# Toward an Integrated Executable Architecture and M&S Based Analysis for Counter Terrorism and Homeland Security

**R. Youssef, B. Kim, J. Pagotto, A. Vallerand, S. Lam, and P. Pace**
Defence R&D Canada Ottawa
Future Forces Synthetic Environment, Ottawa, ON, Canada
Rami.Youssef@drdc-rddc.gc.ca
Bumsoo.Kim@drdc-rddc.gc.ca
Jack.Pagotto@drdc-rddc.gc.ca
Andrew.Vallerand@drdc-rddc.gc.ca
Sylvia.Lam@drdc-rddc.gc.ca
Paul.Pace@drdc-rddc.gc.ca

**C. Pogue, A. Greenley**
Greenley and Associates Inc, Ottawa, ON, Canada
Chris.Pogue@greenley.ca
Anet.Greenley@greenley.ca

## *ABSTRACT*

*Over the past few years, defence organizations have begun to shift from Threat –Based Planning to Capability –Based Planning, focusing on a System of Systems construct. Executable Architecture, a Capability Management methodology, provides the means to conduct dynamic analysis of a system, and is emerging as a supporting methodology. By applying the rigor of systems engineering analysis and techniques, and incorporating a holistic blend of people, process and materiel, Executable Architectures can ensure that capabilities are properly designed, efficiently developed, and sustained with a specific focus on interoperability across government departments and defence organizations. Empowered by the use of modeling and simulation to validate the capability requirements and architectures, defence agencies are able to evaluate the potential effectiveness of adding new tools to current capabilities, such as a new sensor to the C4ISR capability. The goal of this study was to test the hypothesis that Executable Architecture provides an effective methodology or framework to address and analyze counter-terrorism and homeland security Capability gaps. This hypothesis was tested in a Homeland Security simulation scenario, where terrorists planted a dirty bomb close to Parliament Hill in Downtown Ottawa. The experiment consisted in conducting an Executable Architecture-based analysis using CORE™, while looking at multiple capability assets such as ground vehicles and an uninhabited aerial vehicle (UAV) focused to locate the radiological source, and by comparing the performance of these assets in terms of various capability based metrics such as agility, persistence, and range and to effectively measure whether the addition of a military UAV system would increase the effectiveness of the current Counter Terrorism Public Security capability. A validated physics-based Radiological emission and detection model was modeled in STK™, and JFCOM's Joint Semi-Autonomous Forces (JSAF) was the synthetic environment used to complement the executable architecture model, simulate the homeland security scenario, and show that a civilian emergency management SE tool can be interfaced with a defense federation. Finally and perhaps most importantly, the M&S was used to verify whether Executable*

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*Architecture provides the means to study and analyze Capability gaps. The results of the study showed that a significant increase in ISR Capability would be provided by the military asset compared to that provided by the Federal Police in terms of agility and range of the overall effect achieved The hypothesis was thus accepted as this study demonstrated that the executable architecture approach could transform the way Defence organizations and Public Security agencies currently assess and compare capabilities. It is suggested that the convergence of M&S with Executable Architecture actually represents an Integrated Interoperability Framework that further validates the System of Systems construct represented in the Executable Architecture between the various Organizations involved. Further research is required in much more complex systems, scenarios and application of capability metrics.*

## 1.0 INTRODUCTION

The DRDC Ottawa Future Forces Synthetic Environments section (FFSE) has been established to provide an R&D centre of excellence in the area of Synthetic Environments (SE) and Capability Engineering (CE). One of FFSE initiatives is 'JSMARTS', which leverages an ADM(Mat)-lead, enterprise-level effort to embrace the integration of Simulation and Modelling in Acquisition, Rehearsal, Requirements and Training (SMARRT)[1]. JSMARTS, advocated by FFSE, has established itself as an emerging new way of conceptualizing the development of distributed simulation events by rapidly constructing, with minimal development, simulation environments, characterized as a simulation-based 'pick up game',[1] rather than the large scale monolithic simulation-based exercises [2][3].

Capability Engineering is presently being defined and developed within FFSE through the Collaborative Capability Definition, Engineering and Management Technology Demonstration Project (CapDEM TDP) [6]. Capability Engineering extends traditional systems engineering to 'system-of-systems' and includes the use of M&S tools and processes to support Capability Analysis. Therefore, within the execution of a Capability Engineering-based analysis, M&S and 'system-of-systems' engineering converge. The FFSE JSMARTS initiative provides a suitable 'test bed' to begin to explore this convergence providing 'feedback' in terms of the inherent features of existing simulation-based exercises that directly contribute to engineering-level analysis at a 'system-of-systems' level.

The JSMARTS 2 experiment was to explore the role of a CE-based experimentation design and development toward advancing executable architectures and to demonstrate defence-related M&S technologies in an emergency management (first responder) context. This resulted in three key objectives:

- Demonstrate how executable architectures provide an effective methodology or framework to analyze homeland security capabilities
- Illustrate how a rapidly configured distributed simulation involving academia, industry and government can be used to conduct a capability engineering analysis looking at multiple capability states focused on a homeland security scenario, and
- Showing that a civilian emergency management synthetic environment tool can be interfaced with a Defence HLA federation

Therefore, the core capability-based engineering and analysis application is centered on the design and subsequent analysis of the M&S-based experimentally derived results. Additionally, as the JSMARTS concept is underpinned by government, academia and industry collaboration in a rapidly configured, minimally developed environment, new development was to be kept to a minimum (less than 8 weeks).

[1] The 'pick-up game' concept implies using already developed simulation-based resources in innovative configurations to evaluate concepts and federation development constructs. Essentially, participants offer what they have at present to achieve 'ends' rather than designing a bottom-up, requirements based simulation based exercise. A key aspect is to develop M&S 'agility' by bringing these simulations together in a matter of a few weeks. JSMARTS 2 development took about 8 weeks.

The overarching scenario of JSMARTS 2 consisted of civilian emergency management authorities in the City of Ottawa being notified of a radiological agent that had been placed in the city and the activities that the authorities must engage in order to detect and locate the source. Two source locations are to be located, and for each source the location of the source is to be located trough the use of: (1) ground vehicles only; (2) UAV only; and, (3) combined. The experiment is focused on 'detection' and therefore, although C2 elements are essential to provide some degree of execution variability, C2 processes were not formally developed within the CE-based operational architecture.

## 2.0 METHODOLOGY

The overall methodology employed for the conduct of the JSMARTS 2 exercise was based on the evolving elements of Capability Engineering (CE), which itself is being developed and refined within Defence Research and Development Canada (DRDC) under the structure of the Collaborative Capability Definition, Engineering and Management (CapDEM) Technology Demonstration Project (TDP). However, as CE is expected to be refined through application and a formalized CE Process (CEP) will evolve [6][7][8]. The JSMARTS 2 initiative employed a CE 'approach' rather than being a rigorous application of the full CEP.

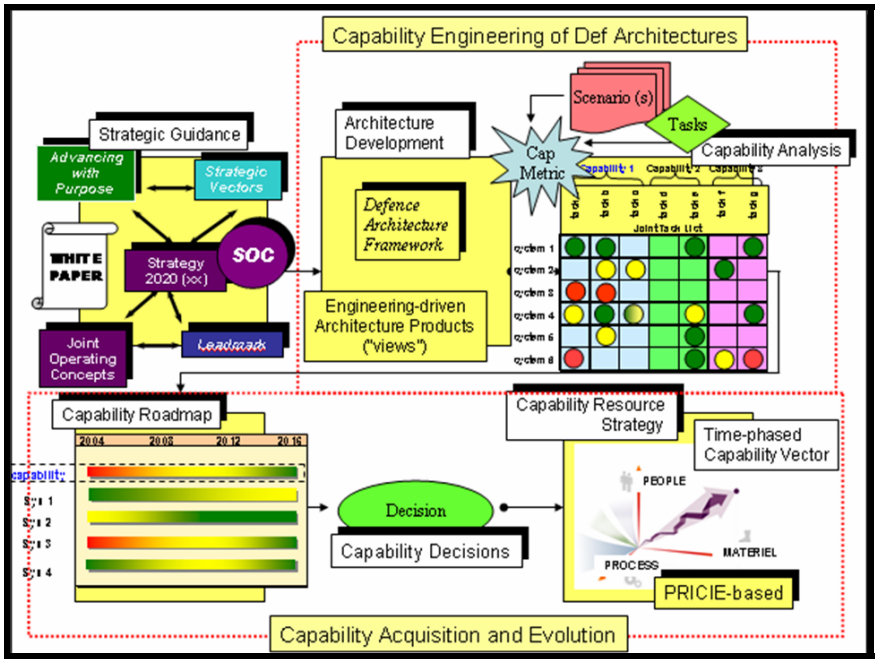


**Figure 1: Capability Engineering - Domain of Application**

The proposed executable architecture concept involves the convergence of the CE approach with the Modeling and Simulation domain in an attempt to align CE-based architecture development, and CE's ability to support Concept Development and Experimentation within a Capability Based Planning paradigm [9], with developing M&S tools and distributed simulation processes. Figure 2 depicts this concept illustrating how the CapDEM framework (and its relationship to CD&E) aligns with the use of M&S/SE technologies and processes. Guided by this conceptual goal, JSMARTS seeks M&S 'agility' coupled with exposure to, and integration with, operational end-users. The use of a CE-developed Operational and System Architecture is proposed as a means to achieve operational engagement within the simulation environment. By advancing rapidly developed and reconfigured M&S-based exercises, the operational community is able to quickly consider existing systems, evolving tactics, techniques and procedures, as well as consider new or even conceptual systems and processes.

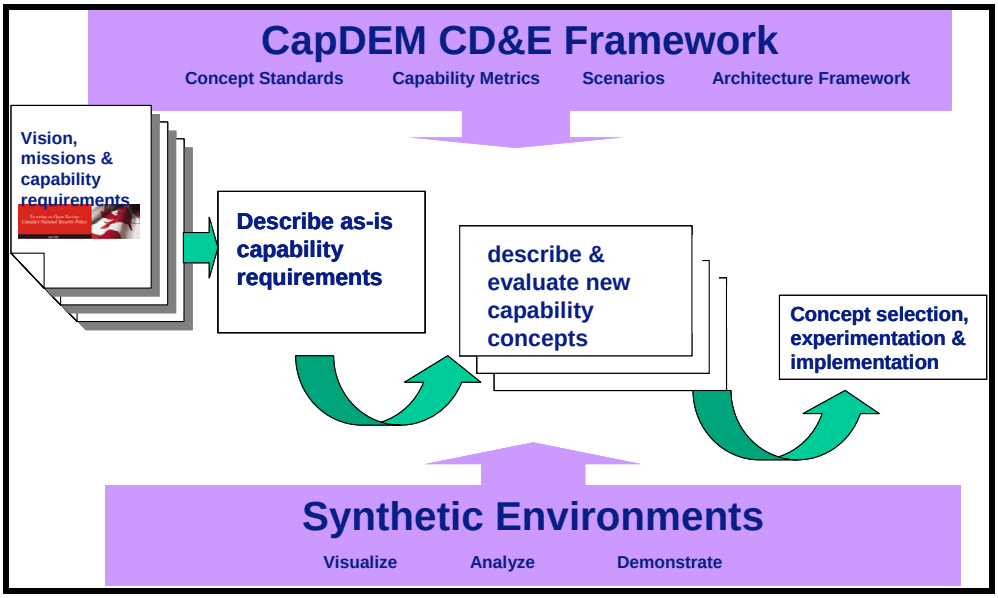


**Figure 2: Capability-based concept development**

## 2.1 CE-based Architecture Development – Structure

Figure 3 depicts the JSMARTS 2 CE-based simulation structure superimposed on the CE domain presented in Figure 2, and depicts the selected DoDAF views either developed specifically within JSMARTS 2 or proposed and conceptually applied to support the simulation event development. The general description below identifies various DoDAF 'views' within the overarching CE context. The Operational Architecture was developed employing the CE approach with traceability to National Security Policy and various guidance documents detailing the city's Emergency Response and Management plans. Operational Nodes (OV-3) and Information Exchange characteristics (OV-3) where then mapped to an operational scenario in which a radiological hazard was to be detected and the area contained (OV-5). The Operational Activity Model (OV-5) provided a natural lead-in product, when coupled with the Event Trace Description (OV-6c) in developing the simulation's Master Event List (MEL). In this experiment, two distinct system-level detection configurations were evaluated, an "as is" capability state which included police cars equipped with radiological detectors and a "to be" state in which a military Uninhabited Aerial Vehicle (UAV) was operated, in both a stand-alone and integrated configuration. The various systems to be simulated were captured in DoDAF System View (SV) artefacts, including the System Interfaces (SV-1), System Functionality Description (SV-4), and System Performance characteristics (SV-7).

