS)	Data (to TESS)
Any	• Communications Control (setup, re-establishment, etc.) • Proprietary Test Commands (e.g. design, production test; reserved section of commands)	• Communications Control (setup, re-establishment, etc) • Proprietary Test Commands (e.g. design, production test; reserved section of commands)
Any	• (Concatenated) Free Text/Data	• (Concatenated) Free Text/Data
TESS (Infantry) TESS (Vehicle) TESS (Weapon)	• Location (UCATT Geographical Code) • Hit (casualty assessment, damage assessment) • Firing (ammunition stock) • Weapon Data (attitude, ammunition stock, etc.) • Associated Weapons, Devices, Players, Protection Device (Jammer, etc.) • BIT results (BIT, battery, configuration, etc.) Status Change • Status Report	• Ammunition Replenishment • Administrative Commands (kill, reset, run BIT, shutdown laser, etc) • Configuration (platform configuration, PID assignment, etc.) • Threat evaluation (result from AWES effect; collateral threat) • Time (time, date) • Test (flash, sound, etc.)

Connected Device	Data (from TESS)	Data (to TESS)
TESS (Infantry) TESS (Vehicle) TESS (Weapon) (cont'd)	• Platform configuration (vehicle type, PID, etc.) • Administrative (Power-On, Cheating, etc.)	
TESS (Infantry)	• Medical Treatment • CBRN Protection Equipment Fitted (e.g., Gas Mask) • C-IED Detection Device	• CBRN Threat (to pass to replica device)
TESS (Vehicle)	• Maintenance Repair • Vehicle configuration (e.g. protection; mine plow, etc.)	•
TESS (Building)	• Hit (resulting from Shoot Through Walls)	•
Instructor Tablet	• Requests to EXCON • Text to EXCON	• Map/Field entity update from EXCON • AAR report from EXCON
TESS (Infantry) TESS (Vehicle) TESS (Weapon) Weapon System, including Virtual simulation (e.g. NLOS SPIKE) Augmented Reality display	• Weapon Attitude	• Entities • Entities (in a defined field of view / flyout)
(Pop-Up) Targetry	• Target status	• Actuate (raise, lower, etc)
C4ISR (Examples: simulated laser designator and simulated Forward Observer laptop)	• Simulated C4ISR data • Laser rangefinder data	• Stimulate external C4ISR device

C1.3.3 Administrative Data

Administrative data – such as a platform's technical status – is not easily identified in the UCATT Functional Architecture. However, Ex-I10 still provides a mechanism for transferring this information between the TESS and PU.

C1.4 EX-I10 INTERFACE REQUIREMENTS

C1.4.1 IS Physical Interface Requirements

In live training use cases, the Tactical Engagement Simulation System (TESS) is a set of appended equipment that performs the laser engagement. The Instrumentation System (IS) is a set of equipment responsible for transferring data between entities during a training exercise. The Player Unit (PU) radio transfers data from the TESS to the EXCON.

During development, the group developed the following considerations:

1) Connection Topology (e.g., TESS-PU connected as Point-to-Point or Multi-Drop bus) (Figure C-6).

Discussion:

- The TESS-PU installed base has both multi-drop (e.g. CAN, RS485, RF) and point-to-point (e.g. RS232) physical implementations.
- Point-to-Point topology is more typical of infantry solutions.
- Multi-Point topology is more typical of vehicle systems comprised of multiple components.

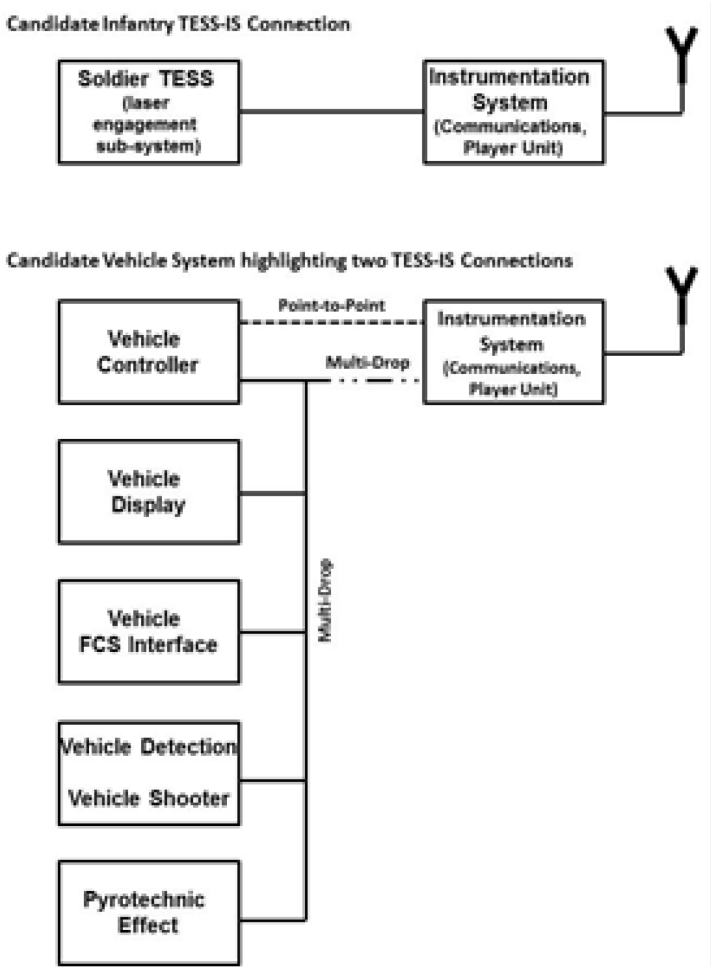


Figure C-6: Infantry/Vehicle Connections.

2) Mechanical Interface

- The Ex-I10 ICD does not make any stipulations as to how TESS or PU components should mount to an entity. However, mounting points should be considered by exercise planners and/or acquisition professionals.

  This is relevant for use cases where guest countries bring their TESS to a multi-national exercise and are fitted with other countries' IS equipment.

C1.5 EXISTING STANDARDS CONSIDERED AS A BASIS FOR EX-I10

The initial approach of the Task Group was to compare a number of in-service interface standards to the required message set defined in the UCATT-3 MSG-098 report.

Candidates for the comparison were:

- French Communication – Localisation ICD (COMLOC).
- German TESS-PU ICD (CANAG).
- US IS-TESS ICD (maintained as part of the US' Live Training Transformation product line).

Availability at the start of UCATT-4:

- GDI (France) provided Infantry Soldier and Vehicle TESS-PU ICDs (in French and English).
- BAAINBw (Germany) provided TESS-IS ICDs (in German).
- PEO STRI (USA) hadn't secured IS-TESS documentation for public release, so this standard was not initially considered.

The available documents were cross-correlated with the MSG-098 data.

The following results were reached:

- Older generation TESS with less functional support favour a centralised solution. In looking to re-use existing ICD's, the group was mindful of the constraints under which the ICDs may have been authored (to support in-service TESS requirements).
- Approximately 50% of the TESS-PU messages are used in an administrative capacity (such as BIT, association of TESS-PU interface, diagnostics, etc).
- A number of virtual effects do not pass across the TESS-PU interface for evaluation. Instead, the engagement result (determined by Player Unit or EXCON) is passed to the TESS.
- Of the MSG-098 messages, some – such as those related to Chemical, Biological, Radiological, and Nuclear (CBRN) threats – may be passed at a modified level to the TESS. For example, in a CBRN plume, the IS may be required to pass CBRN threat level to simulated identification/detection devices, and also to receive from the TESS the presence of Personnel Protective Equipment (PPE). In this case the MSG-098 E1 message is routed to the Player Unit and a sub-set of relevant information is passed across the Ex-I10 interface to support the (cumulative) threat evaluation.

A Physical Layer trade study is documented in A1 UCATT E4-I10 Physical Media Trade Study (160923; 00.C). The summary is summarised in Table C-2.

Table C-2: Physical Layer Trade Study Summary.

Media	Power Consumption	Cost (Acquisition)	Interference	Ease of Use (Setup)	Standard	Ease of Use (Addition)	Multi-Drop
Wired							
RS232	1mA	High	None	Easy	Telecommunications Industry Association	Hard	False
RS485	3mW	High	(own) bus contention	Easy	Telecommunications Industry Association	Medium	True
RS*xxx* and Attention Line(s)		High	(own) bus contention	Easy		Medium	As above
USB	0.35mA	High	None	Easy	USB Implementers Forum	Hard	False
CAN (low speed)	6mW	High	Low	Easy	ISO 11898-3	Medium	True
CAN (high-speed)	6mW	High	Low	Easy	ISO 11898-2	Medium	True
Ethernet	80mW	High	Low	Easy	IEEE 802.3	Medium	True
Wireless							
Bluetooth	0.75mW	Low	Self, External	Pairing Required	Bluetooth Special Interest Group	Easy	True
Zigbee	18mW	Low	Self, External	Pairing Required	ZigBee Alliance, IEEE 802.15.4	Easy	True
Discounted							
RS422/423	Discounted in favour of RS232/RS485 as more dominant protocols.						
Infrared (IR)	Directional nature imposes line of sight constraints which are not practical.						
433MHz, etc	Not globally license exempt band.						
2.4GHz other	A number of protocols including those on standard protocols; need standards to ensure interoperability and longevity.						

C1.6 PRINCIPLES OF THE EX-I10 STANDARDS

The Ex-I10 ICD shall accommodate Country and contractor specific message sets in addition to a common message set. Country and contractor specific messages will be defined in a single appendix to the standard. Supporting these messages will not be required for a system to be Ex-I10-compliant. The Ex-I10 ICD shall support evolutionary development and fielding. Message Definition.

The Ex-I10 TG developed a table of all the messages by name, cross-referenced with the MSG-98, GUEZ ICD, US ICD, COMLOC ICDs. In addition, industry TG members referenced their companies' equivalent ICDs. Below is the first-generation of the cross-reference matrix (Table C-3).

Table C-3: Example Working Draft of First Generation Cross-Reference Matrix.

S/No.	Message	Data Transfer	"Ex"	Content	Possible Content	Not to be Covered
1.	Report Firing	TESS → IS (PU)	E4	Time Fired ammunition type Number of shots fired in one firing event Engagement range Number of shots remaining ----- New from 98Rep F.5.1 ----- Shooter ID	Weapon type Weapon ID Shooter weapon mode Fuse type Fuse settings Shooter Location Shooter Velocity Time of start of the engagement (Trigger Time) Time of end of the engagement (Impact Time) Point of impact Detonation location Effect direction/angle Weapon direction/angle Projectile impact velocity	Effect volume Terrain Atmospheric data Affected DO(s) ID Affected DO(s) location Affected DO(s) velocity
2.	Report Hit	TESS → IS (PU)	E4	Time Player ID of the attacking system (Shooter ID) Received ammunition type Number of shots received in one event Hit Result Operational status of the target	Engagement range Weapon type Weapon ID Fuse type Fuse settings Shooter Location Shooter Velocity Time of start of the engagement (Trigger Time) Time of end of the engagement (Impact Time)	Shooter weapon mode Weapon direction/angle Effect volume Terrain Atmospheric data Affected DO(s) ID Affected DO(s) location Affected DO(s) velocity

S/No.	Message	Data Transfer	"Ex"	Content	Possible Content	Not to be Covered
2. (cont'd)					Projectile impact velocity Point of impact Detonation location Effect direction/angle Weapon direction/angle	
3.	Report Tactical Status	TESS → IS (PU)	E4			
4.	Report Technical Status TESS	TESS → IS (PU)	E4			
5.	Request Technical Status PU	TESS → IS (PU)	E4			
6.	Initialise/Set Tactical Status	IS (PU) → TESS				
7.	Supply Ammunition	IS (PU) → TESS				
8.	Reset Manipulation	IS (PU) → TESS				
9.	Command Area Weapon Hit	IS (PU) → TESS				
10.	Technical Initialisation/Configuration	IS (PU) → TESS				
11.	Set Time	IS (PU) → TESS				
12.	Request for Tactical Status TESS	IS (PU) → TESS				
13.	Request for Technical Status TESS	IS (PU) → TESS				
14.	Report Technical Status PU	IS (PU) → TESS				
15.	Display message	IS (PU) → TESS				
16.	Designator TX Report					
17.	Designator Target Report					

At the time, the TG determined that future versions of the ICD (post-initial fielding) would contain mechanisms for transferring data related to geo-pairing. The group agreed that Audio / Visual data transfer functions would not be supported by Ex-I10 in the near term.

C2.0 COMLOC ICD SELECTED AS INITIAL BASELINE

At the time, the TG determined that the COMLOC ICD provided a public domain baseline and contained a message set that could mostly support the messages listed in the MSG-098 document. They developed an analysis to determine where the gaps existed in the COMLOC standard.

The TG made the decision to use COMLOC as the basis for the candidate Ex-I10 ICD baseline, augmenting it with inputs from other ICDs to fill gaps where COMLOC did not trace to MSG-098. The following two COMLOC reference documents were used in the development of a draft Ex-I10 standard:

- SPECIFICATION TECHNIQUE D'INTERFACE (STI) POUR UN STC FANTASSIN CENTAURISÉ AVEC LE KIT COMLOC DU SYSTEME CENTAURE G2.
- SPECIFICATION TECHNIQUE D'INTERFACE (STI) POUR UN STC VÉHICULE CENTAURISÉ AVEC LE KIT COMLOC DU SYSTEME CENTAURE G2.

C2.1 CONNECTOR DISCUSSION

In selecting a physical connector, the TG considered the following factors:

1) The COMLOC ICD features a “Loop-back” interface. While more expensive, loop-back offers power savings, due to hardware presence detection ahead of the polling serial port.
2) The US MILES product line does not include loop-back hardware. GDI systems include loop-back hardware.

C2.1.1 Man-Worn Connector

Based on Ex-I10 data transfer requirements, the Ex-I10 TG identified the following characteristics for dismounted (man-worn) applications:

- 5-Pin
  - RS232 (transmit)
  - RS232 (receive)
  - RS232 (ground)
  - Power
  - Power Ground
- All cables shall have strain reliefs to protect the connection of the wires to the connector.
- Shielding for the cable shall be connected to the metallic shell of the connector at each end of the cable.

An example connector pair (already in use by the US) supporting this configuration is the Lemo PHG.0B.305.CLLD42Z (male) / Lemo FGG.0B.305.CLAD42Z (female).

- Power transfer requirements.
- Environmental.

As part of the connector discussion, the group considered that power was a (related) design consideration. There are three use cases below (Figure C-7).

1) Both TESS and PU accept (unconditioned) battery pack power.
2) TESS and PU are separately powered. This is considered the near term multi-national solution.
3) PU provides conditioned power to the TESS; i.e. USB (+5V).

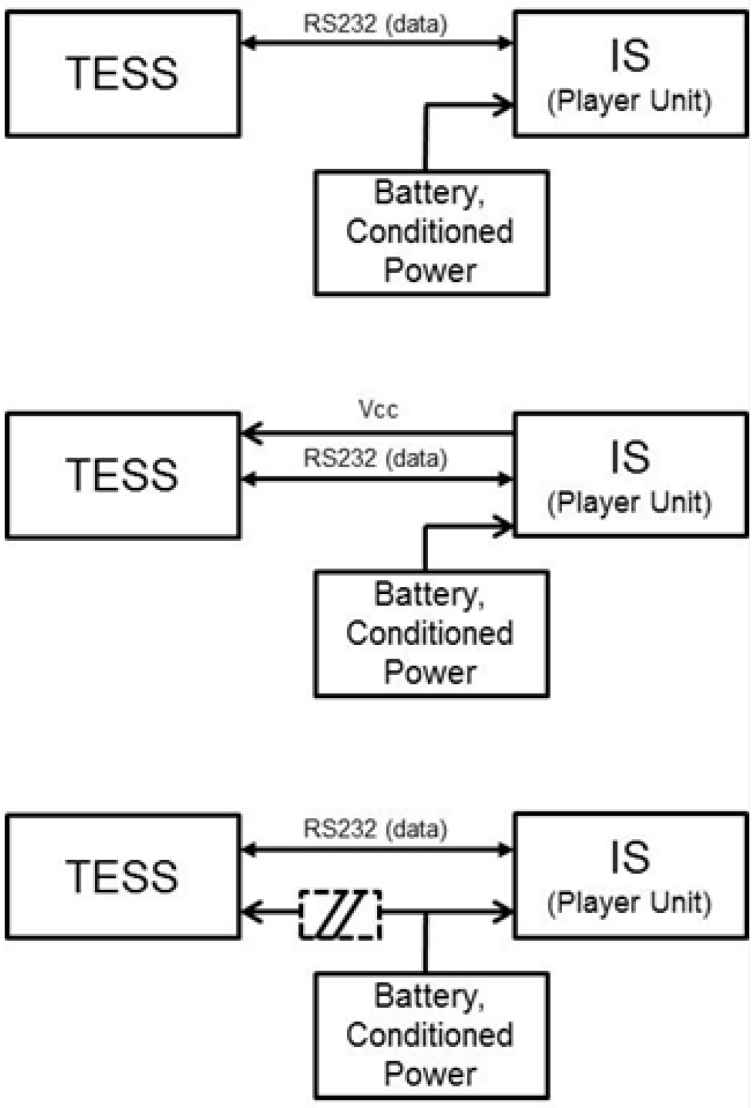


Figure C-7: Power Connector.

The group came to the conclusion that the standard needs to encompass these requirements:

1) Power requirements should not be country-specific.
2) Connectors that support this standard should be available to all participating countries.
3) Connectors should not be vendor-specific.
4) Minimum Life Cycle Cost.

C2.1.2 Vehicle Connector

Based on Ex-I10 data transfer requirements, the Ex-I10 TG identified the following characteristics for mounted (vehicle-based) applications (Table C-4):

- 5 Pins:
  - RS232 (transmit)
  - RS232 (receive)
  - RS232 (ground)
  - Power
  - Power Ground
- All cables shall have strain reliefs to protect the connection of the wires to the connector.
- Shielding for the cable shall be connected to the metallic shell of the connector at each end of the cable.

Table C-4: Original Draft I10 Connector Pin Configuration.

Pin	Purpose	Rationale	Indicative Vendor Perspective	Conclusion
Mandatory Pinout				
1	RS232 Rx	Minimum level of signals pertaining to Ex-I10 interface, allowing DO information transfer		Included in Ex-I10 connector
2	RS232 Tx			Included in Ex-I10 connector.
3	RS232 Gnd			Included in Ex-I10 connector.
Shield				Included in Ex-I10 connection.
Reserved Pins, with candidate assignments				
4	Power (+5V), IS (Player Unit) to TESS	e.g. USB Spec (conditioned power)	Cubic, SAAB, RDE, RUAG, RWD, GD Not required: GDI	Not unanimous but majority agree that Ex-I10 connector transfers power. Remains to be decided the exact voltage range. Green highlight indicates that the two inputs may be consolidated into a single wide-range input. Action: Define the Use Cases for today and future.
5	Power (Battery Pack), IS (PU) to TESS	e.g. Battery Input (raw battery)	Cubic, SAAB, RDE, RUAG, RWD, GD Not required: GDI	
6	Power (raw vehicle power)	e.g. MIL-STD1275 input (vehicle, noisy, power)		
7	Power Gnd			
8, 9	Loop-back	Specific to the GDI / Thales solution		Action to validate; expect to remove.
10, n	Digital I/O	Triggering of effects, Special I/O		Noted as Vendor-specific data point; Use Cases to define.

In addition, the group considered a requirement for galvanic isolation, as some countries already included this as a requirement for their cables. Ultimately, the group found that galvanic isolation should not be a requirement for this connection.

An example connector (already in use by the US) supporting this configuration is the Amphenol MS3126P12-10P. The group determined that the connector must be shielded and feature grounding and galvanic isolation.

There are three options for powering TESS and PU on vehicle applications:

1) TESS and PU are separately powered via batteries.
2) TESS and PU accept unconditioned vehicle power.
3) TESS provides conditioned power to PU. In the US this conditioned power is defined as +12Vdc, <100mVpp ripple, 1.5A.

Table C-5 shows the final characteristics of the vehicle power connector.

Table C-5: Final Vehicle Power Connector.

Pin	Purpose	Rationale		Conclusion
Mandatory Pinout				
1	RS232 Rx	Minimum level of signals pertaining to Ex-I10 interface, allowing DO information transfer		Included in Ex-I10 connector.
2	RS232 Tx			Included in Ex-I10 connector.
3	RS232 Gnd			Included in Ex-I10 connector.
Reserved Pins, with candidate assignments				
4	Power (+12Vdc, conditioned)	conditioned power		On US platforms power may not always be supplied from the vehicle when the vehicle is powered off. This would drive (program) demand for a separate power source (battery) to supply the TESS and IS.
5	Power Ground			
Shield				Included in Ex-I10 connection.

C2.2 MOTIONS

At UCATT PDG meetings, the Ex-I10 TG developed motions for modification of the standard. These motions were tabled in San Diego and voted on in Oslo. This standard has been modified from its original US standard based on the following four motions. These were subsequently updated by MSG-140 Chair / Secretary and saved to UCATT and Science Connect websites.

The following four points are tabled as motions to the MSG-140 Group for balloting in UCATT LSS(6)-Oslo:

1) Physical data transfer medium should be defined as RS232; simple point-to-point wired interface **(UCATT LSS(6)-E4-I10 Motion #1)**.
2) The communications protocol should be developed from an evolved baseline, and not endorsement of an existing standard **(UCATT LSS(6)-E4-I10 Motion #2)**.

3) Architectural decision on the evaluation of the AWES effects outside the TES; i.e. in PU (decentralised) or EXCON (centralised) **(UCATT LSS(6)-E4-I10 Motion #3)**.
4) Power – as a common power supply for existing and future PU of different Live Simulation Systems is not very likely, it is recommended to stay with separate power supply possibilities for international exercises. For future expansion, provision is made on the connector to pass power and serial data transfer **(UCATT LSS(6)-E4-I10 Motion #4)**.

More information on these motions is captured below.

UCATT LSS(6)-E4-I10 Motion #1

The Ex-I10 Task Group proposed the endorsement of RS232 as the physical medium to interface between the TESS and Player Unit.

Rationale: RS232 provides point to point wired communications. RS232 has an installed base in the US. RS232 is a mature technology, reducing integration risk, but is notably being replaced by multi-drop wired (CAN, RS485) or wireless technologies.

UCATT LSS(6)-E4-I10 Motion #2

The E4-I10 Task Group proposed that the communications protocol should be developed from an evolved baseline, and not from an existing standard.

