NORTH ATLANTIC TREATY ORGANIZATION

SCIENCE AND TECHNOLOGY ORGANIZATION

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STO TECHNICAL REPORT **TR-MSG-086-Part-II**

Guideline on Scenario Development for (Distributed) Simulation Environments

(Guide en vue du développement de scénario dans le cadre de simulation distribuée)

Part of the Final Report of MSG-086.

Published January 2015

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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

BOM	Base Object Model
CAS	Close Air Support
CAX	Computer-Assisted Exercise
C-BML	Coalition Battle Management Language
CMMI	Capability Maturity Model Integration
DIF	Data Interchange Format
DIS	Distributed Interactive Simulation
DSEEP	Distributed Simulation Engineering and Execution Process
EU	European Union
FAC	Forward Air Controller
FEDEP	Federation Development and Execution Process
FOM	Federation Object Model
HLA	High Level Architecture
IEEE	Institute of Electrical and Electronics Engineers
IFF	Identification Friend or Foe
ISO	International Organization for Standardization
JEMM	Joint Exercise Management Module
JLVC	Joint Live Virtual Constructive
JTDS	Joint Training Data Services
LCIM	Levels of Conceptual Interoperability Model
ManPAD	Man Portable Air Defence
MEL	Main Events List
MIL	Main Incidents List
M&S	Modelling and Simulation
MSDL	Military Scenario Definition Language
MSG	Modelling and Simulation Group
NAF	NATO Architecture Framework
NATO	North Atlantic Treaty Organization
PMESII	Political, Military, Economic, Social, Information, Infrastructure
OBS	Order of Battle Service
OMT	Object Model Template
SISO	Simulation Interoperability Standards Organization
SME	Subject-Matter Expert
UML	Unified Modelling Language
V&V	Verification and Validation

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Guideline on Scenario Development for (Distributed) Simulation Environments

(STO-TR-MSG-086-Part-II)

Executive Summary

As simulation interoperability was the highest priority capability gap of the NMSG MORS M&S Gap Analysis Questionnaire an Exploratory Team (ET-027) of the NMSG was formed in 2009 to investigate simulation interoperability. ET-027 identified 63 issues which severely limit simulation interoperability. Based on the findings of ET-027, MSG-086 "Simulation Interoperability" was initiated in 2010 and tasked to analyse the ET-027 interoperability issues. This analysis should be used to recommend and prototype information products augmenting the Distributed Simulation Engineering and Execution Process (DSEEP) [DSEEP] to mitigate or obviate identified interoperability issues. In total, 46 interoperability issues are identified and described by MSG-086 and categorized into 9 interoperability issue groups. All issues are documented according to the same schema and relations to relevant M&S standards are identified.

Present standards for distributed simulation environments mostly focus on the technical, the syntactic and (to a limited extent) on the semantic interoperability level. To meet future demands – especially in terms of quality and reduced time and costs – simulation interoperability at higher levels (i.e., on the pragmatic, dynamic, and conceptual interoperability level) is required as well as substantial automation of development, integration, and execution of distributed simulation environments.

This requires standardization of information products created in the process of developing a simulation environment, following e.g., the DSEEP. Such standardized information products must address higher levels of interoperability than present simulation interoperability standards which focus on lower interoperability levels (i.e., on technical, syntactic, and semantic issues).

Based on the identified interoperability issues and their impact on the simulation environment engineering process, MSG-086 focused its further efforts on the issue group "Scenario". To improve simulation interoperability in context of the DSEEP, MSG-086 developed a "Guideline on Scenario Development for (Distributed) Simulation Environments". This guideline augments the DSEEP with regards to scenario development and proposes content and structure of an information product for scenario specification.

Additionally, MSG-086 delivers the following secondary outcomes and deliverables:

- Recommendations for updating AMSP-01 [AMSP-01] with respect to simulation interoperability and scenario development.
- A proposal for updating the NMSG Military Operational Requirements Sub-group (MORS) M&S Gap Analysis Questionnaire.
- Recommendations for SISO working groups (e.g., DSEEP, FEAT, and SCM), especially with regards to scenario development.

A major finding of MSG-086 (besides the detailed documentation of simulation interoperability issues) is that simulation interoperability is not primarily a technical issue, but that simulation interoperability needs to be addressed in a holistic way along the whole simulation environment engineering process. Achieving simulation interoperability requires efforts and standardization on the technical, the syntactic, the semantic,

and the pragmatic level. Focusing only on standards for distributed systems or reuse of components will not lead to simulation interoperability on higher levels.

Based on these conclusions, MSG-086 worked out proposals for future activities within the NMSG and for cooperative actions with SISO. One of the most promising approaches towards improving simulation interoperability is a service-oriented approach, commonly referred to as “M&S as a Service”. It is recommended to continue initial work done by MSG-131 (“Modelling and Simulation as a Service: New Concepts and Service-Oriented Architectures”) and to investigate the potential of M&S as a Service by a dedicated Task Group. Regarding cooperative action with SISO the recommendation is to transform the “Guideline on Scenario Development for (Distributed) Simulation Environments” into an official SISO standard.

Guide en vue du développement de scénario dans le cadre de simulation distribuée

(STO-TR-MSG-086-Part-II)

Synthèse

Puisque le questionnaire d'analyse des lacunes de M&S du MORS du NMSG a déterminé que le manque d'interopérabilité de la simulation constituait la lacune prioritaire à combler en matière de capacité, une équipe exploratoire (ET-027) a été constituée au sein du NMSG pour étudier l'interopérabilité de la simulation. L'ET-027 a identifié 63 problèmes qui limitent fortement l'interopérabilité de la simulation. Le MSG-086 « Interopérabilité de la simulation » a été créé en 2010 sur la base des conclusions de l'ET-027 ; sa mission est d'analyser les problèmes d'interopérabilité mis au jour par l'ET-027. Cette analyse devait servir à recommander et créer des prototypes d'applicatifs qui améliorent les processus de création et réalisation de simulation distribuée (DSEEP, *Distributed Simulation Engineering and Execution Process*) [DSEEP] afin d'atténuer ou éviter les problèmes d'interopérabilité identifiés. Au total, le MSG-086 identifie et décrit 46 problèmes d'interopérabilité et les classe en neuf groupes. Tous les problèmes sont documentés selon le même schéma ainsi que leur lien avec les normes de M&S associées.

Les normes actuelles relatives aux environnements de simulation distribuée se concentrent principalement sur les niveaux technique, syntaxique et (dans une certaine mesure) sémantique de l'interopérabilité. Pour répondre aux besoins futurs, notamment en termes de qualité et de réduction des délais et des coûts, l'interopérabilité de la simulation doit avoir lieu à des niveaux plus élevés (autrement dit, aux niveaux pratique, dynamique et conceptuel) de même que l'automatisation relative du développement, de l'intégration et de la mise en œuvre des environnements de simulation distribuée.

Cela exige une normalisation des applicatifs créés pendant le développement d'un environnement de simulation, à la suite, par exemple, du DSEEP. Ces produits normalisés doivent répondre à des niveaux d'interopérabilité supérieurs aux normes actuelles d'interopérabilité de la simulation, qui se concentrent sur des niveaux inférieurs (autrement dit, les questions techniques, syntaxiques et sémantiques).

En partant des problèmes d'interopérabilité identifiés et de leur impact sur le processus d'ingénierie de l'environnement de simulation, le MSG-086 a concentré ses efforts sur la problématique liée au « scénario ». Afin d'améliorer l'interopérabilité de la simulation dans le contexte du DSEEP, le MSG-086 a rédigé un « Guide au développement des scénarios dans les environnements de simulation (distribuée) ». Ce guide augmente le DSEEP relativement à l'élaboration des scénarios et propose un contenu et une structure d'applicatif pour la spécification des scénarios.

En outre, le MSG-086 délivre les résultats secondaires et documents suivants :

- Recommandations de mise à jour de l'AMSP-01 [AMSP-01] relativement à l'interopérabilité de la simulation et au développement des scénarios.
- Proposition de mise à jour du questionnaire d'analyse des lacunes du Sous-groupe des besoins opérationnels militaires (MORS) du NMSG.
- Recommandations aux groupes de travail de la SISO (par exemple, DSEEP, FEAT et SCM), en particulier au sujet du développement des scénarios.

L'une des grandes conclusions du MSG-086 (en plus de la documentation détaillée sur les problèmes d'interopérabilité de la simulation) est que l'interopérabilité de la simulation n'est pas fondamentalement une question technique, mais qu'elle doit être abordée de manière holistique tout au long du processus d'ingénierie de l'environnement de simulation. L'interopérabilité de la simulation exige du travail et une normalisation aux niveaux technique, syntaxique, sémantique et pragmatique. Il ne suffit pas de se focaliser sur les normes des systèmes distribués ou sur la réutilisation de composants pour améliorer l'interopérabilité de la simulation.

A partir de ces conclusions, le MSG-086 propose des activités futures au sein du NMSG et des actions en coopération avec la SISO. L'une des approches les plus prometteuses pour améliorer l'interopérabilité de la simulation est une approche axée sur le service fourni, couramment appelée « M&S en tant que service ». Il est recommandé de poursuivre le travail initial accompli par le MSG-131 (« Modélisation et simulation en tant que service, de nouveaux concepts et de nouvelles architectures axées sur le service ») et de confier à un groupe de travail spécial l'étude du potentiel de la M&S en tant que service. En ce qui concerne les actions en coopération avec la SISO, il est recommandé de transformer le « Guide au développement des scénarios dans les environnements de simulation (distribués) » en une norme officielle de la SISO.

Chapter 1 – INTRODUCTION

1.1 MOTIVATION

Regardless of the application domain – e.g., training, analysis or decision support – scenarios are used to specify situations and conditions to be represented in a simulation environment for the intended purpose of a simulation application. Typically a scenario specification contains information about the geographic location, involved entities, about the initial situation and about pre-planned courses of action and major events happening during the simulation execution. Therefore, scenarios defined by the user of a simulation environment are paramount sources of requirements for the engineers faced with planning and setting up a simulation environment. As such, well-specified scenarios are of utmost importance. If such scenarios are missing, this may lead to various problems due to misunderstandings when talking about the objectives and scope of a simulation environment. As a result, the conceptual model (and the subsequently developed simulation environment) may not reflect what the user originally wanted. In other words, the simulation environment does not fulfil the original requirements or does not answer the questions originally posed. Therefore, missing or incompletely specified scenarios will lead to simulation results that do not reflect what the user was expecting.

Ideally, a scenario specification should be:

- Complete;
- Consistent; and
- Understandable.

Completeness means that a scenario specification has to contain sufficient information to enable persons in the subsequent process (especially during development of the conceptual model) to use the scenario in a meaningful way and to extract all information required for their activities. Consistency refers to the internal correctness of a scenario specification (e.g., no unit belongs to more than one party; initial positions of all units are within the specified geographic area). Understandability requires that a scenario specification has to be written and structured in a way that it is easily accessible by future users.

1.2 PURPOSE

The purpose of this guideline is to provide detailed information regarding the development of scenarios for (distributed) simulation environments and the relationship of the scenario development process with the overarching simulation environment engineering process. This guideline is based on the Distributed Simulation Engineering and Execution Process (DSEEP) [DSEEP] and augments the DSEEP with additional information specific to scenario development.

This guideline gives an overview of existing standards and tools that may be used for scenario development. However, due to missing experiences and large differences between simulation environments this guideline does not recommend specific standards.

1.3 SCOPE

The primary scope of this guideline is the development of scenarios in context of (distributed) simulation environments.

Although similar in nature, this guideline does not explicitly address scenarios used in live exercises or Computer-Assisted eXercises (CAX). Nevertheless, many considerations laid out in this guideline are also applicable to these application domains.

1.4 INTENDED AUDIENCE

The intended audience of this guideline includes (but is not limited to):

- Primarily, project managers and simulation engineers which need to set up a simulation environment;
- Users and subject-matter experts which define and specify requirements for a simulation environment; and
- Operator personnel that operates simulation systems and other member applications of a simulation environment.

This guideline is not restricted to a specific application domain (e.g., military scenarios), but may be applied in various different application domains (e.g., crisis management scenarios).

1.5 DOCUMENT OUTLINE

- As many problems arise out of different interpretations of the term “scenario”, Chapter 2 defines the term “scenario” and provides related terminology. Afterwards, different types of scenarios within different steps of the DSEEP are identified and described in detail.
- Chapter 3 presents necessary scenario documentation. Based on both practical experiences as well as literature research, a set of documentation items for specifying scenarios is presented.
- Chapter 4 discusses maturity levels for scenario specifications and highlights the importance of formal scenario specifications (e.g., using MSDL).
- Chapter 5 provides an overview of currently available standards and tools for scenario specification. Features currently missing in available standards are identified.
- Annex A and B describe how the NATO Architecture Framework and Base Object Models are related to scenario specifications.
- Annex C and D present two example scenario specifications.

Chapter 2 – SCENARIOS IN DISTRIBUTED SIMULATION ENVIRONMENTS

2.1 DEFINITION "SCENARIO"

The term "scenario" has many definitions. An exhaustive overview of definitions for the term "scenario" is given in [MSG-053] and [12S-SIW-014]. The definition recommended by this guideline in context with the development and execution of simulation environments is the following:

> "*A scenario is a description of the hypothetical or real area, environment, means, objectives, and events during a specified time frame related to events of interest.*" [MSG-053, pp. 2-3]

This definition was proposed by the NATO Modelling and Simulation Group MSG-053 "Rapid Scenario Generation for Simulation Applications" and a similar definition can be found in [NATO_COBP].

As the term "scenario" may have a different meaning in another context (e.g., CAX), it is stressed that this document is primarily concerned with scenarios in the context of (distributed) simulation environments.

Unfortunately, as experience shows again and again, the term "scenario" is used in an ambiguous way, even if there is agreement about the above definition:

1) Use of the term "scenario" in context with the first steps of the development and execution process of simulation environments ("Define Simulation Environment Objectives" (Step 1 of the DSEEP) and "Perform Conceptual Analysis" (Step 2 of the DSEEP), in particular with Step 2, Activity 2.1 ("Develop Scenario") of the DSEEP):

   > "*The purpose of this activity is to develop a functional specification of the scenario. Depending on the needs of the simulation environment, the scenario may actually include multiple scenarios, each consisting of one or more temporally ordered sets of events and behaviours (i.e., vignettes).*" [DSEEP, p. 13]

2) Use of the term "scenario" in context with later steps of the development and execution process of simulation environments ("Develop Simulation Environment" (Step 4 of the DSEEP) and "Plan, Integrate and Test Simulation Environment" (Step 5 of the DSEEP), in particular with Step 4, Activity 4.2 ("Establish Simulation Environment Agreements") of the DSEEP):

   > "*Once all authoritative data sources that will be used in support of the simulation environment have been identified, the actual data stores are used to transition the functional description of the scenario (developed in Step 2; see Figure 4) to an executable scenario instance (or set of instances).*" [DSEEP, p. 26]

To clarify the scenario terminology, the following sections describe the scenario development process and the three different types of scenarios that are developed during this process.

2.2 SCENARIO DEVELOPMENT PROCESS

During the planning and design process of a simulation environment, the scenario specification is continuously refined and augmented with additional information. In order to establish a clear understanding of scenarios and their role within distributed simulation environments, a three-step scenario development process is proposed. As shown in Figure 2-1 three types of scenarios are distinguished:

- Operational scenarios;

- Conceptual scenarios; and
- Executable scenarios.

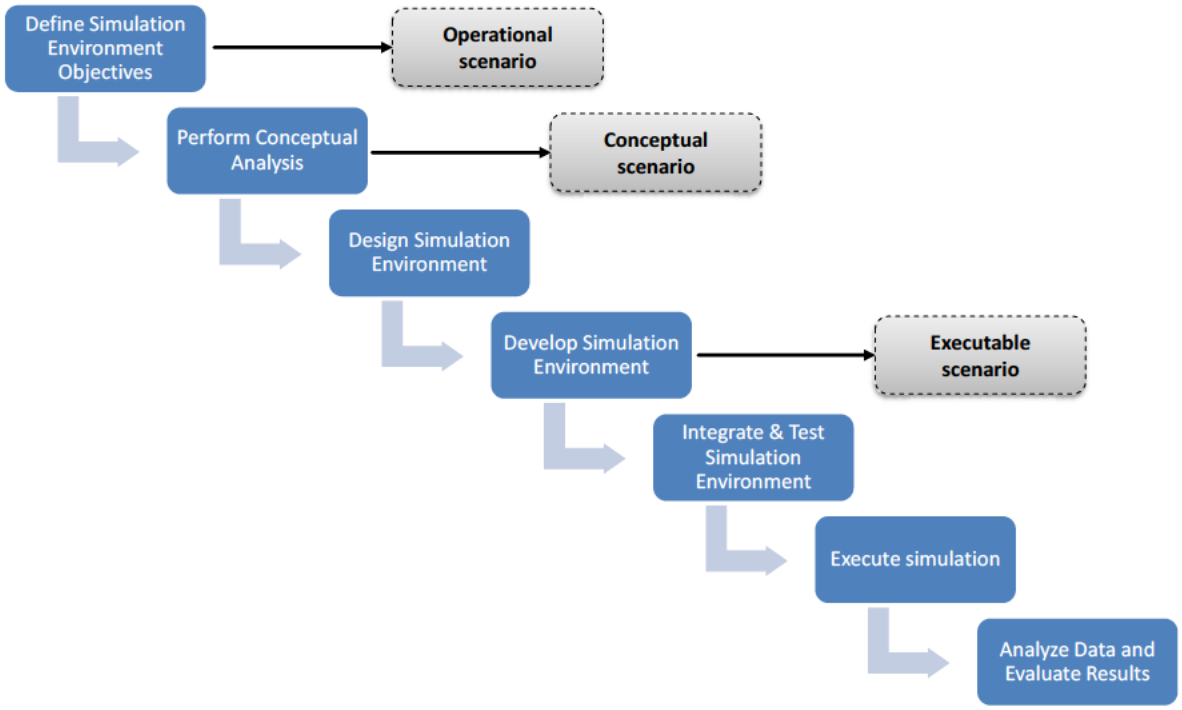

Figure 2-1: Types of Scenarios in the Simulation Environment Engineering Process.

Table 2-1 gives an overview of DSEEP activities in which the three types of scenarios are created and which persons are (mainly) involved. Detailed descriptions on each type of scenario are given in the following sub-sections.

Table 2-1: Types of Scenarios and Their Relation to DSEEP Activities.

Type of Scenario	DSEEP Activities	Involved Persons
Operational scenario	Activity 1.1 "Identify User/Sponsor Needs" and Activity 1.2 "Develop Objectives"	User/sponsor, Subject-Matter Experts (SMEs)
Conceptual scenario	Activity 2.1 "Develop scenario"	M&S experts (assisted by user and SMEs)
Executable scenario	Activity 4.2 "Establish Simulation Environment Agreements"	M&S experts, system operators

Within this guideline the terms "user" and "sponsor" are used in the sense of the DSEEP:

> *"The person, agency, or organization who determines the need and scope of a distributed simulation exercise or event, and establishes the funding and other required resources. The user/sponsor also approves the participants, objectives, requirements, and specifications. The user/sponsor appoints the simulation environment manager and verification, validation, and accreditation/acceptance (VV&A) agents."* [DSEEP, p. 4]

2.2.1 Operational Scenario

Operational scenarios are authoritative descriptions by Subject-Matter Experts (SMEs) – using their domain-specific terminology – of those parts of the real world that need to be represented in the simulation environment. Operational scenarios are required to specify what has to be represented in a simulation environment to fulfil the user's needs and objectives. Authoritative means that operational scenarios are binding requirements for the development of a specific simulation environment.