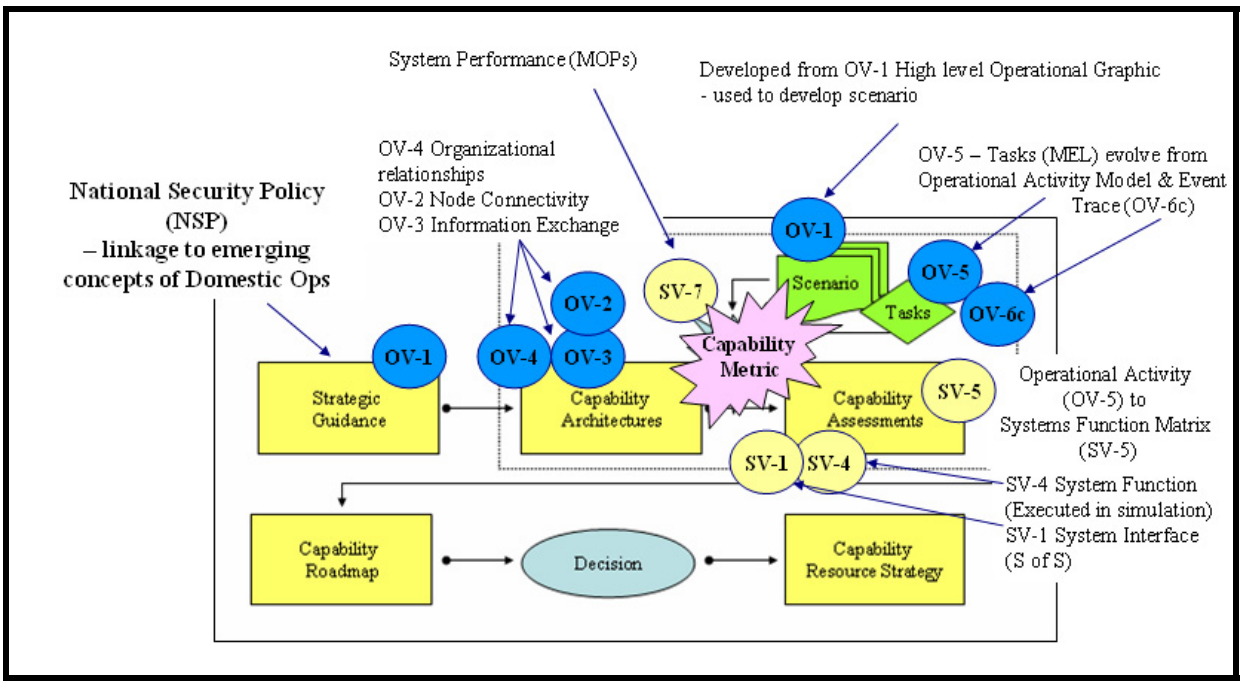


**Figure 3: JSMARTS 2 - CE-based Simulation Structure**

## 2.2 Overview of Generated DoDAF Views

The National Security Policy has six capability areas and the JSMARTS 2 context is situation within Emergency Planning and Management.

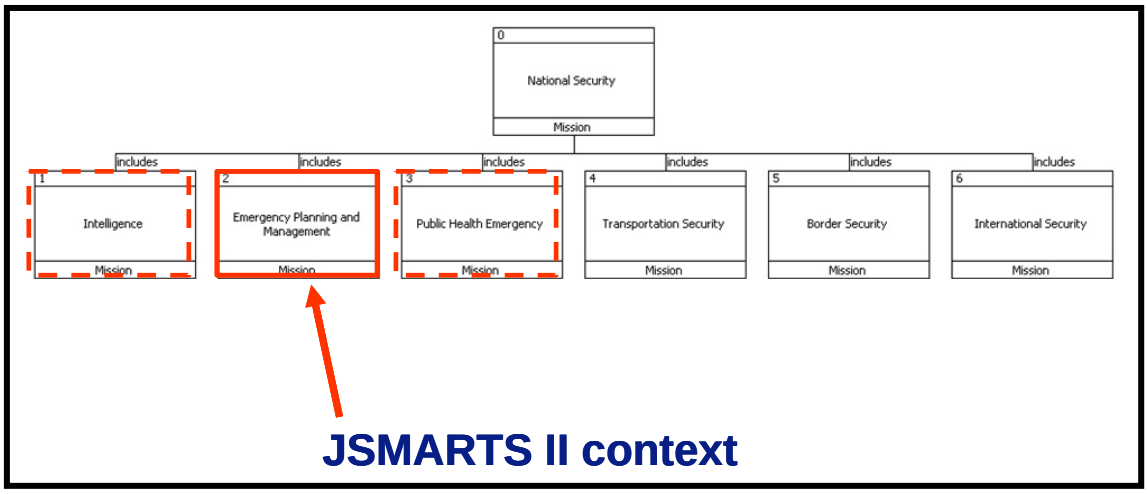


**Figure 4: The National Security Policy Capability Areas and the JSMARTS 2 Context**

Chapter 2 of the Canadian National Security Policy outlines four primary capability requirements:

1. Threat Assessment: “Although many individual federal departments and agencies conduct threat assessments, there has been no comprehensive and timely central government assessment that brings together intelligence about potential threats from a wide range of sources to allow better and more integrated decision-making.”

2. Protection & Prevention: "Integrated threat assessment must be connected to an effective, tactical capability to deploy resources in proportionate response to specific situations, and communicate relevant information to first line responders such as the law enforcement community. It is not, however, enough to connect activities within the federal government. We need to better connect our threat information to first line responders, law enforcement officials, critical infrastructure providers, and provincial, territorial and other governments."
3. Consequence Management: "While much of our national security effort is directed at preventing events from occurring, ***our system needs to be able to respond to incidents and their consequences.*** This can range from providing emergency medical assistance to prosecuting individuals for committing security offences."
4. Evaluation & Oversight: "An effective national security framework must, of necessity, be a continual work in progress. We need to continuously evaluate the success of the system by testing its effectiveness. The Government believes that it is essential to benchmark our progress against appropriate standards including the systems adopted by other countries."

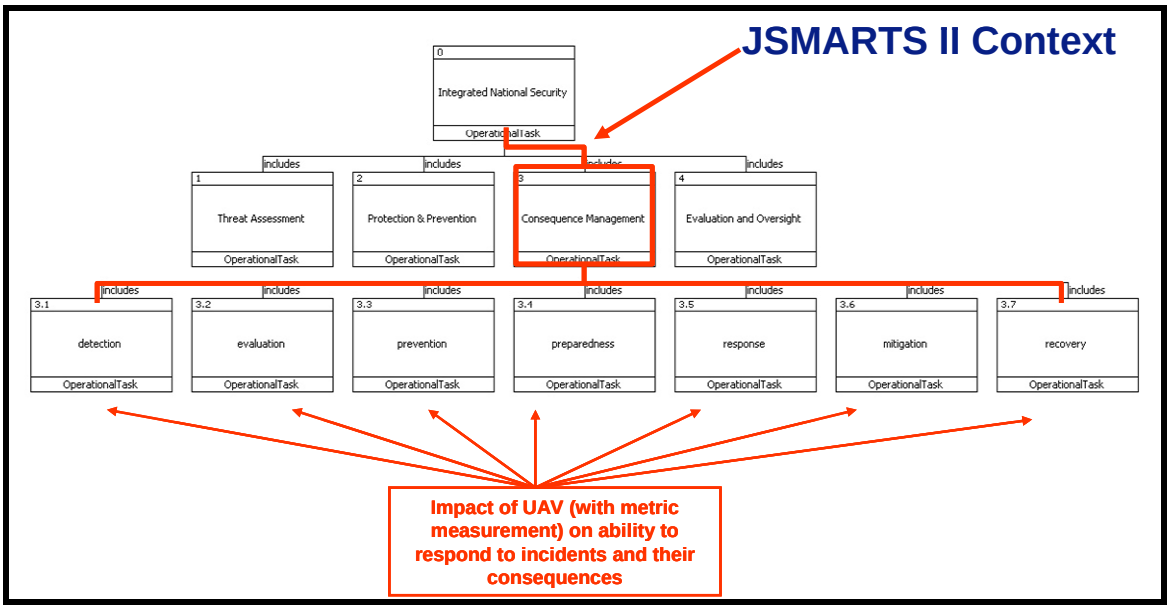


**Figure 5: The National Security Policy Capability Areas and JSMARTS 2 context – highlighting UAV anticipated role**

In developing a CE-based experimentation design the US Department of Defence Architecture Framework (DoDAF) [5] was employed to guide the development of specific Operational and Systems perspectives which would then be instantiated within the simulation environment to support experimentation. The following sub sections describe key aspects of some of the DoDAF products developed within the JSMARTS 2 initiative.

### 2.2.1 All Views – Overview and Summary (AV-1)

The AV-1 provides overview and summary information for the architecture development effort. Initially it serves a means to organize a project in terms of defining the purpose and objectives the sponsoring organizations and points of contact and the scope and context of the architecture project, the outputs and

the time period of the work. As the work progresses and is completed the information is updated to include results, recommendations and reports that may have been generated. In addition to describing the architecture project, the AV-1 may be used to compare or coordinate related projects and initiatives. In the specific case of the JSMARTS initiative the AV-1 was not formally developed and is somewhat represented in the various JSMARTS 2 planning documents. As the CE wok within JSMARTS 2 was not a formal architecture development but rather an exploration of how CE-based architecture products could support the experimental design, the development of a formal AV-1 is not considered critical.

### 2.2.2 Operational View - High Level Operational Graphic (OV-1)

The OV-1 provides a high level perspective that graphically depicts the overall concept of the architecture effort. In the case of JSMARTS 2 the OV-1 depicts the operational graphic of the experiment objectives (National Security Policy) and could also have been developed to illustrate the JSMARTS concept of rapidly configured, minimally developed simulation environments. Figure 6 depicts the JSMARTS 2 OV-1 focused on how the experimental was to address 'consequence management' afforded by faster detection capability.