Rationale: Utilizing an evolved baseline and/or re-use of an existing standard is low-risk based on the maturity of these implementations. The MSG-98 Report and ICDs from German GUEZ, French COMLOC standards are being used as reference material. Request with PEO STRI on public domain release of the US ICD, else this precludes its direct inclusion.

UCATT LSS(6)-E4-I10 Motion #3

The E4-I10 Task Group proposed a system architecture whereby the virtual Area Weapon Effects Simulation (AWES) is conducted either:

- Centralised in EXCON, and result is communicated via Player Unit to the TESS.
- Decentralised in Player Unit, and result is communicated to the TESS.

The architecture decision results in the TESS not performing the AWES threat evaluation and simplifies data communication across the Player Unit – TESS interface.

Rationale: The majority of installed sites use the above centralised or decentralised approaches.

UCATT LSS(6)-E4-I10 Motion #4

The E4-I10 Task Group proposed that the Ex-I10 connector allows for future expansion of the E4-I10 message set (mandatory) and the addition of future capabilities for power transfer.

Rationale: Near term use cases for multi-national integration of TESS and Player Units would involve separately powered TESS and Player Units.

C3.0 INTEGRATION OF US IS-TESS ICD

In response to Motion #2 from the LSS (6) meeting, the US released their IS-TESS ICD (Instrumentation System (IS) Tactical Engagement Simulation Systems (TESS) Interface Standard, Document Number:

PRF-PT-00552, Revision: G, 17 August 2017) for Public Distribution. Within the Working Group the question was raised and discussed of using this US ICD as the Ex-I10 Baseline instead of the original plan, which used the French COMLOC standard as the basis for Ex-I10.

The Ex-I10 Task Group ultimately made the decision to transition to using the US IS-TESS ICD instead of COMLOC based on the following information:

1) What are the major differences between the COMLOC standard and the IS-TESS ICD? (Examples: hit, firing – extra position data).
    a) Definition of an evolutionary approach.
    b) Association (Initial, Thereafter).
    c) Capability to transparently pass data.
    d) Polled vs Event Driven Interface.

Once establishing the major differences between the standards and weighing the benefits of each, the group identified three courses of action that could be followed:

1) Continue to work with the draft standard by integrating the US ICD into the Ex-I10 baseline.
2) Use the COMLOC protocol but use US ICD data structures.
3) Continue using the COMLOC standard as a basis for the Ex-I10 standard (protocol and data structures), and by implication validate against US and other ICDs.

Considerations included:

- Methodology
    - Develop the Ex-I10 standard using an existing standard's primary message set (e.g. laser engagement only) but add the capability to facilitate new functionality (e.g. add medical, CBRN, Geo-Pairing , etc.).
- Maturity
    - Both COMLOC and IS-TESS ICD are in-service so offer low-risk implementation.
    - The installed base is larger for the US set, but the IS-TESS ICD contains US-specific functionality which would need to be modified to accommodate other countries' use cases or be removed.
- Development
    - The group hoped to use a standard that had test tools available to make integration easier. The IS-TESS ICD already has tools that the US uses for testing purposes.

The group determined that the most efficient way to move forward with the standard development process was to follow Course of Action #1.

The initial discussion then moved to a review of the US ICD. Subsequent comments were:

- This standard needed additional enumerated types (such as hit results) to satisfy all countries' requirements.
- Enumerations should be re-used when appropriate.
- The Ex-I10 standard would need to support systems using older versions of the IS-TESS ICD. The group recognised that older versions of the US ICD may contain deprecated messages / functions that may not be relevant to the Ex-I10 use case.

- THE IS-TESS ICD's BIT and Alarm messages must be added to the current draft standard to support stakeholder requirements. The US has legacy materials and references that can be used as reference material while developing the Ex-I10 standard.
- The US ICD contains all messages in the COMLOC standard, but also provides messages for further functionality. The US is willing to make legacy tools available to facilitate the development and/or test of the Ex-I10 standard.
- COMLOC's core message set is limited compared to the US ICD.
- Timing requirements found in the US ICD were too slow; the Ex-I10 standard will revise timing to meet platform requirements.
- The group agreed that the Ex-I10 standard should include power requirements but did not determine which standard should provide them.

C3.1 ENUMERATED TYPES

The Ex-I10 Task Group identified the following candidate sources for Enumerated Types:

- US PRF-PT-00617, "LT2 Interoperability Enumerations": The US maintains their own enumerations document for use with their Live Training Transformation (LT2) product line. This document establishes definitions for common enumerated types related to live training.
- SISO-REF-010-2016: Reference for Enumerations for Simulation Interoperability: SISO-REF-010-2016 specifies numerical values and associated definitions for fields that are identified as enumerations in SISO Standards Products and SISO-sponsored standards published by IEEE for High Level Architecture (HLA) and Distributed Interactive Simulation (DIS). Enumerations for simulations may be applied in other architectures, such as the Test and Training Enabling Architecture (TENA). This version was approved and published on 10 November 2016.

Direct Fire enumerations will follow the UCATT Laser Standard (E1) Ammo Table. Candidate Indirect Fire enumerations will come from the Saab Interoperable Users Coalition. US enumerations contain baseline data, with expectation this will need to be augmented with international platforms/weapons/ammunition/etc.

While examining the US ICD, the group identified that the following messages could not simply be copied from the standard due to Ex-I10 requirements:

- Ammunition Level – Request and Set messages.
- Request for PU Built-In Test.
- Report Alert.
- Version Control – Request and Report messages.
- Variable Data Message.

C3.2 CONCLUSIONS

1) The Ex-I10 TG resolved to integrate the US ICD into the existing draft standard by inserting the IS-TESS protocol and messages in place of the COMLOC protocol and messages.

2) The Ex-I10 solicited a request to industry for existing power transfer specifications across IS-TESS interface.

3) The TG then commenced a review of the US ICD.

4) The Ex-I10 TG prioritised the messages contained within the IS-TESS ICD using the following methodology:
   a) Priority 1: This message set is necessary to support current CTC capabilities (such as direct fire, protocol).
   b) Priority 2: This message set is required to support future capabilities, such as geo-pairing.
   c) Priority 3: This message set is not required to support current CTC capabilities or future capabilities.
5) The Ex-I10 TG performed a cross-reference of the IS-TESS, COMLOC and MSG-098 messages to validate that the IS-TESS ICD can provide the same functionality as the COMLOC ICD. In parallel, the Ex-I10 TG validated traceability of the IS-TESS ICD to the MSG-098 dataset.

Notes:

UCATT TG NATO Architecture Framework Discussion

The Ex-I10 TG met with the UCATT TG NAF to discuss impacts of using the IS-TESS ICD as the basis for Ex-I10. Conclusions:

- NAF framework can add architectural detail on the EXCON (E4-I12) to Player Unit (E4-I11, I10). Currently this has been left as vendor-specific detail, as it pertains to the Player Unit and Comms, but from a functional perspective includes elements such as evaluation of indirect fire effects.
- The E4-I10 TG took an action to provide the new IS-TESS-based E4-I10 draft ICD, including mark-up of the pertinent messages, for inclusion in the architectural model. ('Pertinent' is defined as messages passing E3 and E4 data compared to a number of messages supporting E4-I10 IS-TESS protocol (establishment, retry/acknowledge, etc.).

Ex-I10 Versioning Standards

The TG agreed that the Ex-I10 standard would have a 2-digit version (a primary digit and a secondary digit).

Example: 1.03 – "1" is the primary digit, while "03" is the secondary digit.

Revision Backward Compatibility – the TG's version format helps a reader easily determine compatibility with systems using other versions of this standard. The primary digit of the standard indicates compatibility. If the first digit is not the same on two systems using this standard, compatibility is not assured.

Building Expandability into the Standard

The TG recognised the importance of expanding the standard to accommodate future training requirements and built expandability into Ex-I10. Expandability seeks to address the necessity for an IS-TESS standard that – after passing data to the Player Unit – will have data payload constraints across the Player Unit radio. For example, MSG-098 calls for a Player ID range of 100,000 whereas industry today supports 65,535 (Figure C-8, Figure C-9). There are two methods for handling this mismatch:

1) Specify today's limit (two bytes; 65535). This is not compliant to UCATT-3 MSG-098 intent. It provides no designer guidance.
2) Specify future limit (100,000), knowing that a very near term implementation will have a constraint on what can be communicated across the Player Unit data link. In that respect the E4-I10 ICD definition may result in data-loss (of the upper PID range) in the near term, and outside the Standard supporting definition is required.

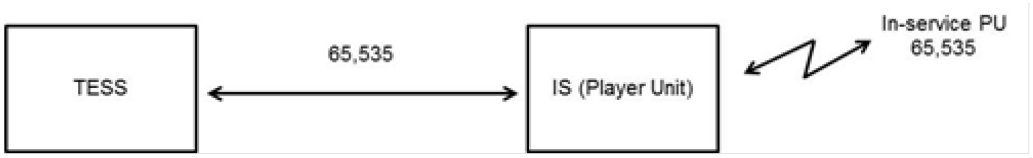


Figure C-8: Today's Limitations.

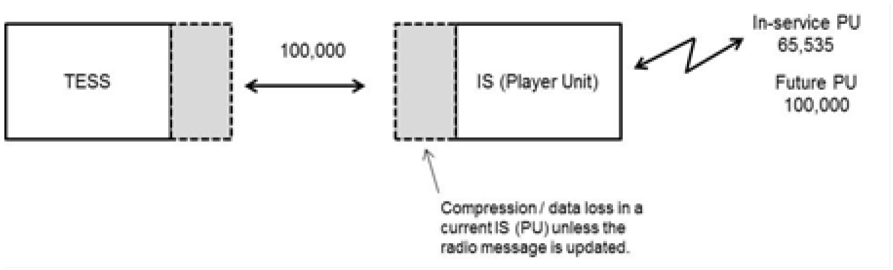


Figure C-9: Future Limitations.

The Forward Compatibility / Roadmap conclusion is to tabulate key data fields in the Ex-I10 message set with Current Revision and Future Revision data structures. This provides designers intent of the E4-I10 standard. An example is tabulated in Table C-6, where the reader should note that the GPS and Time future fields are defined as "extremes" instead of MSG-098 limits for the purposes of reinforcing the future guidance approach. The Rationale column provides the reader with the driver for the updated scope.

Table C-6: Future Guidance.

Parameter	Today Rev 1.00	Future Guidance Rev 2.00	Future Guidance Rationale	Backwardly Compatible (Y/N)
Player ID	65,535	100,000	MSG-098	Y (data)
GPS Location	metres	Centi-metres	Geo-Pairing, etc	Y (data)
Time	seconds	Milli-second	Geo-Pairing, etc	Y (data, not structure)

C4.0 TEST AND ACCREDITATION METHODOLOGY FOR EX-I10

Development of UCATT test, accreditation, and certification strategies is the responsibility of Product Support Groups (PSGs) instead of Product Development Group (PDG) Task Groups. Regardless, the Ex-I10 TG put together some expectations as to how a test and certification strategy could be developed for this standard.

The US' Live Training Transformation (LT2) product line development group maintains test tools for many of its products. They've developed a software-based emulator / test tool for IS-TESS, which is capable of simulating the IS-TESS messages sent between TESS systems and PUs. Though the tool would need to be modified to take into account the changes between IS-TESS and Ex-I10, using this tool as a baseline would greatly reduce the amount of time required to develop a mature test capability.

During Ex-I10 TG meetings, the US has said that they have full rights to the test tool's source code and are willing to release it to UCATT partners (pending security approvals for public release). In addition, the US would make available any test tool documentation or plans/procedures related to IS-TESS testing.

It will be the responsibility of a future Ex-I10 PSG to receive and evaluate these test products for their utility and to develop a strategy for test, certification, and accreditation given the materials they've been provided.

C5.0 SUMMARY

The E4-I10 interface is defined as the first stage for transferring tactical data from the Tactical Engagement Simulation System (TESS) to the Instrumentation System (IS)'s Exercise Control (EXCON). It exists between the TESS and the IS's Player Unit (PU) radio. Since the E4-I10 Task Group (TG) formed at the beginning of the UCATT-4 mandate, the standard has evolved in many ways, precipitating a name change (to Ex-I10) along the way. It was developed during the UCATT-4 (MSG-140) mandate (2015-2019) by a multi-national group of engineers from the government and civilian sectors.

Data transfer is performed via the Recommended Standard 232 (RS232) serial connection, chosen for its proven performance in similar applications. The interface uses a bipolar, asynchronous link over three wires. The standard also provides a mechanism for power transfer over the connection and specifies requirements for a physical connector. Ex-I10 can facilitate both bounded- and variable-length messages.

After experiencing the E1-I2 TG's successes through basing the U-LEIS standard on a mature, fielded standard, the E4-I10 TG commenced looking for an existing standard to serve as the basis for E4-I10. They settled on COMLOC, a French standard that, while quite old, provided a mature, proven interface that featured most of the mechanisms needed for satisfying the E4 interface's requirements. The group set out creating a new standard by modifying the existing standard, adding and modifying functions to match their needs.

Halfway through the development process, the US succeeded in getting their new IS-TESS Interface Control Document (ICD) certified for public release. This standard, while much newer than COMLOC, had already been proven mature, as it had been implemented into many US Instrumentation Systems with great results. In addition, IS-TESS provided many more required functions and had been designed with expansion in mind. The US standard was provided to the E4-I10 group for their evaluation. After performing an extensive comparison of the two standards, the TG realised that basing the E4-I10 standard on the IS-TESS ICD would reduce the amount of work required to develop the new UCATT standard, as many more messages and data types had already been developed in IS-TESS when compared to COMLOC. The TG took their current draft and applied it to a new draft, which was based on IS-TESS.

The resultant draft Ex-I10 standard provides a robust message set that satisfies E4 requirements while remaining extensible – it can be easily modified to support future as new systems or capabilities are fielded.

C6.0 EX-I10 WORKFLOW

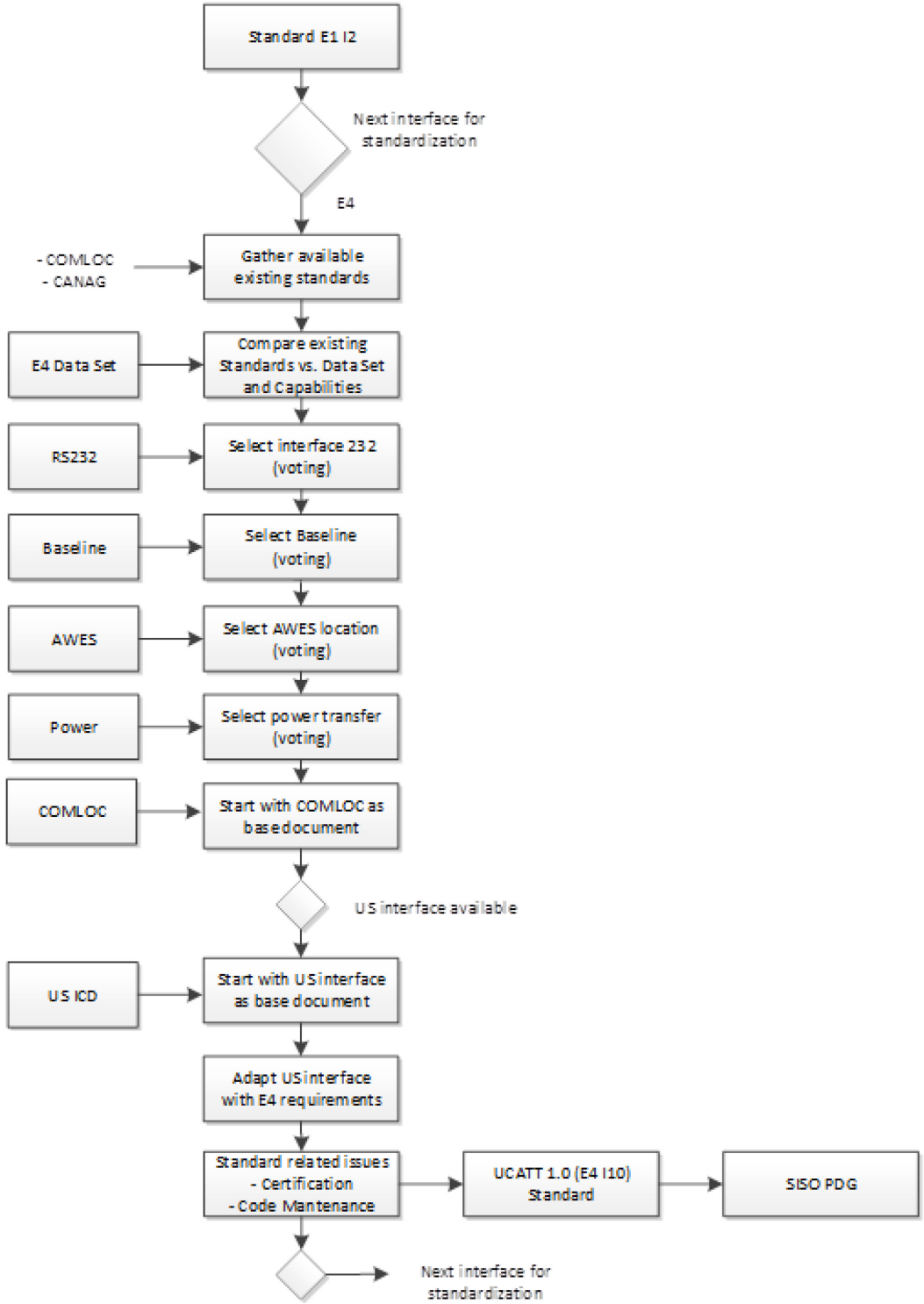


Figure C-10: Final Flow of Work TG E4.

C7.0 REFERENCES

The following documents were referenced during UCATT LSS-4 E4-I10 Task Group work:

[1] SISO-STD-0XX-00-DRAFT Standard for UCATT E4_I10_V0.doc
This document is the E4-I10 standard into which the US ICD protocol and messages have been added.

[2] Consolidated Message List (US, COMLOC, MSG-98) Orlando 171121.xls
This file contains a cross-reference of US / COMLOS and MSG-098 messages.

[3] InService_PowerTransfer.xls
This file is a template for industry to complete on their IS-TESS power transfer.

[4] UCATT I10 communication parameters.xls
This file is a summary of the protocol (PHY,MAC) detail between US ICD, COMLOC and SAAB ICD.

[5] UCATT E4-I10 Physical Media Trade Study (160923; 00.C).

[6] 230916_Cross_Correlation.

[7] Ex-I10-Message-Matrix – 2017-09-08-V0.3.

[8] E4-I10 Installed Base (160923).

[9] French Infantry Soldier TESS-IS ICDs (unmodified):
(STI kit – STC Fantassin Centaurisé) 46 863 901-558 C, signé.pdf, SPECIFICATION TECHNIQUE D'INTERFACE (STI) POUR UN STC FANTASSIN CENTAURISÉ AVEC LE KIT COMLOC DU SYSTEME CENTAURE G2.

[10] French Vehicle TESS-IS ICDs (unmodified):
(STI kit – STC Véhicule Centaurisé) 46 863 902-558 A, signé.pdf, SPECIFICATION TECHNIQUE D'INTERFACE (STI) POUR UN STC VÉHICULE CENTAURISE AVEC LE KIT COMLOC DU SYSTEME CENTAURE G2.

[11] German TESS-IS ICDs (unmodified):
GUEZSB60_ICD-0011G_2015-02-26 mit UBl.pdf

[12] German TESS-IS ICDs (unmodified):
GUEZSB60_ICD-0052H_2013-10-31 mit UBl ESW.pdf

[13] PRF-PT-00552REV_G_IS_TESS_IF_Std.pdf
This document is the US LT2 TESS-IS ICD.

[14] PRF-PT-00617REV_C_LT2_Interop_Enumerations.pdf.
This document contains supporting enumerations to the US ICD. It is Public Distribution.

[15] PRF-PT-00617REV_A_LT2_Interop_Enumerations.doc
This document contains supporting enumerations to the US ICD. It is UCATT only Distribution.

[16] PRF-PT-00617REV_A_LT2_Interop_Enumerations (UCATT Updates PGH 171123).doc

Annex D – FEDERATION OBJECT MODEL FOR THE E8 INTERFACE

D1.0 OVERVIEW

D1.1 The UCATT Functional Architecture

The UCATT Standard for Live Simulation System Interoperability [1] provides a functional architecture capturing what a Live Simulation System can or might do (but not how it does or should do it). The UCATT Functional Architecture – illustrated in Figure D-1 – defines the system boundaries and interfaces. It describes and identifies all functions and interfaces that can be found in a Live Simulation System. It does not definitively identify the interfaces that needed to be standardised to establish interoperability. In order to do that, a difference was made between internal and external interfaces. Internal interfaces handle data communication that only takes place in the system itself or a designated sub-system, whereas external interfaces communicate to either outside the system or to a system component that can be replaced by a non-proprietary counterpart. The internal interfaces where considered proprietary and out of scope for standardisation, since they were not mandatory for achieving interoperability.

By identifying the external interfaces, it is made explicit what interfaces need to be standardised to achieve interoperability. The external interfaces where subsequently give the designation “E”, followed by an identifying number. From there on, these “E’s” formed the basis of all the work done by UCATT.

One of these “E’s” is E8 – the interface to External Systems.

Regarding the physical layer of interfaces, the functional interfaces (Es) are implemented by physical interfaces (I’s). The main aim of the UCATT group is to define and standardise a set of physical interfaces to allow interoperability between systems in the live simulation domain, with possible connections to the virtual and constructive domain.

A physical interface may be found in several functional interfaces. For example, the laser interface (I2) is used for direct engagement simulation (E1), DO technical or operational status control by the Observer/Controller using an umpire gun (E1, E2 and E3) and for indoor positioning (E3).