Operational scenarios have to be provided by the user or sponsor (probably assisted by subject-matter experts) at the very beginning of the planning process of a simulation environment (DSEEP Step 1 "Define Simulation Environment Objectives"). Operational scenarios are of highest importance as they are authoritative sources of requirements for the intended simulation environment. Jointly with further requirements (e.g., regarding cost, schedule or validity) they provide the frame for the M&S experts which are designing and engineering the simulation environment.

As illustrated in Figure 2-2, the simulation application space (i.e., the totality of possible simulation applications) may be structured using the following 5-dimensional structure (see [NMSG-024, Chapter 3]):

1) Simulation application mode (education, training, exercise, research and development, experimentation, execution support).
2) Capability/Activity (defence analysis and planning, operational analysis and planning, conducting operations).
3) Military level (technical (systems), tactical, operational, strategic, political).
4) Kind of mission (Article 5 (missions related to war), Non-Article 5 (missions related to operations other than war)).
5) Staff involved (CJ1, CJ2 (staff taking care of enemy forces), CJ3 (staff taking care of own forces), CJ4 (logistics staff), CJ9, etc.).

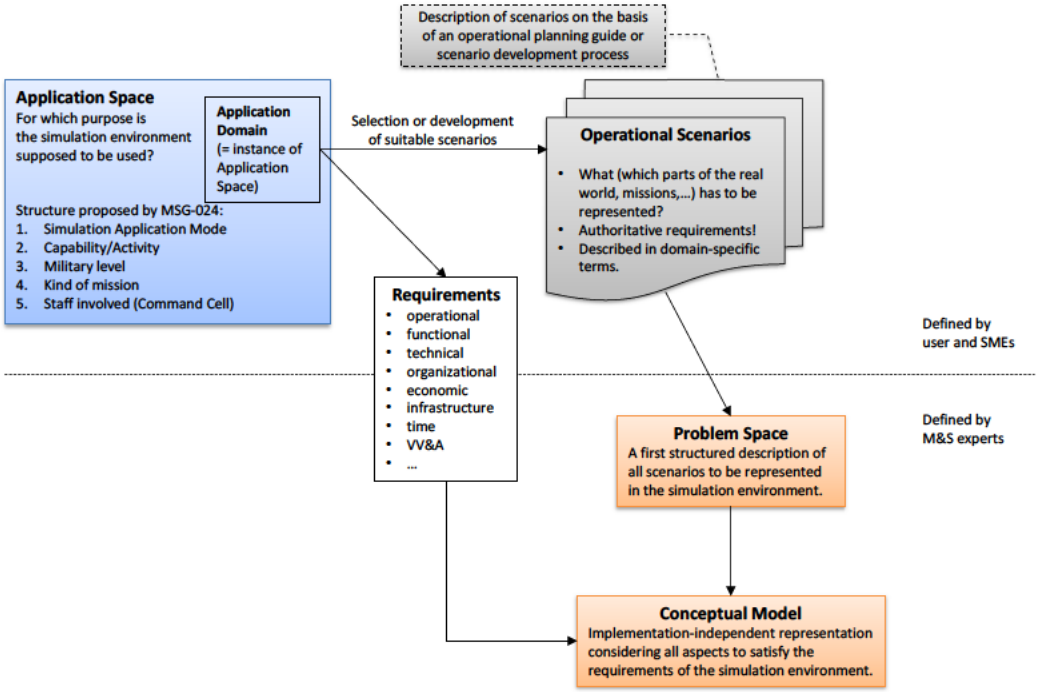

Figure 2-2: Role of Operational Scenarios in the Early Steps of a Simulation Environment Engineering Process.

A single instance of the simulation application space is denoted as "Application domain". An example for an instance of the application space (thus for an application domain) could be:

- For training;
- In defence analysis/planning;
- On the operational level;
- In context with a peace support operation (Non-Article 5); and
- For the CJ4 (Logistics).

Thus, specifying the application domain forces the user to answer the question "For which purpose is a simulation environment supposed to be used?" Based on the specification of the application domain, suitable operational scenarios have to be selected (if available) or developed. In practice, the user often specifies an operational scenario before defining all objectives and questions. In this case, it is important that the application domain is aligned with the given operational scenarios. The alignment process may be iterative, i.e., based on a given operation scenario the application domain and the questions to be answered are specified, these questions may then be used to refine the operational scenarios.

As operational scenarios are authoritative sources of requirements for the subsequent development of the simulation environment they provide:

- A description of a real or fictitious piece of the world of interest, including the initial state and desired end state;
- The effects considered to be necessary for a transition from the initial state to the desired end state;
- The required tasks to accomplish these effects;
- The required capabilities to enable these tasks; and
- The required force packages to assure these capabilities.

It has to be kept in mind that descriptions of operational scenarios differ depending on the level of the scenario (e.g., political, strategic, operational, tactical). For multi-level simulation environments a consistent hierarchy of operational scenarios is mandatory.

Operational scenarios are described in terms the user is familiar with and may be documented in any format. Often a combination of a graphical and a textual description is chosen. Ideally – to capture all aspects of relevance – the descriptions of such operational scenarios should follow an operational planning process or scenario development process as described in [NMSG-024], [NATO_COPD]. For each selected or developed operational scenario it has to be described how it is related to the application domain and how it supports the original objectives and needs of this application domain.

Each scenario description could (depending on the application domain) embrace all or parts of the following information:

- Reason for the creation and use of the scenario, objectives of the scenario, relation to the application domain;
- Relation to higher and/or lower level scenarios (hierarchy of scenarios!);
- Historical context, road to war/operations;
- PMESII (political, military, economic, social [cultural, humanitarian, legal], infrastructure, information);
- Types and numbers of major entities (units, personnel, equipment, resources [facilities, logistics, associated sustainment]) that must be represented within the simulation environment;

- A description of the characteristics, capabilities, behaviour, and relationships between these major entities over time;
- Missions (initial state and desired end state), operations, tasks, and associated effects of these entities over time;
- Sequence of actions or occurrences relevant to the objectives, TOEL (Time-Ordered Event List [-> events can change the environment dynamically]), MEL/MIL (Main Event List / Main Incident List);
- Playbook, game plan (plans, orders, associated behaviours);
- Constraints (doctrines, rules of engagement, orders, control measures);
- A specification of relevant environmental conditions (terrain [urban terrain versus natural area, type of terrain, positions for physical objects], ocean, space, atmosphere/weather, day/night, climate, etc.) that impact or are impacted by entities in the simulation environment; and
- Specific geographic regions (areas of operations, areas of interest, geographical locations of objects of interest).

As far as possible these information should be based on authoritative sources and documents.

A sub-step between the "Operational Scenarios" and the "Simulation Environment Requirements" is the "Problem Space" (see Figure 2-2). The problem space defines which (or which parts) of the operational scenarios (possibly simplified, adapted, or extended) have to be represented in the simulation environment. While the operational scenarios are defined by the user, the problem space is defined by M&S experts (in collaboration and interaction with SMEs). The problem space, together with additional requirements derived from the objectives and needs of the intended application domain, forms the cornerstones for the derivation of the requirements for the development of the conceptual model for a simulation environment.

Thus, operational scenarios are characterized by the following aspects:

- They answer the question "What has to be represented in a simulation environment?";
- They are described by SMEs using domain-specific terminology and guidelines;
- They are human readable;
- They are related to a certain application domain (= instance of the application space); and
- They are a basic pre-requisite and authoritative source for the definition of the problem space, thus for the development of the conceptual model of a simulation environment (DSEEP Activity 2.1).

2.2.2 Conceptual Scenario

The operational scenarios provide a coarse description of the intended situation and its dynamics, but usually do not contain enough information for deriving a conceptual model and designing a simulation environment. For development of a conceptual model as fundamental pre-condition for the development of a simulation environment the operational scenarios need to be refined and augmented with additional information.

This is the focus of DSEEP Activity 2.1 ("Develop Scenario") which will most often be carried out by M&S experts (lead) which are assisted by the user and further subject-matter experts. The resulting "conceptual scenarios" provide a detailed specification of the piece of the world to be simulated and should provide all necessary information for persons which are involved in later steps of the simulation environment engineering process.

Although the conceptual scenarios are primarily developed by M&S experts, a tight integration of the original user and subject-matter experts is usually necessary. This helps to reduce misunderstandings and ensures that the right conceptual scenarios are derived from the given operational scenarios.

Like the operational scenarios also the conceptual scenarios are specified in terms the user is familiar with. Yet, as the development of the conceptual scenarios is led and coordinated by M&S experts this transfer of responsibility is also reflected in the scenario specification. Especially, the M&S experts should aim for a more structured specification of conceptual scenarios and should ensure that all information required for setting up a simulation environment is specified. This may be supported by enforcing a more precise use of simulation-related terms. Also the use of specialized tools or methodologies for scenario specification should be considered.

2.2.2.1 Relation of Conceptual Scenario and Operational Scenario

The totality of operational scenarios to be represented in a simulation environment determines what is also known as the "mission space". Based on the operational scenarios (or the "mission space"), the conceptual scenarios are derived (as abstractions of the underlying operational scenarios). The conceptual scenarios provide a specification of that piece of the real world which is reflected by the mission space (respectively the operational scenarios).

2.2.2.2 Relation of Conceptual Scenario and Conceptual Model

The DSEEP treats the development of conceptual scenarios in Activity 2.1 "Develop Scenario". This activity is intimately connected to Activity 2.2 "Develop Conceptual Model", and as described by the DSEEP the conceptual scenario and the conceptual model may be developed in parallel. The conceptual model describes the entities and their static and dynamic relationships.

For this purpose, the conceptual model may define entity classes and their attributes (much like classes are defined in any object-oriented programming language), for example:

> Entity class "Helicopter H-1"
>
> Attributes: remainingFuel in litres, ammunition in rounds

Following an object-oriented view, conceptual scenarios may reference and instantiate these entity classes (see Figure 2-3). It is important to note that other "views" (e.g., ontology-related approaches [Mojtahed2005, Mojtahed2008], architecture approaches using NAF) exist and may be more appropriate for specifying certain conceptual models. The object-oriented view is chosen here only as an example.

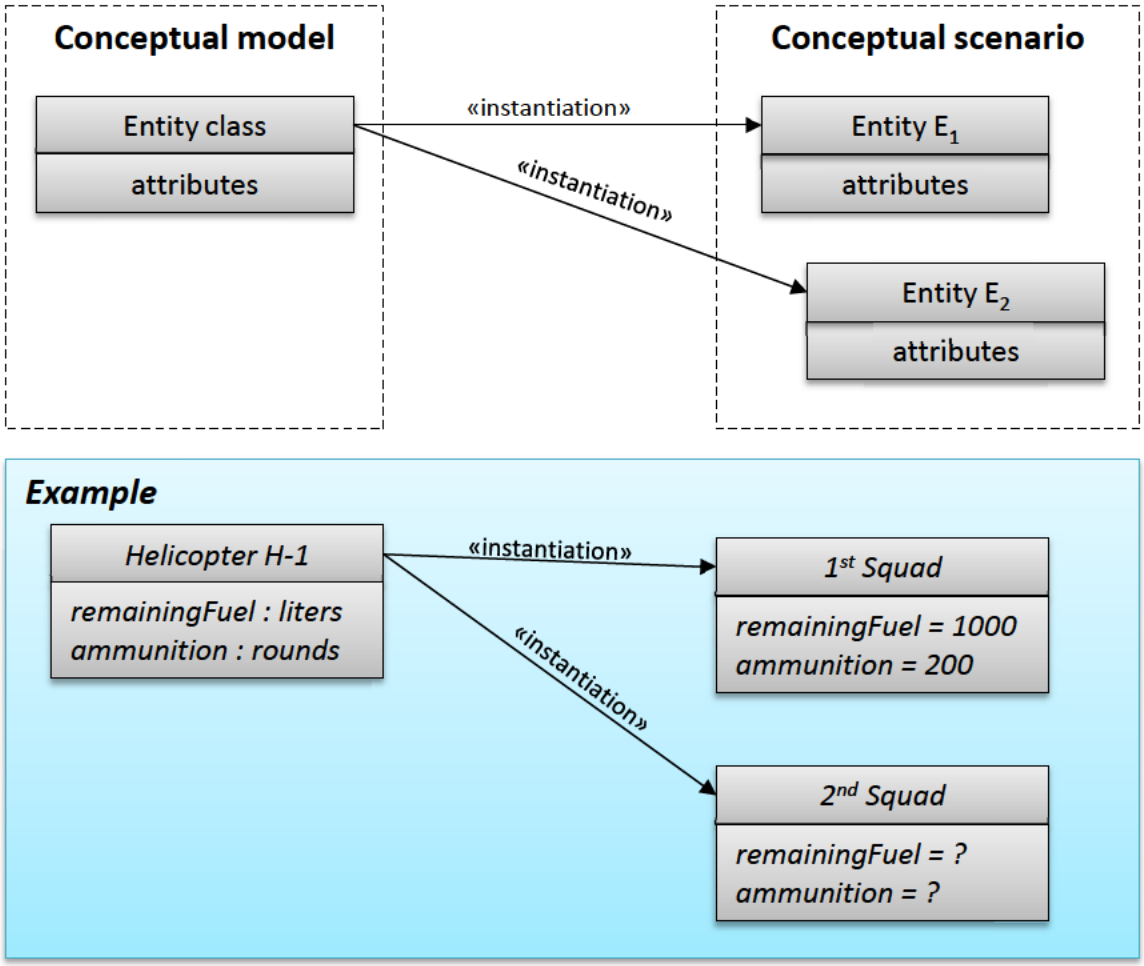

Figure 2-3: Relation of Conceptual Scenario and Conceptual Model Regarding Entity Classes and Entities (Top) and Example (Bottom).

A conceptual scenario may contain multiple entities of the same entity class. For consistency and completeness it is important that the conceptual scenario and the conceptual model are aligned. This requires at least that each entity of the conceptual scenario must be associated with an entity class defined in the conceptual model. Ensuring this alignment is part of the verification and validation activities accompanying the original simulation environment development process.

It is important to identify all attributes (or parameters) and to specify them unambiguously during development of conceptual scenarios (e.g., an attribute for temperature expressed in °F or °C, or wind speed expressed in km/h or m/s). In addition, where applicable, the definition of valid value ranges for attributes can help avoid misunderstanding (e.g., wind speed has to be a positive value).

As illustrated in Figure 2-3, a conceptual scenario may assign values to entity attributes. However, assignment of attribute values is not strictly necessary at this point in time and may be delayed until specification of executable scenarios.

2.2.3 Executable Scenario

Once the simulation environment is designed and set up, the conceptual scenarios have to be made available to all simulation systems and other member applications of the simulation environment. For this purpose the

conceptual scenarios need to be transformed into "executable scenarios". This is the done in DSEEP Activity 4.2 ("Establish Simulation Environment Agreements").

An executable scenario is the specification of a specific situation providing all information necessary for preparation, initialization and execution of a simulation environment. The transformation from conceptual scenarios to executable scenarios is done primarily by the operator personnel of the member applications of the simulation environment (possibly assisted by M&S experts or SMEs). Ideally, the resulting executable scenarios should be specified in a way that they are directly accessible by the member applications (e.g., as a file or via a web service).

The DSEEP is using the term "executable scenario instance". For an expert this term describes quite well what is meant. However, unfortunately this term is not further defined in the DSEEP, and even M&S experts continue to use just the term "scenario" in this context, again and again generating confusion. We propose the following definition for "Executable scenario":

> An **executable scenario** is a specification of a specific scenario that provides all information necessary for preparation, initialization and execution of a simulation environment.

In order to get a simulation environment "ready for execution", three basic steps have to be carried out:

1) The entities to be represented in the execution of a simulation environment have to be selected (as specified in the executable scenario that will be executed). Of course these entities have to be defined in the conceptual model of the simulation environment that was derived from given operational scenarios as described above.
2) These entities have to be allocated to individual federates within a simulation environment (see Figure 2-4). This decision determines which federate executes which entities.
3) Certain initial values have to be assigned to the attributes of these entities (see Figure 2-5).

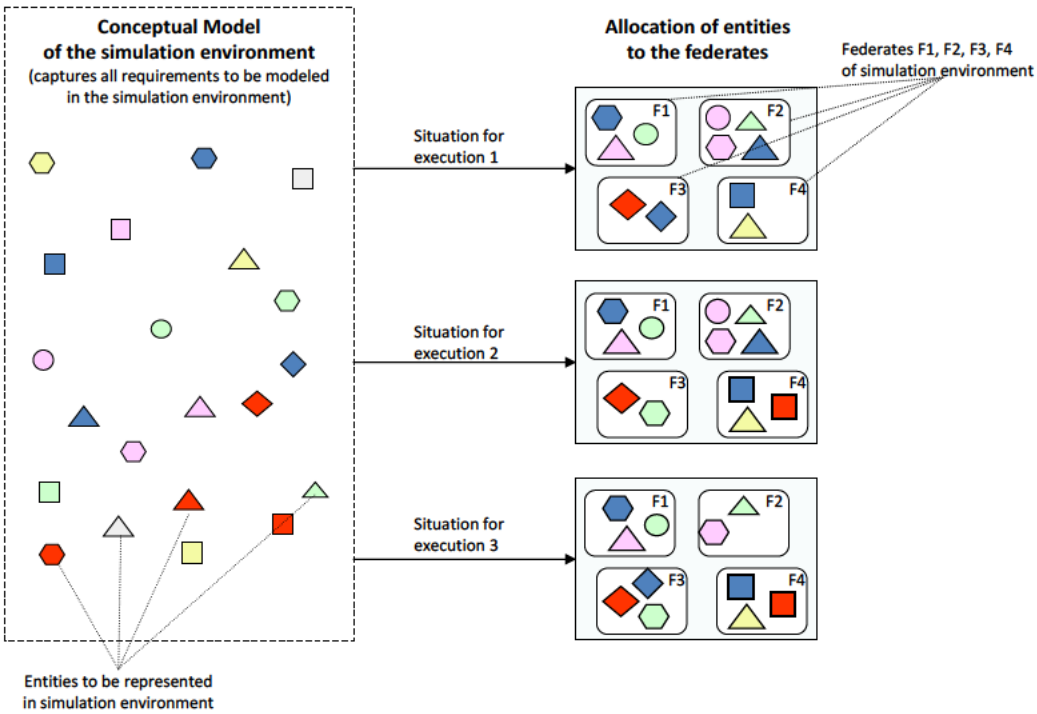

Figure 2-4: Allocation of Entities to Federates of a Simulation Environment for Different Executions of the Simulation Environment.