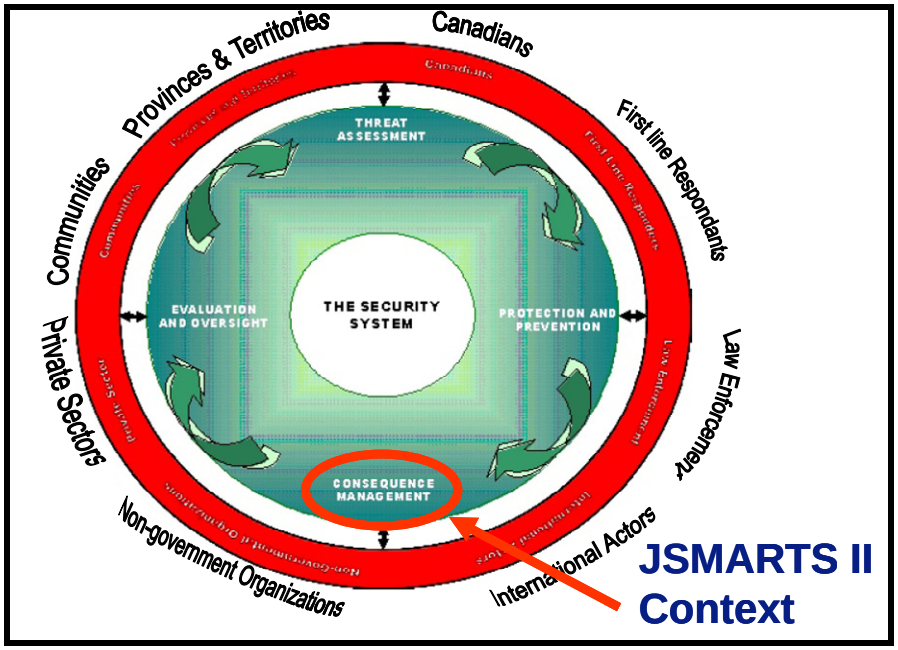


**Figure 6: JSMARTS 2 – OV-1**

### 2.2.3 Operational View – Node Connectivity Diagram – OV-2

The OV-2 depicts the significant operational node's (organizations) dependencies associated with the information flow and exchange requirements necessary to conduct the operational activities depicted in the OV-5 (below). The OV-2 is an important tool in translating concepts into capability gaps and linking organizations to activities. Details of the OV-2 developed for JSMARTS 2 are contained within the CORETM modelling environment; however, a high-level OV-2 is depicted in Figure 7.

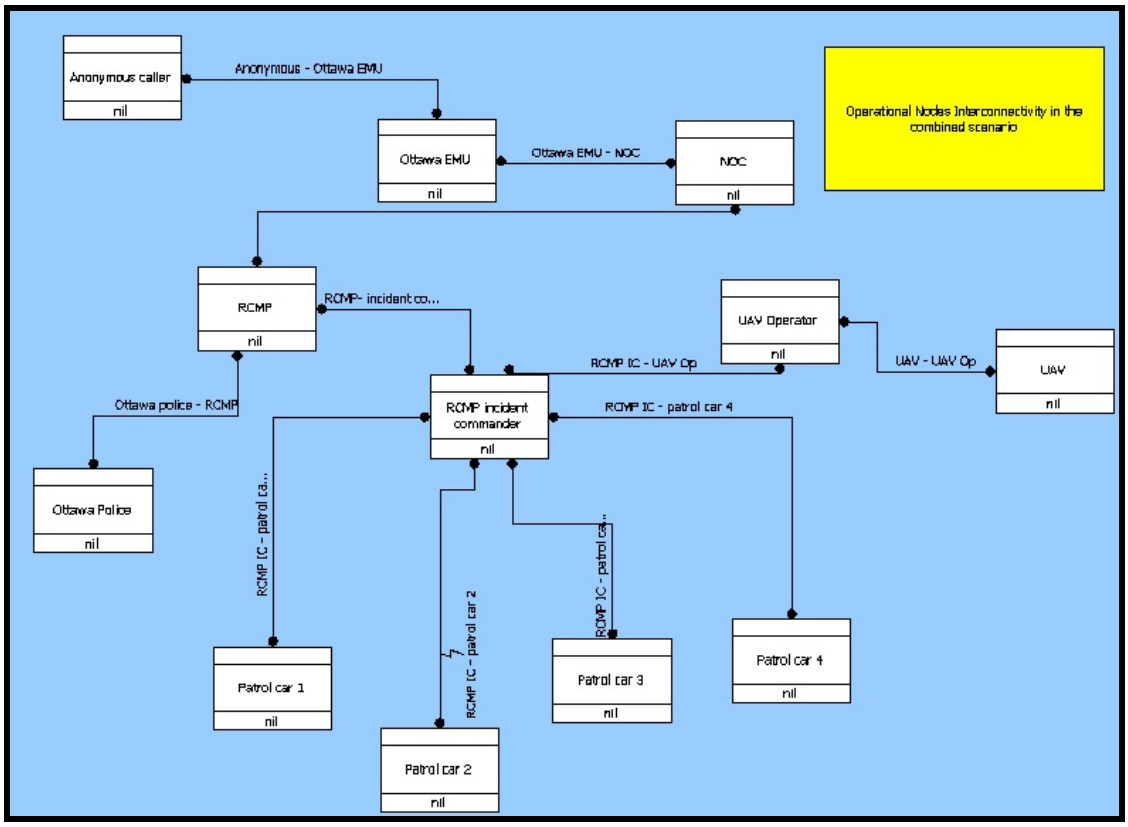


**Figure 7: High-Level OV-2**

### 2.2.4 Operational View – Information Exchange Matrix -- OV-3

The OV-3 tracks "*who* exchanges *what* information, with *whom*, *why* the information is necessary, and *how* the information exchange must occur". As implied in the above description, constructing this requires significant effort, knowledge elicitation and capture. This can be most effectively achieved through selected interviews and model construction, followed by validation. Within the JSMARTS 2 objectives extensive stakeholder interaction was not feasible (e.g., first responder community within Ottawa, etc.) and as such the OV-3 was conceptual and based on the developed OV-5 (Activity Model) focused on specific information exchange in the conduct of the operational search and detection activities.

### 2.2.5 Operational View – Organizational Relationships Chart – OV-4

The OV-4 illustrates organizational relationships and various command and control characteristics to facilitate organizational response to unfolding activities within the architecture and is related directly to the OV-2. Although a formal OV-4 was not developed for JSMARTS 2 as defined "Organizational Relationships" that cross CF-OGD interactions do not exist, the following information was employed in ensuring that the overarching C2 structure employed within JSMARTS 2 was based on documented organizational relationships, including the Joint Biological and Chemical Response Team, DND's Joint NBC Company, Public Security and Emergency Preparedness Canada (SEPC) and the RCMP. In general JSMARTS 2 was executed with a conceptual C2 relationship in which DND was a support agency. PSEPC is responsible for maintaining the National Counter-Terrorism Plan (NCTP) – Canada's primary mechanism for providing a coordinated policy and operational response to a domestic terrorist incident. The Royal Canadian Mounted Police (RCMP) is the Canadian national police service and an agency of the Ministry of Public Safety and Emergency Preparedness Canada. The Department of Defence (DND) plays

a support role to the RCMP preventative, incident response and consequence management responsibilities and contributes to the Joint Biological and Chemical Response Team (JBCRT).

If a terrorist incident involves a CBRN device, the RCMP National Operations Centre notifies the RCMP component of the Joint CBRN Response Team. This is in addition to the regular list of departments and agencies that are notified of a terrorist incident. The National Defence Command Centre notifies the Canadian Forces component of the Joint CBRN Response Team. Therefore, within the JSMARTS 2 context the addition of a defence UAV would be through those channels as a requested level of support.

### 2.2.6 Operational View – Operational Activity Model (OV-5)

The OV-5 is used to describe functional activities and tasks and is used to relate tasks to capability areas and mission requirements. Typically requirements are represented in terms of Activity Hierarchies or Activity Flow Diagrams. OV-5s can be used to demarcate lines of responsibility, expose unproductive or redundant activity and/or identify issues and opportunities. In the JSMARTS 2 initiative the OV-5 represented the high-level Scenario Master Events List (MEL). Figure 8 depicts the OV-5 (Part 1) developed for JSMARTS 2.

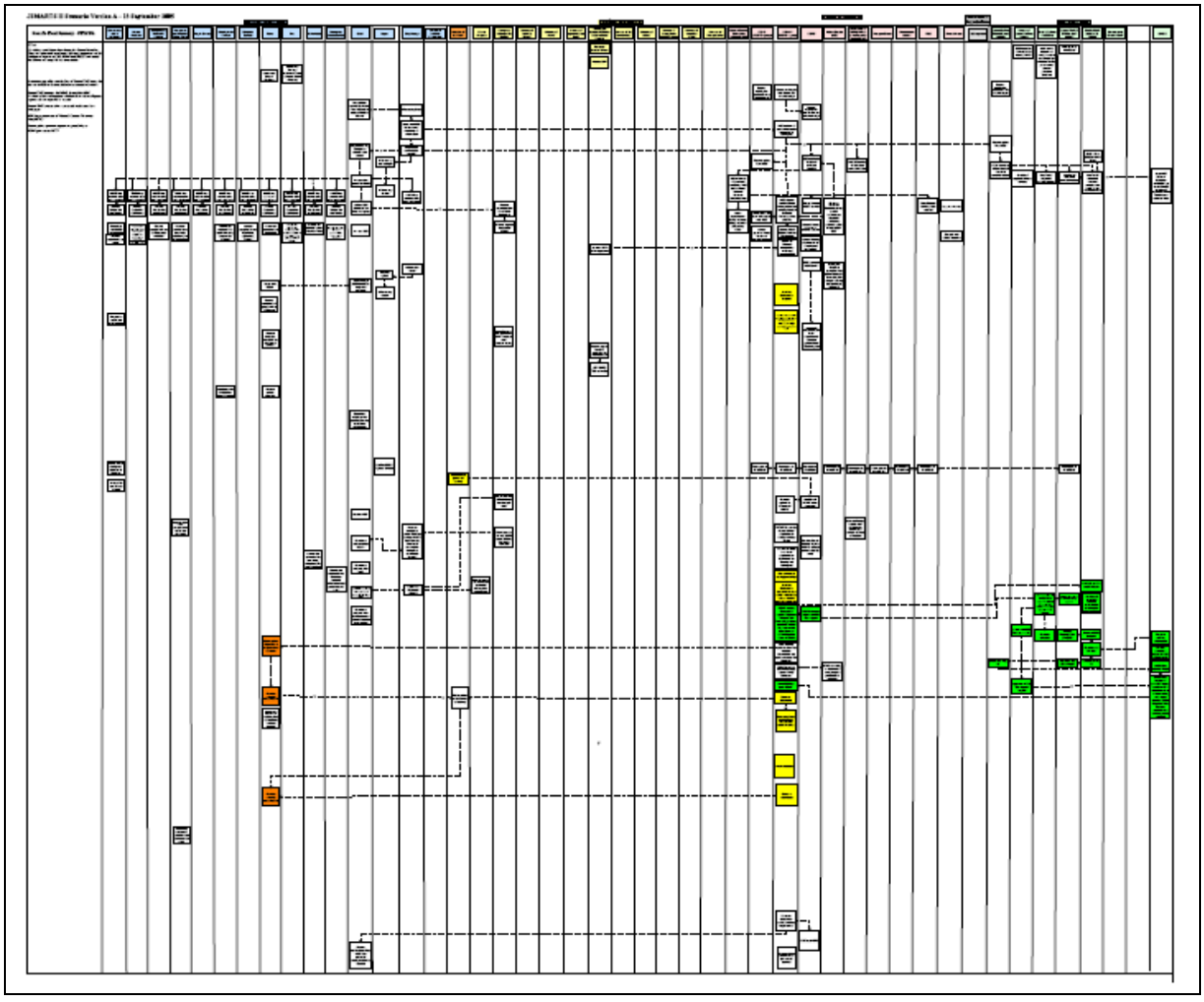

**Figure 8: JSMARTS 2 OV-5 (part1)**

### 2.2.7 System View – System Interface Description – SV-1

The SV-1 identifies system nodes and interfaces, and relates these to the operational nodes reflected in the OV-1 and OV-2. The SV-1 can be thought of as a systems representation of OV-2 dependencies. For JSMARTS 2 the SV-1 comprised two systems; the police cars (4) and the UAV. The exercise did not include extensive support systems (i.e., communications, fuel, personnel, etc.) and therefore the SV-1 was quite simplified and in some respects the overarching simulation architecture provides a conceptual SV-1.