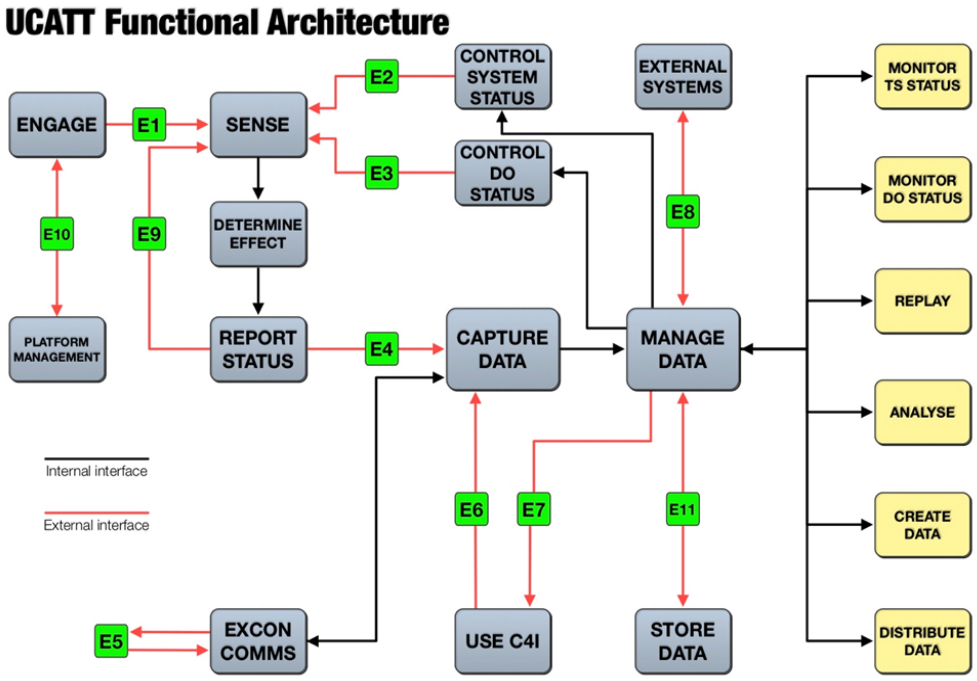


Figure D-1: UCATT Functional Architecture.

D1.2 The E8 Interface

The E8 interface enables the exchange of data between systems, which can influence the course of the training session and generally has a dynamic, time critical character. Examples of such event data exchange are (updates of) status of DOs and the creation of a minefield in System A, which is communicated to System B.

From another point of view E8 enables data exchange between different EXCONs of (different) Live Simulation Systems (L2L use case) and between EXCONs and virtual and/or constructive simulation environments (LVC use case).

With this interface it is possible that all involved systems can display all relevant information in a synchronised way, resulting in a complete and up-to-date operational picture of the exercise. In addition, this interface can contain functionality to control DOs of another training system through their own EXCON. E8 can be defined to include the E2, E3 and E4 functionality. Having E1 and E8 implemented in this way, it is possible to use DOs from different training systems in the same exercise, however requiring all related EXCONs to be present and interconnected.

Examples for the usage of E8 are:

- L2L
  - Connection of NLD Mobile Combat Training Centre to DEU CTC GefÜbZH Altmark.
- LVC
  - Synthetic wrap used to enhance the ‘deep battle’ with constructive entities.
  - Integration of synthetic UAV and ISTAR.
  - Integration of virtual aircraft simulators.

D1.3 The Physical Interface I8

I8 is the physical interface used to communicate between two EXCONs. In most cases, Ethernet is used for this interface with an application protocol like DIS or HLA. I8 represents the physical layer (layer 1) of the OSI model.

D2.0 DSEEP AS THE GUIDE FOR DEVELOPING E8

To have a theoretical basis for the development of E8 it was determined that the DSEEP standard [2] is used as the guideline. Because the E8 standardisation is no development of a federation of a concrete exercise, only parts of the DSEEP steps are relevant.

D2.1 DSEEP Overview

As distributed simulations become more complex, and tend to be systems in their own right, a structured system engineering approach is needed to develop them. Although traditional software development processes may be applied to the development of distributed simulation environments, these processes lack simulation specific steps and activities that are important for distributed simulation environments. For example, the development of a simulation conceptual model and simulation scenario, and the development of a simulation data exchange model with associated operating agreements between member applications. The only recognised industry standard process for distributed simulation environment development is the IEEE standard of the so-called Distributed Simulation Engineering and Execution Process (DSEEP). This process is independent of particular simulation environment architectures (e.g., HLA) and provides a consistent approach for objectives definition, conceptual analysis, design and development, integration and test, simulation execution, and finally data analysis.

The DSEEP was originally developed under the umbrella of the Simulation Interoperability Standards Organization (SISO) by a large community of (distributed) simulation practitioners and became an IEEE standard in 2010. A top-level illustration of this process is provided in Figure D-2. The DSEEP identifies a sequence of seven basic steps with activities to design, develop, integrate, and test a distributed simulation environment of disparate simulation models (Table D-1). Each activity in the DSEEP is further broken down in tasks and work products. The guidance provided by the DSEEP is generally applicable to standalone simulations as well.

Figure D-2 presents an easy overview of the steps and activities of the DSEEP. One can see that the development of a FOM is the activity “Development Simulation Data Exchange Model” of step 4 “Development Simulation Environment”. Before this goal is available the previous steps and activities have to be regarded.

Step 1 – Define Simulation Environment Objectives

The core objective of an E8 based simulation environment is enabling the interoperability between:

- EXCONs of different Live Simulation Systems; and
- EXCON(s) of Live Simulation Systems and virtual and constructive simulators/simulation systems.

The user’s needs in detail and several examples for usage are described in the UCATT-3 report [3].

Step 2 – Perform Conceptual Analysis

Regarding E8 the activities related to step 2 are the definition of the scope of E8, the identification of interface exchange requirements and the development of use cases.

A list of typical live exercises could have been a very useful input for this work, but such information was not available.

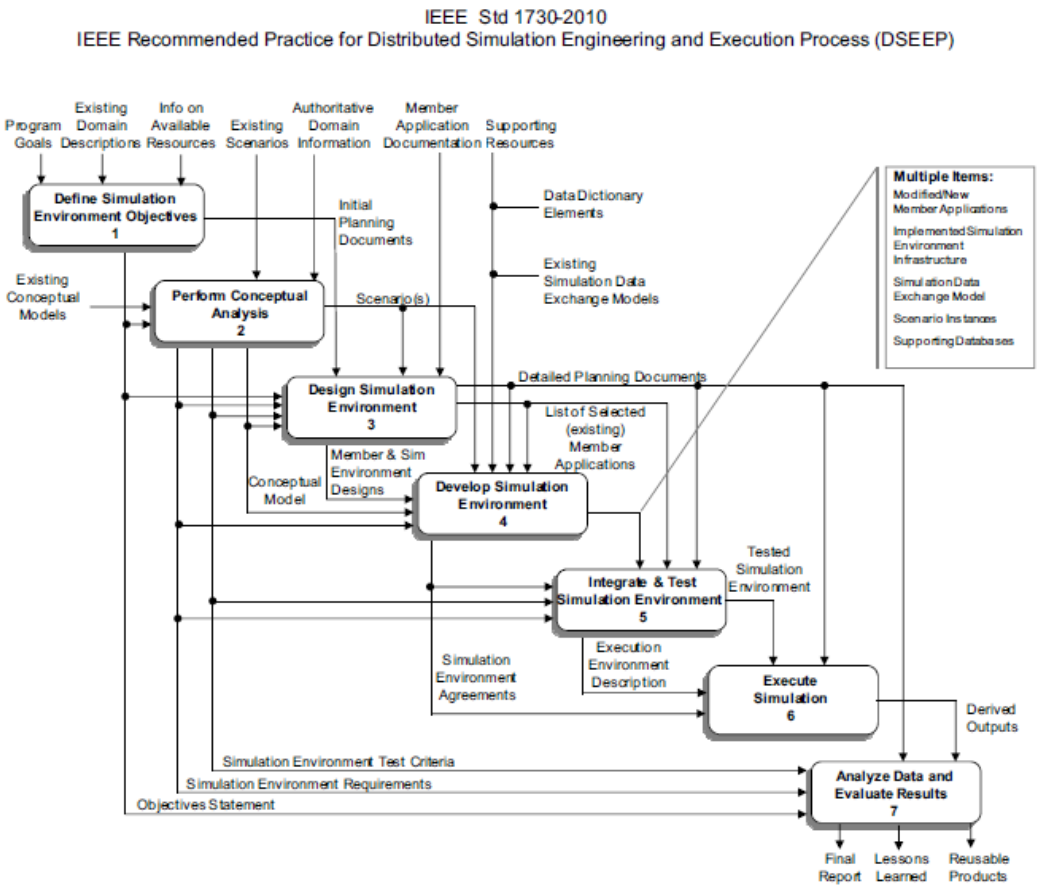


Figure D-2: The DSEEP Model Diagram.

Table D-1: Steps and Activities of the DSEEP.

Step	(1) Define simulation environ-ment objectives	(2) Perform conceptual analysis	(3) Design simulation environment	(4) Develop simulation environment	(5) Integrate and test simulation environment	(6) Execute simulation	(7) Analyze data and evaluate results
Activities	Identify user/ sponsor needs Develop objectives Conduct initial planning	Develop scenario Develop conceptual model Develop simulation environment requirements	Select member applications Design simulation environment Prepare detailed plan	Develop simulation data exchange model Establish simulation environment agreements Implement member application designs Implement simulation environment infrastructure	Plan execution Integrate simulation environment Test simulation environment	Execute simulation Prepare simulation environment outputs	Analyze data Evaluate and feedback results

Step 3 – Design Simulation Environment

A larger overview of potential member applications and a collection of the use of HLA [4], [5], [6] in NATO Live Simulation was not available.

A design of a common (standardised) simulation environment is not part of the E8 activities, because:

- Complete definition/specification of EXCON functionalities is not part of UCATT.
- Functionalities and capabilities of Live Simulation EXCONs are not unique.
- Types, functionalities, capabilities are arbitrary regarding all potential live, virtual and constructive candidates.
- Development of a common LVC architecture is not part of E8. Where functionalities in a common LVC environment are occurring is not significant for E8.

While a design of a common simulation environment is not part of the E8 activities, it has been recognised that some enumerations and Dynamic Object attributes must be defined for the E8 interface as part of the design of the simulation environment, specifically for DO observation purposes. These include DO attributes such as armour, CBRN protection equipment, and medical treatment equipment which, while not included in the E8 Use Cases, will be required to ensure consistency across EXCONs.

All Dynamic Objects are owned by their parent system because a dynamic object is represented in the system by its live simulation equipment. A transfer of ownership of Dynamic Objects between EXCONs is not practical and is not supported.

Step 4 – Develop Simulation Environment

This step includes the main task: the development of the U-FOM.

Simulation environment agreements are delivered by policies which were formulated for the use cases.

Step 5 – Integrate and Test Simulation Environment

Not relevant for E8.

Step 6 – Execute Simulation

Not relevant for E8.

Step 7 – Analyse Data and Evaluate Results

Not relevant for E8.

D3.0 DEFINE THE SCOPE OF E8

D3.1 E8 – EXCON to EXCON – Overview

The physical connection between EXCONs is not important to specify, as anything that supports TCP/IP is suitable. The location of the EXCONs could be so varied that specifying a physical connection is not appropriate and adapters for the various connections are COTS and cheap. The important area to focus on is the various protocols, encodings, etc.
The diagram in Figure D-3 shows that the physical connection depends on the location of the EXCONs.

If co-located, they can use a dedicated link. If they are far apart, they might need to connect via a commercial Internet line, which cannot be specified as it is outside of the control of the training facility.

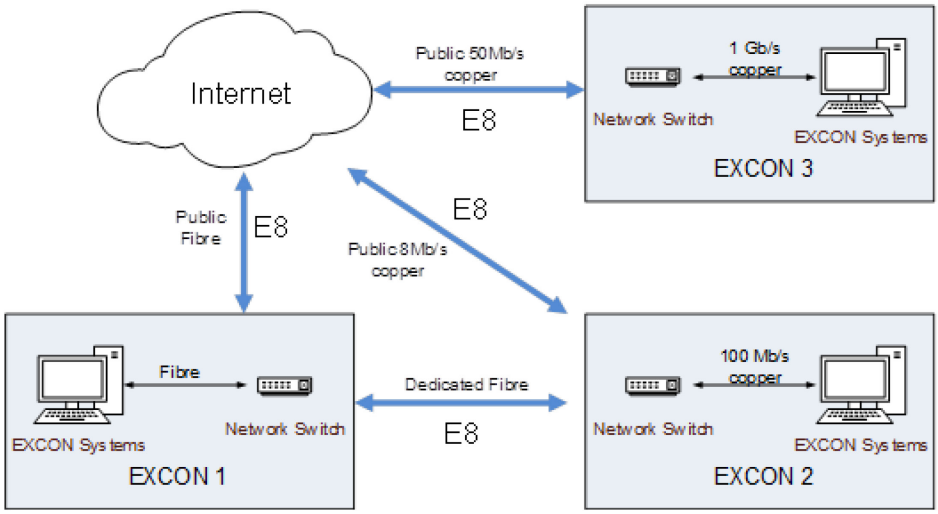


Figure D-3: Physical Connections of EXCONs.

According to section 3.3.1 of the UCATT-2 RTO Task Group 063 report [7] the E8 interface is used for exchange of player status and player commands. But video, audio and reports also need to be considered. The High Level Architecture (HLA) is the approved NATO standard (STANAG 4603) and therefore UCATT should strive to use this. The report states that the HLA RPR FOM [8], [9], whilst being the most appropriate FOM, does not meet all of the needs of live training. A UCATT HLA FOM, probably based on RPR-FOM, could be created to support the live training needs. Video, audio and files all have existing, well-supported standards for transfer (H.264, MP3, FTP, etc) and should be used instead of incorporating them into HLA.

Figure D-4 introduces the use of a UCATT specific HLA FOM that caters to all live needs. Systems could use middleware (as is currently the case) to convert to/from the UCATT-FOM. Over time systems could transition to use the UCATT-FOM natively, thus removing the need for middleware.

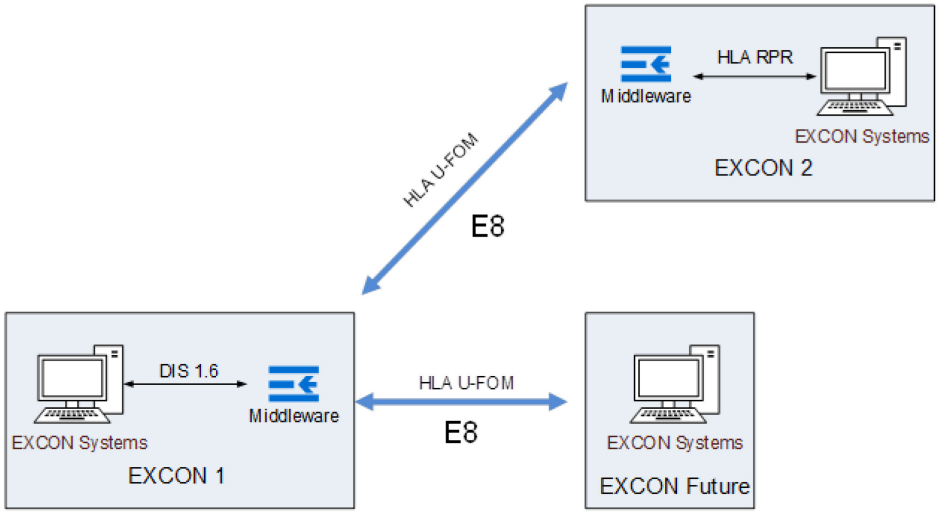


Figure D-4: Illustration of the Use of the U-FOM.

D3.2 EXCON to EXCON Coupling – Data Networks

Figure D-5, Figure D-6, and Figure D-7 give a high level view on the data networks regarding the following cases:

- EXCON to EXCON coupling.
- EXCON to EXCON coupling with consideration of connecting virtual and constructive simulation systems.
- EXCON to EXCON coupling with consideration of different levels of security.

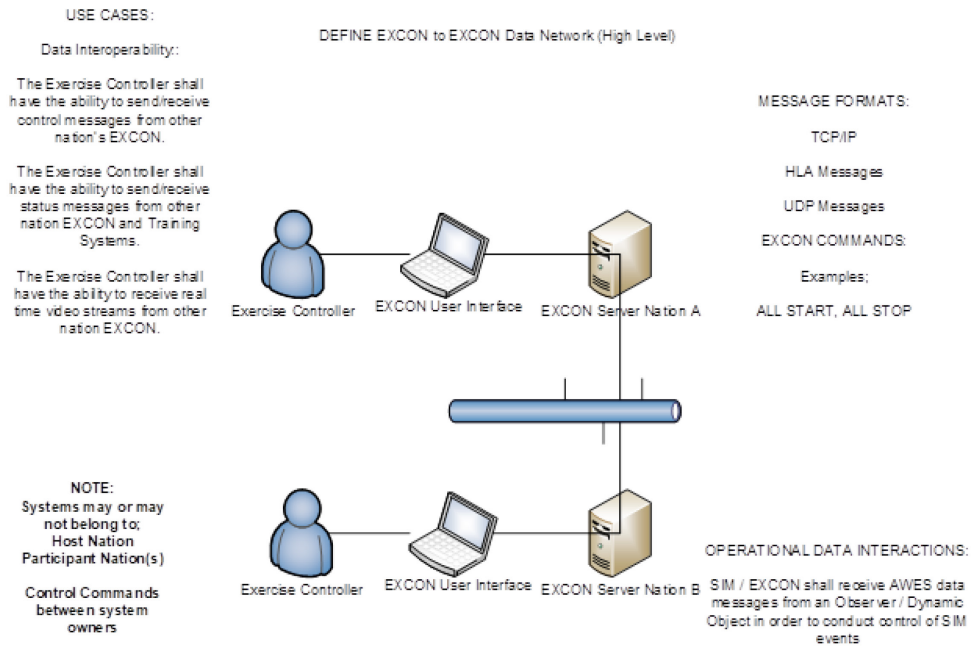


Figure D-5: EXCON to EXCON Data Network (High Level View).

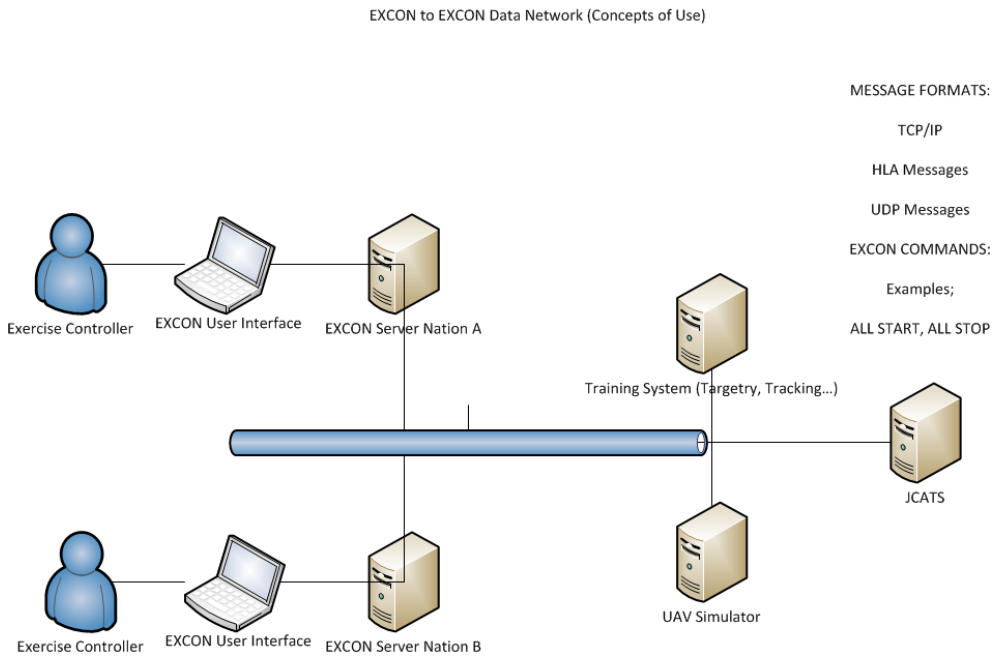


Figure D-6: XCON to EXCON Data Network (Concept of Use).

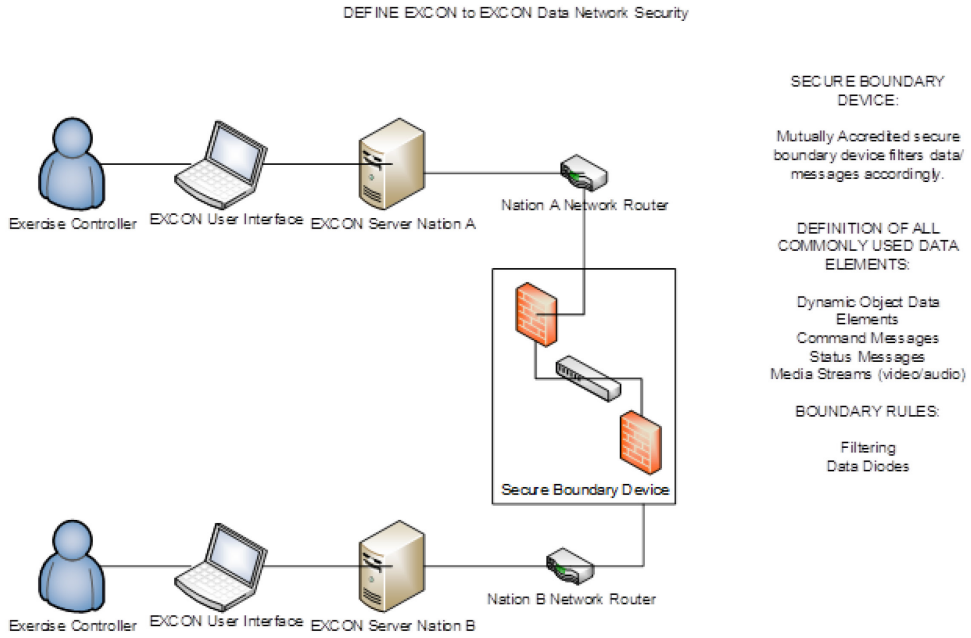


Figure D-7: EXCON to EXCON Data Network (Concept of Use Including Levels of Security).

D3.3 EXCON to EXCON – Video/Audio Exchange

This paragraph refers to streamed videos. Recorded video files can be treated as files and transferred via email, post, USB, CD, FTP, etc. which is part of E11 and not E8. Real-time video and audio streaming protocols may be part of E5. There are a variety of streaming protocols such as RTSP, RTMP and a variety of codecs such as H.264, MPG1, MPG2, and MPG4. It is possible to embed metadata in videos, so the chosen codec must support this. In particular STANAG 4609, which provides video footprint coordinates (e.g., the area of ground that the UAV camera is looking at). A mechanism is also required to advertise the video streams that are available so that the other EXCONs know that they are there.

D3.4 Basic Activities for Exercise Setup

Figure D-8 shows the basic activities for an exercise setup considering the L2L case and the LVC case.