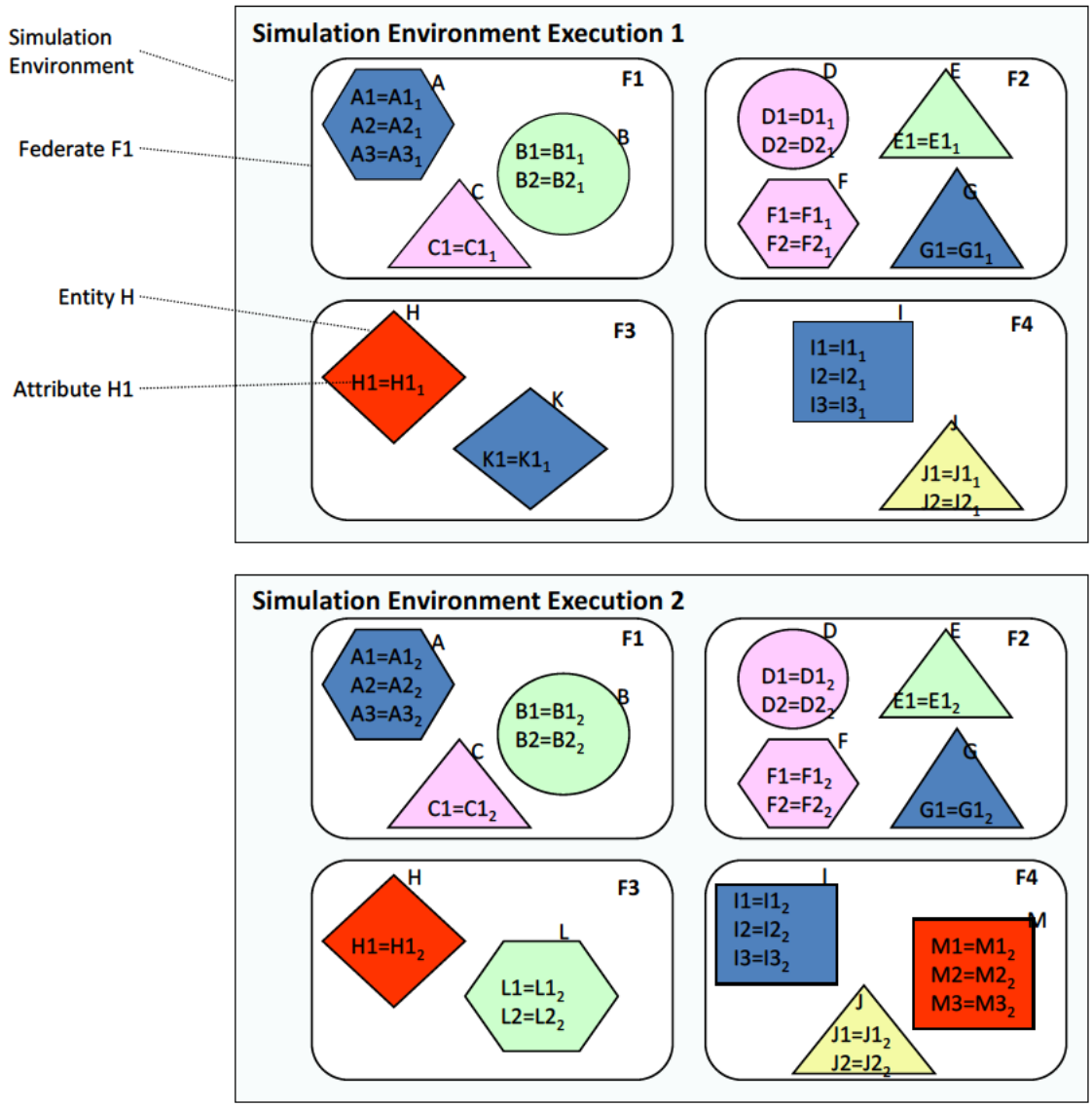

Figure 2-5: Allocation of Values to Attributes of Entities to be Represented by the Different Federates for Different Simulation Environment Executions.

Thus, in this context always the term "executable scenario" should be used. An executable scenario is characterized by the following aspects:

- It answers the question "What (which specific entities with which specific characteristics) has to be represented in a specific federate of a specific simulation environment execution?".
- It represents a sub-space of the problem space, which means parts of the conceptual model of the simulation environment.
- It is a basic pre-requisite for the execution of a simulation environment (DSEEP Activity 4.2). Therefore, it must be possible to derive specific configuration files and settings from an executable scenario to configure and initialize each system of a simulation environment.
- It is developed by mainly by operator personnel (probably assisted by M&S experts) and described using technical terminology and guidelines.
- Ideally it should be machine-readable and re-useable (e.g., using a specific XML schema).

2.3 AUXILIARY TERMS

2.3.1 Vignettes

In order to structure scenario specifications and to allow more flexible reuse of dedicated parts of a scenario, the term "vignette" is regularly used. Currently many definitions exist of which most definitions are to some degree circular [EU CTF, p. 89] [DSEEP, p. 13f.] [DoD M&S Glossary, p. 158]. Furthermore, a practical drawback of these definitions is that they do not distinguish clearly between a scenario and a vignette. More or less, vignettes are considered to be small scenarios or to be smaller than a regular scenario. This leaves much space for interpretation and, from experience, missing clarity and understandability is a key factor for missing user adoption.

Within this guideline a vignette is defined as follows:

> A **vignette** is a reusable temporally ordered set of events and behaviours for a specific set of entities.

As described in the EU Core Technical Framework study [EU CTF, p. 103ff.], vignettes may be thought of as small, ideally self-contained parts of a scenario.

2.3.2 Scenario Variants

For purposes of experimental design a scenario is often analysed and executed in different variants. We propose the following definition in this context:

> A **scenario variant** is a scenario which is derived from another scenario by variation of isolated parameters for purposes of experimental design (e.g., different units but otherwise no changes).

Scenario variants may be specified for all three types of scenarios, although they are most common in context of executable scenarios. Table 2-2 illustrates an example for usage of scenario variants during the scenario development process.

Table 2-2: Example of Scenario Variants.

Conceptual Scenario "Air Defence"	**Executable Scenarios**		
Unit "Enemy Helicopter"	**Base Variant**	**Variant 1: Low Altitude Approach**	**Variant 2: High Altitude Approach**
Attribute "Height : Metres"	Height = 500	Height = 50	Height = 2300
Attribute "Remaining Fuel : Litres"	Remaining Fuel = 1000	Remaining Fuel = 1000	Remaining Fuel = 1000
Attribute "Ammunition : Rounds"	Ammunition = 200	Ammunition = 200	Ammunition = 200

2.3.3 MEL/MIL

A further term commonly used in context of executable scenarios used for training and exercise purposes is "Main Events List" or "Main Incidents List" (MEL/MIL). In this terminology, events are major occurrences or a sequence of related incidents, which are actions or situations that provide greater clarity to an event [Cayirci2010]. The only publicly available definition is the following:

"Master scenario events list:
A chronological list that supplements the exercise scenario with event synopses; expected participant responses; capabilities, tasks, and objectives to be addressed; and responsible personnel. It includes specific scenario events (or injects) that prompt players to implement the plans, policies, and procedures that require testing during the exercise, as identified in the capabilities-based planning process. It also records the methods that will be used to provide the injects (i.e.,> phone call, facsimile, radio call, e-mail)." [DoD M&S Glossary, p. 121]

Such event lists define courses of action within a surrounding situation. Therefore, they may be used similarly as vignettes to specify dedicated parts of a scenario in a reusable way.

Chapter 3 – CONTENT OF A SCENARIO

Following the scenario definition given above the content of a scenario specification consists of three parts:

- Initial state;
- Course of events; and
- Termination conditions.

As these contents can be part of all three types of scenarios (operational scenarios, conceptual scenarios and executable scenarios), we do not distinguish between these three types of scenarios in this section unless explicitly noted otherwise. As illustrated in Figure 3-1, the content is continuously refined and augmented with additional information (e.g., regarding the actual systems used for executing a scenario).

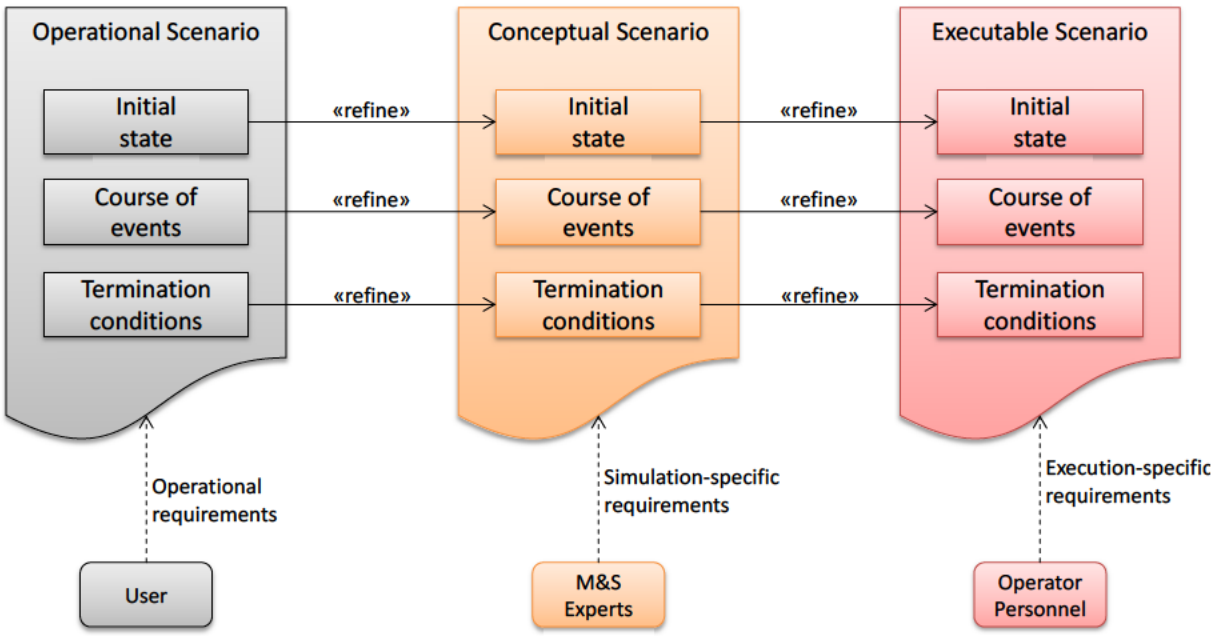

Figure 3-1: Refinement and Extension of the Content of a Scenario Along the Scenario Development Process.

3.1 PRELIMINARY REMARKS

Scenarios may be described on very different levels (e.g., scenarios on the political level, scenarios on the strategic level, scenarios on the tactical level). Ideally there should be a consistent hierarchy of scenarios from the political level down to the technical level. For example, a scenario on the strategic level should be derived from a political level scenario on top of it; a scenario on a tactical level should be derived from a scenario on a strategic level, and so on. Depending on the purpose of a simulation environment scenarios at a suitable level have to be selected and provided by the user. As many content items of a scenario description are the same for scenarios on all levels, we do not distinguish between scenarios of different levels in the following sub-sections, but present generic content items which are required in almost all scenario descriptions.

Furthermore, as the operational scenario is defined by the user, it is usually described in a way (regarding terminology and presentation) the user is familiar with. As the user usually is not an M&S expert, operational

scenarios may contain other or much more information than proposed in the following sections. During the process of transforming operational scenarios into conceptual scenarios, it is a major task of the M&S experts to structure the existing operational scenario description, to add missing information, and to strip off too detailed information. Yet, the following proposed content items for a scenario description may also serve well for describing operational scenarios.

3.2 INITIAL STATE

The initial state of a scenario defines the situation at the beginning of the scenario timeline. Therefore, the initial state typically contains information regarding the following aspects:

1) Objects and units;
2) Forces and force structure;
3) Geography;
4) Date/time;
5) Surrounding conditions; and
6) Rules of engagement.

The mentioned set of information items for describing the initial state of a scenario is suitable for a wide range of (military) scenarios. Nevertheless, specific scenarios may require more or other information items. Especially the presented set of information items is suited for scenarios which are directly involving forces and units. It is, for example, less suited for describing scenarios in context of cyberwar.

All information items are described in more detail in the following sub-sections.

3.2.1 Objects and Units

Enumeration and description of all objects and units of this scenario.

The purpose of this information item is to describe which units and objects take part in the scenario. It is particularly important to describe for each unit and each object why its participation in the scenario is necessary. It is necessary here to see the issue in connection with the requirements and justify the participation of the units and objects. In turn, the question should also be answered: What would be the consequence if a specific unit or object was not part of the scenario?

Every unit and object should be described by a common pattern (see Table 3-1 for an example). The JC3IEDM [JC3IEDM] describes in great detail which information is necessary (at least from an operational point of view) to describe an object, a unit, their states, attributes and capabilities. Therefore, the JC3IEDM may be taken as a starting point for deriving such a common documentation pattern.

Table 3-1: Example Information Set for Describing Units and Objects.

Information	Description
Identifier	Every unit and object should have an unambiguous identifier.
Description	The unit or object has to be described. If possible (or necessary) suitable sources or references should be given.
Number	The numbers in which the units and objects are present in the scenarios have to be determined.
Capabilities	All capabilities of the units and objects that are relevant for the scenario have to be described. It has to be justified with a view to the objectives of the simulation environment and the target values and requirements why a specific capability is important.
Behaviour	In what way(s) do the units act? Do alternative behaviours exist?
States	Which states (e.g., mobile, partly mobile, degree of damage) have to be distinguished concerning the units and objects?
Attributes	For each object and unit all attributes have to be identified that are required in context of the current scenario. If possible, valid value ranges for all attributes should be specified.

An important remark is that all relevant units and objects of a scenario have to be described. In turn, a scenario must not contain units or objects that are not described here.

3.2.2 Forces and Force Structure

Definition of forces and force structures, as well as definition of relationships of objects and assignment of units to forces. Also, command and control hierarchies may need to be specified.

This information is also known as Order of Battle (ORBAT):

> "*The identification, strength, command structure, and disposition of the personnel, units, and equipment of any military force.*" [AAP-06]

3.2.3 Geography

The purpose of this information item is to describe the geographic requirements for a scenario:

1) **Area of Interest**: Specification of the area of interest of this scenario (e.g., as rectangular bounding box);
2) **Special Requirements**: Requirements regarding buildings (e.g., real buildings or geotypical buildings), vegetation, roads, ditches; and
3) **Environmental Conditions**: Specification of all environmental conditions which are of interest within this scenario (e.g., day/night/dawn, rain/fog/snow/dust).

Again, the question has to be answered: Why are certain requirements necessary? All requirements must be derived from the objectives of the simulation environment.

3.2.4 Date/Time

Specification of date and time of the beginning of the scenario.

3.2.5 Surrounding Conditions

The surrounding conditions provide an overview of all scenario-related information and are described according to the PMESII approach:

1) Political situation;
2) Military situation;
3) Economic situation;
4) Social situation / Cultural aspects;
5) Information; and
6) Infrastructure.

This information item is especially important if real operators are integrated into the simulation environment (operating either virtual or live systems). Unless the behaviour of the real operators is completely determined *a priori*, the surrounding conditions may affect the actions of a real operator (e.g., whether a crowd is considered to be harmful or not, how to respond to enemy behaviour).

Especially if real operators are involved, it is important to stress that executable scenarios are not only specific files for initializing constructive simulations but may also be explanations, MEL/MIL, or story boards to "initialize" humans (e.g., personnel operating virtual systems).

3.2.6 Rules of Engagement

A clear definition of rules of engagement is necessary to ensure the correct (i.e., intended) behaviour of all participating personnel operating live and virtual systems as well as participating constructive systems.

3.3 COURSE OF EVENTS

Besides a specification of the initial state a typical scenario specification includes pre-planned events happening at a specific time. Such events are usually triggering some kind of reaction, either of a participating simulation system or a trainee within the simulation environment.

We propose to distinguish the following types of events:

1) Communication events;
2) Interaction events;
3) State change events; and
4) Environmental events.

Each event (whether triggered at a pre-planned point in time relative to the starting time of the scenario or triggered by some condition) injects a specific influence into the scenario. Typically, events (e.g., communication events like orders or interaction events like direct fire) are used to generate a specific situation onto which the participating member applications (live, virtual or constructive) have to react in a certain way. Intended reactions of the systems may be very different and depend heavily on the purpose of the simulation environment.

In general, the course of events of a scenario is defined by a set of events and corresponds to the Main Events List (MEL) used for training and exercise purposes.

The following sub-sections describe the four event types in more detail.

3.3.1 Communication Events

Communication events include all type of scenario-related communication (e.g., reconnaissance reports, orders). The sender of a communication may either be a participant of the simulation environment itself (e.g., another simulation system) or communication may be injected by exercise control (e.g., provision of fictitious news reports to operator personnel of a virtual or live system).

3.3.2 Interaction Events

Interaction events define explicitly interactions regarding objects and units of the scenario (e.g., one unit attacking another one or explosion of an improvised explosive device).

3.3.3 State Change Events

State change events are similar to interaction events but concern only a single object or unit (e.g., collapse of a bridge or breakdown of an armoured vehicle due to some technical malfunction).

3.3.4 Environmental Events

Sub-types of state change events are environmental events which specify state changes within the environment (e.g., beginning of rain).

3.4 TERMINATION CONDITIONS

Within (distributed) simulation environments conditions should be defined for each scenario determining the achievement of a final state and thus leading to a termination of the simulation run. Although FEDEP and DSEEP do not include termination conditions within their respective scenario definition, they mention termination conditions as one result of Activity 2.1 (“Develop Scenario”) [FEDEP, p. 10] [DSEEP, p. 14].

Two typical termination conditions for a scenario can be distinguished:

1) A specific condition is achieved (e.g., destruction of all enemy units); and
2) A pre-defined time is elapsed (e.g., two hours of simulation time).

Explicitly defining termination conditions is especially important for simulation environments which are executed in a fully automated fashion. Typical examples for this are constructive simulation systems used within data farming setups.

3.5 REUSE IN THE SCENARIO DEVELOPMENT PROCESS

As mentioned, operational scenarios are specified by the user. Therefore, the way to define and describe operational scenarios is usually dominated by domain-specific regulations (e.g., operational planning processes in the military domain). To avoid interference with these planning processes, considerations regarding reuse in the scenario development process are focussed on conceptual scenarios and executable scenarios. Nevertheless, operational scenarios may also be subject to reuse and specific operational scenarios should be derived from authoritative sources (e.g., major scenarios defined in defence policies).

Focusing on conceptual scenarios and executable scenarios, two general options for exploiting reuse in the scenario development process may be distinguished:

1) Reuse of a scenario as a whole; and
2) Reuse of specific parts of a scenario.

The first option requires putting in place sufficient storage mechanisms as well as augmenting scenarios with specific metadata (e.g., MSC-DMS [MSC-DMS]) for efficient retrieval. As the scenarios are reused as a whole, this option does not place any specific requirements on the scenario development process and does not impose any constraints on the scenario specification. All organizations involved in planning and developing (distributed) simulation environments should aim for at least this level of scenario reuse. Within this guideline, this option is not discussed any further.

Compared to the first option, the second option promises improved reuse possibilities and added flexibility. At the same time, option two requires decomposing a scenario into smaller parts (building blocks) which may then be assembled according to some rules to form a scenario. The remainder of this section is concerned with exactly this option and will discuss how the different parts of a scenario (initial state, course of events, termination conditions) may be split into components.