### 2.2.8 System View – System Functionality Description – SV-4

The SV-4 describes various system-level functions. It is used during the Capability Assessment to support analysis as system functions are mapped to operational activities to assess overall performance of mission requirements. System characteristics were captured during SME interviews with participants, were represented in the simulation entities, and were employed during the application of Capability Metrics.

### 2.2.9 System View – Operational Activity to System Functions – SV-5

Creating an SV-5 is a matrix mapping exercise involving relating operational activities to system functions (SV-4). It serves a critical purpose and, notably, can be extended to relate missions to capabilities, capabilities to activities, activities to functions, and functions to systems. In JSMARTS 2 the SV-5 essentially emerged during the Capability Metrics application.

### 2.2.10 System View – System Performance Matrix – SV-7

The SV-7 represents system level performance characteristics and was developed during interaction with SMEs.

### 2.2.11 Operational View – Operational Rules and Constraints (OV-6)

The OV-6 series describe the business rules that govern operational activities. For existing operational elements, Doctrine and Standard Operating Procedures (SOPs) provide the basis for constructing the OV-6 – many of these documents were reviewed in developing the JSMARTS 2 experimentation protocol. As the OV-5 Operational Activities diagram provides the “sequencing” reference for developing OV-6s through which they can be instantiated within the simulation environment. The OV-6a can be used to map scenario tasks to operational activities to indicate how operational activities are driven by scenario tasks. A subsequent product, the OV-6b is a graphic depiction of event-driven state transition. The related OV-6c includes a time-ordered examination of information exchanges, i.e. an OV-6c allows for the tracing actions in a scenario. In sum these Views describes how the current state of a process or activity changes over time in response to external and internal events. The CE activities within JSMARTS 2 did not formally develop OV-6 products; however, the overarching OV-5 logic was explored within CORE in support of the experimentation development [11]. Figure 9 depicts a conceptual OV-6 application of the OV-5 logic developed in CORE.

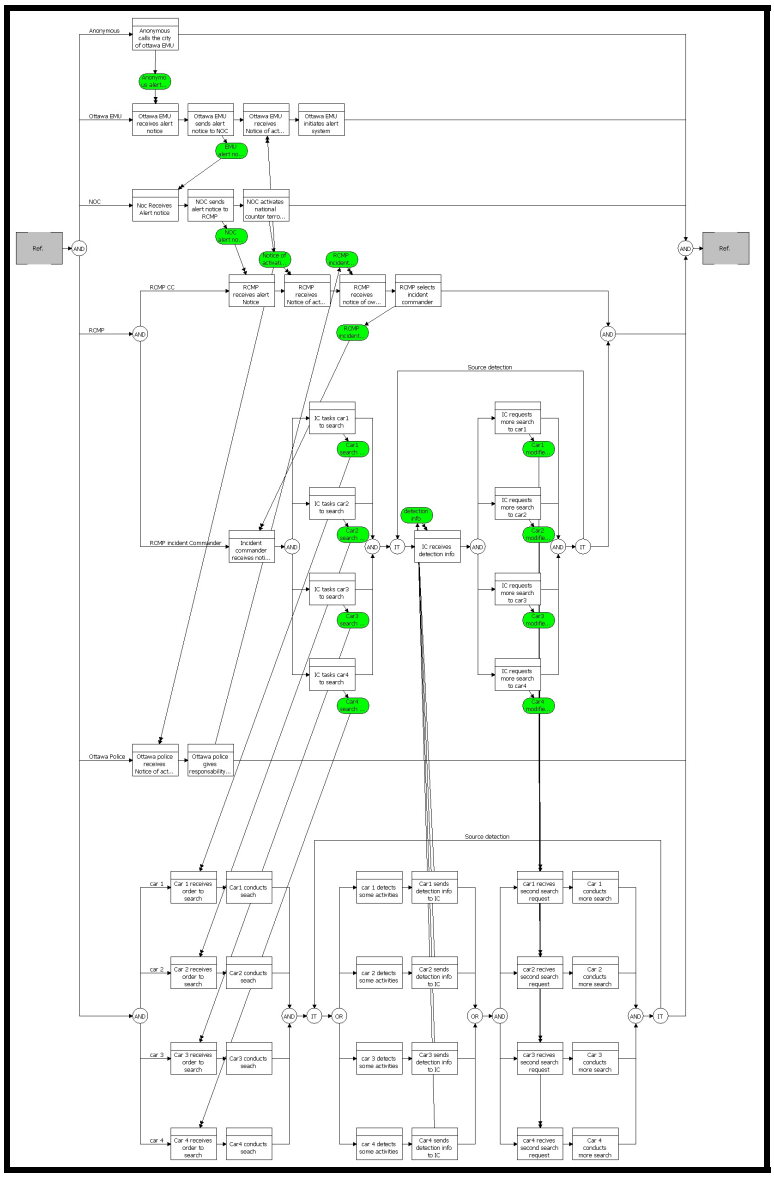


**Figure 9: Conceptual high level OV-6 Executed in CORE (Cars Only)**

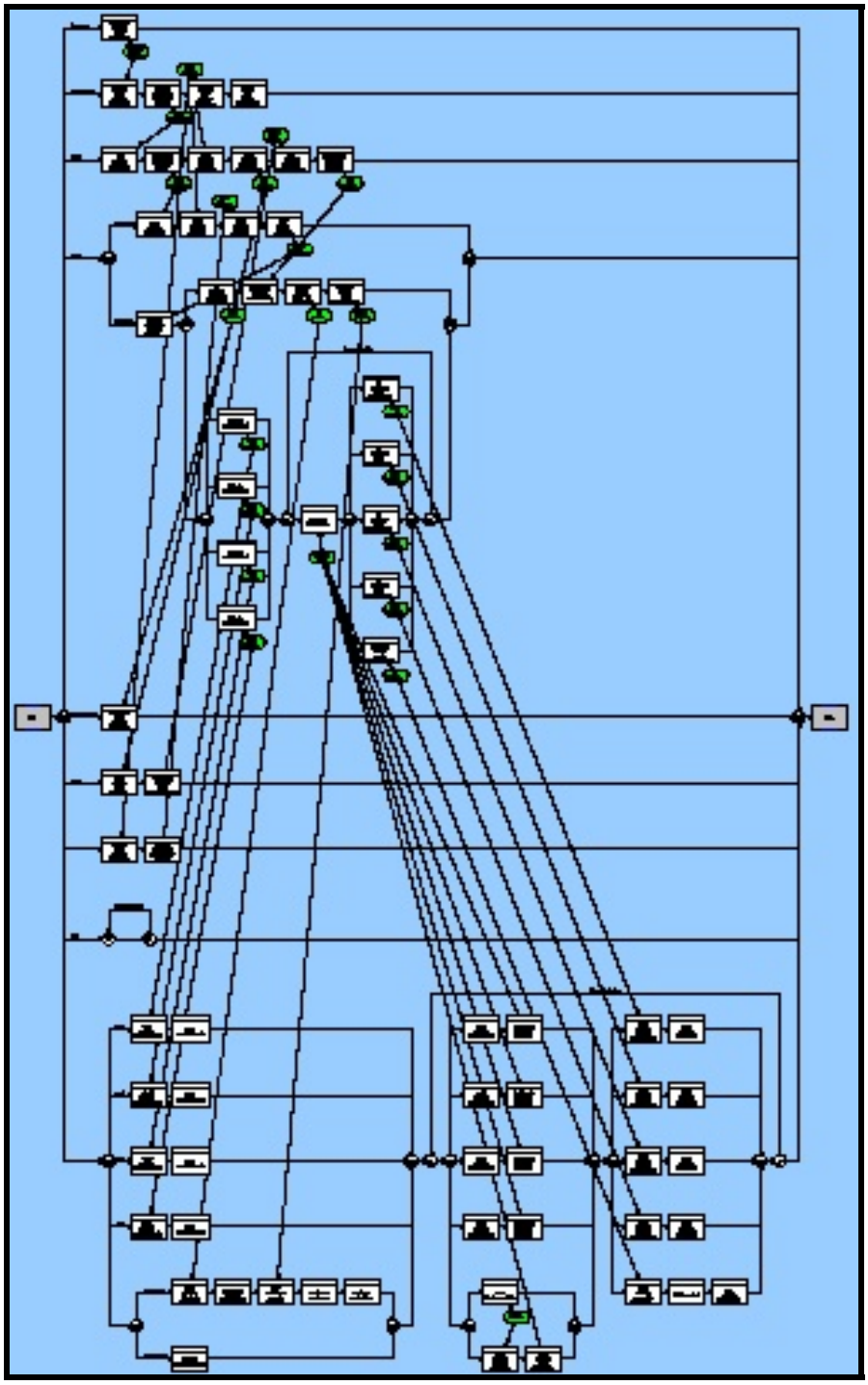

**Figure 10: Conceptual high level OV-6 Executed in CORE (Cars and UAV)**

## 2.3 Experimental Environment – Instantiating the Architecture

The overarching scenario consisted of civilian emergency management authorities in the City of Ottawa being notified of a radiological agent that had been placed in the city and the activities that the authorities must engage in order to detect and locate the source. The simulation exercise was run for six variants with two source locations. Therefore, for each source location the exercise was run three times: (1) ground vehicles only; (2) UAV only; and, (3) combined. As for the simulation environment, a validated physics-based Radiological emission and detection model was modeled in STK™, and JFCOM's Joint Semi-Autonomous Forces (JSAF) was the SE used to complement the executable architecture model, simulate the homeland security scenario, and show that a civilian emergency management SE tool can be interfaced with a defense federation. The following diagram shows the technical buildup of the simulation environment