Examples:

LVC

1) Live Tactical Engagement Simulator + VBS3;
2) Dynamic Object to VBS3 (all live players);
3) UAV Entity State, All Live Player Dynamic Object states;
4) No interactions allowed;
5) HLA 1.3;
6) Unrestricted (no boundary devices needed);
7) TCP/IP v6.

L2L

1) Live Tactical Engagement Simulator Nation A to Nation B;
2) Dynamic Objects (all live players);
3) All Live Player Dynamic Object states;
4) Engagement / AWES interactions (Kill/Wound) – no remote control commands;
5) HLA Evolved;
6) Unrestricted / SECRET (Simulation Network Type X);
7) TCP/IP v6 and UDP over Radio VPN.

Following the relevant aspects for each item of the list:

1) Define system:
   - Define all participating systems for a specific training environment;
   - Examples for systems:
     - Host Nation Exercise Control Centres;
     - Host Nation Instrumented Training Village;
     - Virtual Simulators (e.g., UAV Simulator);
     - Constructive Simulation/Wargame (e.g., JCATS);
     - Tactical Engagement Simulation Network;
     - Tactical Data Link (e.g., Link 16).

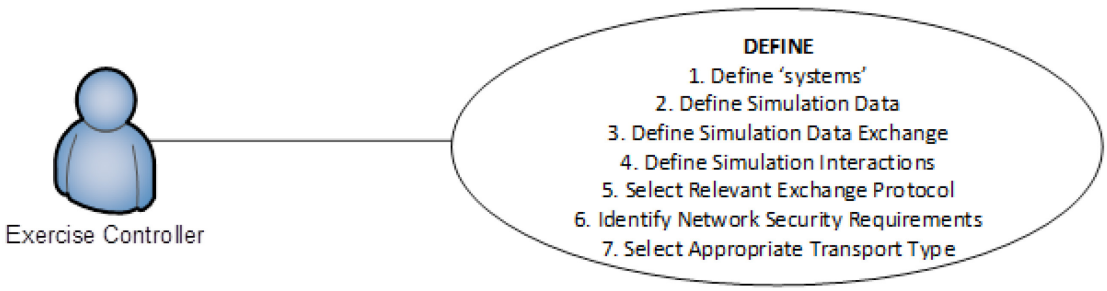


Figure D-8: Basic Activities for Exercise Setup.

2) Define Simulation Data:
   - Define all virtual, constructive and live objects and events;
   - Definition of environmental data (weather, terrain);
   - Audio and video data.

3) Define Simulation Data Exchange:
   - Define DOs attributes and event attributes;
   - DO Identifier between systems;
   - SISO-REF-010-2015 (Enumeration for Simulation Interoperability) [10].

4) Define Simulation Interactions:
   - Definition of interactions required to satisfy training objectives;
   - Types of implementation (automated/manual procedures);
   - Types of interactions.

5) Select relevant exchange protocols:
   - Candidates for the session layer for simulation data network:
     - HLA;
     - DIS;
     - TENA;
     - DDS;
     - JSON;
     - SIMPLE;
     - SOAP;
     - REST.
   - Select appropriate video and audio codecs:
     - ITU-T, H.264, MPEG-1,-2, SMTPE, MP3, WAV, OGG ;
     - Identify useful meta data.

6) Identify Network Security Requirements:
   - Define relevant network security requirements for each participating country and organization;
   - Identify mutually approved secure boundary devices;
   - Select appropriate encryption method;
   - Define information filtering between network domains (and data flow directions).

7) Select Appropriate Transport Type:
   - Define wired and wireless transport, layer protocols:
     - TCP/IP v4 and v6;
     - IEEE 802.11 a/b/e/g/n;
     - RTSP;
     - Zigbee;
     - UDP broadcast;
     - UDP multicast.

D3.5 E8 – Conclusions

The following conclusions may be drawn from the aspects considered above:

- The interface E8 is driven by the data to be exchanged. Focus on data definition as the core interoperability enabler.

- Definition of all DO data elements required – at least E8 DO tables. Common unique understanding of simulation data definitions and the use of that data.
- The E8 interface is used for the exchange of DO status and DO commands.
- Exchange of reports (data files) or data bases for evaluation (dump of exercise data) are not necessary, because all relevant data will be provided via E8. Each EXCON could produce their own reports, etc.
- Regarding the analysis of Section D3.3 the exchange of (live) video and audio streams is not part of an E8 interface for exchange of DO data and require an additional E8 interface specification. Because the protocol standards appropriated for DO data exchange providing only limited or no capabilities for video and audio stream exchange.
- The exchange of recorded video/audio data are not part of E8 (may be part of E11).
- Real-time video and audio streaming protocols are not part of E8 (may be part of E5).

D4.0 CANDIDATES FOR DATA EXCHANGE PROTOCOL

D4.1 Assumptions

For the investigation of candidates for the data exchange protocol following assumption are determined:

- E8 occurs over a mutually approved secure network depending on exercise agreements;
- E8 occurs over Ethernet.

D4.2 Candidates

This section provides the main characteristics of each candidate.

D4.2.1 HLA

Regarding the High Level Architecture (HLA) [4], [5], [6] the following aspects are significant:

- HLA is a NATO Standard (STANAG 4603);
- HLA is a living IEEE standard developed and supported by the SISO;
- HLA defines “only” data exchange protocol and a format for data exchange models (OMT);
- HLA interface depends on a use-specific FOM;
- The RPR-FOM [8], [9] is a well-established FOM used in many federations;
- Different HLA versions are existing and still in use;
- Federates have to use the same RTI (vendor and version);
- Scalability;
- Federation of Federations (e.g., status) can be built;
- The WSDL provides a web services access to HLA;
- Update rate is too low for fast moving entities (e.g., aircraft);
- Widely used / established in many versions;
- HLA gateways exist for several architectures;
- HLA support multicast and WAN.

D4.2.2 DIS

The following items are relevant regarding the DIS standard [11]:

- DIS requires no middleware. It is easy to use (integrate, start up, debug, …);
- DIS defines a fixed data exchange model, but extension can be added;
- DIS supports multicast and WAN;
- DIS is widely used and established;
- DIS is like HLA a living IEEE standard developed and supported by the SISO;
- DIS is still required by customers;
- DIS is used commonly in real-time/virtual simulators;
- DIS could be replaced by DDS;
- DIS is the transport protocol for SIMPLE [12].

D4.2.3 TENA

Aspects of TENA [13] are:

- TENA is a middleware based architecture for US coalition members;
- High capacity event management system for large-scale distributed LVC environments;
- TENA provides object models for all systems and infrastructure (satellites, range, …);
- Extensive to support a broader range of use cases than UCATT (experimentation, weapon testing, Air-Land-Sea Exercises);
- TENA provides a CORBA based IDL for compiling interfaces;
- HLA-/DIS-Gateway Configuration Tool available;
- TENA would be an overkill for TESS exercises but would be a significant enabler for LVC integration.

D4.2.4 DDS

Data Distribution Service [14] aspects are:

- DDS is an industry standard by the Object Management Group OMG (freely available sources/IDL).
- It can be quickly adopted for real-time Publish-and-Subscribe-Systems including tactical networks, combat systems, platform management, fire and control (replaces MIL-STD-1553 based legacy systems).
- DDS is largely used for mission systems and it is coming up to include Training and Simulation.
- HLA/DIS Gateways to DDS would enable easily coupling.
- DDS is ideal for small networks (replaces DIS).
- DDS is easy to instantiate with legacy applications (user's wrappers).
- DDS is IDL based.
- A DDS environment requires an agreed data model (similar to a FOM for an HLA federation):

- UCATT could prepare a data model for E8;
- Recommend a middleware or an agreed middleware per exercise.

- NGVA uses DDS:
  - Primarily focused on Land Vehicles, Land Simulators.

D4.2.5 SIMPLE

Aspects of SIMPLE [15], [16] are:

- SIMPLE is widely used for communication of tactical data link data.
- DIS is the transport protocol for SIMPLE.
- Supports DIS PDUs.
- SIMPLE is a NATO standard: widely implemented STANAG 5602.
- Well appropriated for real-time fast moving entities.
- Typical broadcasts in tactical radio networks (Link 16).
- SIMPLE extends across multi-bearer networks.
- SIMPLE supports broadcast, multicast, TCP, serial.
- SIMPLE enables only NATO nations to integrate:
  - SISO-J exists for use by non-NATO nations;
  - SIMPLE to SISO-J translators exist.
- Regarding E8 SIMPLE is interesting for:
  - Integration of live aircraft;
  - Integration of virtual flight simulators (high fidelity simulators);
  - Connection to Air-Battle-Management Systems and Simulators;
  - Connection to ground-based air defence systems;
  - Integration of naval indirect fire support.

D4.2.6 Web Services

Regarding Web Services and E8 there is actually nothing specific. But in general Web Service solutions can be extended if required. In the future, Web Service could be significant regarding the relations to the C2SIM domain.

D4.3 Prioritization

The decision was made that the first protocol for standardisation of E8 shall be realised with HLA:

The HLA Evolved Standard (IEEE-STD-1516-2010, IEEE-STD-1516.1-2010, IEEE-STD-1516.2-2010) was selected as transport layer.

D5.0 CANDIDATES FOR DATA EXCHANGE MODEL

One important result of UCATT-3 was the development of a common data model for UCATT: the DO Data Tables [1]. Within UCATT-LSS the DO Data Tables were supported by the TG Architecture.

E8 requires a protocol specific data exchange model. But that is not only a mapping of the DO Data Tables to a specific format, because the tables do not define an exchange model of a "UCATT-System" to any other system. It defines the inner data model for the functional architecture of UCATT.

From this it follows that first the content of an E8 data exchange model must be identified. Then it can be transferred to any protocol specific format.

Because HLA was prioritised as the data exchange protocol the data exchange model is a FOM, which is called U-FOM (UCATT-FOM). So, the task is developing the U-FOM.

The well-known and widely used RPR-FOM [8], [9] together with the Enumerations for Simulation Interoperability [10] were analysed as basis for the U-FOM development. Additionally, the NETN-FOM [16] was regarded.

The NETN-FOM was developed by MSG-068 (NATO Education and Training Network) and is maintained by MSG-134 (Distributed Simulation Architecture and Design, Compliance Testing and Certification). The main focus is the domain of constructive simulation. It is an extension of the RPR-FOM with specific NETN-FOM Modules but only the RPR-FOM Base Module and the Physical and Aggregate Modules are used. The analysis results in that:

- The extensions are not very appropriate for the live simulation domain and,
- RPR-FOM classes which may be useful for UCATT are not used by the NETN-FOM.

Finally, the decision was:

Develop a U-FOM based on parts of RPR-FOM 2.0 and the SISO Enumerations for Simulation Interoperability as data exchange model.

Regarding the L2VC Use Case and the L2L Use Case the main reasons are:

- L2VC Use Case
  - RPR-FOM and the Enumerations for Simulation Interoperability are well-established in the domains of constructive and virtual simulations.
  - RPR-FOM covers much of the data required to exchange via E8 between a Live Simulation EXCON and constructive and virtual simulators including:
    - Exercise administration (e.g., start/stop);
    - Aggregates – EXCON (Live) and Constructive Simulation.
- L2L Use Case
  - First results of analysing data that will be exchange via E8 show that the RPR-FOM covers parts of them.
  - Extension are required because of:
    - The higher complexity of Live-specific data that have to be exchange via E8;
    - OC and EXCON Engagement/Status Change;
    - DO Area Engagement;
    - MOUT aspects.

D5.1 Representation of DOs in the U-FOM

DOs are a central concept in the UCATT domain. A DO is a live, virtual or constructive element in the training environment that has a presence in the environment and either has a valid status, or 3) can influence the status of other DOs (execute engagements) or possesses both of these characteristics. A DO can be seen, observed or detected in the training environment. For example, a vehicle can be seen by the naked eye, observed in infrared, detected by radar and be tracked by C4I systems. But even a CBRN area can be detected with specific sensors.

Each DO has a status including its position. Both can be changing during an exercise. Generally, a DO can influence the status of other DOs. For example, a soldier can fire an anti-tank weapon at a vehicle a CBRN area can affect unprotected DOs that enter it.

Regarding the U-FOM a DO is represented by an instance of an object class. But – see below – there is a distinction between players, vehicles, devices, etc. with a one-dimensional representation (position is given by one geographical point) and any types of DOs represented by areas. In the following chapters area are called as feature areas in general including engagement areas (providing a direct effect on a DO status like a minefield for example) and influencing areas (which may influence the activity of a DO like an obstacle area).

All Dynamic Objects are owned by their parent system (by their EXCON) because a dynamic object is represented in the system by its live simulation equipment. A transfer of ownership of Dynamic Objects between EXCONs is not practicable and is not supported.

D6.0 E8 USE CASES, SEQUENCES AND CONSTRAINTS

D6.1 E8 Use Cases

"Exercise Controller" is the actor of the following use cases. E8 connects two or more EXCONs together. The information that needs to be exchanged via E8 is EXCON data which is generated or consumed by the EXCON functionalities. These functionalities are controlled by activities of the EXCON operators (EXCON Controllers).

D6.1.1 Exercise Control Activities

The core activities of the EXCON Controllers are Observe, Control, Manage, and Report (Figure D-9).

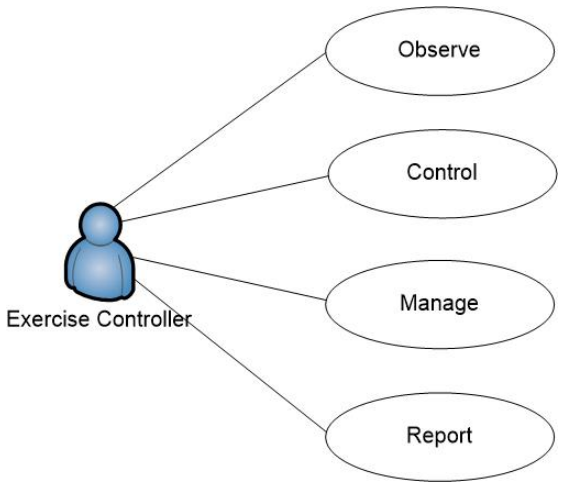


Figure D-9: User Context Diagram – Exercise Controller Activity Overview.

D6.1.2 EXCON Observe Activities

The Observe activities related to E8 include (Figure D-10):

- Monitor the positions, status and engagements of the players controlled by the own EXCON and controlled by other EXCONs;
- Monitor events/interactions;
- Observe the situation on a map.

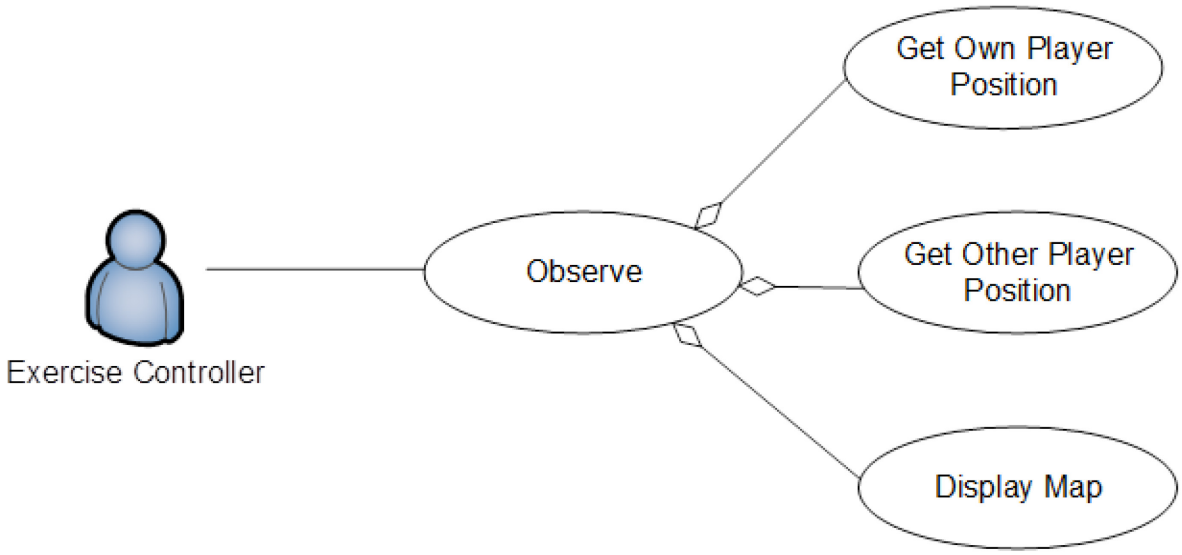


Figure D-10: User Context Diagram – Exercise Controller Observe Activities.

D6.1.3 EXCON Control Activities

"Control" covers several activities of an EXCON Controller related to E8 (Figure D-11):

- Sending and Receiving exercise command requests (start/stop exercise e.g.,) with other EXCONs;
- Publishing Indirect Fire Events of the own EXCON to other EXCONs;
- Create Environmental Features/Feature Areas and publishing them to other EXCONs;
- Change status and association of DOs;
- Change damage and status of buildings;
- Change contamination of DOs; and
- Publishing Weapon Fire of own players to other EXCONs.

Each EXCON is only able to control its own players. If an EXCON would like to change the status of a player (e.g., to combat ready), the EXCON can send a command request to another EXCON. Receive command request would be the answer.

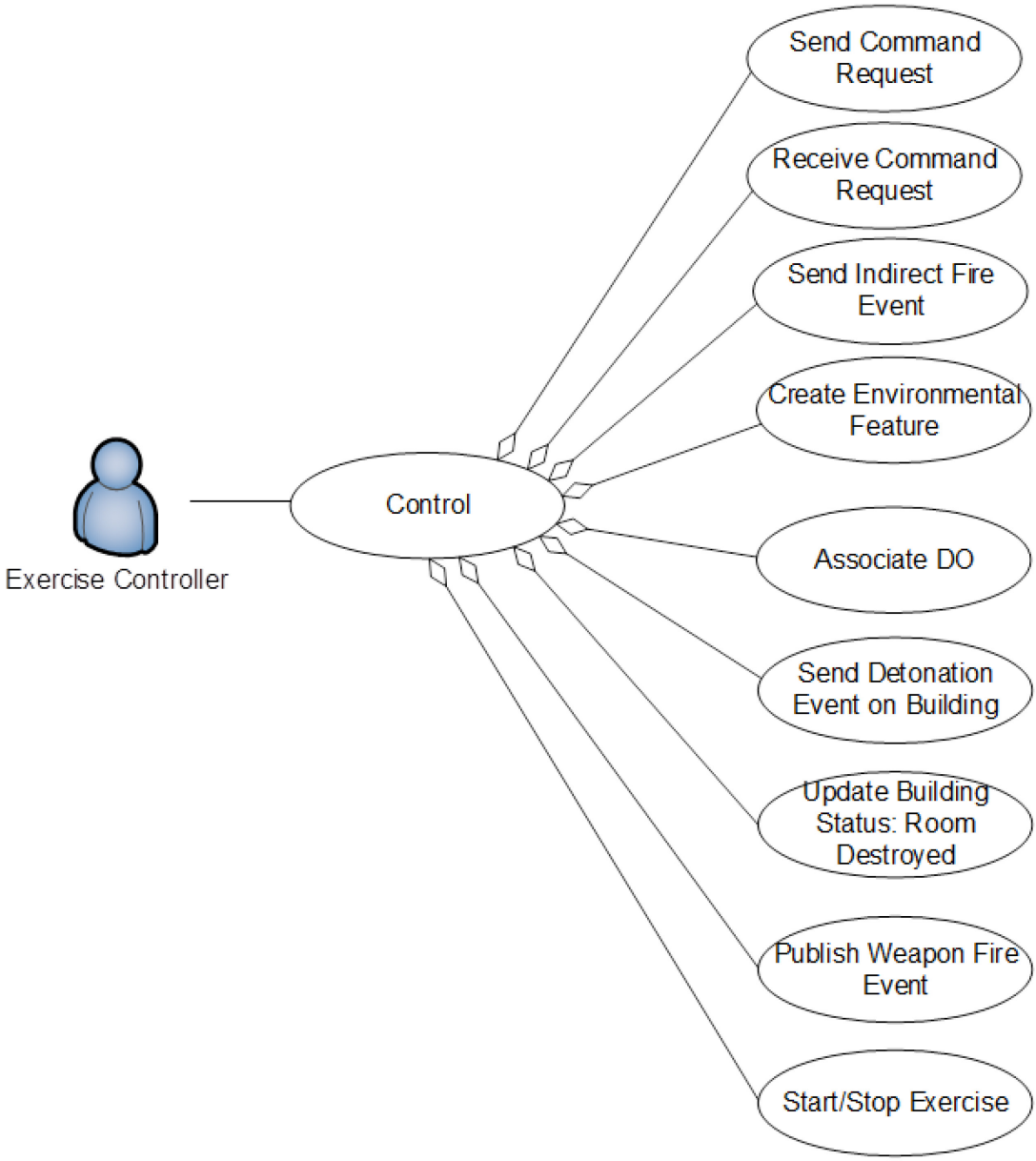


Figure D-11: User Context Diagram – Exercise Controller Control Activities.

D6.1.4 EXCON Manage Activities

"Manage" covers also several activities of an EXCON Controller related to E8 (Figure D-12):

- Changing the ORBAT in coordination with other EXCONs;
- Handling of area weapon effects and other areal objects (here, only some representatives are presented).

D6.1.5 EXCON Report Activities

This activity regards the aspect of reporting data (Figure D-13).

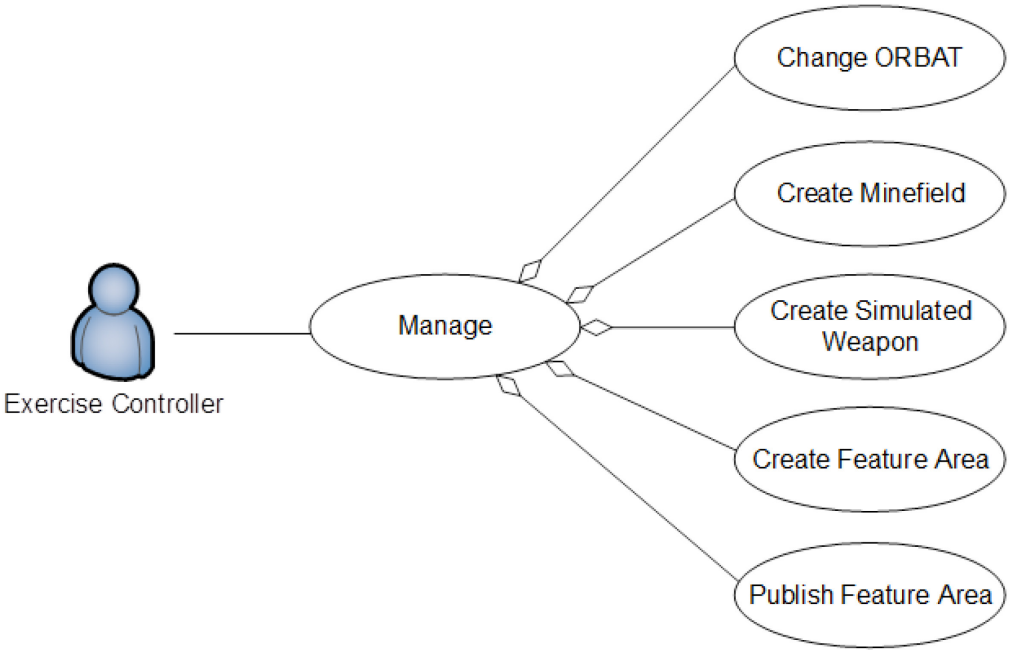


Figure D-12: User Context Diagram – Exercise Controller Manage Activities.