An obvious requirement for reuse of all kinds is that the applicability of existing components in a new context has to be thoroughly evaluated each time. This is also true for scenario components and has always to be kept in mind.

3.5.1 Components Regarding Initial State of a Scenario

Almost all parts of the initial state can be considered as components which may be reused separately in multiple scenarios. This is especially true for lists of objects and units as well as for information about forces and force structures. Similarly, the rules of engagement are a candidate for reuse as certain areas of operation are often associated with the same rules of engagement. Depending on the level of detail PMESII-related information (e.g., storybooks, country books) is also a candidate for reuse.

3.5.2 Components Regarding Course of Events of a Scenario

Although the term “vignette” is often not clearly distinguished from the term “scenario”, the basic idea behind it is highly valuable. The basic idea is to decompose a scenario into smaller components and to assemble new scenarios from existing components (cp. Section 2.3.1).

For the possibility to assemble new scenarios from existing building blocks (i.e., vignettes) and to achieve maximum reuse it is necessary to specify vignettes independently of scenarios. Therefore, a vignette should not contain specific geographic locations or similar information (cp. [EU CTF]).

For example, a simple vignette “air refuelling operation” might specify the rendezvous of a jet fighter and a tanker aircraft in detail without referring to actual coordinates. Instead, the vignette would describe positions relative to an imaginative starting point. Integrating this vignette into a specific scenario would only require specification of the coordinates of the starting point. This integration of a vignette into a specific scenario is done by introducing “vignette configurations” [EU CTF]:

A **vignette configuration** places a vignette or set of vignettes in a context of a specific scenario.

As vignettes describe a set of activities in a generic way they may roughly be associated with classes in object-oriented programming languages. Assigning actual values by defining a vignette configuration may then be associated with creating instances of a class (usually called an “object”).

With regards to the example above, the actual values needed for instantiating the vignette are the actual coordinates of the starting point for the air refuelling operation.

Figure 3-2 illustrates the relation of vignettes and vignette configurations in a scenario. Once vignettes are defined, multiple vignettes can be combined and instantiated with actual values to form a specific scenario.

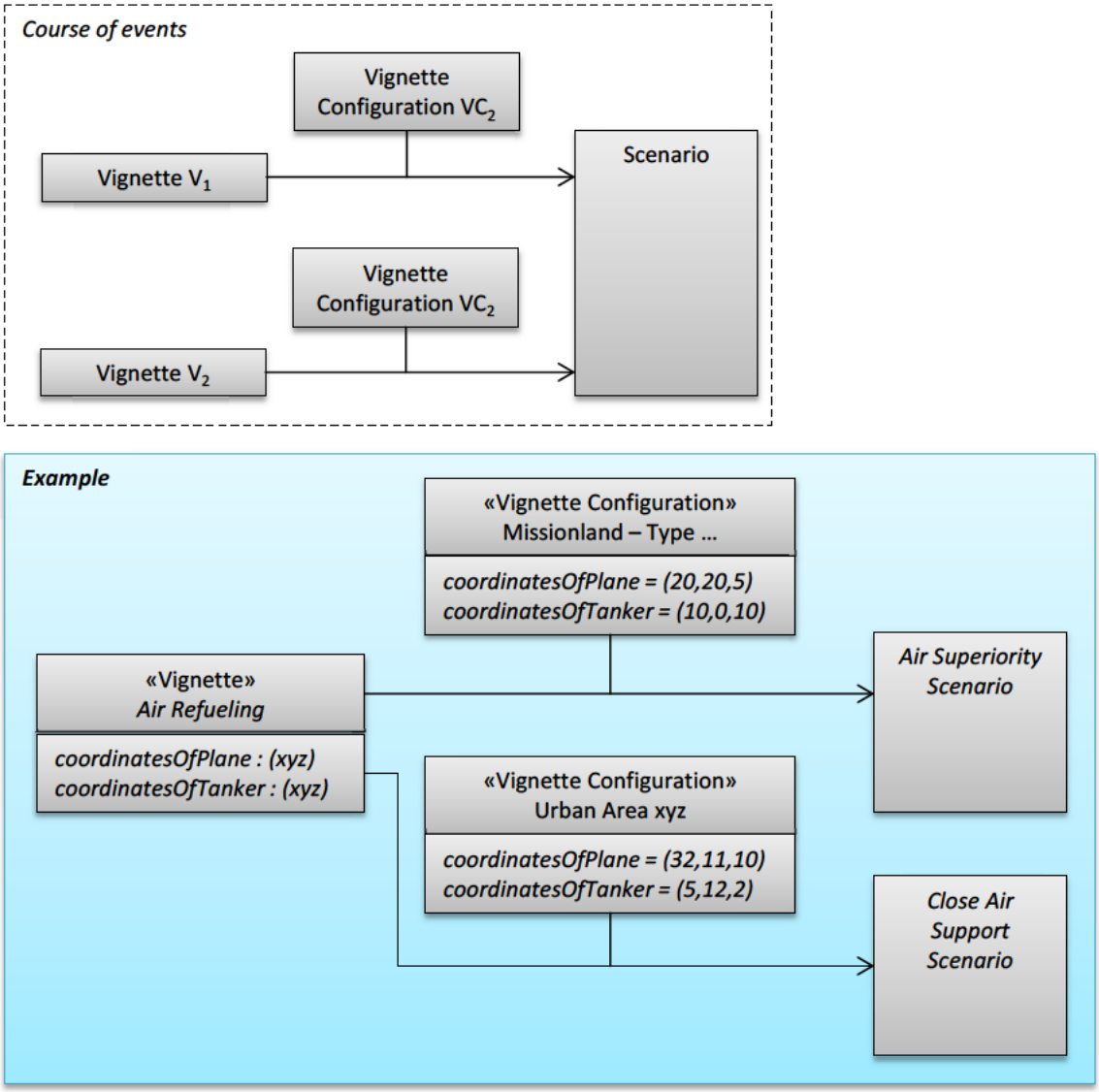

Figure 3-2: Relationship between Vignettes and Vignette Configurations for Composing a Scenario.

It is obvious that each vignette which is integrated into a scenario imposes certain requirements on the scenario (e.g., with regards to the area, entities). Two examples for vignettes are an air refuelling operation and a camp patrol task. Both impose specific requirements on the scenario:

1) **Air Refuelling Operation**: This vignette requires certain specific units to be defined in a scenario (like a tanker and a jet fighter) as well as a sufficiently large area; and
2) **Camp Patrol Task**: This vignette requires a specific terrain with a camp for which the patrol task will be executed.

It follows immediately that certain verification activities are required to ensure that selected vignettes and the remainder of the scenario are compatible with each other.

An important aspect is that vignettes should make use of parameters. Each parameter will be associated with an actual value during the process of integrating the vignette into a scenario. Examples:

1) **Air Refuelling Operation**: Possible parameters may be the starting points of the tanker and the jet fighter to be refuelled; and
2) **Camp Patrol Task**: Possible parameters may be the units executing the patrol task and their initial positions.

In general, the parameters used in vignettes give scenario developers the same degree of freedom as in common programming languages when writing methods. This includes the scenario developers decision on the degree of parameter usage for specific vignettes, i.e., vignettes might be specified in a way that "everything is parameterized" or vignettes may be defined in a way that "many to all aspects are hard-coded". The following two snippets of pseudo code show an example of a camp patrol task.

```
simple_campPatrolTask(unit u)
   // assume that unit u is at the camp's main gate
   While (scenario is running)
     Move south 500 metres
     Move east 300 metres
     …
   Endwhile
```

```
advanced_campPatrolTask(unit u, waypoint_list waypoints)
   // assume that unit u is at the camp's main gate
   While (scenario is running)
     For each waypoint in waypoints do
        Move to waypoint
      endfor
   Endwhile
```

The respective benefits of using parameters or hard-coding certain parts are the same as in programming languages. While hard-coded vignettes are quick and easy to create, they require detailed knowledge (e.g., about the camp) and effectively prohibit reuse (e.g., because the patrol task is intimately connected to a specific camp). Therefore, the use of parameters is highly encouraged.

3.5.3 Components Regarding Termination Conditions of a Scenario

The reuse of termination conditions is not detailed any further as the potential benefit of reuse seems to be too small compared to the effort for specifying the termination conditions.

Chapter 4 – MATURITY LEVELS OF SCENARIO SPECIFICATION

In order to assess the quality of a scenario specification, this guideline introduces maturity levels. Maturity levels are well known from CMMI (Capability Maturity Model Integration) which provides the following definition:

> "*Maturity level:*
> *Degree of process improvement across a predefined set of process areas in which all goals in the set are attained.*" [CMMI, p. 445]

With regards to CMMI, the core idea is to use maturity levels as an indicator for process improvement, i.e., a maturity level indicates that all goals defined for this level are achieved. Similarly, maturity levels may be used to indicate the quality of a scenario specification.

A 4-level maturity model for scenario specifications is proposed:

- Level 0 – No written scenario specification;
- Level 1 – Non-standardized scenario specification;
- Level 2 – Standardized scenario specification; and
- Level 3 – Formal scenario specification.

Table 4-1 provides an overview of the maturity levels of scenario specifications and typical ways to represent scenario specifications on each maturity level. Detailed descriptions are provided in the following sub-sections.

Table 4-1: Maturity Levels of Scenario Specification.

Maturity Level of Scenario Specification	Representation of the Scenario Specification
0 – No written scenario specification	Thoughts and ideas within the mind of the military user/SME; oral explanation.
1 – Non-standardized scenario specification	Free text documentation.
2 – Standardized scenario specification	Documentation which is structured according to a standard or agreed guideline or template.
3 – Formal scenario specification	Formal specification of a scenario.

4.1 LEVEL 0 – NO WRITTEN SCENARIO SPECIFICATION

Maturity Level 0 refers to the situation where no written scenario specification is available at all. In this case the scenario is only available within the minds of the participating persons and explained and communicated orally. Obviously, this kind of (unavailable) documentation is error-prone, arbitrarily fuzzy and effectively prevents all types of scenario reuse. Also, traceability and understandability are reduced to a minimum.

For these reasons, achieving only maturity Level 0 is in almost all conceivable cases not sufficient. Very seldom exceptions may be very small and focused simulation environments which are planned and set up by a single person (or very few persons).

4.2 LEVEL 1 – NON-STANDARDIZED SCENARIO SPECIFICATION

Maturity Level 1 indicates the existence of a scenario specification at least in a non-standardized way. In this context "non-standardized" means that the scenario specification is not created according to a generally accepted standard but structured according to the likings of the persons participating in planning and designing the simulation environment.

Compared to maturity Level 0, the main benefit of a non-standardized scenario specification is the availability of a scenario specification at all. The existence of documentation at all allows basic traceability of requirements and improves understandability of the simulation environment for directly involved persons as well as third parties.

However, a non-standardized scenario specification still comes along with many problems:

1) Due to a missing standardized documentation template, the familiarization effort for involved parties (user, M&S experts, system operators, etc.) is quite high;
2) Ensuring completeness of the scenario specification is complicated (due to missing checklists);
3) Comparability of scenario specifications is low as each scenario is specified differently; and
4) Reuse is hampered due to low comparability of scenario specifications and thus limited possibilities for efficiently searching and finding suitable existing scenarios.

Maturity Level 1 requires only the existence of a written scenario specification but does not require that this specification is structured according to any specific standard. Therefore, everybody who is specifying a scenario may use a different, custom structure for the scenario documentation. The scenario documentation may follow available standards like the DSEEP which give a few hints about the necessary content of a scenario specification. As the DSEEP does not provide detailed templates for scenario specification, it is sufficient to achieve maturity Levels 0 and 1, but is insufficient for achieving higher maturity levels of scenario specification.

4.3 LEVEL 2 – STANDARDIZED SCENARIO SPECIFICATION

Maturity Level 2 requires the creation of a standardized scenario specification and is a great step forward compared to maturity Levels 0 and 1. We deliberately interpret "standardized" rather broad and consider any scenario specification to be standardized if the standard is agreed upon beforehand jointly by all participants in the engineering process and if the standard is used across multiple simulation environments. Therefore, this broad use of the term "standardized" includes open standards and local standards (as defined by [AMSP-01]).

Open standards are defined by AMSP-01 [AMSP-01] as "Specifications that are developed by a standards organization or a consortium to which membership is open, and are available to the public for developing compliant products (with or without some license fee)". Examples for standards organizations are SISO, IEEE, and ISO. A key characteristic of open standards is their public availability that allows broad usage of such a standard.

AMSP-01 uses the term "Local standards" to denote specifications and standards that are organization-specific and usually not publicly available. Local standards reflect the fact that standards are used by different communities at different levels.

Only by using a standardized and ideally open (i.e., publicly available) standard for scenario specifications, potential benefits may be realized. The main benefits of a standardized scenario specification are:

1) As all persons involved in the scenario specification process are familiar with the standard and the scenario structure defined by this standard, initial familiarization efforts are minimized.
2) Following an analogue reasoning, a standardized structure allows easier access to scenario documentation for all persons working on these scenarios. This includes the M&S experts which set up the simulation environment, the V&V experts responsible for the quality management as well as all readers of the scenario specification in general.
3) A precisely defined scenario specification structure simplifies quality management activities (like evaluation of completeness of a scenario specification).
4) Similarly, a clearly defined scenario specification structure (ideally accompanied by explanatory texts) simplifies the development of a "good" scenario specification. This availability of such a scenario specification structure is especially important if scenario specifications have to be created by persons with few or zero experience in this area.
5) A precisely defined scenario specification structure is the necessary prerequisite for the formal specification of a scenario.

As scenarios are decisive sources of requirements for the intended simulation environment, the provision of at least a standardized (and complete) scenario specification is required for achieving interoperability of simulation systems on the pragmatic, dynamic and conceptual level as defined by the Levels of Conceptual Interoperability Model [Wang2009].

4.4 LEVEL 3 – FORMAL SCENARIO SPECIFICATION

Maturity Level 3 requires the formal specification of a scenario. Several possibilities exist for defining such a formal specification. One of the most prominent choices, especially in the software engineering domain, is XML Schema [XMLSchema]. Other options include RELAX NG [RelaxNG], UML [UML] and OWL [OWL].

The benefits of a rigorous formal scenario specification are manifold:

1) Ideally ambiguities are eliminated or at least reduced to a minimum.
2) Secondly and maybe even more important, automated processing of scenario specifications and extensive utilization of tools is made possible. This opens up a wide range of possible applications:
    a) Automated consistency checks (e.g., no units have overlapping positions; no units are positioned outside the specified geographic boundaries).
    b) Automated initialization of all simulation systems and other member applications (like, e.g., computer-generated forces) which are part of the simulation environment. Benefits are a reduced risk of errors due to manual misconfiguration or human errors as well as an improved reproducibility.
    c) Semi-automated or fully automated cross-checks with other information products developed during the engineering process (e.g., whether the Federation Object Model (FOM) provides interaction classes for all communication events defined in the scenario).
3) Reuse is simplified. Scenario specifications may be archived and retrieved for later reuse.

Transfer and sharing of scenario specifications is easily possible.

4.5 RELATION OF MATURITY LEVELS TO SCENARIO TYPES

While in principle each maturity level may be assigned to any of the three types of scenarios, in practice only certain combinations are possible or likely. Table 4-2 indicates:

- Which maturity levels are generally applicable to which type of scenario (non-empty cells);
- Which maturity levels are currently achieved (C) or at least partially achieved (/C/); and
- Which maturity levels should be aimed for specifying the different types of scenarios (A).

Table 4-2: Relation of Maturity Levels to the Different Types of Scenarios.

Maturity Level of Scenario Specification	Type of Scenario		
	Operational Scenario	Conceptual Scenario	Executable Scenario
0 – No Written Scenario Specification	C	C	
1 – Non-Standardized Scenario Specification	C	C	C
2 – Standardized Scenario Specification	/C/	/C/	/C/
3 – Formal Scenario Specification	A	A	/C/ A

Regarding operational scenarios, in our experience currently non-standardized scenario specifications prevail. Although most users follow some kind of schema for describing operational scenarios, we are not aware of any commonly used standard or even template. For specifying operational scenarios, the mid-term target should be to achieve maturity Level 2. A necessary prerequisite for achieving this is the development and adoption of a common standard for specifying operational scenarios.

Specifications of conceptual scenarios are regularly achieving maturity Levels 1 and partially also Level 2. The short-term goal should be to consistently achieve maturity Level 2 across a large number of simulation environment engineering process applications. The mid-term to long-term target should be maturity Level 3, i.e., formally specified conceptual scenarios. A critical factor for achieving this target will be the availability of specialized tools which allow a formal specification of conceptual scenarios by M&S experts on the one hand, and which provide a customized presentation and output of the conceptual scenario for discussion with the user and sponsor on the other hand.

Currently, executable scenarios are most often specified on maturity Levels 1 and 2. Approaches for formally specifying scenarios are available (e.g., MSDL), but are not as regularly used as they could be. A reason for this may be that currently available standards are missing important features or are not providing enough benefits compared to currently used “legacy” standards. The target must be to achieve maturity Level 3 for the specification of executable scenarios in order to realize the potential benefits.

Chapter 5 – STANDARDS AND TOOLS FOR SCENARIO SPECIFICATION

Table 5-1 lists available standards and tools for scenario specification. This compilation is not exhaustive but tries to give an overview. The assignment of standards and tools to the different types of scenarios indicates for which type of scenario a standard or tool is most likely to be used. This assignment does not exclude the use of a standard or tool for a different type of scenario. More detailed explanations on the standards and tools are given in the following subsections and may also be found in AMSP-01 [AMSP-01].

Table 5-1: Standards and Tools for Scenario Specification.

Maturity Level of Scenario Specification	Type of Scenario					
	Operational Scenario		Conceptual Scenario		Executable Scenario	
	Standards	Tools	Standards	Tools	Standards	Tools
0 – No Written Scenario Specification						
1 – Non-Standardized Scenario Specification	"Everybody uses his own standard." DSEEP	General purpose software	Unified Modelling Language (UML) Systems Modelling Language (SysML)	General purpose software Wiki engines UML editors	Individual documentation (e.g., MEL/MIL, story books)	General purpose software
2 – Stand-ardized Scenario Specification	NATO Comprehensive Operations Planning Directive (formerly: "NATO Guidelines for Operational Planning")	General purpose software	NATO Architecture Framework (NAF) VEVA documentation guidelines (in Germany)	General purpose software Wiki engines UML editors	Proprietary (vendor-specific) data exchange formats	
3 – Formal Scenario Specification	C-BML JC3IEDM ADatP-3		Base Object Models (BOM)	JEMM	MSDL JTDS Order of Battle Service C-BML C2IEDM/JC3IEDM	XML editors MSDE, WebMSDE Saab Scemanta C2LG GUI Exonaut Tool Suite

5.1 STANDARDS AND TOOLS FOR OPERATIONAL SCENARIOS

5.1.1 DSEEP

***Type of Standard**: Open standard, publicly available from SISO and IEEE.*

The Distributed Simulation Engineering and Execution Process (DSEEP) [DSEEP] describes a generic 7-step process for developing and executing a simulation environment. Each step of the DSEEP is further sub-divided into more specific activities, and for each activity inputs and outputs are specified by the DSEEP. As the DSEEP is considered as a generalized, high-level framework which has to be adapted to individual needs, the DSEEP does not provide very detailed guidance or even documentation templates for activity outcomes. It is assumed that each organization that uses the DSEEP provides this detailed guidance as part of the individual adaptation.