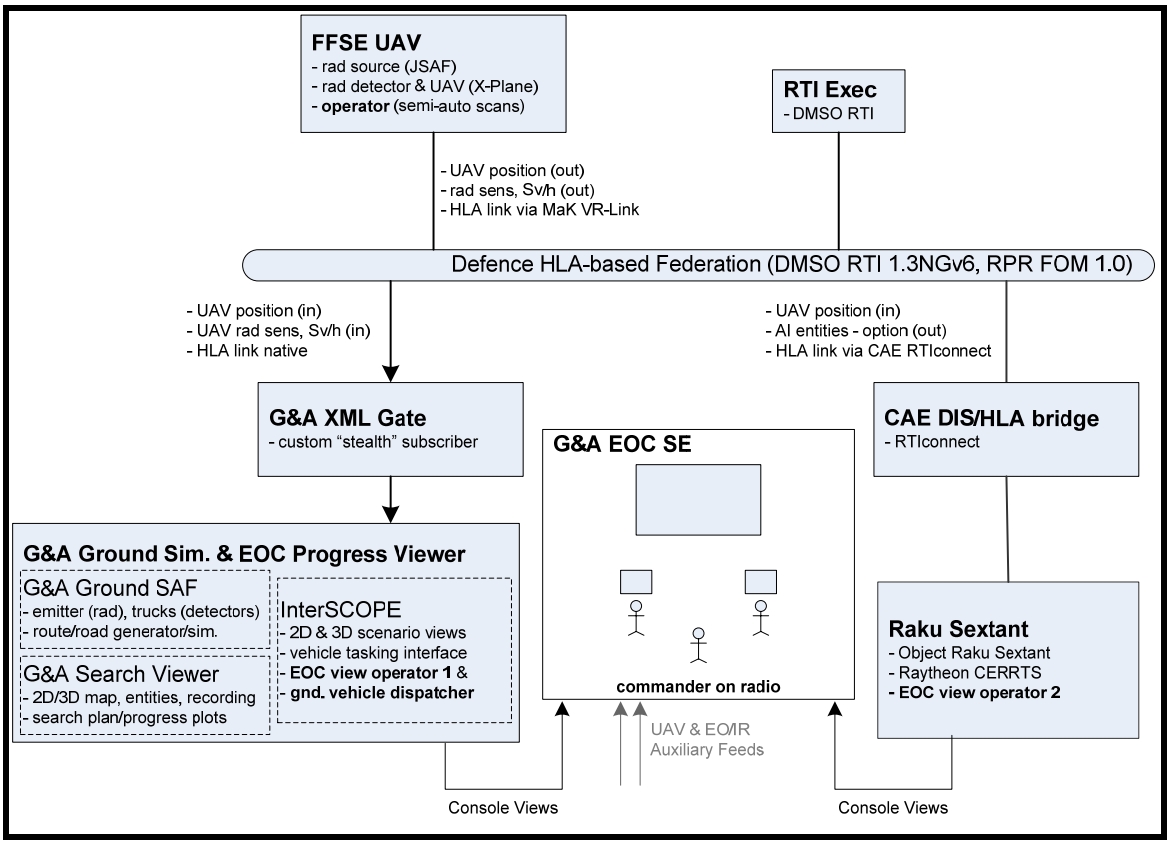


**Figure 11: Experiment Systems configurations**

### Area of Operations

The simulation extent is depicted in Figure 12 as the area in grey. This area was defined for the simulated EOC commander and used to direct the assets (cars and UAV) on the search pattern and to localize the target once detection was made.

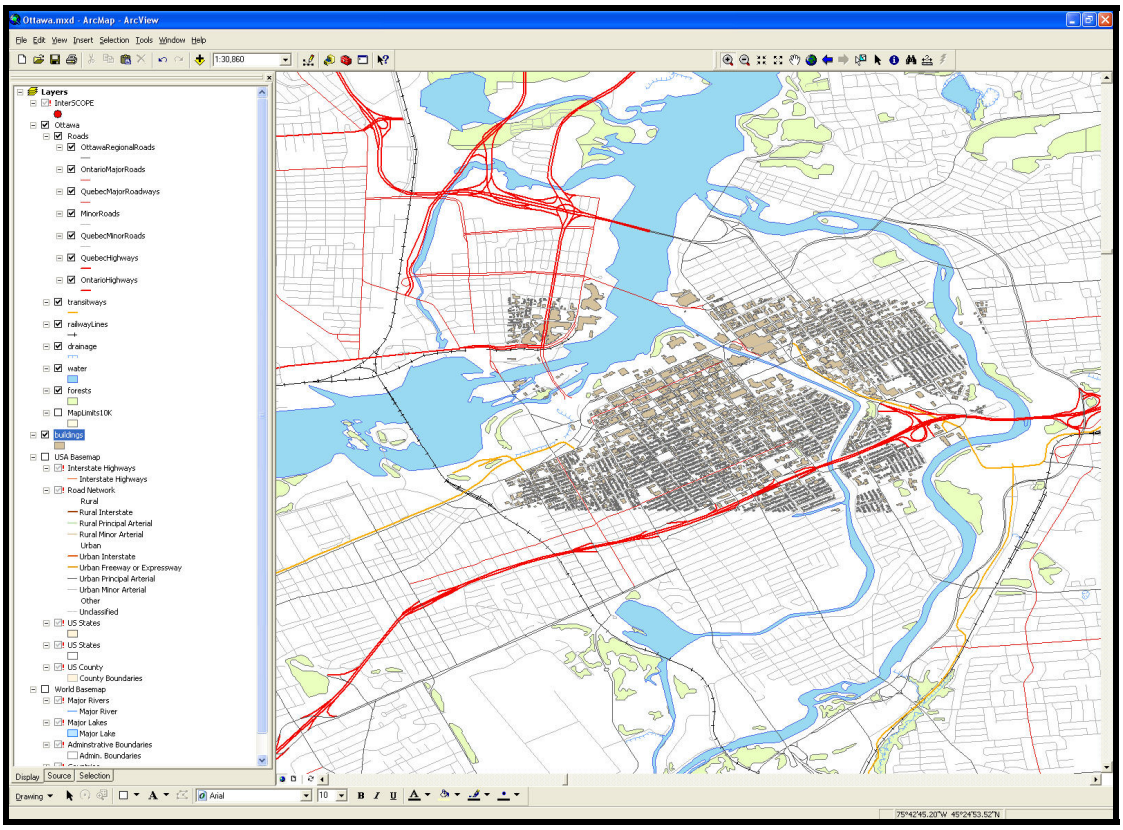


**Figure 12: Simulation Exercise Scenario Area of Operations**

### Radiological Agent

The source material employed consisted of 5000 Ci of Cobalt-60, a substance that is used for industrial (food and sundry) irradiation and therefore considered available to the terrorists within the scenario. The source locations are depicted in figure 13 (open parking lots) and were defined using UTM[2] as:

445995 E and 5028992 N – Parking lot near Museum of Nature

445611 E and 5030037 N – Parking lot amongst buildings near Parliament Hill, behind DNBCD

[2] Valid for WGS84 and for NAD83, Zone 18N – coordinate system employed by GPS.

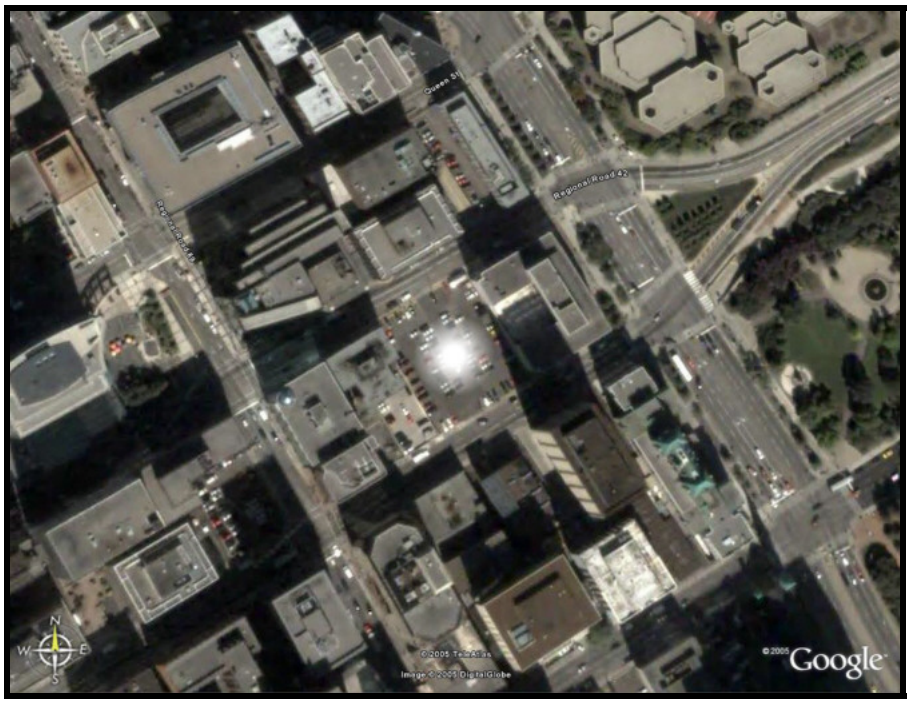


**Figure 13: Source 2 – Parking lot amongst buildings near Parliament – 445611 E 5030037 N**

### Ability to adapt

Although not a formally constructed C2 experiment, there was a desire to allow for command variability and adaptation; that is, if a pattern in detection emerged (as plotted on-screen), the EOC commander would logically direct cars and the UAV to move near to the projected hotter area (estimated by eye perhaps), at which point they could each continue otherwise fixed-pattern data collection. This is a normal refining or "annealing" of a search process. This was reasonably straightforward for the UAV due to speed and ease of relocation. Therefore, flexibility in a search pattern was incorporated into ground vehicles through a command tasking capability (via use of zones).

### Ability to Localize

Localization typically occurs some time after detection(s), with the use of some further localization tactics in terms by the EOC Commander. It was noted that interpretation and recommendation of the most likely location may first come from (sub-) commanders of each of the UAV and Ground Fleet search teams as they are on-site, which is then followed by a brief period of discussion between EOC and field commanders, and finally followed by the EOC Commander's decision. When the EOC Incident Commander was able to identify a 50 sq m area as the location for the source, the source was then being said to be localized.

### Starting Point – Launch Location

As the primary focus was detection and hence would be measured by time to detect the starting point for all the vehicles and the UAV was established to be the RCMP Headquarters, 1200 Vanier Parkway, Ottawa, Ontario; although there was some variability due to the degree of control available for the UAV simulation.

**Scenario Variations**

The scenario was run three times for each location for a total of six iterations in the simulation exercise:

(1) Ground vehicles (cars) only;

(2) UAV only; and

(3) Ground vehicles and UAV.

# 3.0 CAPABILITY ANALYSIS – APPLYING CAPABILITY METRICS

A key aspect of the CE-development within JSMARTS 2 was the direct application of Capability Metrics [4] [10] to the 'as is' and proposed 'to be' Capability states for detection, based on an analysis of the simulation results. The following sections describe the overarching Capability Metric construct and provide details on its application within the JSMARTS 2 exercise.

## 3.1 Capability Metrics – Background

Within the development of Capability Engineering a conceptual Capability Metrics framework [4] has been developed based on the principles of Value-Focused Thinking (VFT) [13] and the US C4ISR Imperatives [12]. VFT is employed to develop desired "effects" statements which link back to high-level strategic guidance and are described in term of Capability Metrics. Therefore, Capability Metrics are based on 'effects-based' outcomes and are defined by five abstract concepts depicted in Figure 14 – Range (or spectrum of effects), Reach, Information, Agility and Persistence (e.g., it would be potentially desirable to assess any approach to achieving an 'effect' in terms of its overall 'persistence', etc., when compared against desired end-state capability levels).[3]

[3] Agility: The quantification of the ability to re-direct. There are three aspects to agility speed of effect, speed of redirection, and discrimination of effect.

Information: Aspects of information as enablers: Information precision, quality, security, timeliness, sharing and survivability.

Reach: A measure of where and when effects can be applied within the desired area of influence. Reach includes a raw distance component, but is also involves the capability to achieve effects in urban environments, space, and during day or night.

Persistence: is similar to but different that Reach. Reach is a measure of the ability to use an effect at particular time and place while persistence describes the ability of the effect to exist in the environment.

Range: describes the ability to use a variety of effects (potentially simultaneously) to achieve a particular objective. A limited range of effects would be the response or deterrent approach whereas having no ability implies no range of response. Range or spectrum is the heart of Joint Operations achieving results that none of the environments could achieve independently.