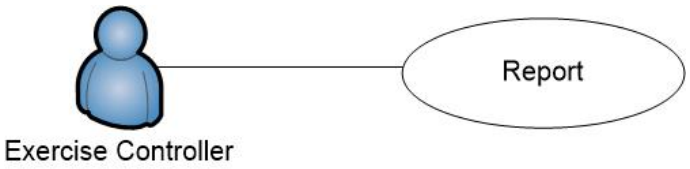


Figure D-13: User Context Diagram – Exercise Controller Report Activities.

D6.2 E8 Sequences and Policies

To define a data exchange model for E8 it is necessary to identify the information that would be published and subscribed via E8. The chosen method was to develop representative sequence diagrams for the use cases.

The messages which are "E8 messages" are coloured red and blue:

- Red means: the data of this messages is covered by the RPR-FOM 2.0;
- Blue means: the data of this message requires an extension to the RPR-FOM 2.0.

As constraints pre-conditions and policies were expressed if necessary.

A classification was made in "Host EXCON" and "Guest EXCON". The Host EXCON provides the training area. It is assumed that only the Host EXCON has sufficient knowledge of buildings on the training area (floor plans, instrumentation, and damage models) and because of that indoor tracking is performed by the Host EXCON.

A further classification is that an EXCON provides only functionalities for exercises in basic terrain (without instrumented buildings) meanwhile another EXCON includes functionalities for exercises in MOUT areas.

D6.2.1 Use Case 1: Publish DO Status

A DO Player reports a status change to its EXCON. This EXCON publishes the status change via E8 (Figure D-14). There is no difference if the Host EXCON or a Guest EXCON is publishing.

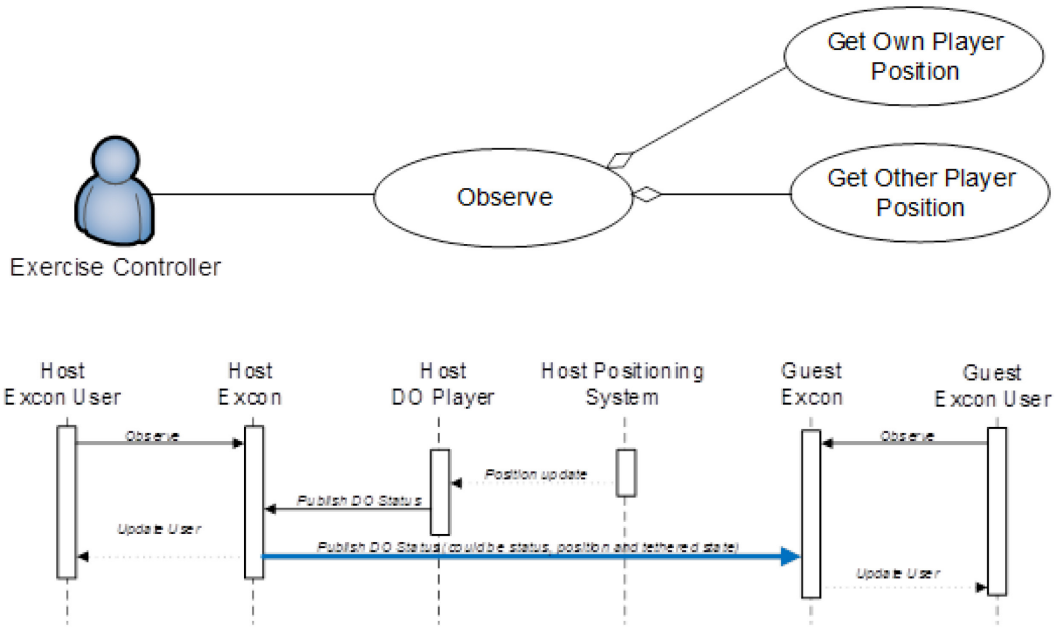


Figure D-14: Sequence Diagram – UC1: Publish DO Status.

Pre-conditions:

- All DOs start in a known active state.

Policy:

- DO status will be published on change.
- The status refers to the tactical status and not the technical status (e.g., GPS kit failure).

D6.2.2 Use Case 2: Send Command

One EXCON publishes a command request to change the status of a DO controlled by another EXCON (Figure D-15). There is no difference if the Host EXCON or a Guest EXCON is publishing.

Pre-Condition:

- The EXCON supports requests for DO status change.

Policy:

- An EXCON cannot change the status of players owned by another EXCON, instead it must request it to be changed.
- An EXCON would only make a request of another EXCON, it can control its own players.

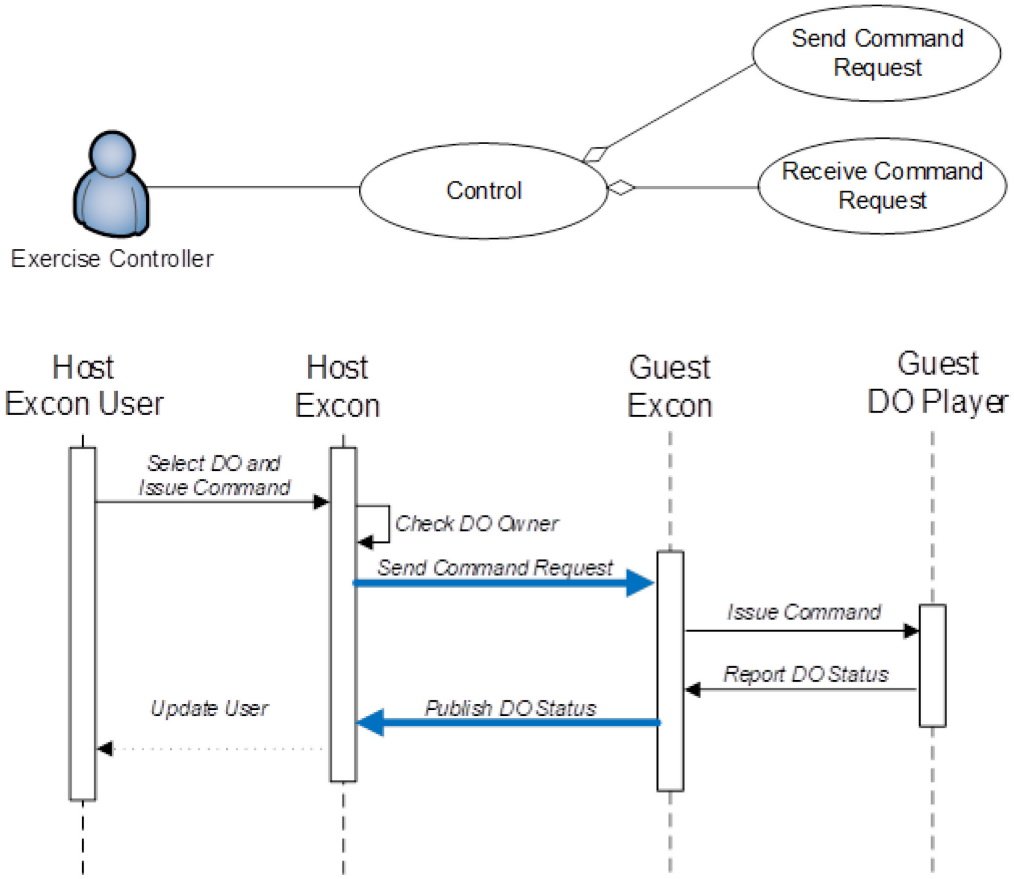


Figure D-15: Sequence Diagram – UC2: Send Command.

D6.2.3 Use Case 3A: Issue Weapon Effect Area (Centralised)

In this case a Guest EXCON publishes a weapon effect area (indirect fire, for example) (Figure D-16). The exercise includes buildings which details or only known by the Host EXCON. Both EXCON have a centralised area weapon effect model.

In the case without buildings, there is no difference if the Host EXCON or a Guest EXCON is publishing the weapon effect area.

Policy:

- The Player Unit will revert to Centralised control by the Host when it enters a MOUT building.
- The Guest EXCON may determine its own effects on Guest DO's or wait for a Host EXCON request.
- The Host EXCON will need to notify any effected DO's in the building of the event (sound effect).

D6.2.4 Use Case 3B: Issue Weapon Effect Area (Decentralised)

In this case a Guest EXCON publishes a weapon effect area (indirect fire, for example) (Figure D-17). Guest EXCON and Host EXCON have both a decentralised area weapon effect model.

There is no difference if the Host EXCON or a Guest EXCON is publishing the weapon effect area.

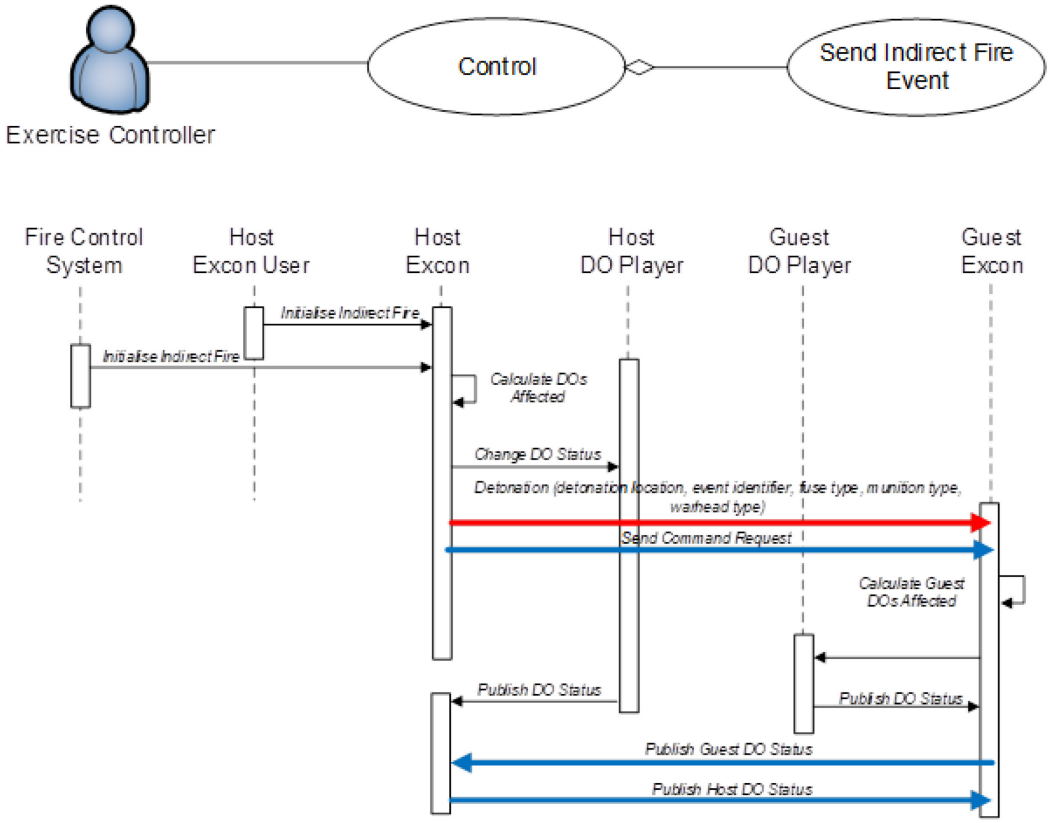


Figure D-16: Sequence Diagram – UC3A: Issue Weapon Effect Area (Centralised).

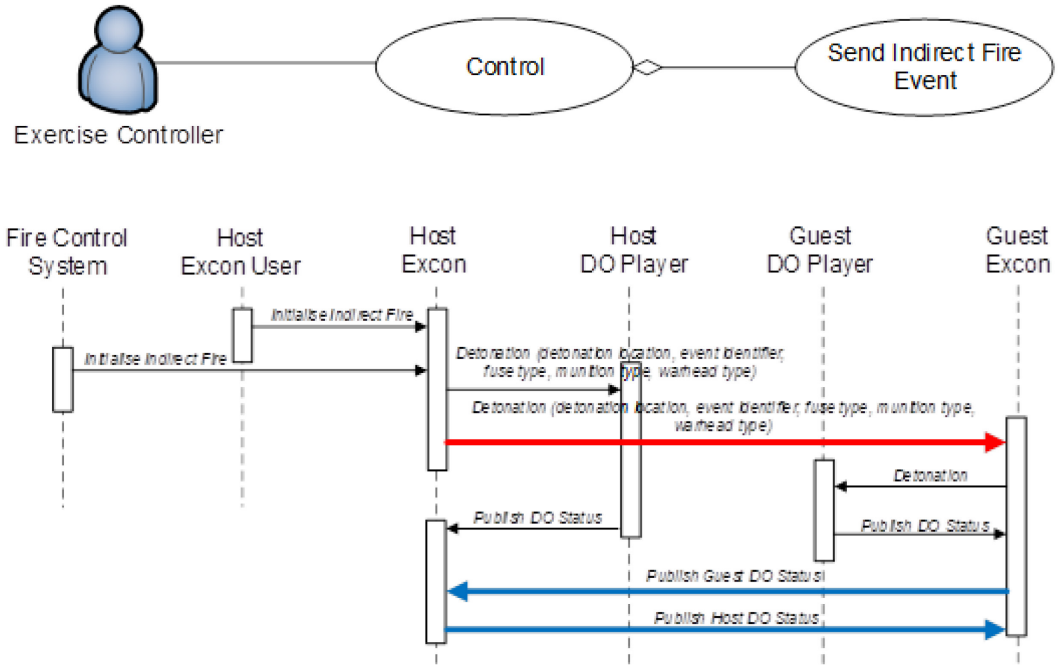


Figure D-17: Sequence Diagram – UC3B: Issue Weapon Effect Area (Decentralised).

D6.2.5 Use Case 4A: Create Environment Feature (Centralised)

The Host EXCON publishes a minefield in the case that Guest EXCON and Host EXCON have both a centralised model (Figure D-18). There is no difference if the Host EXCON or a Guest EXCON is publishing the minefield.

Explanation:

Regarding the RPR-FOM an empty minefield object is created with a location and the types of mine it contains, but there are no mines in it. Each individual mine is added later using a separate object class for each mine.

Policy:

- The EXCON that creates the minefield is responsible for the centralised assessment of all (guest and host) players. The minefield information is shared with other EXCONs only for observation purposes.

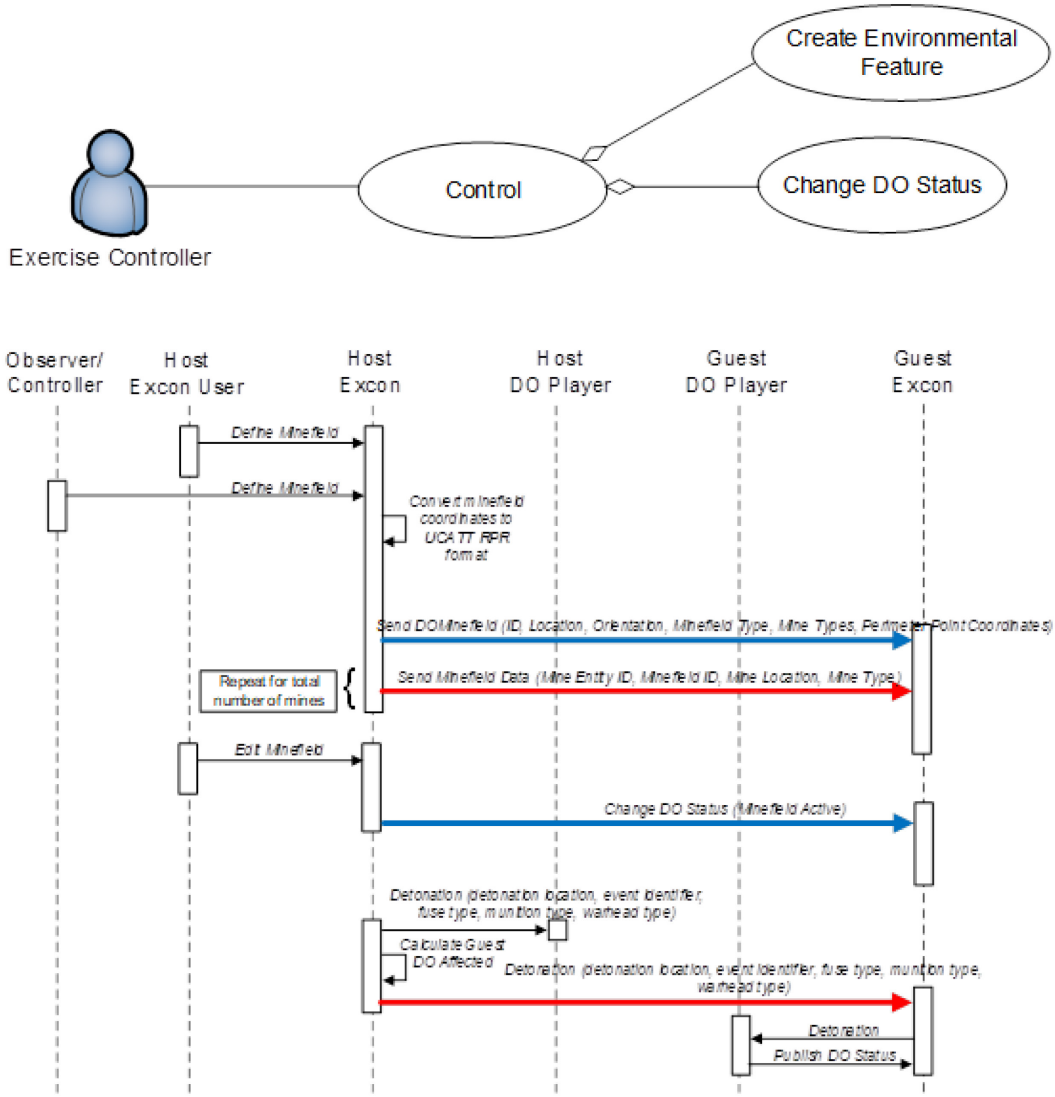


Figure D-18: Sequence Diagram – UC4A: Create Environment Feature (Centralised).

D6.2.6 Use Case 4B: Create Environment Feature (Decentralised)

The Host EXCON publishes a minefield in the case that Guest EXCON and Host EXCON have both a decentralised model (Figure D-19). There is no difference if the Host EXCON or a Guest EXCON is publishing the minefield.

Explanation:

Regarding the RPR-FOM an empty minefield object is created with a location and the types of mine it contains, but there are no mines in it. Each individual mine is added later using a separate object class for each mine.

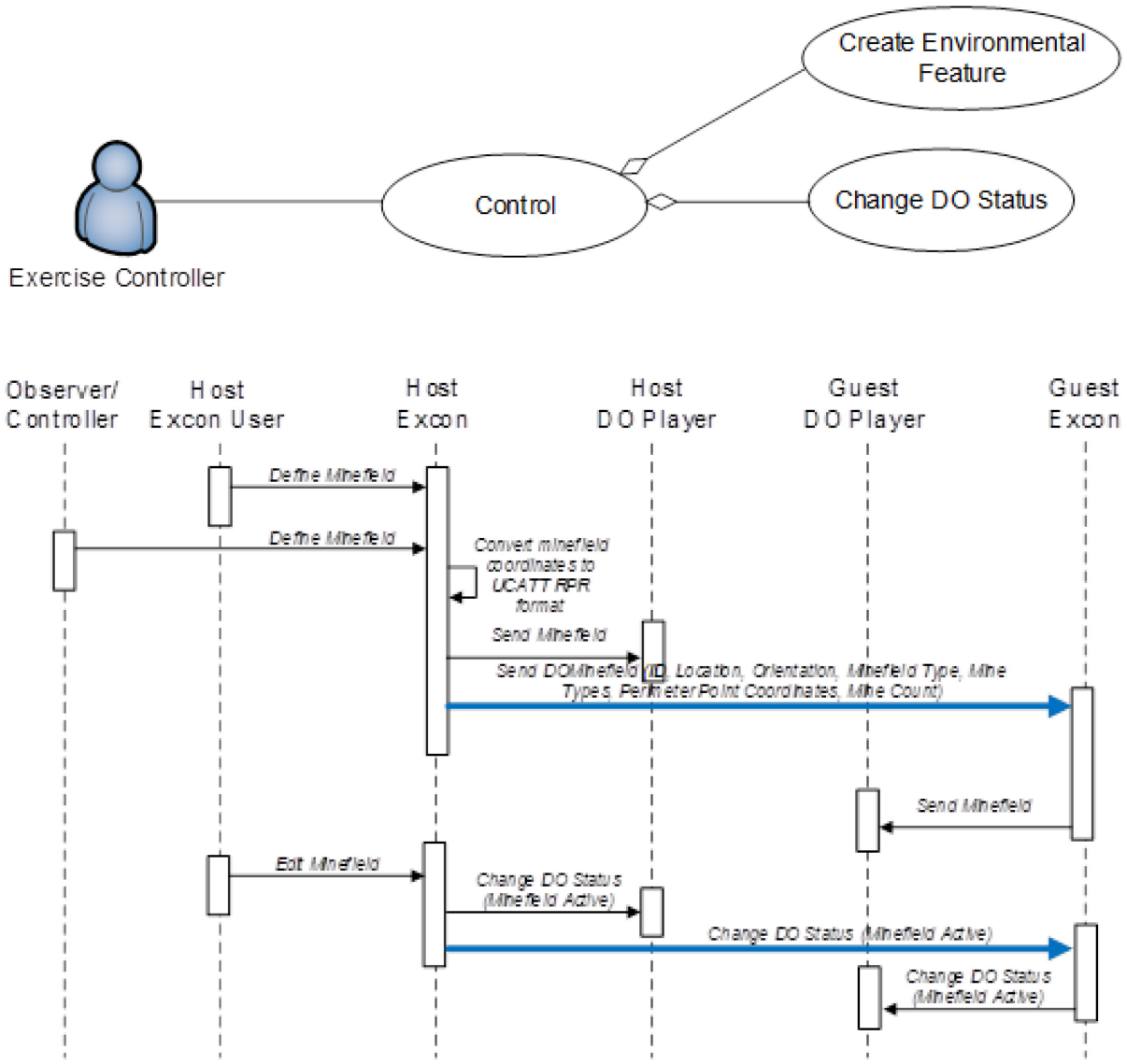


Figure D-19: Sequence Diagram – UC4B: Create Environment Feature (Decentralised).