Nevertheless, the DSEEP provides basic guidance on the content of a scenario specification [DSEEP, p. 13ff.].

5.1.2 NATO Comprehensive Operations Planning Directive

***Type of Standard**: Open standard, publicly available.*

The NATO Comprehensive Operations Planning Directive (COPD) [NATO_COPD] (formerly: "NATO Guidelines for Operational Planning") and its national counterparts define operational planning procedures. Although these planning procedures are not dedicated solely to scenario development they are agreed guidelines and can thus be seen as standards.

5.1.3 General Purpose Software

***Type of Tool**: Open tool, publicly available.*

Any general-purpose software may be used to document scenarios. Typically used software includes:

- Word processors (e.g., MS Word, OpenOffice Writer).
- Presentation programs (e.g., MS PowerPoint, OpenOffice Impress).
- Graphics editors (e.g., Adobe Photoshop, gimp).

5.1.4 Joint C3 Information Exchange Data Model (JC3IEDM)

***Type of Standard**: Open standard, publicly available from Multi-lateral Interoperability Programme (MIP).*

The Joint Consultation, Command, and Control Information Exchange Data Model (JC3IEDM) [JC3IEDM] is a data exchange model that aims to improve interoperability between systems that exchange Command and Control (C2) information. The JC3IEDM development is managed by the Multi-lateral Interoperability Programme (MIP).

Following [JC3IEDM] the scope of this data model is directed at producing a corporate view of the data that reflects the multi-national military information exchange requirements for multiple echelons in joint/ combined wartime and Crisis Response Operations (CRO). The data model is focused on information that supports:

- Situational awareness;
- Operational planning;

- Execution; and
- Reporting.

The scope includes data from various functional areas according to the requirements levied by MIP and NATO.

As the JC3IEDM is used to describe operational situations it is obvious that it may also be used to describe operational scenarios.

5.1.5 Allied Data Publication 3 (ADatP-3)

***Type of Standard**: NATO STANAG.*

As explained by [ADatP-3] the standard provides the rules, constructions and vocabulary for standardised character-oriented message text formats that can be used in both manual and computer-assisted operational environments. These message formats are to be used for all formatted character-oriented messages within the NATO Command, Control and Information System (NCCIS) unless specifically excluded by multi-national agreement. It is concerned solely with the part of a message that contains the thought or idea the originator wishes to communicate. The transmission of formatted messages remains in accordance with the instructions given in relevant Allied Communications Publications.

As ADatP-3 is used to describe operational situations (like JC3IEDM) it is obvious that it may also be used to describe operational scenarios.

5.1.6 Coalition-Battle Management Language (C-BML)

***Type of Standard**: Open standard, publicly available from SISO.*

The Coalition-Battle Management Language (C-BML) currently under development by SISO provides an effort for a publicly available standard which may be used for specifying the course of events within a scenario.

5.2 STANDARDS AND TOOLS FOR CONCEPTUAL SCENARIOS

5.2.1 NATO Architecture Framework (NAF)

***Type of Standard**: Open standard, publicly available.*

The NATO Architecture Framework (NAF) [NAF] defines several views which may be used for documenting a simulation environment engineering process (as described in [EU CTF] and [10S-SIW-027]). The NAF defines only the content of the various views, but not how these views should be filled (i.e., which methodologies or modelling languages should be used). Furthermore, the NAF is originally intended for developing and describing complex (hardware and software) systems and not specifically for documenting scenarios. Although NAF does not directly address scenario documentation it may be used for this purpose (see Annex A for an example).

5.2.2 Unified Modeling Language (UML)

***Type of Standard**: Open standard, publicly available from OMG and ISO/IEC.*

Also, the Unified Modeling Language (UML) [UML] defines several diagram types which may be used to document specific parts of a scenario. For example, class diagrams may be used to define unit hierarchies and deployment diagrams may be used to document which units are simulated by which simulation system. As the UML is a generic modelling language it is not specifically designed for documenting scenarios.

5.2.3 Systems Modelling Language (SysML)

***Type of Standard**: Open standard, publicly available from OMG.*

The UML language comes from the software engineering world. The system engineering world has derived the Systems Modelling Language (SysML) from UML. Large parts of UML and SysML overlap, but SysML adds two additional diagram types: requirements diagrams and parametric diagrams. The first can be used for requirements analysis and the latter for engineering analysis of critical system parameters. Given that a distributed simulation environment is more than software only, SysML could be beneficial for the development of a distributed simulation environment. Specifically for specifying scenarios there is probably not too much difference between using UML or SysML.

5.2.4 Base Object Models (BOMs)

***Type of Standard**: Open standard, publicly available from SISO.*

A standard which directly addresses defining and reusing components of models, simulations and federations is the Base Object Model (BOM) Template Specification [BOM]. As described therein, "BOMs serve to provide an end-state of a simulation conceptual model and can be used as a foundation for the design of executable software code and integration of interoperable simulations." Regarding scenario documentation:

> "*The aspects of a simulation conceptual model found in a BOM contain static descriptions of items resident in the real world described in terms of conceptual entities and conceptual events. In addition, those aspects of a simulation conceptual model found in a BOM contain information on how such items relate or interact with each other in the real world in terms of patterns of interplay and state machines.*" [BOM, p. 7]

A detailed analysis regarding usability and practicability of using BOMs for scenario documentation is presented in [13S-SIW-019]. Also, Annexes B and C provide examples for the usage of BOMs for scenario specification.

5.2.5 VEVA Process Model

***Type of Standard**: Local standard, used by German Armed Forces, partially publicly available.*

Representatives of a different approach are the VEVA documentation guidelines. The VEVA process model is a German approach for operationalizing the DSEEP and provides detailed documentation guidelines covering the whole simulation environment engineering process [11S-SIW-044] [11F-SIW-023] [Siegfried2010]. Especially, the VEVA documentation guidelines provide specialized documentation templates for scenarios. The documentation templates defined by VEVA are most applicable for documentation of operational scenarios and conceptual scenarios. Obviously, the VEVA is not an official, public standard, but as the VEVA is used regularly within the German Armed Forces it is considered as a standard (in the sense of the definition given in Section 4.3).

5.2.6 Joint Exercise Management Module (JEMM)

***Type of Tool**: Local tool, available from NCIA.*

JEMM (NC3A Joint Exercise Management Module) [Cayirci2010] is a so-called "Exercise and Scenario Management Tool".

Exercise and Scenario Management tools can be used for the automation of processes, information management and information exchange throughout an exercise process. They can help in preparation and management of scenarios as well as the Main Event and Master Incident Lists (MEL/MIL). A MEL/MIL tool can also be very useful in synchronizing and managing the flow of an exercise according to the exercise objectives, as well as, planning, collecting and analyzing the observations. MSG-068 used JEMM for this purpose [NMSG-068].

5.3 STANDARDS AND TOOLS FOR EXECUTABLE SCENARIOS

5.3.1 Military Scenario Definition Language (MSDL)

***Type of Standard**: Open standard, publicly available from SISO.*

The most widely known and publicly available standard for specifying executable scenarios is the Military Scenario Definition Language (MSDL) [MSDL] which is developed and maintained by SISO. In its current version, MSDL allows especially the specification of the initial state of a scenario. Dynamic properties of a scenario (i.e., course of events) are currently not part of the MSDL.

5.3.2 Order of Battle Service (OBS)

***Type of Standard**: Local standard used by JTDS.*

The Order of Battle Service (OBS) which is part of the US Joint Training Data Services (JTDS) provides pre-populated Order of Battle data sets for use within the Joint Live, Virtual, Constructive (JLVC) Federation [11F-SIW-034]. The JTDS OBS XML Schema defines the XML interchange format used to exchange initialization data between JTDS and the JLVC federation. Similar to MSDL, the OBS XML Schema allows representation of force sides, units, facilities, relationships, etc. Due to various reasons, the OBS XML Schema was developed in parallel with MSDL [MSDL].

Chapter 6 – REFERENCES

Reference / Key	Full Bibliographical Information
11F-SIW-034	A. Bowers, C.L. Budde, B.C. Gregg and D. Winkowski, "JLVC Data Initialization", SISO 2011 Fall SIW, Orlando, FL, USA, 11F-SIW-034.
Cayirci2010	E. Cayirci, Tutorial on "Joint Exercise Management Module (JEMM)", 5th NATO CAX Forum 2010, Ottobrunn, Germany, August 2010.
DoD M&S Glossary	Department of Defense: Modeling and Simulation (M&S) Glossary, Published by Modeling and Simulation Coordination Office, 1 October 2011.
MSC-DMS	Department of Defense Modeling and Simulation Coordination Office: Modeling and Simulation (M&S) Community of Interest (CoI) Discovery Metadata Specification (MSC-DMS), Version 1.4, 24 December 2010.
DSEEP	IEEE: IEEE Recommended Practice for Distributed Simulation Engineering and Execution Process (DSEEP), 2011, IEEE Std 1730-2010.
FEDEP	IEEE: IEEE Recommended Practice for High Level Architecture (HLA) – Federation Development and Execution Process (FEDEP), 2003, IEEE Std 1516.3-2003.
JP3-09.3	Joint Publication 3-09.3 Close Air Support, 8 July 2009, http://www.fas.org/irp/doddir/dod/jp3_09_3.pdf.
Keuning2008	M. Keuning and A. Gerretsen, "Effective Realism", I/ITSEC 2008, Paper 8187.
Mojtahed2005	V. Mojtahed, M.G. Lozano, P. Svan, B. Anderson and V. Kabilan, "DCMF-Defence Conceptual Modelling Framework", FOI-R–1754–SE, ISSN 1650-1942, November 2005.
Mojtahed2008	V. Mojtahed, E. Tjörnhammer, J. Zdravkovic and A.H. Khan, "The Knowledge Use in DCMF", FOI-R–2606–SE, ISSN 1650-1942, November 2008.
JC3IEDM	Multilateral Interoperability Programme (MIP), "Joint Consultation, Command and Control Information Exchange Data Model", (JC3IEDM), Version 3.1.4, 14 February 2012.
NATO_COBP	NATO: Code of Best Practice for C2 Assessment, October 2002.
NATO_COPD	NATO, "NATO Comprehensive Operations Planning Directive", 17 December 2010.
MSG-024	NATO: Final Report of MSG-024 "M&S Support to Non-Article 5 Operations", RTO-TR-MSG-024 AC/323(MSG-024)TP/27, January 2008.
MSG-053	NATO: Final Report of MSG-053 "Rapid Scenario Generation for Simulation Applications", RTO Technical Report TR-MSG-053 AC/323(MSG-053)TP/302, May 2010.
MSG-068	NATO: Final Report of MSG-068 "NATO Education and Training Network", RTO Technical Report RTO-TR-MSG-068 AC/323(MSG-068)TP/407, February 2012.
NAF	NATO Consultation, Command and Control Board (NC3B): NATO Architecture Framework. Version 3, AC/322-D(2007)0048-AS1, 2007.

Reference / Key	Full Bibliographical Information
AAP-06	NATO Standardization Agency (NSA): NATO Glossary of Terms and Definitions, Edition 2013.
ADatP-3	ADatP-3, Part 1, NATO Message Text Formatting System (FORMETS) – System Concept Description and Management (October 1987), Brussels: NATO Headquarters.
AMSP-01	NATO: NATO Modelling and Simulation Standards Profile, AMSP-01, Edition (B), Version 1, June 2011.
Relax NG	The Organization for the Advancement of Structured Information Standards (OASIS), "RELAX NG Specification", Committee Specification, http://relaxng.org/spec-20011203.html, 3 December 2001. (See also "ISO/IEC 19757-2:2003 Document Schema Definition Language (DSDL) – Part 2: Regular-Grammar-Based Validation – RELAX NG" for an ISO version of RELAX NG Specification.)
UML	Object Management Group (OMG), "Unified Modeling Language", Version 2.4.1, http://www.omg.org/spec/UML/2.4.1/, August 2011.
EU CTF	Saab Systems and Combitech: Core Technical Framework for Distributed Simulation, Part of EU Core Technical Framework Study, EDA reference number 08-R&T-004, July 2009.
11S-SIW-044	R. Siegfried, G. Herrmann, J. Lüthi and M. Hahn, "VEVA as German Approach Towards Operationalizing the DSEEP: Overview and First Experiences", SISO 2011 Spring SIW, Boston, MA, USA, Paper 11S-SIW-044.
11F-SIW-023	R. Siegfried, G. Herrmann, J. Lüthi and M. Hahn, "A Comparison of DSEEP with the German Approach VEVA", SISO 2011 Fall SIW, Orlando, FL, USA, Paper 11F-SIW-023.
12S-SIW-014	R. Siegfried, A. Laux, M. Rother, D. Steinkamp, G. Herrmann, J. Lüthi and M. Hahn, "Scenarios in Military (Distributed) Simulation Environments", SISO 2012 Spring SIW, Paper 12S-SIW-014.
12F-SIW-046	R. Siegfried, A. Laux, M. Rother, D. Steinkamp, G. Herrmann, J. Lüthi and M. Hahn, "Components and Reuse in Scenario Development Processes for Distributed Simulation Environments", SISO 2012 Fall SIW, Orlando, FL, USA, Paper 12F-SIW-046.
13S-SIW-019	R. Siegfried, H. Oguztüzün, U. Durak, A. Hatip, G. Herrmann, P. Gustavson and M. Hahn, "Specification and Documentation of Conceptual Scenarios Using Base Object Models (BOMs)", 2013 SISO Spring SIW, San Diego, CA, USA, Paper 13S-SIW-019.
Siegfried2010	R. Siegfried, A. Laux, G. Herrmann and J. Lüthi, "VEVA – A Procedure Model for Distributed Simulation Experiments", NATO MSG Symposium 2010, Utrecht, Netherlands, Paper 010.
BOM	SISO: Base Object Model (BOM) Template Specification, 31 March 2006 – SISO-STD-003-2006.
MSDL	SISO: Military Scenario Definition Language (MSDL), 14 October 2008 – SISO-STD-007-2008.

Reference / Key	Full Bibliographical Information
CMMI	Software Engineering Institute: CMMI for Development, Version 1.3, Technical Report CMU/SEI-2010-TR-033, November 2010.
10S-SIW-027	J. Tegner and R. Suzic, "Core Technical Framework Stud: DSEEP Adaption and MODAF Mapping", SISO 2010 Spring SIW, Orlando, FL, USA, 10S-SIW-027.
Voogd2009	J. Voogd, A. Lemmers, A. Gerretsen, M. Roza and R. Karelse: "Effective Use of Simulation Means in Collective Mission Simulation", I/ITSEC 2009, Paper 9198.
OWL	W3C, "OWL 2 Web Ontology Language", W3C Recommendation, http://www.w3.org/TR/owl2-overview/, 27 October 2009.
XMLSchema	W3C, "XML Schema", W3C Recommendation, http://www.w3.org/XML/Schema, 28 October 2004.
Wang2009	W. Wang, A. Tolk and W. Wang, "The Levels of Conceptual Interoperability Model: Applying Systems Engineering Principles to M&S", SCS Spring Simulation Multiconference, San Diego, CA, USA, 23-27 March 2009.

Annex A – SCENARIO SPECIFICATION USING THE NATO ARCHITECTURE FRAMEWORK

This annex describes how the development of a scenario may be supported and documented using the NATO Architecture Framework (NAF).

A.1 RATIONALE

The following citation from [NAF] roughly describes what is commonly understood by the term "architecture":

> *An architecture is the fundamental organisation of a system embodied in its components, their relationships to each other and to the environment and the principles guiding its design and evolution. [...] An **architecture** is little more than a **plan** put together in accordance with certain rules.*

When creating an architecture, the architect normally uses a specific type of formal description for their work. Documenting the architecture in a formalized way ensures that every expert capable in understanding the formal notion can also read and understand the architecture, its elements, relations and ideas expressed therein. This fosters coherent design and reuse.

Depending on the specific domain many formal notions of architectures have evolved, e.g., floor plans in the construction domain or UML diagrams in the software domain. The formalized notion for an architecture within a single application domain may be called "architecture framework". It typically comprises some kind of symbology, elements of the domain, their abstract roles and relationships and the integration of these parts into different views (plans) according to certain templates.

In this sense the NATO Architecture Framework (NAF) provides many different views and related templates to describe system architectures to be used in the NATO military domain for different purposes like for example:

- Capabilities Integration, Development and Portfolio;
- Planning, Programming and Execution;
- Acquisition;
- Systems Engineering; and
- Operations Planning.

Several of these activities will also have to be carried out on the design and execution of distributed simulation. According to [DSEEP] for example the following tasks will occur:

- Develop Objectives, Initial Planning (Capabilities, Portfolio);
- Develop Scenario (Operations Planning); and
- Develop and Integrate Simulation Environment (Systems Engineering).

Due to the similarity of the real-world military domain and the design of simulation environments and simulations for the military domain, it is very likely that at least some parts of the NAF will also be helpful to support the design and execution of distributed simulation. Extensive work has been carried out in [10S-SIW-027] to analyse and demonstrate the usability of architecture frameworks in this context (using the Ministry of Defence Architecture Framework MoDAF instead of NAF). Following these ideas and convinced

of the general usability of NAF in the context of distributed simulation in the military domain in the following sections concentrates on the question on how the development of a scenario may be supported using the NAF.

It should be pointed out, that this use of architectures and the corresponding frameworks must not be confused with simulation architectures like the High Level Architecture (HLA). Although the latter describes federates, object models and federation rules and therefore forms some kind of architecture framework, it concentrates on the construction of distributed simulation systems only and lacks the templates necessary to describe scenarios.

A.2 ARCHITECTURES IN THE SCENARIO DEVELOPMENT PROCESS

Section 2.2 explains the differences between operational, conceptual and executable scenarios within the scenario development process.

Operational scenarios have to be provided by the user and form the starting point of the scenario development process. They are described in terms the user is familiar with and often are a combination of graphical and textual descriptions of involved entities, actions, tasks and events. The user normally will not be aware that by creating these graphical and textual descriptions they may actually be creating a NAF NOV-1 High Level Operational Concept Description. Also their description may contain information on doctrine, tactics, and procedures, concepts of operations, environmental conditions, and technical standards to be used and so on. From the NAF point of view such information is captured in templates from the NAV All View, NOV Operational View, NSV System View and NTV Technical View sections. However, the user normally is not familiar with the NAF and will have no support by an architecture expert during the creation of the operational scenario. Although the use of NAF templates even in this early phase of scenario development would be feasible and desirable, normally operational scenarios are being developed without any relations to the NAF.

Conceptual scenarios refine the operational scenarios. They are created by M&S experts by analysing the operational scenario and extracting the conceptual information necessary to construct a simulation environment matching the operational scenario. It is obvious, that this work will benefit from the application of NAF because the main goal of NAF is the support of the analysis and design of complex systems and finally creating an architecture of the system to be constructed. This will be detailed in the next section. However, it should be noted here that an M&S expert is not necessarily a NAF-aware system architect. To gain optimal results, a system architect familiar with the NAF should be involved in the development of the conceptual scenario, at least as long as the M&S experts are not familiar with the NAF themselves.