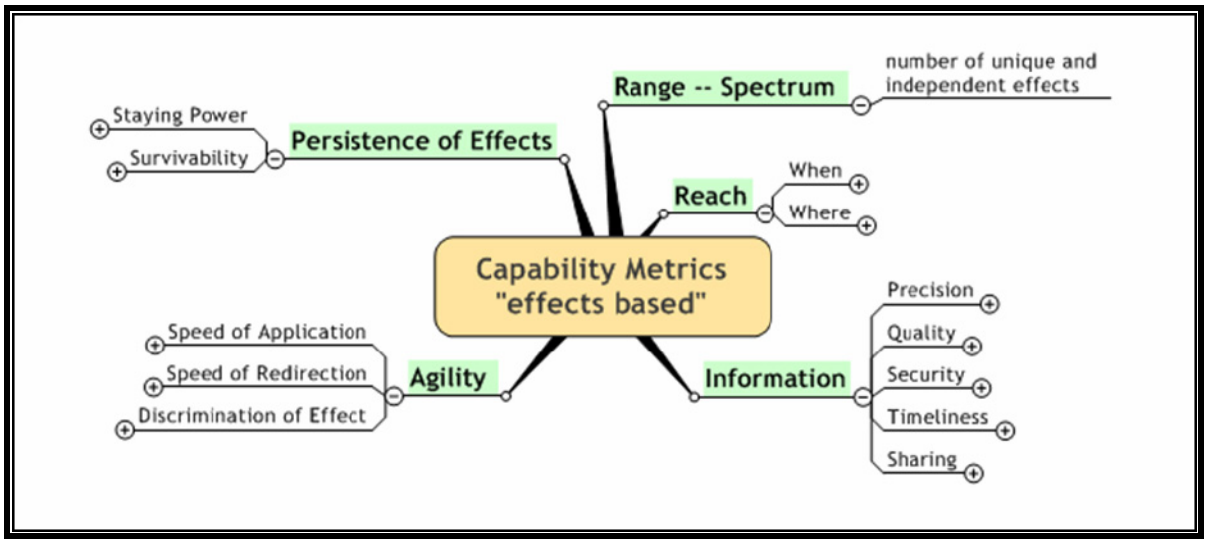


**Figure 14: 'Effects-based' Capability Metrics [12]**

Additionally, the Capability Metrics framework has been developed within an integrated measurement hierarchy that supports diagnostic, system-level analysis aggregated into a cross-capability level structure. Measures of Performance (MOP), by design, are generally specific to the particular "system" (e.g., speed, range, endurance, sensor characteristics, etc.), and are measured through various Dimensional Parameters (DP). Measures of Effectiveness (MOE) are typically defined within a scenario and determined through an analysis of a specific task (e.g., does System A provides greater situational awareness than System B). MOE are logically extended to define Measures of Force Effectiveness (MoFE) when multiple, broadly representative scenarios are considered.[4] Within the measurement hierarchy, an overarching Measure of Policy Effectiveness (MoPE) is envisioned to link the objectives of DND/CF (or the City of Ottawa in the case of JSMARTS 2) to those of the Government of Canada which is represented within strategic guidance. Figure 15 depicts this measurement hierarchy illustrating how the system-level measures of performance (potentially captured in the SV-7) are aggregated upward and then assessed in terms of a Capability Metric.

As the Capability Metrics focus on operational "effects" which are determined through an analysis and aggregation of scenario-specific MOEs, the structure aligns the **means** in which a desired "effect" is delivered as the **ends** (e.g., detection of the radiological hazard). Therefore, as end-users (operators) define a value-hierarchy to which subsequent measurement is traceable, it provides an additional advantage by connecting the measurement of the various **means,** to the end-user who will employ those **means** to achieve the desired **ends** (i.e., "effects").

[4] In the specific case of JSMARTS 2 the scenario was limited to detection and confined to one specific city and selected radiological hazard detection systems.

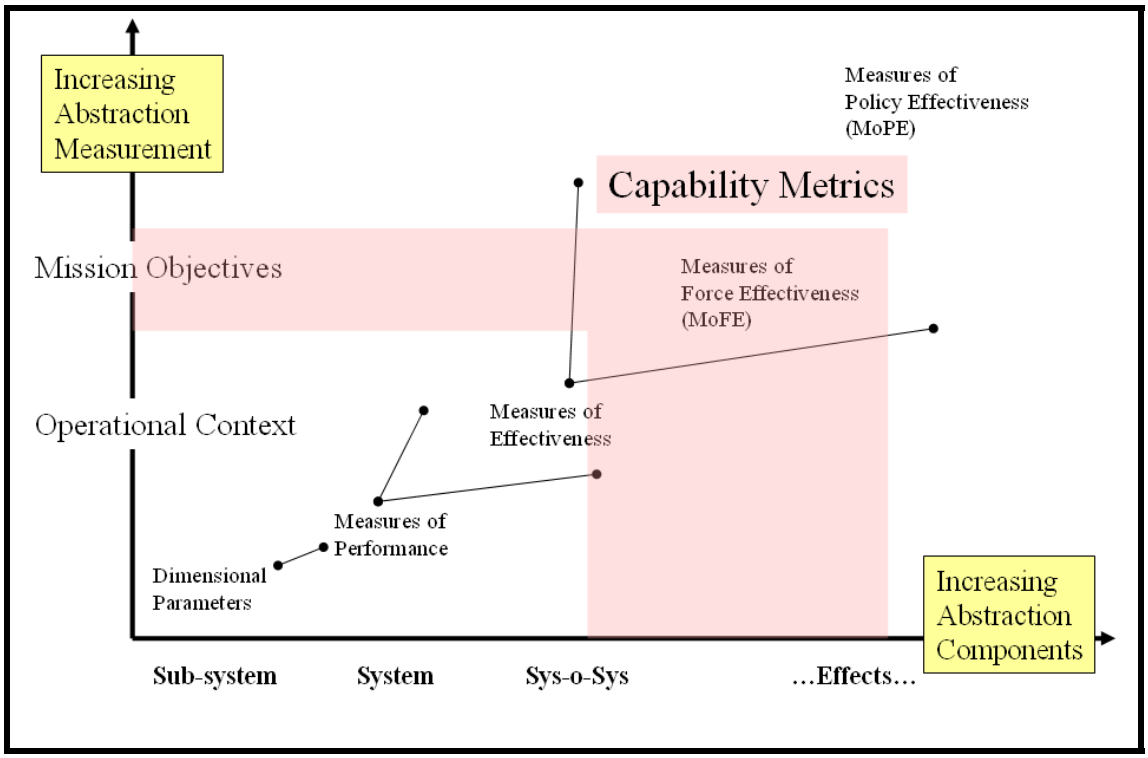


**Figure 15: Measurement Hierarchy**

## 3.2 Applying Capability Metrics – JSMARTS 2

In developing Capability Metrics for the JSMARTS 2 exercise limited interaction with the operational community was possible and therefore elements of the Capability Metrics methodology described above were performed by the analysis team based on available performance criteria contained within the City of Ottawa (DRAFT Emergency Response Plan and the National Security Plan.

Figure 17 depicts the metrics mapped to the National Security Plan.

Results of the simulation event were then analysed within the structure of the SV-5 in which Operational Activity (OV-5) is mapped to System Functionality (SV-4) employing MOPs, aggregated to a Measure of Effectiveness (MOE) for the selected scenario. Six separate simulation executions of the Operational Architecture were performed and analysed employing three configurations:

(1) Ground federate (4 Police cars) performing detection in isolation;

(2) UAV federate performing detection in isolation; and,

(3) UAV and ground federate combined.

The analysis was performed using an architectural tool as well as a synthetic environment Overall, 58 MOPs were developed and mapped to the Capability Metrics in terms of their respective ability to achieve ‘improved detection and containment’ as a desired “effect”. Figure 18 depicts a ‘snapshot’ of the Capability Metrics spreadsheet which is provided separate from this report. In essence, each MOE was decomposed into several measurement criteria some of which were directly assessed based on the simulation results and some of which were ‘constructed’ based on information provided by the SMEs or through discussion of the assessment team. Where appropriate ‘explanatory notes’ were developed and a

resultant ‘measure’ applied – using a bi-polar scale in which “5” was considered performance that met the objective and “0” assessed as no discernable impact on the desired ‘effect’. Where measurement was possible (e.g., time to detection and redirection of assets – rated within Capability Metric of “agility”) actual values were used to rate the criteria. Figure 19 depicts the aggregated, normalized analysis results based on the preliminary review of the simulation results. In this illustration the “as is” detection capability state is contrasted with two S-of-S configuration options. It is not the intent to suggest that the JSMARTS 2 exercise serves as an exhaustive analysis suitable for acquisition decision-making but rather as a structure from which to establish the necessary rigour for developing the simulation exercise based on the concept an Executable Architecture.