D6.2.7 Use Case 5: Assign DO to Vehicle

A DO Player (e.g., a soldier) owned by one EXCON gets in a DO Player (e.g., vehicle) owned by another EXCON (Figure D-20). There is no difference in changing Host EXCON and Guest EXCON.

Policy:

- Vehicle DO may or may not communicate directly with Player DO via E9 on entry of vehicle.
- Vehicle DO communicates association to owning EXCON.
- Owning EXCON communicates association to other EXCON.

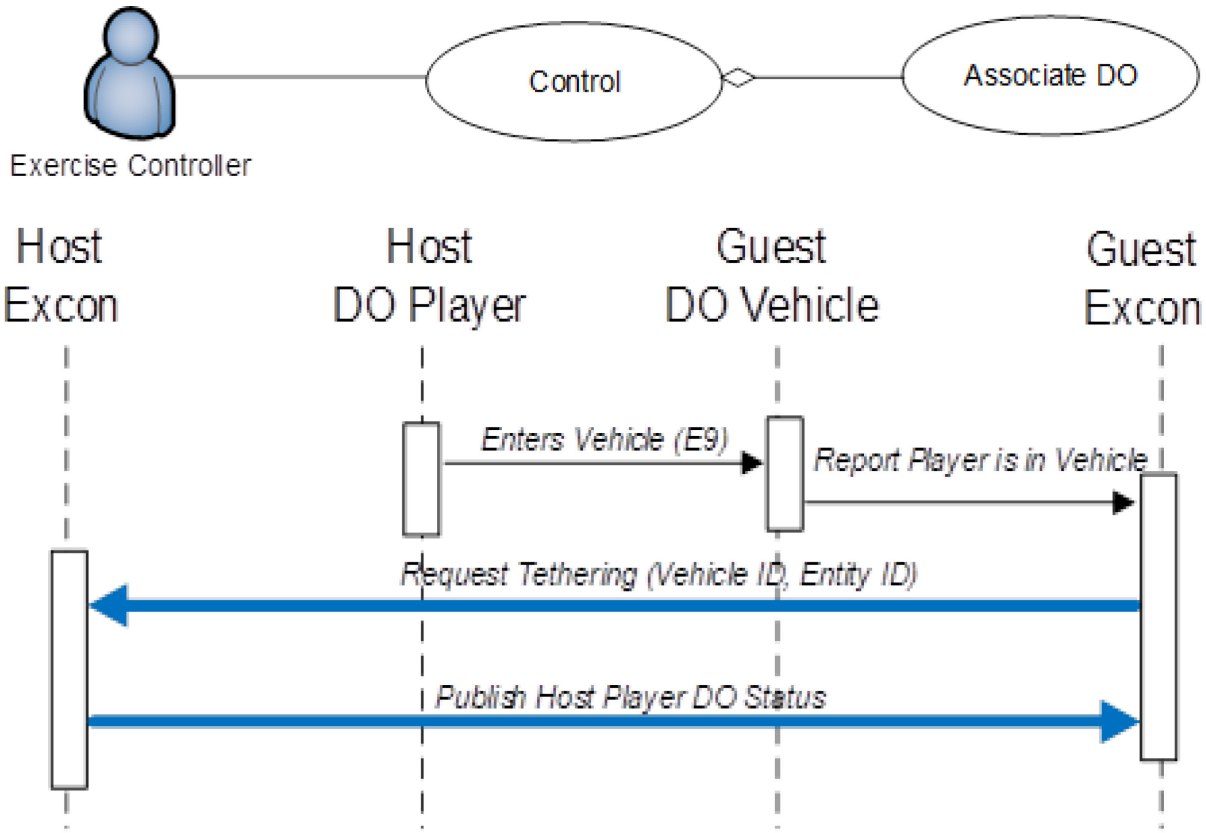


Figure D-20: Sequence Diagram – UC5: Assign DO to Vehicle.

D6.2.8 Use Case 6A: Change Environment (Centralised)

A building controlled by the Host EXCON is damaged by detonation and also Players inside this building get wounded or killed. One of these Players is owned by the Host EXCON the other one is owned by the Guest EXCON. Both EXCONs have a centralised model (Figure D-21).

Policy:

- DO Engagement Event can be issued from any EXCON or DO.
- Indoor tracking performed by Host EXCON.
- Only the Host EXCON will Report the activities taking place in that building for AAR.

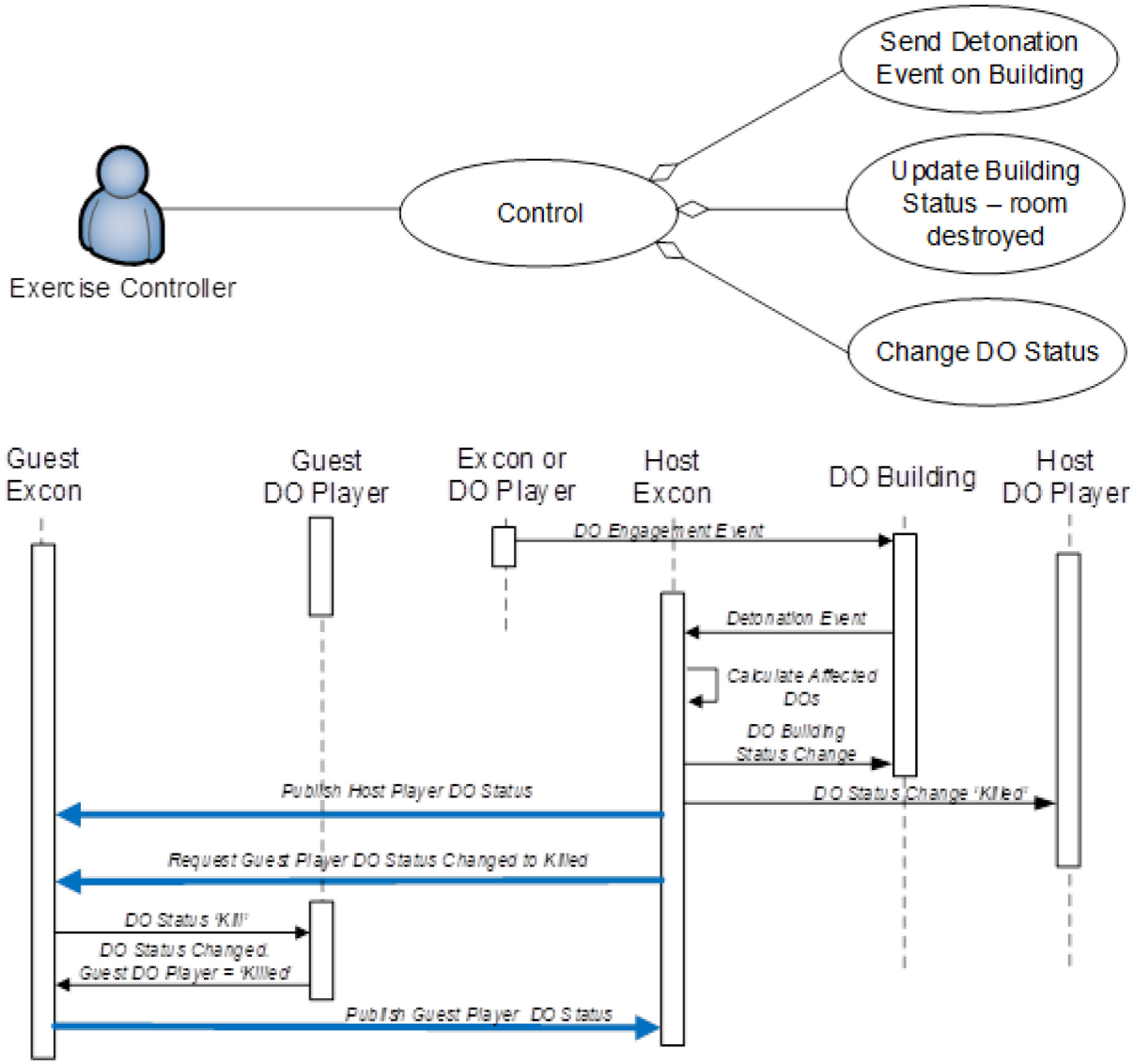


Figure D-21: Sequence Diagram – UC6A: Change Environment (Centralised).

D6.2.9 Use Case 6B: Change Environment (Decentralised)

A building controlled by the Host EXCON is damaged by detonation and also Players inside this building get wounded or killed. One of these Players is owned by the Host EXCON the other one is owned by the Guest EXCON. Both EXCONs have a decentralised model (Figure D-22).

Policy:

- This sequence may include centralised or decentralised effect adjudication on DO players within building.
- Indoor tracking is performed by Host EXCON.
- The Host EXCON may be excluded for decentralised control.
- Only the Host EXCON will Report the activities taking place in that building for AAR.

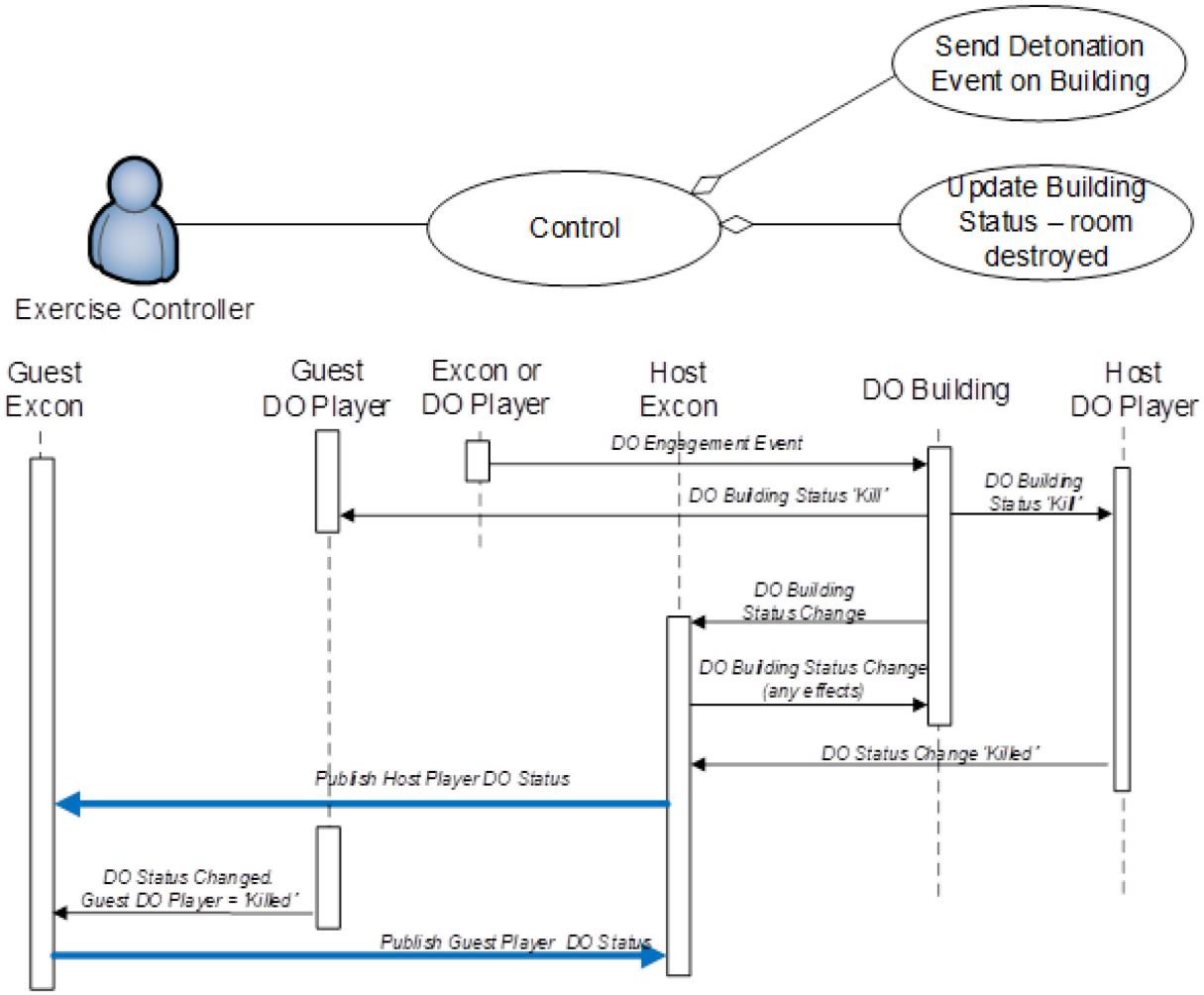


Figure D-22: Sequence Diagram – UC6B: Change Environment (Decentralised).

D6.2.10 Use Case 7: Change ORBAT

One EXCON requests to change the ORBAT in the case that Players are affect owned by another EXCON (Figure D-23). There is no difference in changing Host EXCON and Guest EXCON.

Policy:

- ORBAT is defined during exercise planning.
- ORBAT will be manually loaded at both EXCONs (E11).
- ORBAT may be imported as C-BML via C2SIM interface (E6/E7) iaw MSG-145.
- ORBAT may be changed for the following reasons:
  - Late joining formation (New DOs and aggregations);
  - DO attached to a different unit (aggregation);
  - DO changes affiliation and unit;
  - Aggregation of DOs are joined to another unit (Platoon moves to another Company);
  - Aggregation of DOs are joined to another unit and Unit type must change (Mechanised Infantry Unit ->Armoured Cavalry Unit);

- ORBAT was not previously defined.
- Either Host or Guest EXCON may change the BLUFOR and OPFOR ORBAT.
- Only the owning EXCON may change its own ORBAT of DOs.

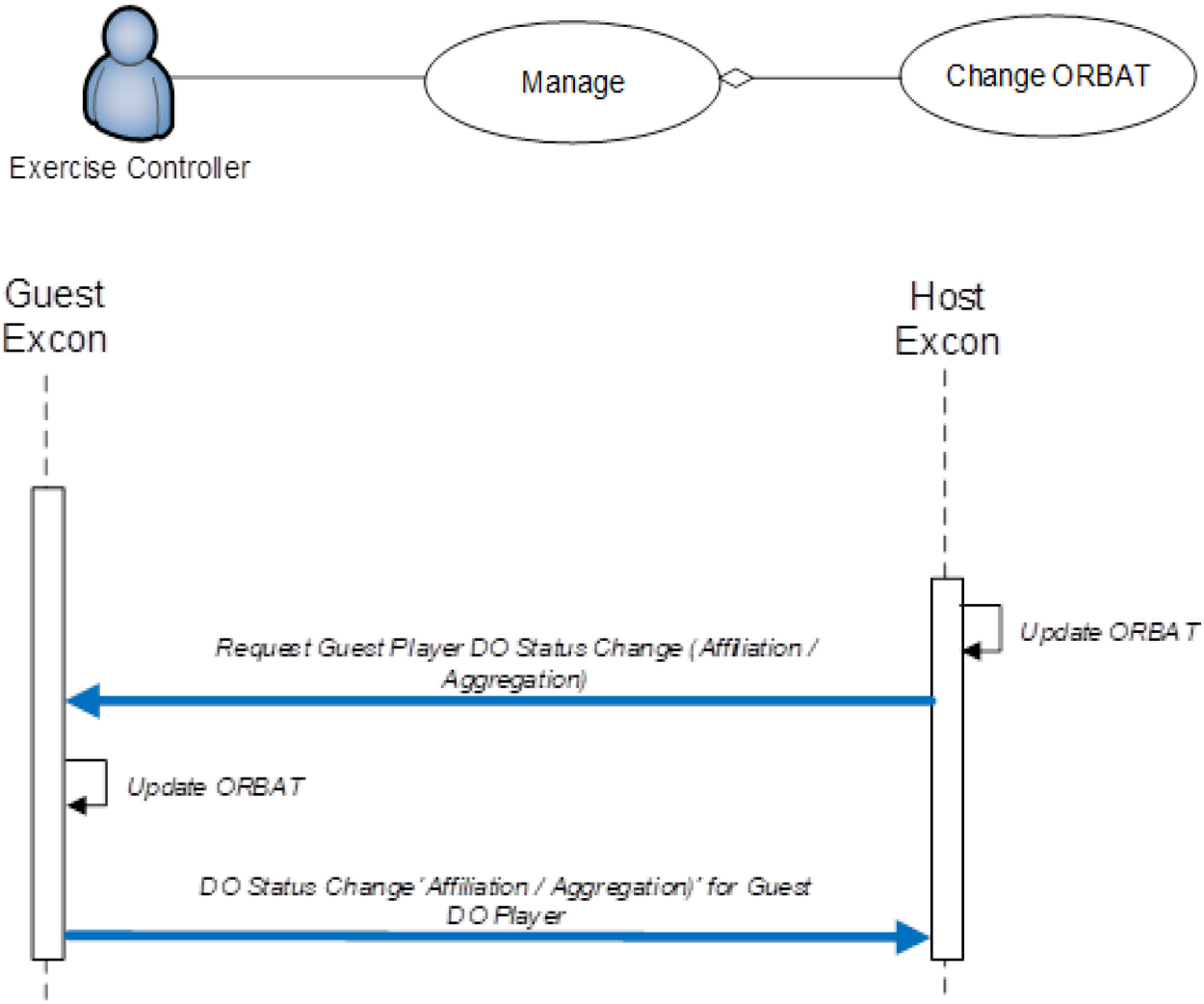


Figure D-23: Sequence Diagram – UC7: Change ORBAT.

D6.2.11 Use Case 8: Contaminate DO

A DO Player owned by a Guest EXCON gets in a contaminated vehicle or building controlled by the Host EXCON (Figure D-24). In the case without buildings there is no difference in changing Host EXCON and Guest EXCON.

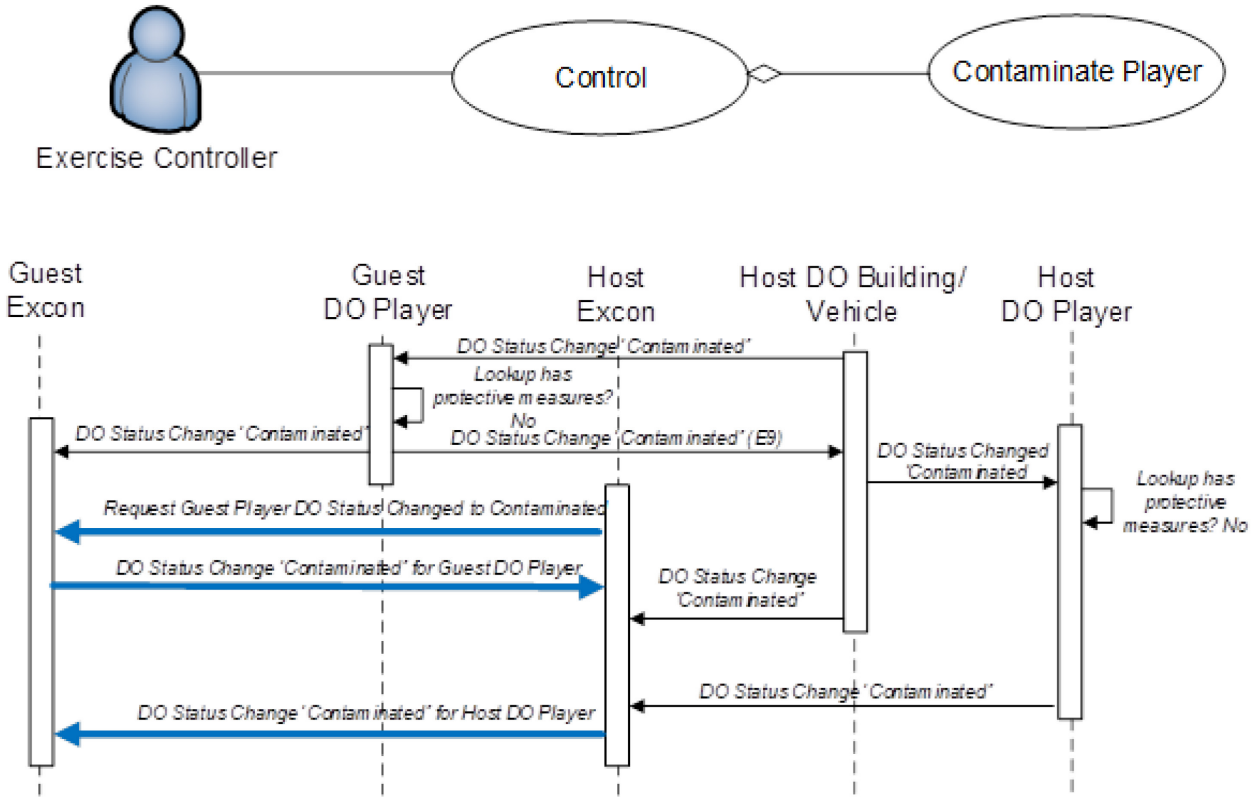


Figure D-24: Sequence Diagram – UC8: Contaminate DO.

Policy:

- DO Player enters or is inside a contaminated building or vehicle.
- DO Vehicle will communicate contamination on tethering / association event.
- E9/E4 is in use (required to determine that a DO Player is in the DO building/vehicle).

D6.2.12 Use Case 9: Missile

A DO Player owned by the Host EXCON fires a missile (Figure D-25). A Player owned by the Host EXCON and another Player owned by the Guest EXCON are affected by the missile detonation. There is no difference in changing Host EXCON and Guest EXCON.

Pre-Condition:

- Target designation may or may not occur and could be live or simulated.

Policy:

- The missile simulation is performed in the EXCON that owns the player firing the missile.
- The Host and/or Guest EXCON resolves any collateral event on other DOs.
- The detonation location can be either the target DO location, or a coordinate location specified in the weapon fire event or the detonation event.