Executable scenarios finally contain all information necessary for preparation, initialization and execution of the simulation environment. They contain the most detailed specification of the scenario and are derived from the corresponding conceptual scenarios by M&S experts and system operators, preferably in machine readable form. The use of NAF templates to describe these detailed scenarios probably won't be feasible, because the information to be captured in most cases will be too specific to be described by NAF templates. In addition there is no standardized machine-readable format for NAF.

A.3 NAF TEMPLATES FOR CONCEPTUAL SCENARIOS

The analysis in the previous section shows, that the derivation of conceptual scenarios from operational scenarios will benefit most from the use of NAF.

The typical architecture creation process does not follow any specific sequence of templates, nor will all templates featured by the framework have to be created for the description of a particular architecture.

Instead the decision on the templates to be created and the sequence of template creation has to be made on a case by case basis to gain optimal results. For a description of conceptual scenarios using templates of the NAF a good starting point would be the creation of the NAF operational view, because the operational scenario is already present and will provide a good starting point. Therefore the following sequence of steps is proposed as a guideline.

A.3.1 NOV Operational View

The creation of the operational view mainly consists of a capturing and structuring of information already present in the operational scenario in an unstructured form. Following and augmenting the recommendations from [10S-SIW-027], the NOV templates from the NAF may be used in this way.

Table A-1: Usability of NAF Operational View Templates for the Description of Scenarios.

NAF Template	Usage
NOV-1 High-Level Operational Concept	Describe the context, major entities and actions involved in the operation. May already be available in the operational scenario description. Additional constraints or preferences, e.g., on environmental conditions may be stated here.
NOV-2 Operational Node Connectivity	Describe operational nodes★ and their roles and collaboration patterns from an operational point of view. Describe activities to be performed by nodes.
NOV-3 Operational Information Requirements	Describe operational information to be exchanged among the nodes.
NOV-4 Organizational Relationships	Describe organizational relationships if relevant for the operation.
NOV-5 Operational Activities	Describe activities that are relevant for the operational scenario.
NOV-6 Operational Activities Sequence and Timing	Describe the sequencing of activities and events.

★ According to NAF, operational nodes are logical collections of operational activities. Operational nodes produce or consume information and may represent an operational realization of capabilities.

We explicitly note here that this proposed structuring of operational information in NAF templates has nothing to do with simulation. It is the same task as designing, e.g., a defence architecture using real weapon systems on the basis of a real-world operational scenario. The transformation to a simulation environment occurs at a later stage by replacing the real systems by simulation models with the appropriate capabilities.

Given the operational scenario from Annex C for example the NOV-5 activity tree may look as depicted in Figure A-1.

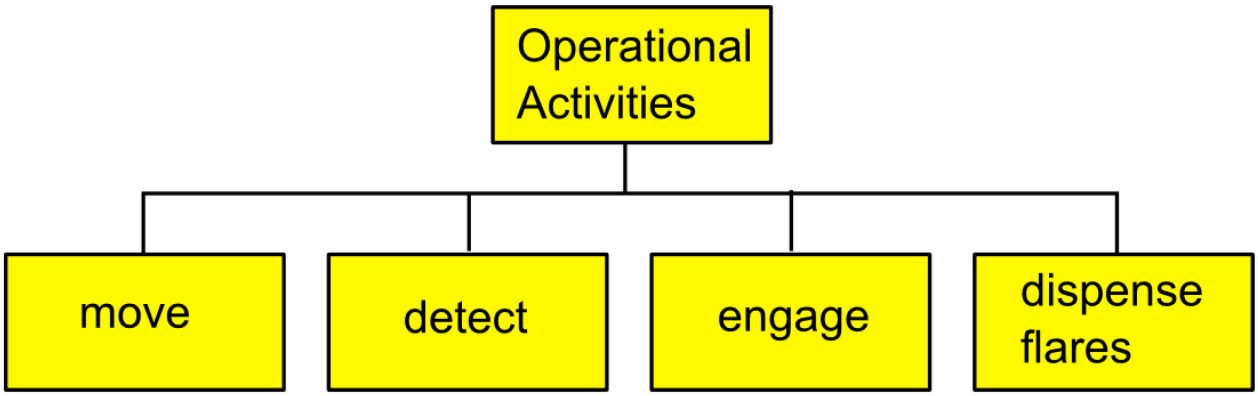

Figure A-1: NOV-5 Operational Activity Tree for Scenario Example from Annex C.

For the example operational scenario (see Annex C) two operational nodes may be identified, the AH-1 helicopter and the infantry troop, and assign operational activities to the nodes. To express the opponent role of the helicopter, different colours for the operational nodes are used. No operational information is exchanges between the nodes, so (in NAF terminology) a "need line" between the nodes is missing. Additionally the nodes may be attributed with the activities performed at the nodes. The NOV-2 operational node connectivity diagram then might look as shown in Figure A-2.

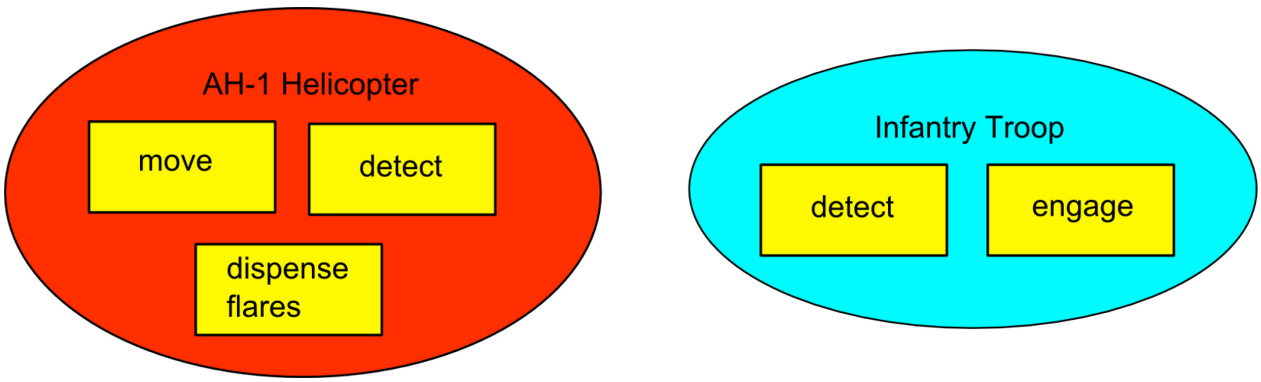

Figure A-2: NOV-2 Operational Nodes for Scenario Example from Annex C.

A.3.2 NSV System View

In a next step some templates of the NAF System View may be deduced from the operational view. In this phase special M&S knowledge will be necessary because the systems will not be real-world weapon systems, but will be simulation systems or individual simulation models and therefore their specific requirements will have to be taken into account.

According to [10S-SIW-027] Table A-2 below, the following NSV templates from the NAF are useful.

Table A-2: Usability of NAF System View Templates for the Description of Scenarios.

NAF Template	Usage
NSV-1 System Interfaces	Describe the interfaces (simulated operational interfaces and simulation specific interfaces) of the systems.
NSV-2 System Communication	Describe system or model communication, message exchanges and (simulation) communication quality requirements.
NSV-5 System Functions to Operational Activity Tracing	Describe system functions (e.g., model capabilities) necessary to perform the required operational activities.
NSV-4 System Functionality	Describe systems or models to be present and their functionality to be represented.
NSV-10 Rules, Sequence and Timing	Describe system rules, state transitions and event traces.
NSV-11 System Data Model	Describe data to be represented in the simulation environment, may be focused on exchanged data (FOM, in HLA terminology).

Continuing the example from above, the list of system functions (1st column) and their mapping to operational activities (1st row, see table above) as NSV-5 matrix may appear as presented in Table A-3 below.

Table A-3: NSV-5 Operational Activities to System Function Traceability Matrix for Scenario Example from Annex C.

	Move	Detect	Engage	Dispense Flares
Radar Detection		X		
Visual Detection		X		
IR Detection			X	
Flight Helicopter	X			
Flight Missile	X			
Flight Flare	X			X
IR Emission		X		X
Radar Reflection		X		

Each of the operational activities thereby requires one or several system functions to be implemented in the system. These system functions therefore may be identified with individual functions or capabilities of simulation models. Similar to the assignment of operational activities to operational nodes in the operational view, these system functions may be assigned to individual systems. From the assignment of system functions to system nodes and from the necessary data flows between the system functions then follows the NSV-2 System Communication template.

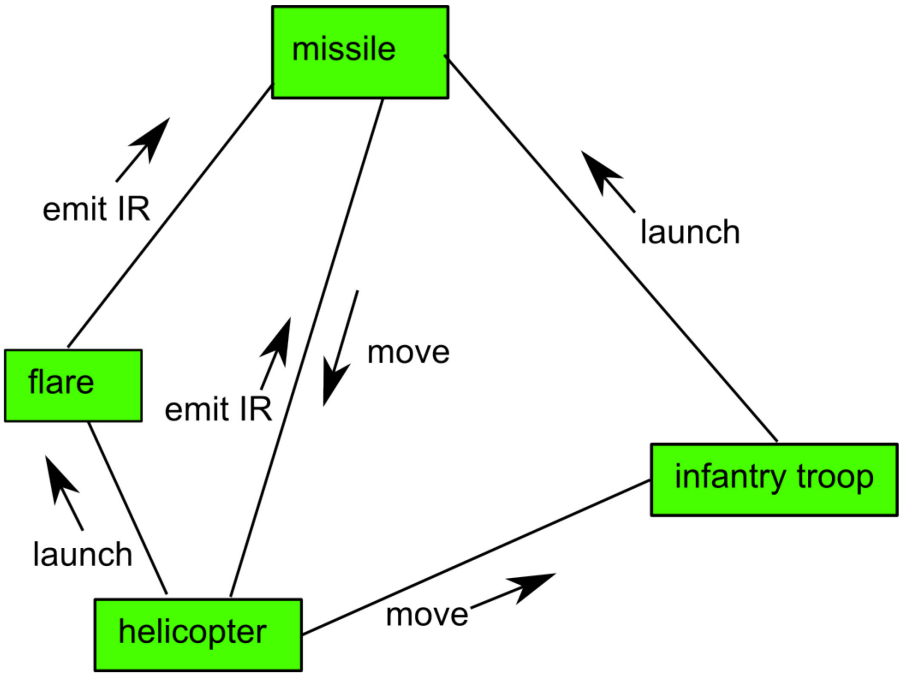

Figure A-3: NSV-2 System Communication Template for Scenario Example from Annex C.

Here the green boxes denote the individual simulation models, which implement the system functions listed in the table. Each of the models may contain sub-models not shown in this figure, e.g., the missile model may be composed of a movement model (implementing the "flight missile" system function) and an IR seeker model (implementing the "IR detection" system function). In contrast to the NOV-2 operational node connectivity diagram there is intensive data exchange between the individual systems/models. This is depicted by the connection lines in the figure above, the transmitted information and direction of data flow indicated by the arrows and their labels.

For example, the infantry troop model needs information on position and movement of the helicopter to implement the visual detection system function. On detection it will launch the missile (model). The helicopter model will need the position information from the missile model to implement radar detection of the missile and to launch the flare. The missile will need position information from the helicopter and the flare to implement target detection, guidance and distortion of detection/guidance by IR emissions from the flare.

It is obvious, that these information exchanges form a starting point for the definition of the data (exchange) model NSV-11 (the FOM in HLA terminology) or a description of event sequence and timing NSV-10.

A.3.3 Other Views and Templates

In addition to the templates listed above several other templates from the NAF may be used to further detail the conceptual scenario description. Examples are:

- NTV-1 Technical Standards Profile: Describes the (simulation and operational) technical standards to be followed;
- NTV-3 Standard Configuration: Describes the standard system configurations that are known to work; and
- NAV-2 Integrated Dictionary.

Annex B – SCENARIO SPECIFICATION USING BASE OBJECT MODELS

B.1 OVERVIEW OF THE BOM STANDARD

As stated in [BOM], "Base Object Models (BOMs) provide a component framework for facilitating interoperability, reuse, and composability". For this purpose the "Base Object Model (BOM) Template Specification" defines the format and syntax for describing the elements of a template for representing BOMs.

A Base Object Model is composed of four major components:

- Model Identification (Metadata);
- Conceptual Model Definition;
- Object Model Definition; and
- Model Mapping.

All four components are described in more detail in the following sub-sections.

B.1.1 Model Identification

The "Model Identification" component of a BOM associates important metadata (i.e., information about the base object model itself) with the model. This information is necessary for purposes of search and retrieval of BOMs as well as for maintaining traceability and facilitating reuse of BOMs.

B.1.2 Conceptual Model Definition

The "Conceptual Model Definition" component of a BOM is used for specifying the conceptual model represented by this BOM. For defining the conceptual model the BOM Template Specification defines four template components as sub-components of the "Conceptual Model Definition":

- Entity Type;
- Pattern of Interplay;
- State Machine; and
- Event Type.

The entity types define the types of conceptual entities required for representing all aspects of the conceptual model.

The pattern of interplay defines a set of patterns of interplay (including pattern actions, variations, and exceptions) which are required to represent the activities and interactions within the conceptual model.

The state machine identifies the conceptual entities and their respective states as well as the state transitions which are required within this conceptual model.

The event types define types of conceptual events (directed, undirected) which are required for representing the pattern action of a pattern of interplay.

B.1.3 Object Model Definition

"The Object Model Definition defines the structure of object and interaction classes, and their associated attributed and parameters" [BOM, p. 48]. In its current version, the BOM Template Specification refers to the HLA OMT for defining object and interaction classes (e.g., using the classes "HLA Object Class" and "HLA Interaction Class" as respective root classes for objects and interactions).

B.1.4 Model Mapping

The "Model Mapping" component of a BOM template provides the link between the entities and events of the Conceptual Model Definition and the classes specified by the Object Model Definition.

B.1.5 Documentation of BOMs

Each of the four main components of a BOM may be documented and represented in many ways (e.g., textual, tabular, graphical). Additionally, the BOM Template Specification describes the BOM Data Interchange Format (DIF). The BOM DIF is specified as XML Schema and provides the possibility to represent a BOM as XML.

Basically, the BOM Template Specification uses table-based approach for specifying data. However, almost all tables may be transformed into respective UML diagrams (e.g., sequence diagrams for patterns of interplay, state diagrams for state machines). Figure B-1 shows an example.

State Machine Name	Conceptual Entity	State			Note
		State Name	Exit Condition		
			Exit Action	Next State	
ShooterStates	FiringEntity	Ready	CommandToFire	Fire	na
		Greet	WeaponFireAction	MunitionFlight	na
		Seat	MunitionDetonationAction	Ready	na
Note	na				

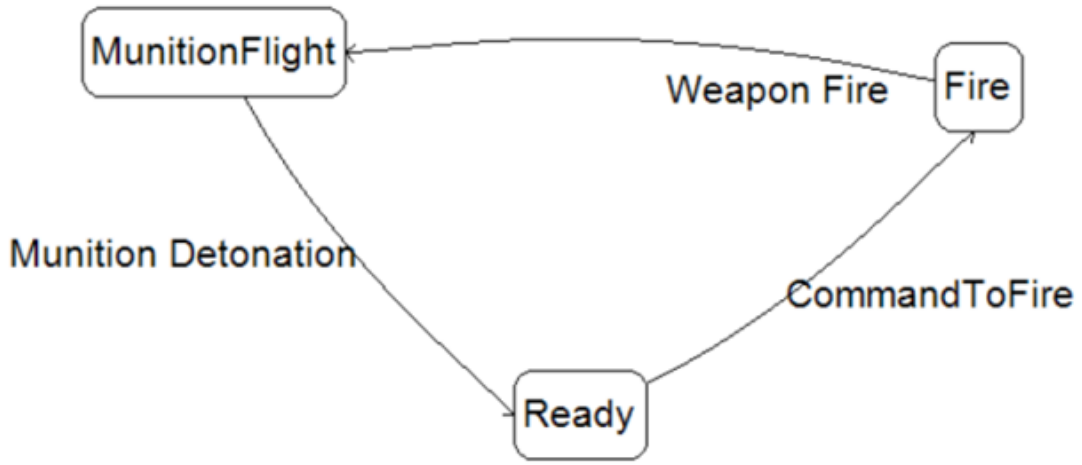

Figure B-1: Example Specification of State Machine as a Table (Top) and as a Diagram (Bottom) [BOM].

B.2 EVALUATION

In Annex C an operational scenario is presented, which is refined into a conceptual scenario. First, a textual documentation of the conceptual scenario is shown and secondly it is shown how the conceptual scenario may be documented using the BOM Template Specification.

B.2.1 Positive Experiences

The BOM standard proved to be very useful for documenting conceptual scenarios for various reasons.

First, the formal notation imposed by the BOM Template Specification requires a scenario developer to be much more precise when specifying conceptual scenarios (compared to a free-text documentation of conceptual scenarios). Especially the development of the patterns of interplay and the development of the state machines revealed many shortfalls which were not identified when developing the textual documentation of the conceptual scenario.

Although these shortfalls might generally also be identified when developing a textual documentation, we believe that the usage of UML as formal notation (which requires precision) simplifies this process and requires a certain scrutiny of scenario developers. Shortcuts which are easily taken even by experienced developers (e.g., due to missing information or time) are a lot easier to identify during quality management processes.

Secondly, the well-structured templates of the BOM standard lead to a well-structured documentation of conceptual scenarios. This simplifies both understanding and comparing conceptual scenarios as the reader (e.g., user, model developer, or V&V agent) is familiar with the way a conceptual scenario is documented.

The possibility to document (and present!) the same information in different ways is further supported by the BOM standard which defines at least three different representations: tabular, graphical, BOM DIF. This allows presenting the same information differently for different users (e.g., sequence diagrams for user, BOM DIF for tools).

Finally, the BOM Data Interchange Format (DIF) itself is a great advantage of the BOM standard. The BOM DIF is the prerequisite for enabling any kind of tool support and automated processing of conceptual scenarios.

B.2.2 Negative Experiences

Although the BOM Template Specification was very useful, the focus on HLA (especially of the Object Model Definition and Model Mapping components) seems to be a drawback. In our opinion, the BOM standard would benefit if terminology would be relaxed to be non-HLA-specific and aligned with DSEEP (which is architecture-neutral).

B.2.3 Ideas for Improving the BOM Standard

Besides relaxing terminology, it would be beneficial if the current mapping mechanism of the BOM standard (which maps entities and events of a Conceptual Model Definition onto classes defined by an Object Model Definition) would be generalized. Especially in the context of scenario specifications, it would be of great value if mappings between entities and events of the Conceptual Model Definition and arbitrary elements defined in other specifications (e.g., in MSDL or C-BML files) could be defined. This would open up the opportunity to create a direct link between the specification of conceptual scenarios and elements of corresponding executable scenarios. Such links would also allow augmenting the specification of conceptual scenarios with more detailed specifications where necessary and would improve traceability between conceptual and executable scenarios a lot.

Annex C – EXAMPLE SCENARIO "AIR DEFENCE"

The example scenario "Air defence" is concerned with the study of the operational effectiveness of Man Portable Air Defence (ManPAD) systems for defending a manoeuvring unit against airborne attacks.