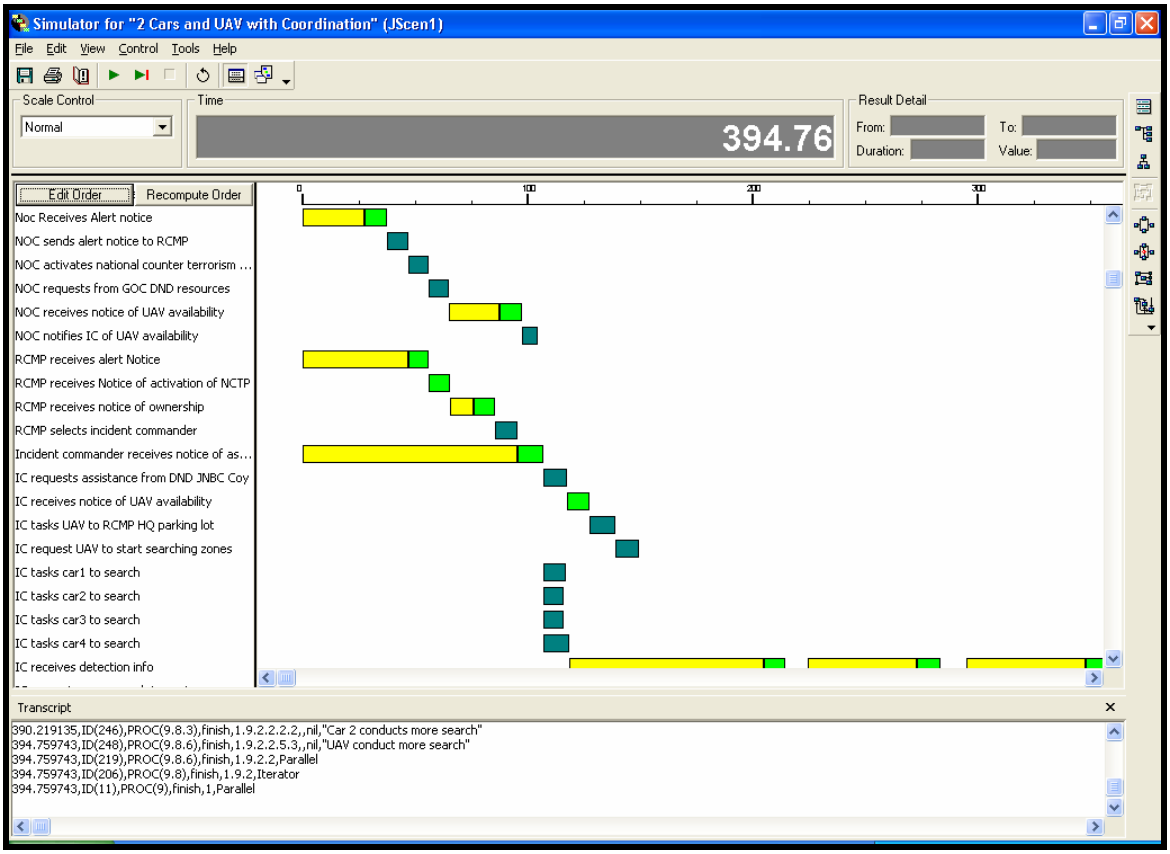


**Figure 16: A high level simulation example of the JSMARTS2 scenario**

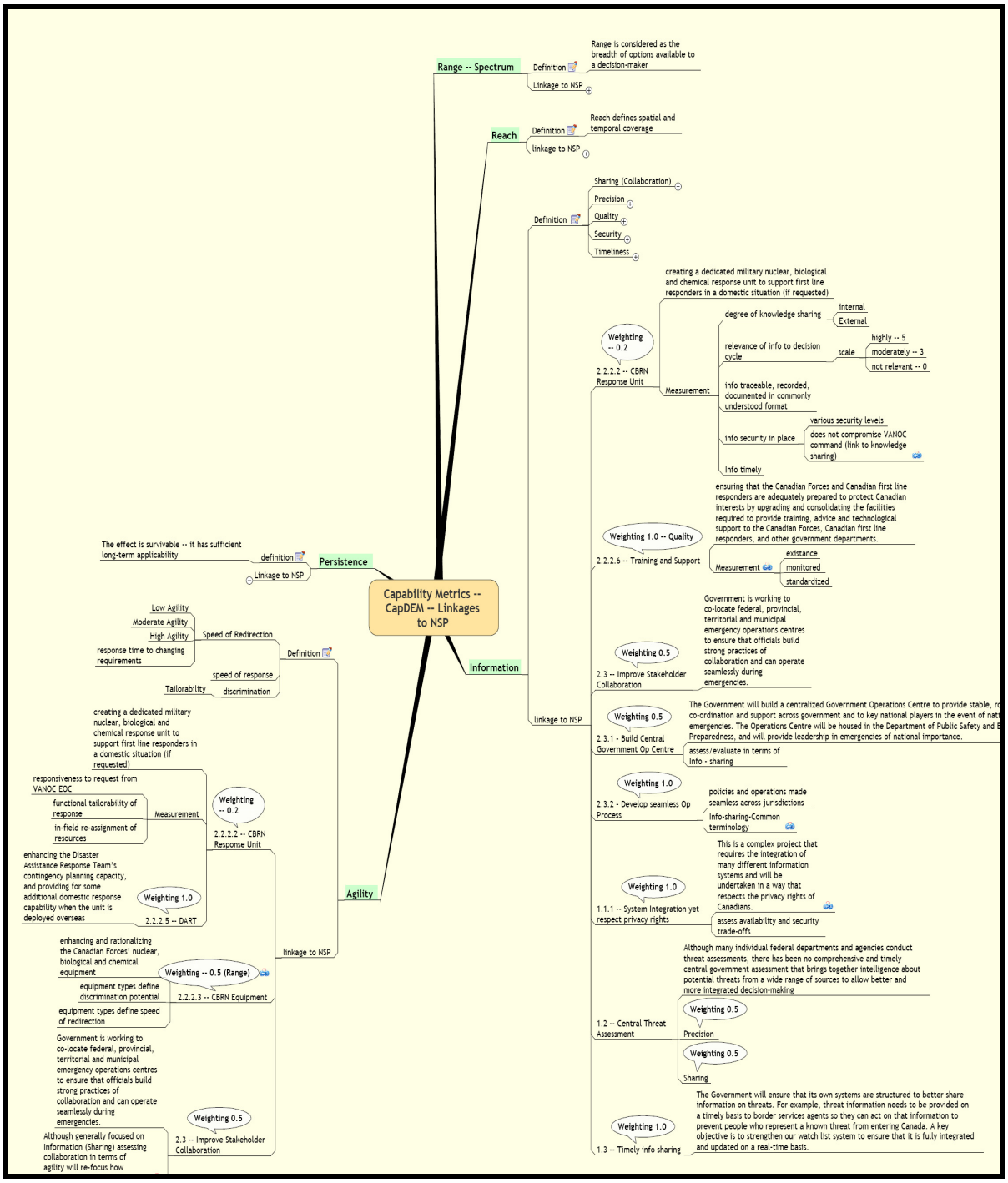


**Figure 17: National Security Plan –Metrics**

| | | | As-is | | Option 1 | |
|---|---|---|---|---|---|---|
| **MOEs based on Scenario specifics** | **Measurement/Assessment Constructs** | **Measurement Notes** | **Rated Value** | **Specific Measure** | **Rated Value** | **Specific Measure** |
| Survivability | security from terrorists/tampering/ influence | based on threat assessment - assumed that terrorists are not extensive group across the city that can attack cars | 4 | more assets - more survivable | 3.5 | Lower threats than ground target |
| | awareness (stealth) inherent in sensor use | public awareness might affect sensor use (e.g., traffic, etc.) -- also includes vulnerability from attack | 2.5 | Vulnerable to public dynamic | 4 | Draw public attention |
| | hardening or protection (degree) | of asset | 3 | None | 1 | None |
| | sensor redundancy | | 3 | only one per unit | 1 | None |

**Figure 18: Example of MOEs through MOPs – employed to develop Capability Metric**

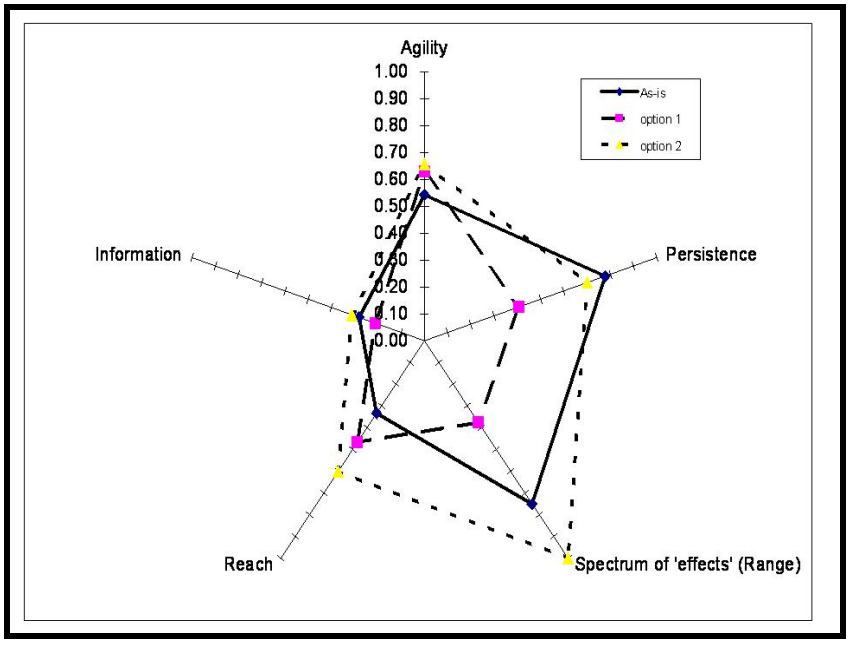


**Figure 19: Preliminary Results of JSMARTS 2 Capability Metrics Application**

## 4.0 DISCUSSION

Overall the JSMARTS 2 initiative built upon the concept developed for JSMARTS 1 in advancing defence, industry and academia collaboration in the execution of a distributed simulation exercise. Additionally, JSMARTS 2 sought to advance the idea of rapidly constructed simulation environments that were not purpose built but rather emulated a simulation 'pick up game'. However, as JSMARTS 2 was decidedly structured to explore two specific objectives, described at both a Macro and Micro level, as follows:

a. Macro – to demonstrate that the use of M&S as an effective tool for Capability Engineering (CE) analysis of homeland security requirements and also showing that a civilian emergency management SE tool can be interfaced within a defence federation; and,

b. Micro – to conduct a CE analysis/experiment looking at multiple capability states focused on a homeland security scenario with terrorists threatening the detonation of a dirty bomb.

The consequence of those objectives influenced the 'speed' at which the simulation could develop. The need to develop an Operational Architecture that was sufficiently traceable to strategic guidance documentation required additional resources; however, once developed the same Operational Architecture could serve as the underpinning for several 'system-level' analysis trials. Additionally, several simulation development issues arose throughout the JSMARTS 2 initiative and it is not the intent of this report to discuss or explore these issues; however, the overall development work load has been anecdotally reported to have generally exceeded the 'minimal development' vision of the JSMARTS concept.

In general, JSMARTS 2 has addressed the macro objective well in that a CE-based development and analysis approach served the experimental objectives and supported analysis in the homeland security domain, albeit limited first responder interaction was possible. Additionally, a civilian emergency management tool was integrated with the defence simulation to a degree; although, technical issues emerged that are more likely due to the technical architecture of the GIS-based emergency management tool than the ability for defence simulation to integrate within the homeland security and emergency management sector. The micro level objectives were met, albeit on a limited scale (e.g., cars with radiological sensors compared to a similarly equipped defence-operated UAV). The application of CE-developed Capability Metrics supported the simulation-based analysis and provided conclusions.

The following list provides a representative depiction of 'lessons learned' in executing JSMARTS 2 and is not expected to be exhaustive. Select 'lessons learned' are as follows:

- Developing a distributed simulation environment remains an illusive challenge and requires additional investment. As it is the centrepiece of the JSMARTS construct developing network 'permanence' is warranted.
- The commercially developed GIS-based operating picture environment employed within JSMARTS 2 provided challenges as direct technical support was not readily available.
- The JSMARTS 2 initiative represented an 'extra' activity for most team members and did not serve as the primary work objective (note that JSMARTS 2 was generally an unfunded effort for the industry and academic partners) which challenged the timely execution of work.
- Overall JSMARTS 2 leadership was not vested in one office (person) and as it was a 'collaborative' development clear unity of command and authority was not evident – this affected the overall execution of work.
- The Capability Engineering 'structure' migrated well into the simulation development environment and the developed DoDAF products seemed to naturally support simulation development (e.g., OV-5 as Master Events List).

## 5.0 CONCLUSION

Overall, the objectives of the JSMARTS concept remain valid – as the defence community evolves toward the use of M&S technologies the ability to respond rapidly is critical. As the vision of JSMARTS diverges from large scale monolithic simulation events it holds great promise, particularly in the realm of Capability 'design' and exploration or discovery experimentation. Key aspects from the 'lessons learned' will need to be considered in continuing to pursue the concept. In fact, the Public Security Technology Program (PSTP) is going to adopt the JSMARTS 2 approach as a means to conduct capability engineering based M&S.

Therefore, while the concept remains valid – its execution demonstrated challenges. It is proposed that additional exploration of how the CE-based architecture development can be mapped to traditional simulation development processes (e.g., SEDEP) is explored and that a distributed simulation network be developed toward achieving rapidly configured SE-based exercises.