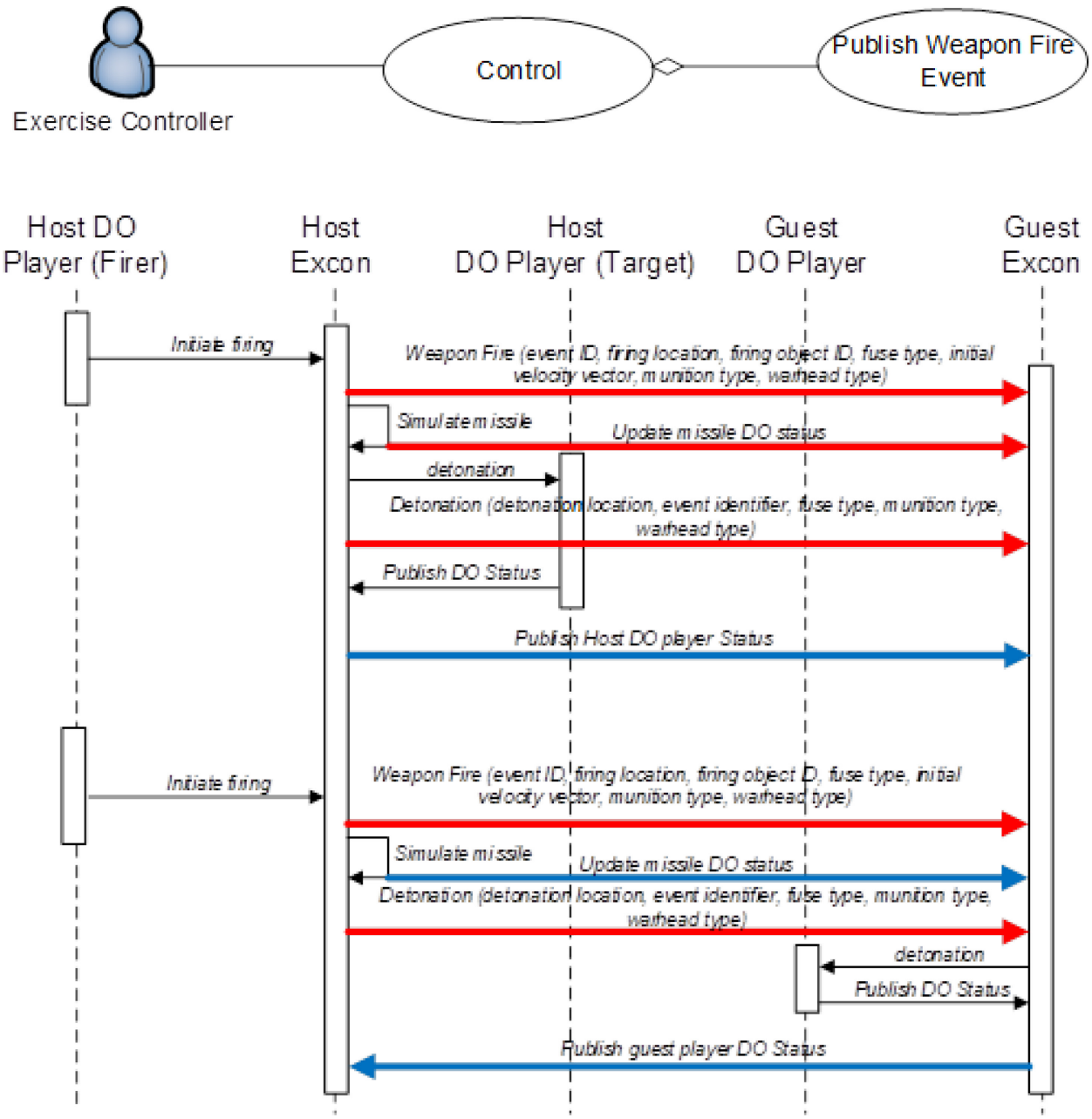


Figure D-25: Sequence Diagram – UC9: Missile.

D6.2.13 Use Case 10: Indoor Tracking

As already described, indoor tracking is performed by the Host EXCON (Figure D-26). In the case that guest players are instrumented for indoor tracking by the Host: if a DO Player owned by a Guest EXCON gets in a building the Guest EXCON may be receive still GPS positions (of low quality) but the Host EXCON knows that the Guest DO Player has indoor tracking positions.

Pre-Condition:

- All DOs start in a known active state.
- A guest DO player does not need to know its indoor location for decentralised events.

Policy:

- DO status will be published on change.
- The status refers to the tactical status and not the technical status (e.g., GPS kit failure).

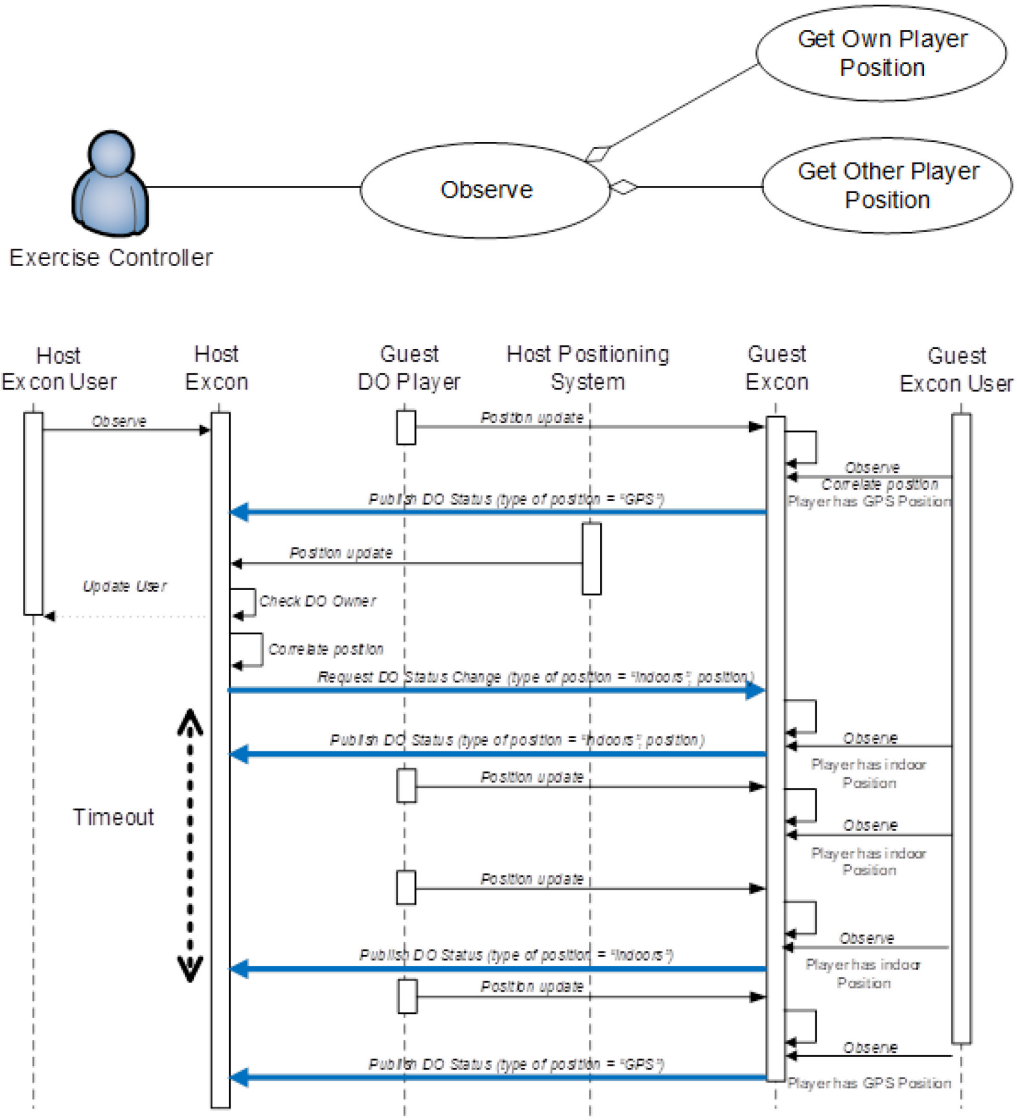


Figure D-26: Sequence Diagram – UC10: Indoor Tracking.

D6.2.14 Use Case 11A: Environment Feature (Centralised)

The Host EXCON publishes an area feature in the case that Guest EXCON and Host EXCON have both a centralised model (Figure D-27). There is no difference if the Host EXCON or a Guest EXCON is publishing the area feature.

D6.2.15 Use Case 11B: Environment Feature (Decentralised)

The Host EXCON publishes an area feature in the case that Guest EXCON and Host EXCON have both a decentralised model (Figure D-28). There is no difference if the Host EXCON or a Guest EXCON is publishing the area feature.

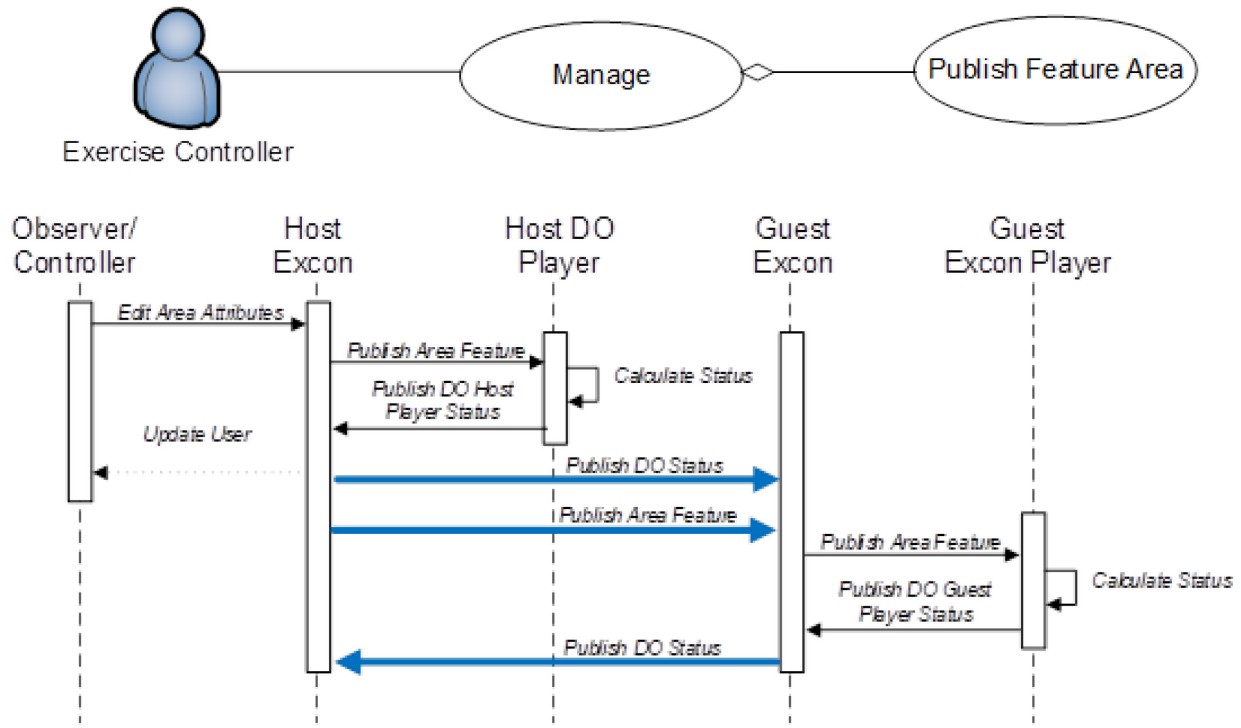


Figure D-27: Sequence Diagram – UC11A: Environment Feature (Centralised).

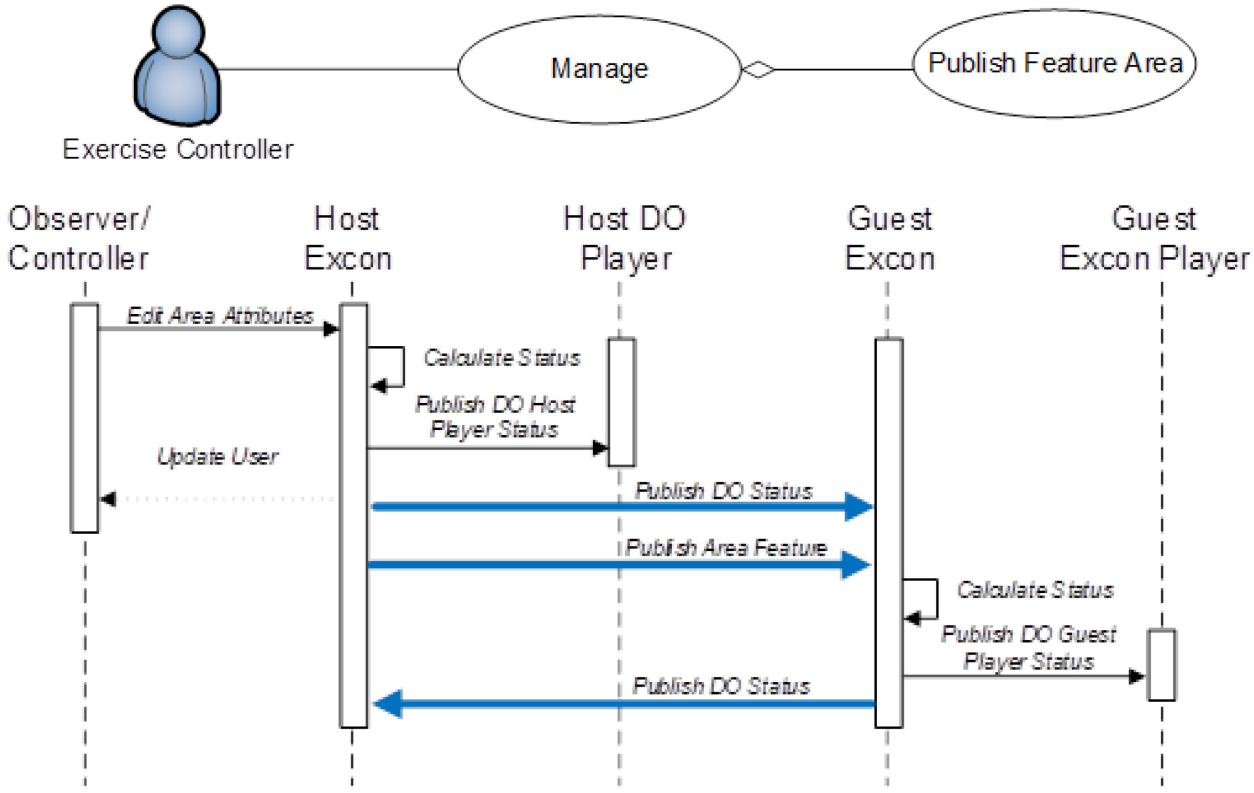


Figure D-28: Sequence Diagram – UC11B: Environment Feature (Decentralised).

D7.0 THE UCATT-FOM

Based on the previous results the U-FOM is developed. This chapter gives an overview of the object and interaction classes of the U-FOM and their attributes and parameters respectively.

The presentation of more detail is not part of this report. Further details are described in the documents for the SISO standardisation of E8.

D7.1 U-FOM – Object Classes

Table D-2 presents the object classes of the U-FOM. Figure D-29 shows a diagram of the OMT-editor for U-FOM Object Classes.

Table D-2: U-FOM Object Classes.

Class 1	Class 2	Class 3	Class 4	Class 5
BaseEntity (S)	AggregateEntity (PS)			
	PhysicalEntity (S)	Platform (S)	Aircraft (PS)	DOAircraft (PS)
			AmphibiousVehicle (PS)	DOAmphibiousVehicle (PS)
			GroundVehicle (PS)	DOGroundVehicle (PS)
			SurfaceVessel (PS)	DOSurfaceVessel (PS)
		Lifeform (S)	Human (PS)	DOPlayer (PS)
				DOObserverController (PS)
			NonHuman (PS)	DONonHuman (PS)
		Munition (PS)	DOMissile (PS)	
EmbeddedSystem (N)	MinefieldData (PS)			
	EmitterSystem (PS)	DOJammer (PS)		
Minefield (PS)				
EnvironmentObject (N)	ArealObject (N)	OtherArealObject (N)	DOFieldEngineering (N)	DOMinefield (PS)
				DOMinefieldBreach (PS)
				DOObstacleArea (PS)
				DOObstacleAreaBreach (PS)
			DOCBRNArea (N)	DOChemicaAgentArea (PS)
				DOBiologicalAgentArea (PS)
				DONuclearArea (PS)
				DORadiologicalArea (PS)
				DOEWInfluencingArea (PS)
			DOFeatureArea (N)	DOFireSupportArea (PS)
				DODecontaminationArea (PS)
				DOMedicalAttendanceArea (PS)
				DOSupplyArea (PS)
				DORepairArea (PS)
				DORestrictedArea (PS)
				DONoFireArea (PS)
				DOAirSpaceManagementArea (PS)
				DOWeaponEffectModificationArea (PS)
				DOPrisonerHoldingArea (PS)
				DOWeatherArea (PS)
	PointObject (N)	StructureObject (N)	DOBuilding (PS)	

Explanations:

- The red coloured classes are the RPR-FOM 2.0 classes used for UCATT.
- The blue coloured classes are the UCATT specific extensions.
- The names of the UCATT specific classes start always with “DO”.

Figure D-29: U-FOM Object Classes – Diagram of OMT-Editor.

Policies:

- "PS": It is allowed:
  - To subscribe to this class;
  - To publish object instances of this class.
- "S": Subscribing is allowed, publishing is not allowed.
- "N": Subscribing and publishing is not allowed.
- A Live Simulation EXCON will always publish object instances of the UCATT specific object classes:
  - Exceptions are the RPR-FOM classes "AggregateEntity", "Minefield", and "Minefield Data".

- A Live Simulation EXCON will, depending on their need, subscribe to:
  - UCATT specific object classes;
  - The RPR-FOM classes “AggregateEntity”, “Minefield”, and “Minefield Data”; and
  - Other RPR-FOM classes in the case of the L2VC use case.
- Special Case: minefields:
  - L2L use case: The “DOMinefield” class should be published and subscribed. (The RPR-FOM description of minefield is not quite appropriate for the live simulation domain.)
  - L2VC use case: The RPR-FOM classes Minefield” and “Minefield Data” would be supported for easier interoperability with virtual and constructive simulators if Live EXCON is able to provide the data needed by these classes.

D7.2 U-FOM – Interaction Classes

Table D-3 presents the interaction classes of the U-FOM. Figure D-30 shows a diagram of the OMT-Editor for U-FOM Interaction Classes.

Table D-3: U-FOM Interaction Classes.

Class 1
MunitionDetonation (PS)
WeaponFire (PS)
Acknowledge (PS)
ActionRequest (PS)
ActionResponse (PS)
StartResume (PS)
StopFreeze (PS)
DOJammerEngagement (PS)
DORepairActivity (PS)
DOMedicalAttendance (PS)
DOSupplyActivity (PS)
DOObserverControllerEngagement (PS)
DORequestNewStatus (PS)
DORequestOrbatChange (PS)
DORequestPositionChange (PS)

Explanations:

- The red coloured classes are the RPR-FOM 2.0 classes used for UCATT.
- The blue coloured classes are the UCATT specific extensions.
- The names of the UCATT specific classes start always with “DO”.

Policies:

- “PS”: It is allowed:
  - To subscribe to this class;
  - To publish object instances of this class.
- “S”: Subscribing is allowed, publishing is not allowed.
- “N”: Subscribing and publishing is not allowed.

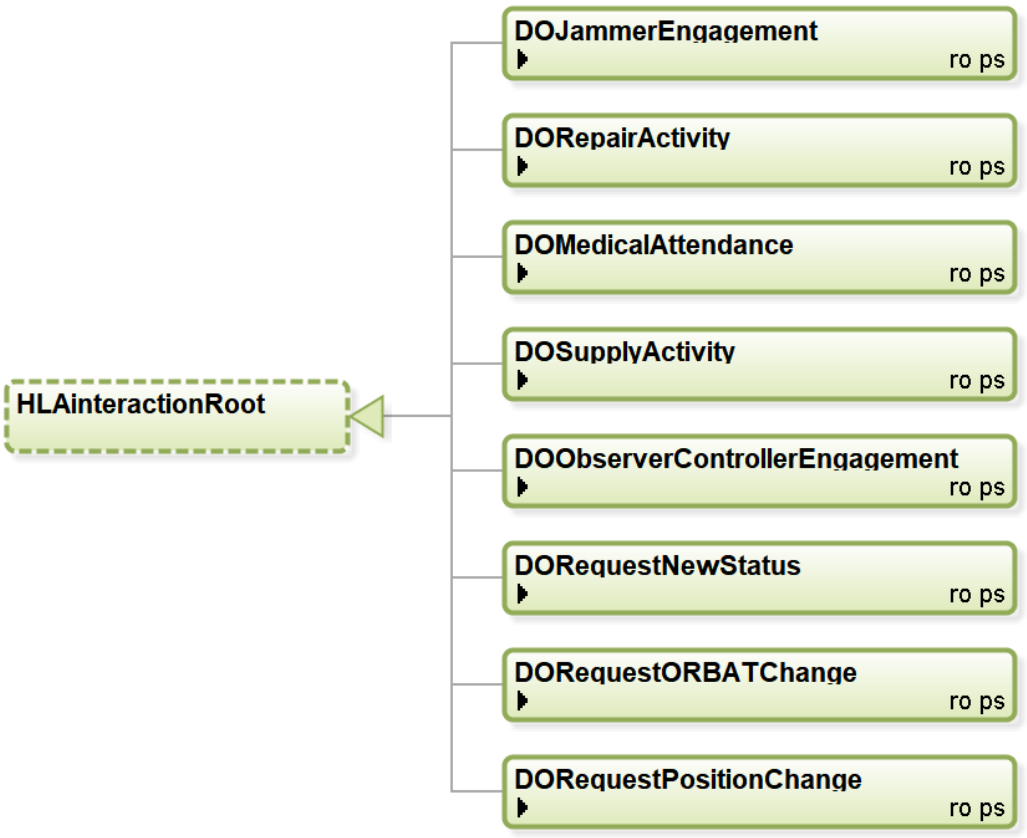


Figure D-30: U-FOM Interaction Classes – Diagram of OMT-Editor.

D7.3 Use of RPR-FOM Classes

Live simulation has the general limitation that only the data provided by the real players (soldiers, tanks, weapon systems, etc.) on the training area are available. This depends on the technical solutions of live simulation equipment and their level of integration into the real systems. The EXCON capabilities may be able to enhance this data by rational algorithms and models.

That means that a live simulation system (maybe) will not provide so much details for objects and interactions (events) like a constructive simulation system or like a virtual simulator. Typical examples are velocity and orientation of players. Today, soldiers and vehicles do not deliver this data. But progress can be expected for the future.