C.1 DESCRIPTION OF THE OPERATIONAL SCENARIO

A ManPAD team consisting of a commander, an observer and a gunner, is supporting a manoeuvring unit. The ManPAD team is deployed around 400 metres behind the manoeuvring unit on high ground. At the instant when the ManPAD commander receives an early warning with the assumed target location, the manoeuvring unit is heading north and the ManPAD team is behind the unit. The ManPAD observer starts searching the sector from which the aircraft is approaching.

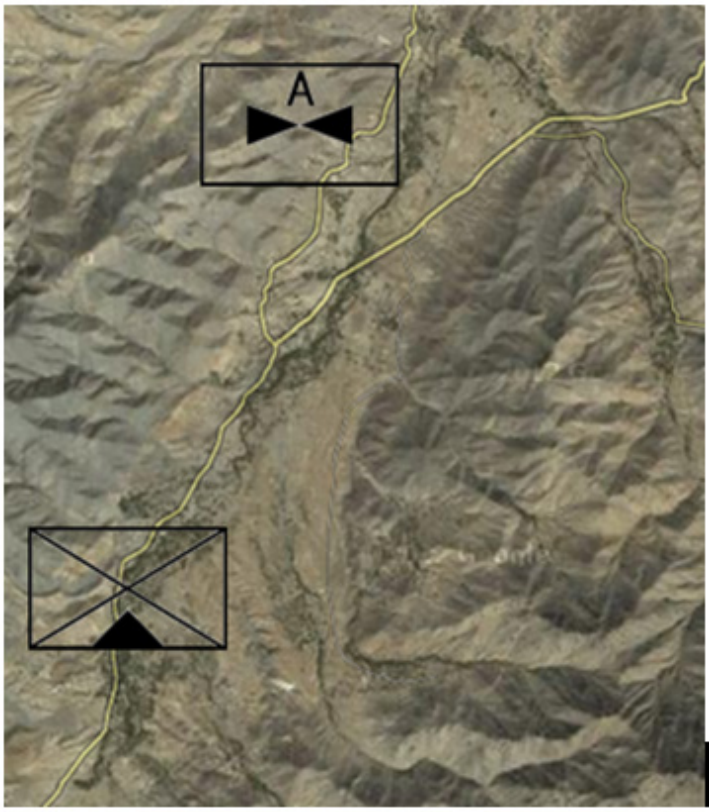

Figure C-1: Area of Interest.

The ManPAD observer catches a glimpse of a blade flash from rotating helicopter blades approaching from North. Since the ManPAD team is in Weapons Free status, the ManPAD gunner starts an interrogation procedure. As soon as the target is in range ring, he triggers an IFF (identification friend or foe) operation. As the target is identified as hostile, the ManPAD Commander orders a Fire Command.

At the instant of fire, the enemy helicopter is at 500 metres altitude and has a speed of 45 metres per second with straight flight. The ManPAD gunner launches the missile from 80% of range ring, and the missile approaches the target from the front. As soon as the helicopter detects the engagement, it throws a dozen flares to protect against the missile when it is within the last kilometre.

The ManPAD observer then evaluates the first missile and reports the result to the ManPAD commander for consecutive action.

C.2 TEXTUAL DESCRIPTION OF THE CONCEPTUAL SCENARIO

This section presents a typical textual description of a conceptual scenario. The textual description provided in this section is introduced for comparison with the specification of the conceptual scenario using Base Object Models which will be presented in the following section.

The textual description of the conceptual scenario follows the scenario documentation template outlined in Chapter 3.

C.2.1 Initial State

The initial state specifies the situation at the beginning of the scenario time line which includes participating units, forces and the force structure, geography, surrounding conditions and the rules of engagement. Below is the initial state of the example Air Defence scenario.

C.2.1.1 Units

Unit	Attribute	Value
Manoeuvring Unit	Initial position	0, 400, 0 in Local NED
ManPAD Team	Initial Position	0, 0, 0 (Local NED origin)
	Sub Units	ManPAD Commander, ManPAD Observer, ManPAD Gunner
	Equipment and Weapons	IFF and ManPAD-X
	Status	Weapons Free
Target	Type	AH-1 similar helicopter
	Altitude	500 metres
	Speed	45 m\s to South (-45, 0, 0)
	Manoeuvre	Straight flight
	Position	0, 5500, -500 in Local NED
	Engagement Ring	2500 m

C.2.1.2 Forces and Force Structure

ManPAD Team

- Composed of: ManPAD commander, ManPAD observer, ManPAD gunner.
- Command structure: ManPAD observer and ManPAD gunner are under the command of ManPAD Commander.
- Spatial position: All three units at the same location.
- C2: Receives voice messages/commands over radio.

C.2.1.3 Geography

Attribute	Value
Area	Hypothetical area
Terrain	Flat earth
Atmosphere	ICAO Standard
Wind	5 m/s from East

C.2.1.4 Surrounding Conditions

Not applicable.

C.2.1.5 Rules of Engagement

ManPAD Team:

1) If any approaching object is identified and the status is Weapons Free then IFF operation will be triggered as soon as object heads into the range ring; and
2) If object is identified as hostile and the object is in 80% of range ring, weapon is fired.

Helicopter:

1) Apply any means of soft kill (flares, manoeuvre, etc.) as soon as a missile attack is detected; and
2) Attack any manoeuvring target within engagement ring.

C.2.2 Course of Events

Besides specifying the initial conditions, the conceptual scenario shall also specify pre-planned events that are triggered at a specific time or due to a specific condition. These events may include communication, interaction, state change or environmental events. The course of events in the example air defence scenario is provided below.

C.2.2.1 Communication Events

Time	Event
00:00	ManPAD commander receives a voice message with early warning information for a target at a specific position.

C.2.2.2 Interaction Events

Event Type	Attribute(s)	Trigger/Condition
Target Identification	Target Position	Within 5 km of ManPAD team
IFF Operation	Target Position	In the range ring of ManPAD missile
Missile Fire	IFF Status	Foe
	Target Position	In 80% of range ring
Missile Detection	Missile Position	Within 1.5 km of helicopter

Event Type	Attribute(s)	Trigger/Condition
Flare Dispense	Missile Slant Range	1400 m
	Dispense Number	12
	Initial Dispense Time	0.6 s
	Dispense Interval Time	0.1 s

C.2.3 Termination Conditions

Each conceptual scenario shall specify termination conditions which define the end of a scenario. Typical termination conditions can be that a predefined time has elapsed or that a specific condition is achieved. Below is the termination condition of the example air defence scenario.

Termination Condition: The missile either hits the target or misses and self-destructs.

C.3 USING BOMs FOR SCENARIO SPECIFICATION

This section describes how the BOM Template is used for specifying the conceptual scenario (in contrast to the textual description of the conceptual scenario outlined in the previous section).

C.3.1 Model Identification

We are convinced that the "Model Identification" component is a very important component which should always be specified in "real world" scenario development efforts. Although it might be argued that it provides little additional value in the context of this example, we deliberately do not omit the "Model Identification" component of the BOM Template Specification.

Category	Information
Name	Air defence of a manoeuvring unit using ManPADs
Type	BOM
Version	1.0
Modification Date	2012-12-10
Security Classification	Unclassified
Release Restriction	Publicly releasable
Purpose	Analysis of the operational effectiveness of Man Portable Air Defence (ManPAD) systems for defending a manoeuvring unit against airborne attacks
Application Domain	Analysis
Description	This BOM specifies interactions between infantry using ManPADs against helicopters
Use Limitation	This BOM is not applicable for airborne attacks carried out by jet fighters or bomber units

Category	Information
Use History	
Keyword Taxonomy Keyword Value	
POC POC Type POC Name POC Organization POC Telephone POC Email	 Primary author Halit Oguztüzün … … …
POC POC Type POC Name POC Organization POC Telephone POC Email	 Technical POC Umut Durak, Aylin Hatip … … …
Reference Type Identification	None
Other	None
Glyph Type Alt Height Width	No glyph provided

C.3.2 Conceptual Model Definition

As described in Section 2.2.2, conceptual scenarios are tightly connected to the conceptual model of a simulation environment. Strictly speaking, the definition of entities (and their properties) is part of the conceptual model and not part of a conceptual scenario. However, a conceptual scenario will usually reference parts of a conceptual model (e.g., entities).

If a separate documentation of a conceptual model is available for a simulation environment, a reference to this documentation of the conceptual model may be included in the "Reference" sub-component of the "Model Identification" component. Otherwise, the BOM Template provides the possibility to include information about entity types, etc., directly into the BOM.

C.3.2.1 Entity Types

The BOM is made of several key elements; one of them is the conceptual model. Our conceptual model includes

- Commander Entity;
- Observer Entity;
- Gunner Entity;

- Hostile Object Entity;
- Firing Entity; and
- Target Entity.

Entity Type			
Name	**Description**	**Characteristics**	**Description**
Commander Entity _identifier	Thing that is the commander information	ID	Unique ID for entity
		Location	Physical position of the entity
Observer Entity _identifier	Thing that is the observer information	ID	Unique ID for entity
		Location	Physical position of the entity
Gunner Entity _identifier	Thing that is the gunner information	ID	Unique ID for entity
		Location	Physical position of the entity
Hostile ObjectEntity _identifier	Thing that is the hostile object information	ID	Unique ID for entity
		Location	Physical position of the entity
		Velocity	Velocity for the entity
Firing Entity _identifier	Thing that fires a weapon at a target	ID	Unique ID for entity
		Location	Physical position of the entity
Target Entity_identifer	Thing that is the target information	ID	Unique ID for entity
		Location	Physical position of the entity
		Velocity	Velocity for the entity
MissileEntity_ identifier	Thing that is the missile information	ID	Unique ID for entity
		Location	Physical position of the entity
		Velocity	Velocity for the entity

C.3.2.2 Pattern of Interplay

The major pattern of interplay within this air defence scenario is the sequence from observing the airspace until detection, identification and engagement of the target.

This pattern of interplay is illustrated in Figure C-2 using a UML sequence diagram. The transitions (arrows) are annotated with the communication and interaction events between actors. We chose to distinguish two types of transitions (indicated by stereotypes in Figure C-2):

- Communication (represents exchange of information between two parties); and
- Action.

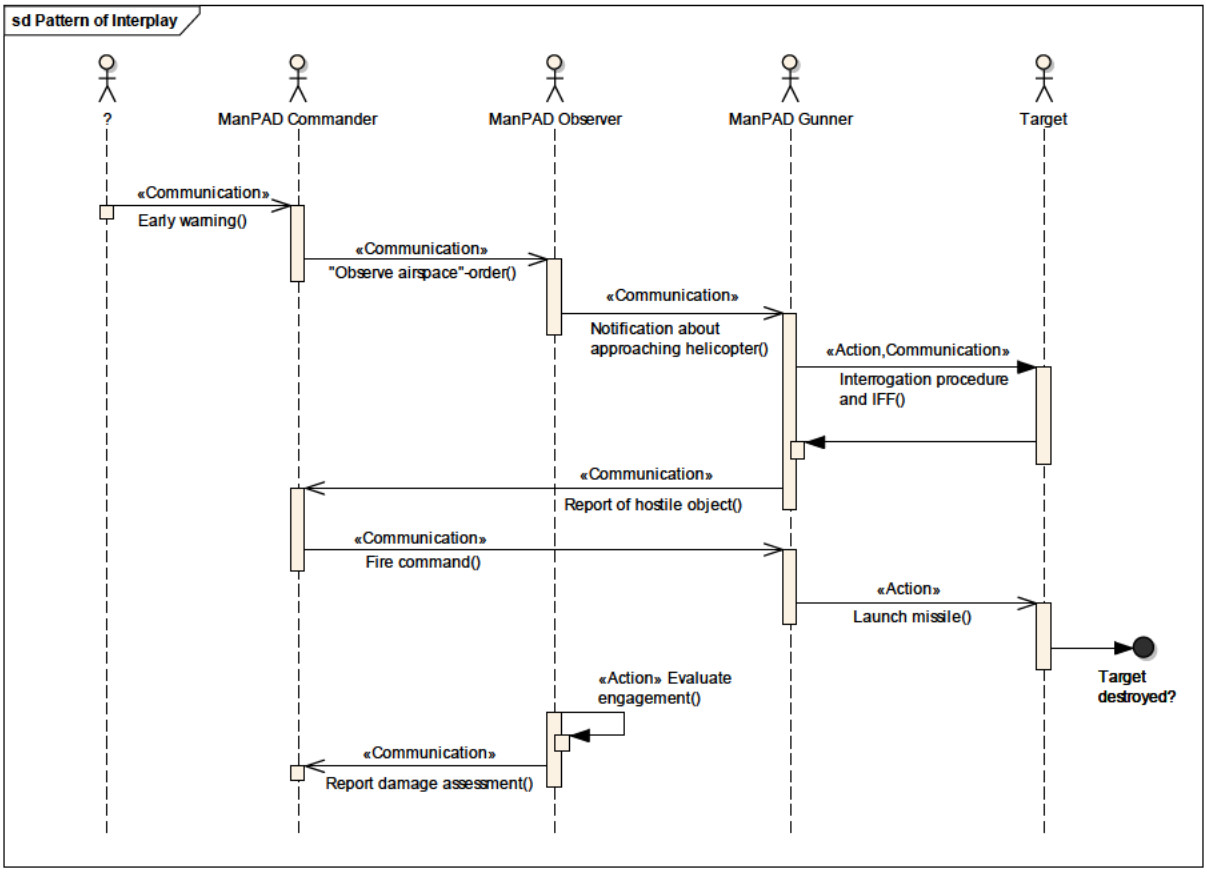

Figure C-2: Overview of Pattern of Interplay in Example Scenario "Air Defence".

Currently, the distinction is used only for clarifying the scenario developers' intention and the chosen types are not described any further. Ideally, a scenario developer can choose from a set of well-defined transition types which are standardized within an organization or across the M&S community (e.g., as SISO standard).

During development of the sequence diagram, we identified a couple of shortfalls in the original operational scenario:

- Who sends the "early warning"? The missing information is indicated in Figure C-2 by using "?" for the actor that sends the early warning.
- What precisely is the "Interrogation procedure and IFF"? Within the sequence diagram we annotated this transition with the stereotypes "Action" and "Communication" to indicate that it may be an interaction (e.g., sending an IFF request) or a communication (e.g., radio communication). However, a clear description of this procedure is missing.
- What precisely contains the "Report of hostile object"?
- The ManPAD Observer has to evaluate the engagement. How is this activity triggered?

In summary, specifying a scenario using a sequence diagram has proven very useful as it requires a scenario developer to be much more precise compared to textually specifying a scenario.

C.3.2.3 State Machines

The Pattern of Interplay gives an overview over the whole scenario, but does not provide detailed information about behaviour of single entities. Specification of behaviour of single entities may be done using UML state machines. In the following, each entity of the example scenario is described and its behaviour is defined using state machines.

ManPAD Team

The state machines of the ManPAD team are provided in Figure C-3, Figure C-4, and Figure C-5.

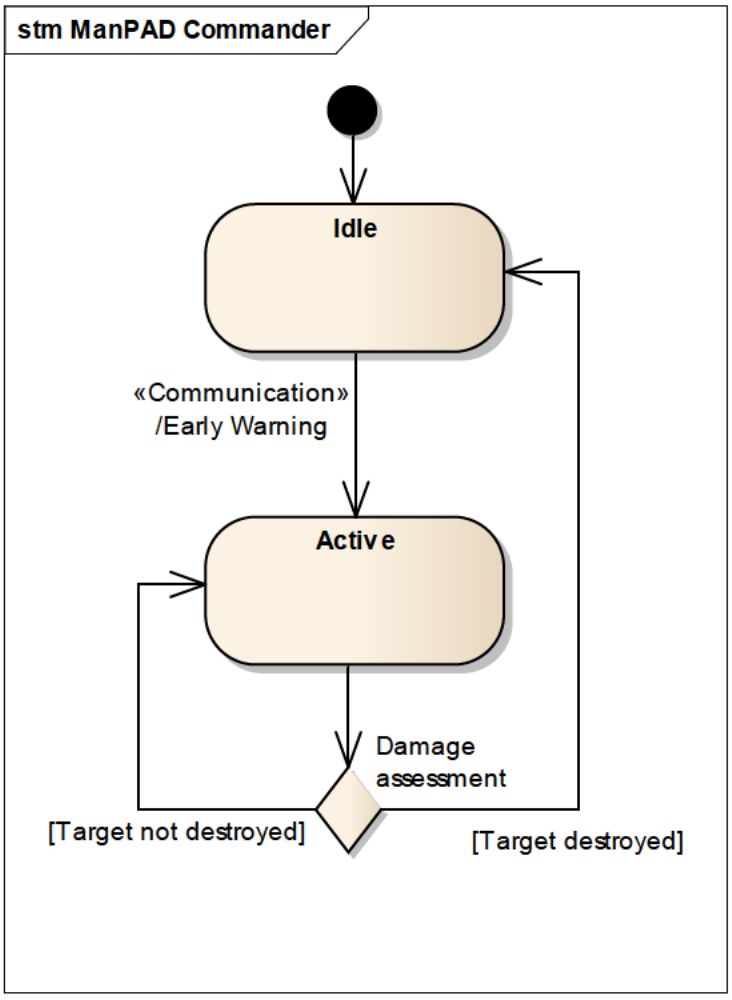

Figure C-3: State Machine of ManPAD Commander.

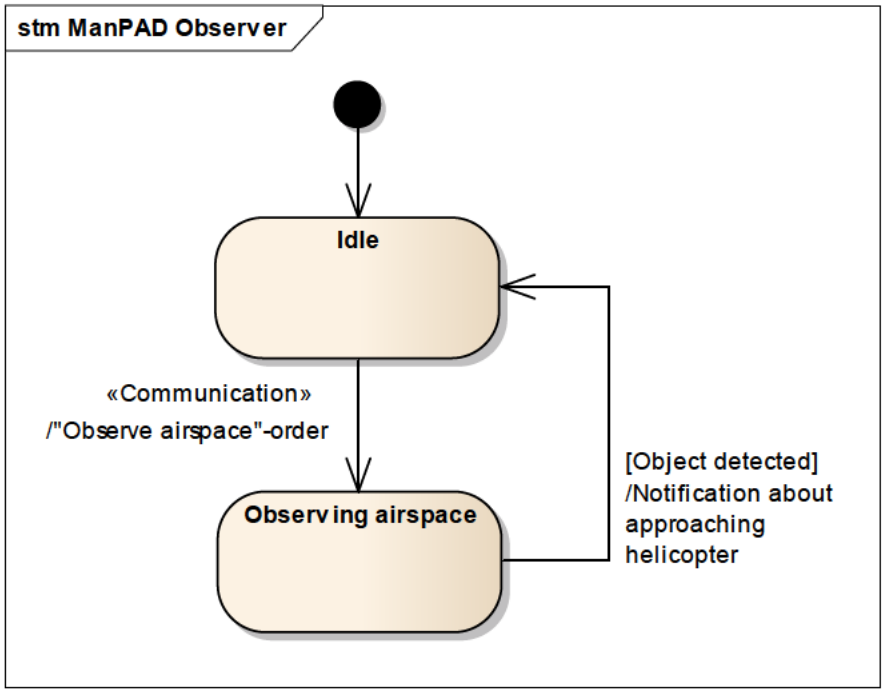

Figure C-4: State Machine of ManPAD Observer.

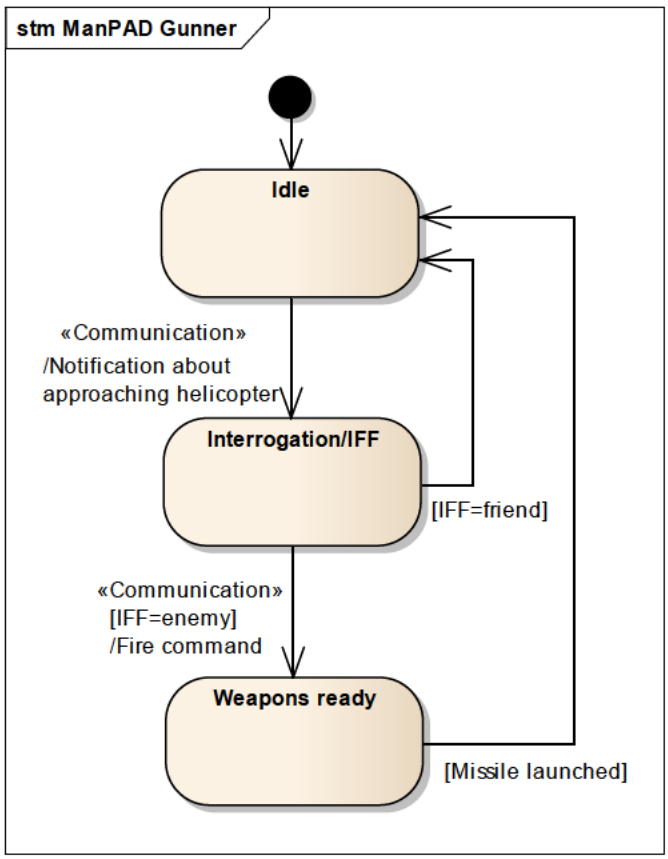

Figure C-5: State Machine of ManPAD Gunner.

Figure C-3 shows the state machine of the ManPAD Commander. As can easily be conceived from the state machine, the ManPAD Commander has a very simple behaviour. Basically, they are just responding to the reception of an early warning message and enter the "Active"-state once they receive this communication. They stay in "Active"-state until the target was successfully destroyed.

Figure C-4 shows the state machine of the ManPAD Observer. The observer is "Idle" until they receive an "Observe airspace"-order. The observation of the airspace is continued until an object is detected. In this case, a notification is send to the ManPAD gunner and the ManPAD observer goes back into "Idle"-state.

Figure C-5 presents the state machine of the ManPAD Gunner. The gunner is "Idle" until they receive a "Notification about approaching helicopter". Upon reception of this communication, the gunner starts the interrogation procedure and IFF. The result of the IFF is reported back to the ManPAD Commander (see Figure C-2). If the ManPAD Commander sends the "Fire command", the gunner launches a missile and goes back into "Idle".

The case of an approaching helicopter being identified as friendly was not described in the original operational scenario. Yet, when developing the conceptual scenario and creating the state machine for the ManPAD Gunner, it became obvious that such a state transition (as indicated Figure C-5 in by "IFF=friend") is necessary. Otherwise, the ManPAD Gunner would be stuck once they are in "Interrogation/IFF"-state.

Figure C-6 shows the state machine of a Target. As described in the operational scenario, a target is in straight flight until an approaching missile is detected. Upon detection of an approaching missile, the target goes into "Self-defence" state and throws its flares. Depending on the result of the defensive actions, either the missile is destroyed (respectively does not hit and destroy the target) or the target is hit and destroyed.

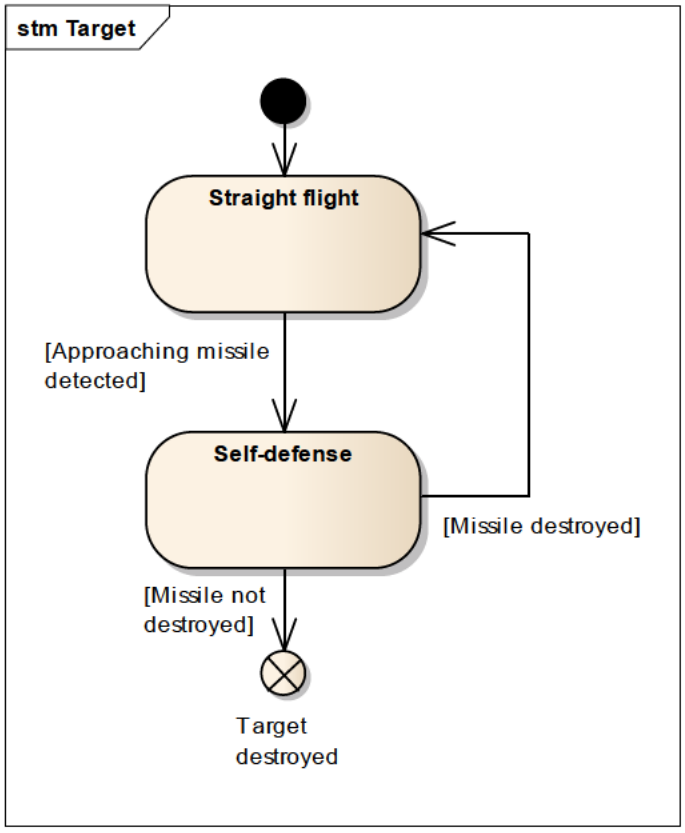

Figure C-6: State Machine of Target.

Finally, Figure C-7 shows the state machine of the Missile. The behaviour of a missile is rather simple. Once launched, a missile flies towards the target and either destroys the target or misses the target. Independently of the result, the missile is destroyed.

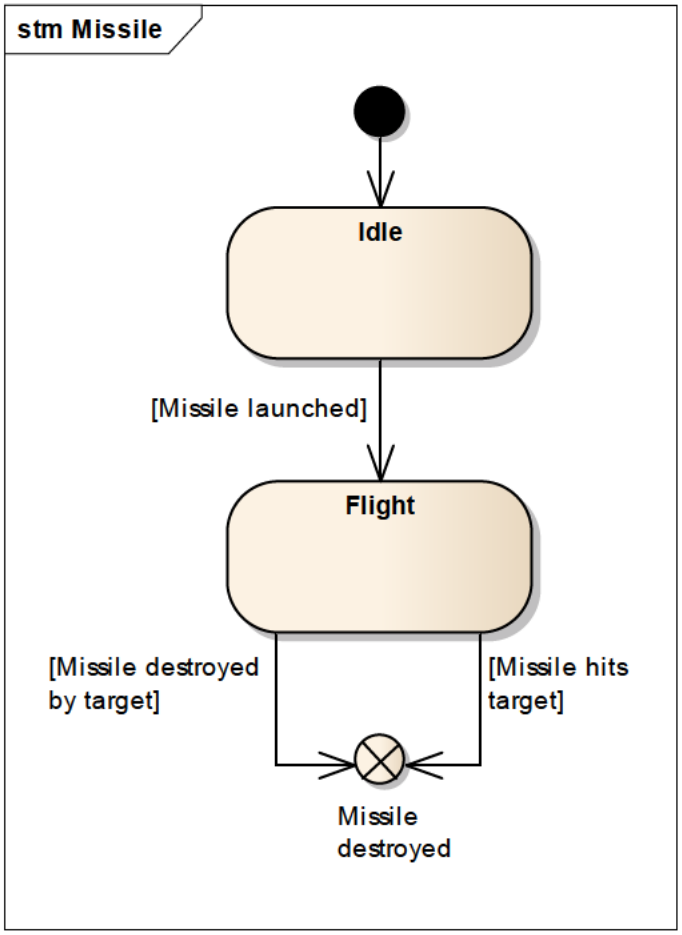

Figure C-7: State Machine of Missile.

C.3.3 Object Model Definition and Model Mapping

The Object Model Definition and Model Mapping components of the BOM Template Specification are neither suitable nor necessary for documenting conceptual scenarios.

Annex D – EXAMPLE SCENARIO "CLOSE AIR SUPPORT"

In this annex, an example is given how the information products related to scenario can be applied to a real world scenario. A Close Air Support scenario is described, where a Forward Air Controller (FAC) team on the ground and a flight of fighter aircraft work together to deliver a laser-guided weapon on a target (see [JP3-09.3] for more details about Close Air Support procedures). This example is based on work also described in [Keuning2008] and [Voogd2009].

In the next sections, the operational scenario and conceptual scenario for this case are given.

D.1 OPERATIONAL SCENARIO

Below is the operational scenario, as it could be given by an operational person. This operational scenario is given as free text, so it is using an unstructured scenario specification.

> A friendly infantry unit is being attacked by insurgents from a building. A flight of two F-16 aircraft is on a close air support mission and is flying above the mission area. The aircraft are equipped with laser guided bombs. The Forward Air Controller (FAC) team of the infantry unit requests air support from the F-16 flight.
>
> The flight lead determines which of the two aircraft will deliver the close air support. The attacking pilot contacts the FAC team on the ground. The FAC team requests a Type 1 CAS attack and delivers the information about the target using the standard 9 liner procedure.
>
> Using their Targeting Pod (TGP), and while communicating with the FAC team, the pilot identifies the target. After successful identification the pilot starts their attack run. They will only release their weapon after the FAC team announced CLEARED HOT. The pilot will announce when the weapon is 10 seconds before impact and at the moment the FAC team will start to illuminate the target with their laser.
>
> After weapon impact the damage is assessed by the pilot and the FAC team. If needed, another attack is made.

D.2 CONCEPTUAL SCENARIO

D.2.1 Initial State

D.2.1.1 F-16 Flight

- Structure:
  - Flight lead; and
  - Wingman.
- Equipment:
  - Radio;
  - Laser guided bomb; and
  - Targeting pod.
- Initial position:
  - In a holding pattern somewhere above the battlefield.

The UML use case diagram below shows the actors within this scenario and indicates that both the flight lead and the wingman can become the attacking aircraft when close air support is requested. The flight lead will determine which aircraft is in the best position to deliver the support once the request is made.

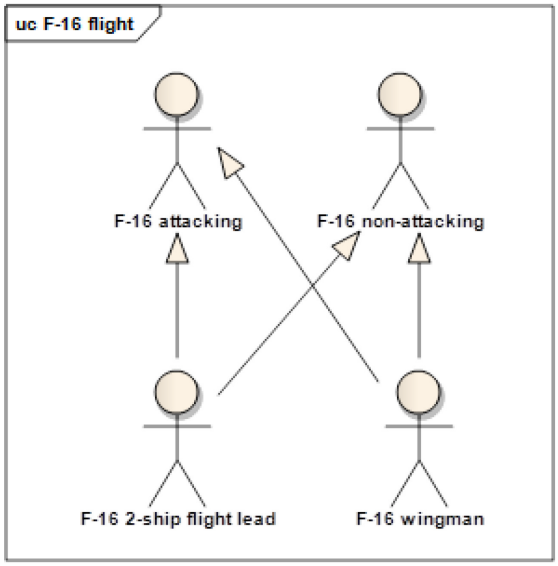

Figure D-1: Actors.

D.2.1.2 FAC Team

- Structure:
  - Team leader; and
  - Laser operator.
- Equipment:
  - Radio; and
  - Laser designator.
- Initial position:
  - Near the infantry unit; and
  - Within visual range of the insurgents.

The UML diagram below shows the two roles in the FAC team graphically.

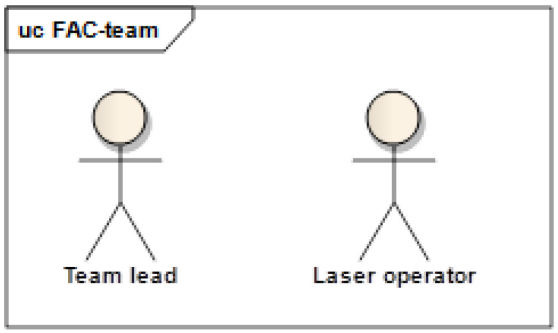

Figure D-2: Two Roles in the FAC Team.

D.2.1.3 Infantry Unit

- Initial position:
  - Near insurgents.

D.2.1.4 Insurgents

- Initial position:
  - Inside a building.

D.2.1.5 Geography, Date/Time

- Rural environment.
- Day time.

D.2.1.6 Surrounding Conditions

- Clear weather.
- No wind.

D.2.1.7 Rules of Engagement

- F-16:
  - Must have identified the target;
  - Must have identified the location of friendly forces around the target; and
  - Must have received CLEARED HOT instruction from FAC team.

D.2.2 Course of Action

D.2.2.1 Communication Events

- FAC team leader requests CAS from F-16 flight lead.
- F-16 flight lead acknowledges CAS request.
- FAC team leader provides basic target information to F-16 flight lead.
- F-16 flight lead reports to F-16 wingman who is going to be the attacking aircraft.
- FAC team leader provides detailed target information to the attacking F-16.
- Attacking F-16 reports ready for attach run once target has been identified.
  - FAC team leader reports CLEARED HOT when allowed to employ weapon.
  - Attacking F-16 reports to FAC team leader 10 seconds before expected weapon impact.

D.2.2.2 Interaction Events

- Insurgents fire at infantry unit.
- Attacking F-16 identifies target (building with insurgents).

- Attacking F-16 releases laser-guided bomb.
- FAC team laser operator illuminates target with the laser designator.
- Laser-guided bomb acquires laser signal.
- Laser-guided bomb impacts on target or ground.

D.2.2.3 Environmental Events

- N/A.

The UML activity diagram below shows the basic interactions between the different actors in the scenario.

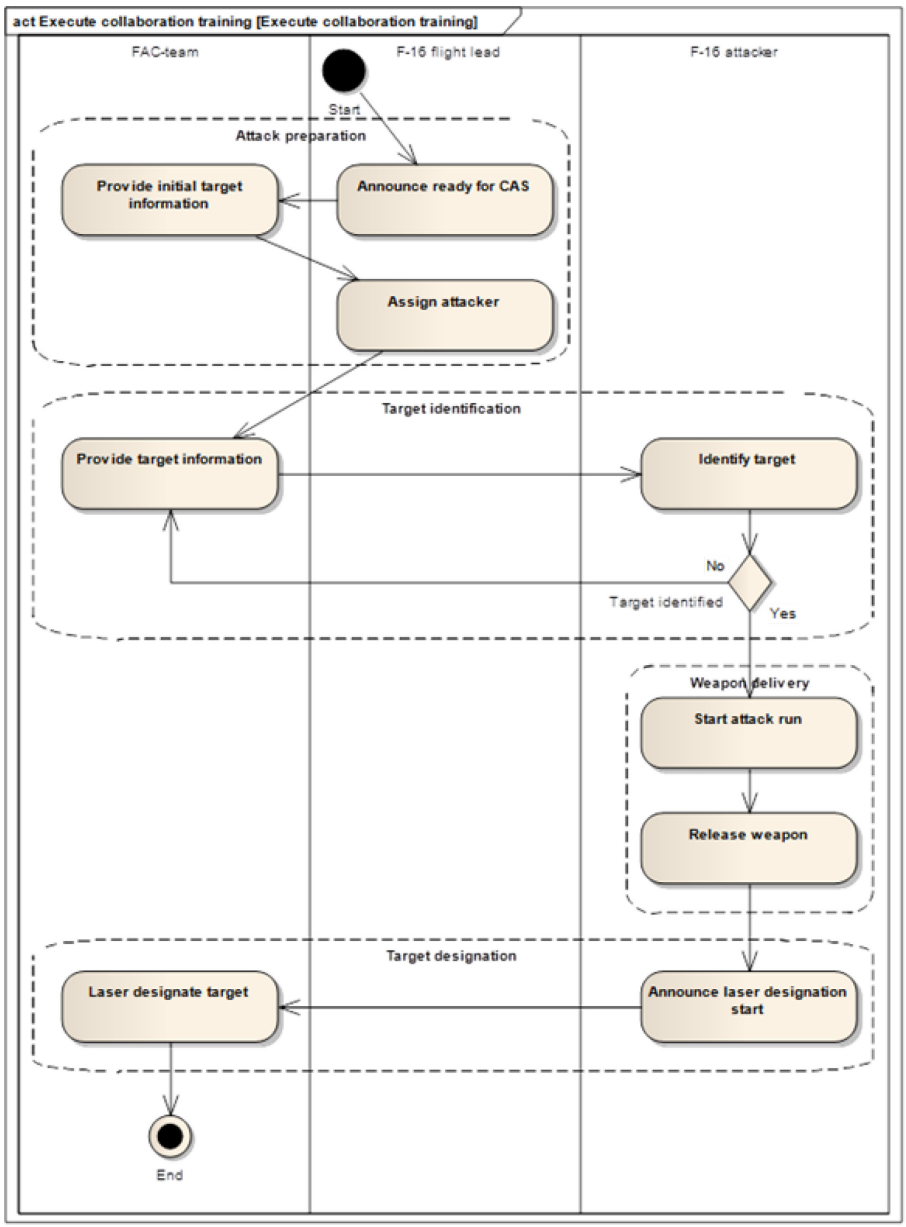

Figure D-3: Scenario Interactions Between Different Actors.

D.2.3 Termination Criteria

- Weapon has detonated and damage has been assessed.

D.3 DISCUSSION

Compared to the other example scenario, this example has chosen a different level of detail to describe certain elements of the conceptual scenario. This section discusses why this decision has been made. The required amount of detail should be balanced for each specific scenario.

On one hand, as much detail as possible should be provided, since that eases the task to transform a conceptual scenario into an executable scenario. Any detail that is not included in the conceptual scenario will have to be determined by the developer producing the executable scenario.

On the other hand, if different variants of the same scenario are used, it might be useful to make the conceptual scenario more generic, since that allows usage of the same conceptual scenario for deriving multiple executable scenarios.

In the specific case of this example scenario, two variants of the same scenario were used in a real-world project. One variant situated the close air support mission in a training context, while the other variant put it in a mission rehearsal context. As a result of this, the conceptual scenario does not provide very detailed initial position and related information of the different units.

When describing the course of events, the different interactions have been described slightly more detailed than the other example scenario. This has been done because the different interactions going on between the entities in the scenario were an important aspect in the project the scenario comes from. Specifying them in more detail helped with the development of the conceptual model.

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14. Abstract

Simulation interoperability is most often considered to be a technical problem (e.g., "Does every system support the same HLA standard and which RTI should we use?") or semantic problem (e.g., "How do we map different object models onto each other?"). Yet, reliably achieving high-quality distributed simulations requires to also consider more abstract questions regarding pragmatic, dynamic and conceptual issues (e.g., "How is aggregation and disaggregation treated by different simulation systems?", "Do different simulation systems interpret Rules of Engagement in the same way?").

In 2009, the Exploratory Team ET-027 identified 63 major issues which limit "true" simulation interoperability. In 2010, MSG-086 "Simulation Interoperability" was tasked to analyze the ET-027 interoperability issues in order to recommend and prototype information products augmenting the DSEEP to mitigate or obviate the identified issues.

MSG-086 analyzed 46 interoperability issues in total and categorized these issues into nine issue groups. Detailed descriptions of all interoperability issues have been developed specifying the original problem, its influence on simulation interoperability as well as possible solution approaches and already existing work in the specific problem area. Based on the identified interoperability issues, MSG-086 developed a "Guideline on Scenario Development for (Military) Simulation Environments" to overcome scenario-related interoperability issues.

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