Consequently, for the use of RPR-FOM classes follows: The RPR-FOM classes should be used in accordance with the GRIM document [9]. The mandatory attributes and parameters should be principally filled with simulation data. Of course, this can be only realised if the data are available. The predefined default values should be used for optional attributes and parameters if no simulation data is available.

In the case of a federation where constructive simulation systems and/or virtual simulators are federates it has to be assumed that this federates support the RPR-FOM but do not support the UCATT-FOM extensions. Because of the rules of HLA, it is sufficient if the live simulation federates publish exclusively extension classes. Then the RPR-FOM based federates receive RPR-FOM attribute/parameter values of the object instances/parameters. If the live simulation federates are interested in the objects and interactions of the constructive/virtual federates it is necessary to subscribe the RPR-FOM classes, too (e.g., publishing only “DOGroundVehicle” but subscribing “DOGroundVehicle” and “GroundVehicle”).

D7.4 The U-FOM in Detail

For the description in detail of the UCATT-FOM see [17] that describes the U-FOM with status at the end of editing of this report.

Further work in detail is done within the SISO activities to standardise the U-FOM.

D8.0 REFERENCES

[1] SISO-GUIDE-003-00-2016 Guide for UCATT Live Simulation Standards and Architecture, Version 1.0, 9 May 2016.

[2] IEEE-STD-1730-2010 (DSEEP) IEEE Recommended Practice for Distributed Simulation Engineering and Execution Process.

[3] NATO STO: STO Technical Report TR-MSG-098 Urban Combat Advanced Training Technology Architecture.

[4] IEEE-STD-1516-2010 IEEE Standard for Modeling and Simulation (M&S) High Level Architecture (HLA) – Framework and Rules.

[5] IEEE-STD-1516.1-2010 IEEE Standard for Modeling and Simulation (M&S) High Level Architecture (HLA) – Federate Interface Specification.

[6] IEEE-STD-1516.2-2010 IEEE Standard for Modeling and Simulation (M&S) High Level Architecture (HLA) – Object Model Template (OMT) Specification.

[7] NATO STO: STO Technical Report TR-MSG-063 Urban Combat Advanced Training Technology.

[8] SISO-STD-001.1-2015 Standard for Real-time Platform Reference Federation Object Model, Version 2.0.

[9] SISO-STD-001-2015 Standard for Guidance, Rationale, and Interoperability Modalities for the Real-time Platform Reference Federation Object Model, Version 2.0.

[10] SISO-REF-010-2015 Reference for Enumerations for Simulation Interoperability.

[11] IEEE-STD-1278.1-2012 Distributed Interactive Simulation (DIS).

[12] SISO-STD-002-2006 Evaluation (SIMPLE) Standard for: LINK 16 SIMULATIONS.

[13] TENA: https://www.tena-sda.org/display/TENAintro/Home.

[14] DDS: http://www.omg.org/omg-dds-portal/.

[15] NATO STANAG 5602 Standard Interface for Multiple Platform Link.

[16] AMSP-04 – NATO Education and Training Network Federation Architecture and FOM Design (NETN FAFD), Edition (A) Version 1.0 (Draft 3).

[17] UFOM_v0.1.pdf.

Annex E – TAP AND TOR UCATT-LSS

TECHNICAL ACTIVITY PROPOSAL (TAP)

ACTIVITY REFERENCE NUMBER	MSG-140	ACTIVITY TITLE URBAN COMBAT ADVANCED TRAINING TECHNOLOGY LIVESIM STANDARDS (UCATT LSS)	APPROVAL
TYPE AND SERIAL NUMBER	**RTG**		START 2015
LOCATION(S) AND DATES		2015 Kickoff meeting Paris 2015 I-ITSEC meeting USA, Orlando 2016 ITEC/ spring meeting 2016 PDG/PSG autumn meeting 2016 I-ITSEC meeting USA, Orlando 2017 ITEC/ spring meeting 2017 PDG/PSG autumn meeting 2017 I-ITSEC meeting USA/Orlando 2018 ITEC/ spring meeting	END 2018
COORDINATION WITH OTHER BODIES		SISO	
NATO CLASSIFICATION OF ACTIVITY		RELEASABLE TO THE PUBLIC	Non-NATO Invited Yes
PUBLICATION DATA		TR	UU
KEYWORDS	URBAN COMBAT ADVANCED TRAINING TECHNOLOGY, UCATT, Live Simulation, Standards		

I. BACKGROUND AND JUSTIFICATION (RELEVANCE TO NATO):

NATO Studies SAS 030, Study on Urban Operations 2020 and Land Operations 2020 clearly indicate that Urban Areas are the most likely battlefield in the 21st century.

The problems and limitations associated with developing the first generation of Military Operations on Urban Terrain (MOUT) training facilities are to be understood.

A team of experts from NATO NAAG completed a feasibility study in 2002 and concluded that a number of potential interoperability areas were identified and assessed to be worthy of further investigation.

MSG-032 UCATT (2003 – 2007) of NMSG started to identify and investigate some areas and reported them in their final report for the live domain. A number of areas were not completely covered or needed more investigation also a number of areas are new.

The UCATT report became more or less the guideline for URBAN COMBAT TRAINING facilities design.

Also the first steps in order to bring the defined interface specification to a standard (through the SISO) process had been started. MSG-063 UCATT-2 (2007 – 2011) the follow on of MSG-032 UCATT displayed the result of UCATT work approach in a life (technical) demonstration of interoperability between (modified) existing systems. A spin off of the UCATT work was a new laser standard (OSAG-2) that is already in use with a number of European countries. Goal of UCATT is that after SISO approval OSAG-2 is replaced by the laser implementation of the UCATT SISO standard.

Under the SISO organisation, a study group was formed (UCATT SG) to prepare the release of a product nomination for the UCATT standard framework.

MSG-063 was followed up by 2 new groups: MSG-098 (UCATT Architecture) and MSG-099 (UCATT Standards) (2011 – 2015).

They were tasked to refine the architecture (098) and writing the first SISO Standard (099). At the same time the SISO process was worked through by writing and getting approved the final SISO study group report.

A product nomination was submitted and approved. The PDG (Product Development Group) was established. The first release of the UCATT Standard with the laser implementation was submitted for balloting.

The virtual and constructive domain was explored and existing (SISO) standards were reviewed as a result of the UCATT architecture.

UCATT deliverables to date: Site register, Research needs, Interoperability specification, functional architecture, documented life interoperability demonstration, best practices, first release of SISO Standard (laser implementation), draft of player interface-implementation (E4).

In the last couple of years UCATT has become NATO's focal point for Live training technologies. Beside that UCATT has become the focal point of information exchange for the military user community, government procurement and the leading Industries with respect to live training & simulation.

II. OBJECTIVE(S):

Further development and support of the SISO UCATT standard. Transfer the currently used functional architecture into the NATO Architectural Framework (NAF) where applicable to verify the validity of the

architectural approach in relation to physical implementations. Feedback as to the effectiveness of the physical implementation solutions will be given from the group's military experts with respect to the existing Use Cases. Identify, maintain and improve a suitable architecture and a standard set of interfaces that enable interoperability of live training & simulation components covering the urban aspects that does not inhibit future research and enhancements.

Validate the applicability of existing standards for interfacing to the simulation environment. Further develop the SISO UCATT standard (PDG) in accordance with the Product Nomination (PN) and maintain the Standard as a Product Support Group (PSG).

Maintain function as focal point for live training & simulation technologies and standards.

III. TOPICS TO BE COVERED:

Operational Concepts: continuous maintenance of the comprehensive list of developed Generic User Requirements in conjunction with NATO Training Groups and Military Users on the live, virtual and the constructive domain.

Further standardisation through the SISO process of UCATT defined and prioritised interfaces following the functional architecture. Maintain the UCATT functional architecture for live training & simulation.

Establishment of a PSG to maintain the UCATT Standards.

IV. DELIVERABLES (E.G., MODEL, DATABASE, …) AND/OR END PRODUCTS:

- Technical Report
- SISO Standard(s)

V. TECHNICAL TEAM LEADER AND LEAD NATION:

Lead Nation:	Germany
Points of Contact:	Chair: Mr Armin THINNES, Germany (arminthinnes@bundeswehr.org, +49 261 400 5234) Deputy Chair: Mr Ingo WITTWER, Germany (ingo.wittwer@ruag.com, +49 4103 939 580)

VI. NATIONS WILLING/INVITED TO PARTICIPATE:

NATO Nations and Bodies:	all NATO Nations and Bodies invited
PfP Nations:	all PfP nations invited
Industries:	all relevant industries are invited
Global Partners:	Australia, Japan, South Korea and New Zealand invited

The following Nations willing to participate: Germany, Great Britain, Netherlands, France, Sweden, United States of America, Austria and Switzerland.

The following Industries are willing to participate: Cubic Defence systems (USA/NZL), SAAB AB (SWE), Thales Training and simulation (FRA), Airbus Group (FRA), GDI Simulation (FRA), RUAG (DEU /CHE) and Rheinmetall Defence (DEU).

VII. NATIONAL AND/OR NATO RESOURCES NEEDED (PHYSICAL AND NON-PHYSICAL ASSETS):

Personnel resources (technical/scientific and military) are to be provided through national contributions.

Travel costs are to be provided through national contributions.

SISO membership fees for NATO and PfP representatives, support for meeting-facilities and PR-material if applicable.

VIII. CSO RESOURCES NEEDED (E.G., CONSULTANT FUNDING):

Standard support for STO Task Groups in accordance with the current edition of the STO Operating Procedures.

TERMS OF REFERENCE (TOR)

MSG-140 / RTG

ON

URBAN COMBAT ADVANCED TRAINING TECHNOLOGY LIVE STANDARDS (UCATT-LS)

I. ORIGIN

A. Background

NATO Studies SAS 030, Study on Urban Operations 2020 and Land Operations 2020 clearly indicate that Urban Areas are the most likely battlefield in the 21st century.

The problems and limitations associated with developing the first generation of Military Operations on Urban Terrain (MOUT) training facilities are to be understood.

A team of experts from NATO NAAG completed a feasibility study in 2002 and concluded that a number of potential interoperability areas were identified and assessed to be worthy of further investigation.

MSG-032 UCATT (2003 – 2007) of NMSG started to identify and investigate some areas and reported them in their final report for the live domain. A number of areas were not completely covered or needed more investigation also a number of areas are new.

The UCATT report became more or less the guideline for URBAN COMBAT TRAINING facilities design.

Also, the first steps in order to bring the defined interface specification to a standard (through the SISO) process had been started. MSG-063 UCATT-2 (2007 – 2011) the follow on of MSG-032 UCATT displayed the result of UCATT work approach in a life (technical) demonstration of interoperability between (modified) existing systems. A spin off of the UCATT work was a new laser standard (OSAG-2) that is already in use with a number of European countries. Goal of UCATT is that after SISO approval OSAG-2 is replaced by the laser implementation of the UCATT SISO standard.

Under the SISO organisation, a study group was formed (UCATT SG) to prepare the release of a product nomination for the UCATT standard framework.

MSG-063 was followed up by 2 new groups: MSG-098 (UCATT Architecture) and MSG-099 (UCATT Standards) (2011 – 2015).

They were tasked to refine the architecture (098) and writing the first SISO Standard (099). At the same time the SISO process was worked through by writing and getting approved the final SISO study group report.

A product nomination was submitted and approved. The PDG (Product Development Group) was established. The first release of the UCATT Standard with the laser implementation was submitted for balloting.

The virtual and constructive domain was explored and existing (SISO) standards were reviewed as a result of the UCATT architecture.

UCATT deliverables to date: Site register, Research needs, Interoperability specification, functional architecture, documented life interoperability demonstration, best practices, first release of SISO Standard (laser implementation, draft of player interface-implementation (E4).

In the last couple of years UCATT has become NATO's focal point for Live training technologies. Beside that UCATT has become the focal point of information exchange for the military user community, government procurement and the leading Industries with respect to live training & simulation.

B. Justification (Relevance for NATO)

- Maintenance of comprehensive list of Generic Harmonised (between Nations) User Requirements in conjunction with NATO Training Groups and Military Users on the live, virtual and the constructive domain.
- SISO standardised LIVE simulation & training interoperability interfaces to cope with the defined Use Cases enabling international interoperable training.
- Extension of the live functional architecture for LIVE training according to new Use Cases.

II. OBJECTIVES

Further development and support of the SISO UCATT-standard. Transfer the currently used functional architecture into the NATO Architectural framework (NAF) where applicable to verify the validity of the architectural approach in relation to physical implementations. Feedback as to the effectiveness of the physical implementation solutions will be given from the group's military experts with respect to the existing Use Cases. Identify, maintain and improve a suitable architecture and a standard set of interfaces that enable interoperability of LIVE training & simulation components covering the urban aspects that does not inhibit future research and enhancements.

Validate the applicability of existing standards for interfacing to the simulation environment. Further develop the SISO UCATT standard (PDG) in accordance with the Product Nomination (PN) and maintain the Standard as a Product Support Group (PSG).

Maintain function as focal point for live training & simulation technologies and standards.

III. RESOURCES

A. Membership

Members should be specialists in the field of Live simulation & training from the contributing NATO nations and other NMSG's associated members.

3 face-to-face meetings per year are planned. Between the personal meetings work is planned to be carried out using Internet. Appropriate collaboration mechanisms will be used as support tools (e.g. Mailing-Lists, Website, Sharepoint etc.).

Lead Nation:	Germany
Points of Contact:	Mr. Armin THINNES (arminthinnes@bundeswehr.org) Mr. Ingo WITTWER (ingo.wittwer@ruag.com)

Nations willing/invited to participate:

- Willing: Germany, Netherlands, United Kingdom, United States, France, Sweden, Switzerland, and Austria.

- Invited: all NATO and PfP Nations, Global Partners
- Industries willing/ invited to participate:
- Cubic Defence systems (USA/NZL), SAAB AB (SWE), Thales Training and simulation (FRA), Airbus Group (FRA), GDI Simulation (FRA), RUAG (DEU/CHE) and Rheinmetall Defence (DEU).
- Invited: All relevant simulation industries.

B. National and/or NATO Resources Needed

- Personnel resources (technical/scientific and military) are to be provided through national contributions.
- Travel costs are to be provided through national contributions.
- SISO membership fees for NATO and PfP representatives, support for meeting-facilities and PR-material if applicable.

C. CSO Resources Needed

- Standard support for STO Task Groups in accordance with the current edition of the STO Operating Procedures.

IV. SECURITY CLASSIFICATION LEVEL

The activity and the deliverables are classified as “RELEASABLE TO THE PUBLIC” (UU).

V. PARTICIPATION BY PARTNER NATIONS

PfP Nations: all PfP nations invited

Global Partners: Australia, Japan, South Korea and New Zealand invited

VI. LIAISON

- SISO (coordination with UCATT PDG standardisation activities)

Annex F – UCATT-LSS ATTENDANCE

This Annex lists all persons who attended one or more of the UCATT-LSS meetings. During the UCATT-LSS mandate 12 meetings were organised, which are listed in Table F-1.

Table F-2 contains the names of the attendants, how many and which meetings they attended and in which TG(s) of UCATT-LSS they participated: Steering Group (SG), TG Architecture (ARCH), TG NAF (NAF), TG E4 (E4), TG E8 (E8) or TG Marketing (MARK).

Table F-1: UCATT-LSS Meetings.

2015			1	SEP/OCT 2015 Stockholm, SWE	2	NOV 2015 Orlando, USA
2016	3	APR 2016 Bremen, GER	4	SEP 2016 Walenstad, CHE	5	NOV 2016 Orlando, USA
2017	6	MAY 2017 San Diego, USA	7	SEP 2017 Oslo, NOR	8	NOV 2017 Orlando, USA
2018	9	MAY 2018 Ottawa, CAN	10	SEP 2018 Canberra, AUS	11	NOV 2018 Orlando, USA
2019	12	APR 2019 Washington, USA				

Table F-2: UCATT-LSS Meeting Attendance.

First Name	Last Name	Nation	No.	1	2	3	4	5	6	7	8	9	10	11	12	TG
Danny	Adkins	USA	3													ARCH
Magnus	Alexandersson	SWE	11													SG|E4
Dave	Bagguley	GBR	9													E8
James	Benslay	USA	2													ARCH
Fidel	Bernold	CHE	2													ARCH
Par	Blomqvist	SWE	7													E8
Cory	Bogler	USA	5													E4
Ralph	Briggs	USA	3													ARCH
Greg	Campbell	CAN	2													ARCH
Jesse	Campos	USA	4													ARCH
Jennifer	Cassar	CAN	5													ARCH
Fredric	Chamaud	FRA	2													ARCH
Mark	Chamberlain	GBR	12													SG|ARCH
Judd	Cheatwood	USA	4													E4
Ernst	Christians	DEU	9													ARCH
Tom Ståle	Christoffersen	NOR	10													ARCH
Sebastian	Cichowski	CHE	5													E4
Mark	Cockerall	AUS	1													ARCH
Mark	Collins	GBR	6													ARCH
Michel	Coriat	FRA	6													ARCH|(NAF)
Sander	Cruiming	NLD	12													SG|ARCH
Dan	D'Agostino	USA	3													ARCH
Phillipe	Desruelles	FRA	2													ARCH
Uwe	Dobrindt	DEU	11													E8
Bruce	Douglas	CAN	1													ARCH
Joachim	Eisenhauer	DEU	5													E4
David	Fallon	AUS	2													ARCH
Max	Fenner	CHE	12													ARCH|MARK
Andy	Gales	GBR	7													ARCH
Mike	Gardner	GBR	1													ARCH
Shelly	Gillespie	NZL	1													ARCH
Marc	Gimbel	USA	6													E8
Wayne	Golon	USA	3													ARCH
Roberto	Gomez	USA	2													ARCH

First Name	Last Name	Nation	No.	1	2	3	4	5	6	7	8	9	10	11	12	TG
Rudi	Gouweleeuw	NLD	11	■	■	■	■	■	■	■	■	■	■		■	SG|ARCH
Sjur	Grindstuen	NOR	1	■												ARCH
Johnny	Gullstrand	SWE	7	■	■	■	■	■		■		■				ARCH
Wolfgang	Habitzl	AUT	3	■			■					■				ARCH
Per	Hagman	SWE	6						■		■	■	■	■	■	ARCH
Gary	Hall	USA	1					■								ARCH
Tamara	Hammond	CAN	6		■	■	■		■	■		■				ARCH
Paul	Handley	NZL	9	■	■	■	■		■		■	■		■	■	E4
Tony	Hawkins	USA	1						■							ARCH
Cory	Hemmingway	USA	1				■									ARCH
Lilian	Hery	FRA	7				■	■	■	■		■	■	■		ARCH
Russ	Hinds	USA	1							■						ARCH
Simon	Hoey	NZL	1										■			ARCH
Jan Erik	Holen	NOR	12	■	■	■	■	■	■	■	■	■	■	■	■	E8
Anders	Holmquist	SWE	2								■			■		ARCH
Robert	Horak	AUT	3									■		■	■	ARCH
Mark	Horn	AUS	1										■			ARCH
Tomas	Huldt	SWE	6							■	■	■	■	■	■	NAF
Magnus	Karlsson	DEN	7				■	■	■	■		■	■	■		E8
Roger	Karlsson	SWE	3							■	■			■		ARCH
Mika	Kärsämä	FIN	5								■	■	■	■	■	ARCH
John	Kent	GBR	1	■												ARCH
Steve	Kerslake	USA	1										■			ARCH
Joe	LaBalbo	USA	2											■	■	ARCH
Patrice	Le Leydour	FRA	1											■		ARCH
Steve	Madsen	AUS	1										■			ARCH
Peter	Makowski	DEU	11	■	■	■	■	■		■	■	■	■	■	■	ARCH|MARK
Staffan	Martinsen	SWE	11	■		■	■	■	■	■	■	■	■	■	■	NAF
Sergio	Mian	ITA	1									■				ARCH
Jean-Philippe	Michel	FRA	9	■	■	■	■	■	■	■	■	■				E4
Holger	Neugebauer	DEU	1		■											E4
John	Nicholls	AUS	1										■			ARCH
Rob	Nolan	AUS	1										■			ARCH
Kelly	O'Neill-Mogridge	CAN	4									■		■	■	E8
Patrick	Ogden	USA	5		■	■	■		■			■				ARCH

First Name	Last Name	Nation	No.	1	2	3	4	5	6	7	8	9	10	11	12	TG
Joe	Olsen	USA	1													ARCH
Nicolas	Panelli	FRA	1													ARCH
Kipp	Peppel	USA	8													ARCH
Rob	Phillips	USA	9													E8
Rhea	Pritchett	USA	3													ARCH
Dusan	Renar	SLV	2													ARCH
Karl	Roschei	DEU	12													ARCH
Paul	Smith	USA	3													E4
Troy	Stevens	AUS	3													ARCH
Armin	Thinnes	DEU	12													SG|ARCH
Patrick	Thonon	CAN	1													ARCH
Dan	Turcotte	CAN	3													ARCH
Cyndi	Turner	USA	2													ARCH
Pierre	Victor-Lemaire	FRA	2													E4
Dirk	Vormann	DEU	5													ARCH
Alex	Voss	DEN	8													ARCH
Chris	Walls	GBR	1													ARCH
Dieter	Werberich	DEU	1													ARCH
Ingo	Wittwer	DEU	10													E4
Kwok	Wong	GBR	1													ARCH
Catherine	Zundel	FRA	1													ARCH

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14. Abstract

Groups within the NMSG and SISO. The aim is to identify, create and maintain a standard set of interfaces that enable interoperability of live training components.

The objective of MSG-140 "UCATT Live Simulation Standards" (UCATT-LSS) was to further develop and support the SISO UCATT family of standards. The TG has: 1) validated the applicability of existing and evolving standards for interfacing to the simulation environment; 2) elaborated the user requirements and functional requirements of the interfaces based on current training practices and military and technological developments; 3) transferred the currently used functional architecture into the NATO Architecture Framework (NAF); 4) prepared for handover to SISO the drafting of two new standards: UCATT Networking Instrumentation and TESS Equipment (U-NITE) for transferring data from a Dynamic Object to Exercise Control and the UCATT Federation Object Model (U-FOM), a standard data exchange model required for System to System interoperability.

With the involvement of military, government and industry, UCATT has developed to become a focal point of knowledge and information exchange on live simulation within NATO and PfP. The UCATT activities will continue within MSG-174 "UCATT Live Simulation Standards 2" (UCATT-LSS(2)).

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