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# Toward an Executable Architecture and M&S Based Analysis for Homeland Security (JSMARTS II)

R. Youssef, A. Vallerand, J. Pagotto, C. Pogue

Future Forces Synthetic Environment-DRDC Ottawa

October 5, 2006

Defence Research and Development Canada

Recherche et développement pour la défense Canada

Canada

# Outlines

- Introduction
  - JSMARTS
  - Problem description
  - Approach
  - Objectives
- Background
  - Capability Engineering
  - Architecture
  - DOD AF
- Experiment Design/Details
- Preliminary Results
- Conclusion

# JSMARTS II

- Investigate use of M&S within JSMARTS context, or M&S at the Enterprise level;
- Leverage existing systems, experiments and lessons learned
- Rapid implementation of Distributed Simulation: Network connectivity, Synthetic Environment, Scenario,experiment setup, HLA Federation Dev. and execution – 4-6 weeks.
- Engage Government DND and Public Security communities in M&S discussions through presentation of results.
- Capitalize and augment interoperable M&S capabilities of Government, Academia and Industry
- Create a persistent ability to easily employ M&S in Government, Academia and Industry to jointly explore/analyze new Capabilities

**Carleton U: CH 146 NTS Sim**

**DRDC: UAV RTB Pilot Interface**

**Distributed HLA Simulation**

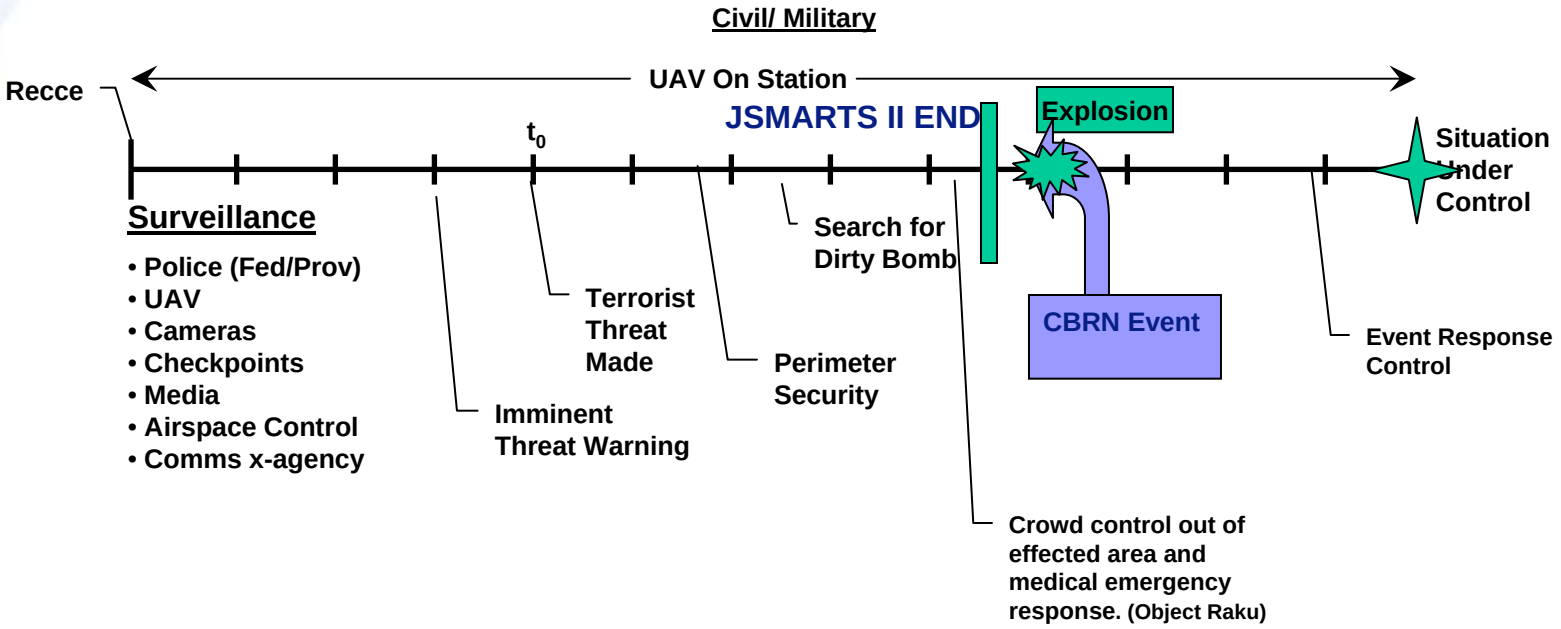
**Needs Analysis & Concept Dev & Exp.** | **Definition** | **Production, Acquisition & Support** | **Operation** | **Training Rehearsal**

**JSMARTS**

# JSMARTS II Objectives

- Macro Level
  - experiment/demonstration that is emergency responder centric (civil), enabled by military simulation capability
  - Demonstrate that CE experiments using M&S are both feasible, relevant and offer good ROI
  - Demonstrate that M&S can be used in Homeland Security context
    - Cost effective planning and procedure validation
    - Cost effective / realistic C2 training
- Micro Level
  - Conduct a Capability Engineering (CE) experiment
    - Condition 1: dirty bomb incident using traditional means of detection and control prior to detonation
    - Condition 2: dirty bomb incident using enhanced means of detection and control prior to detonation

# JSMARTS II Scenario

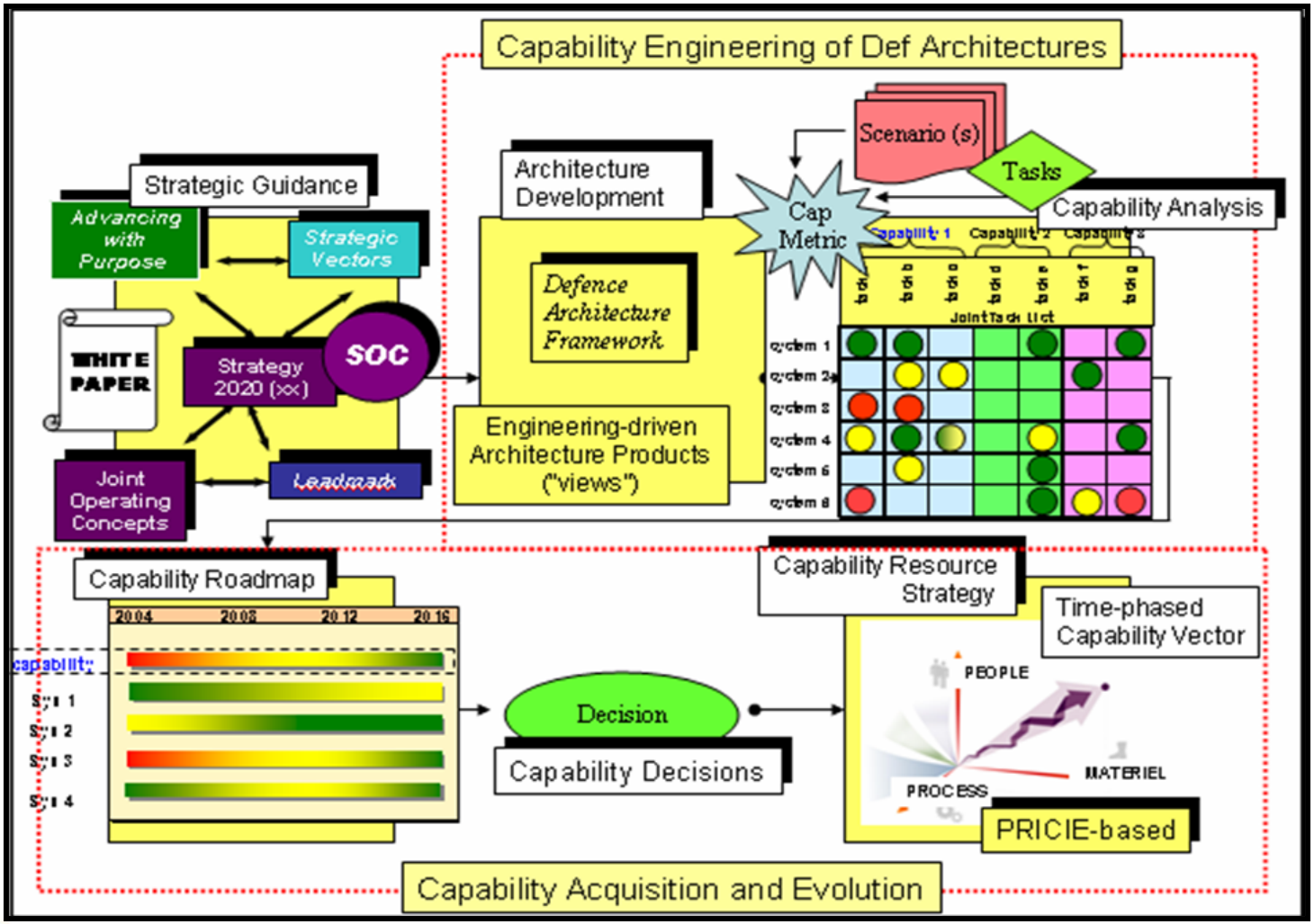



**Experiment**

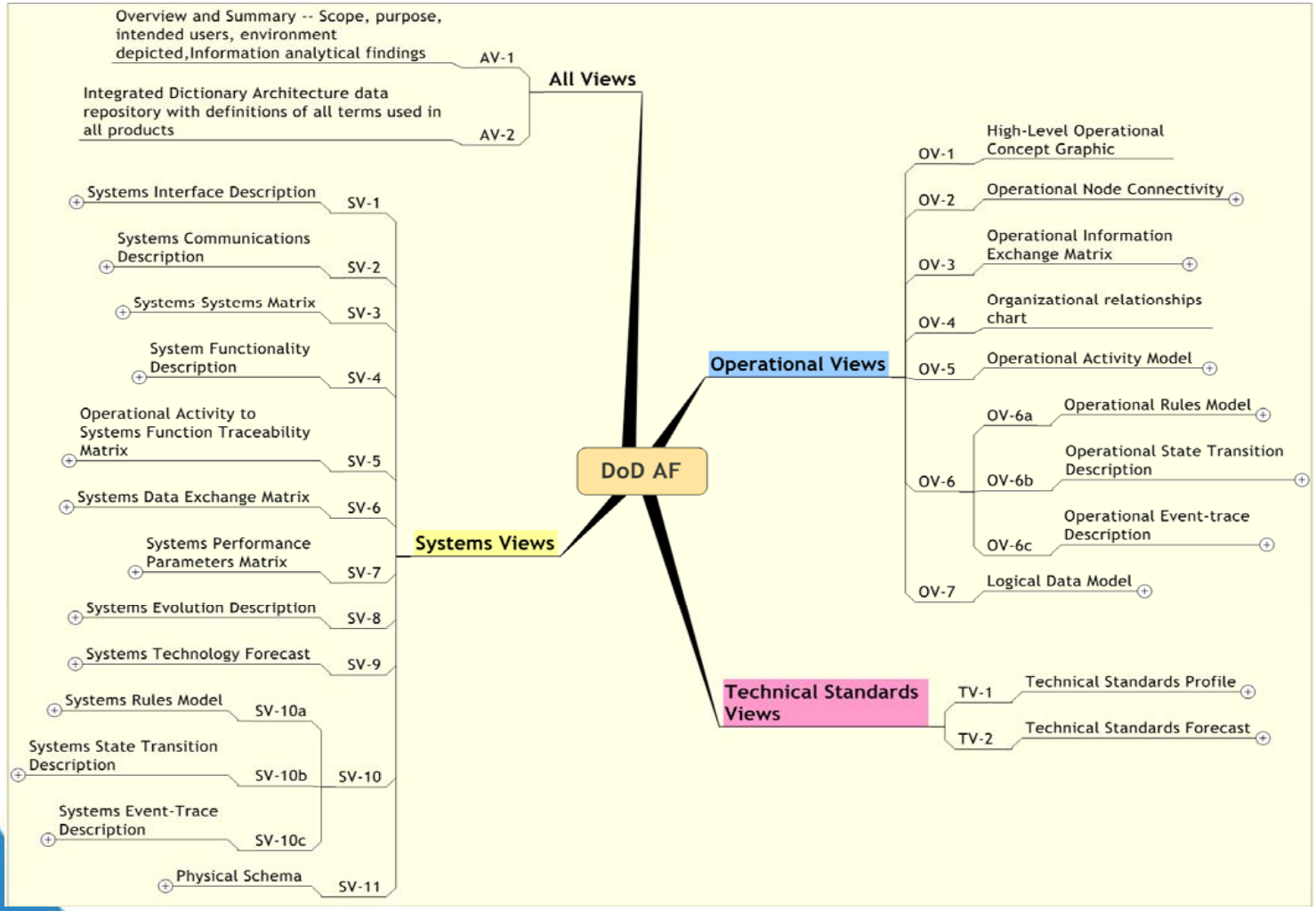
$C^2$ Players
- Performance
- Situation Awareness
- Workload
- CE Analysis 2 Conditions
-Network Performance, Latency and RTI analysis

**CAPABILITY ENGINEERING (CE)**
**Driven By CE Analysis:**
**Identify Capability Gap and Solution**

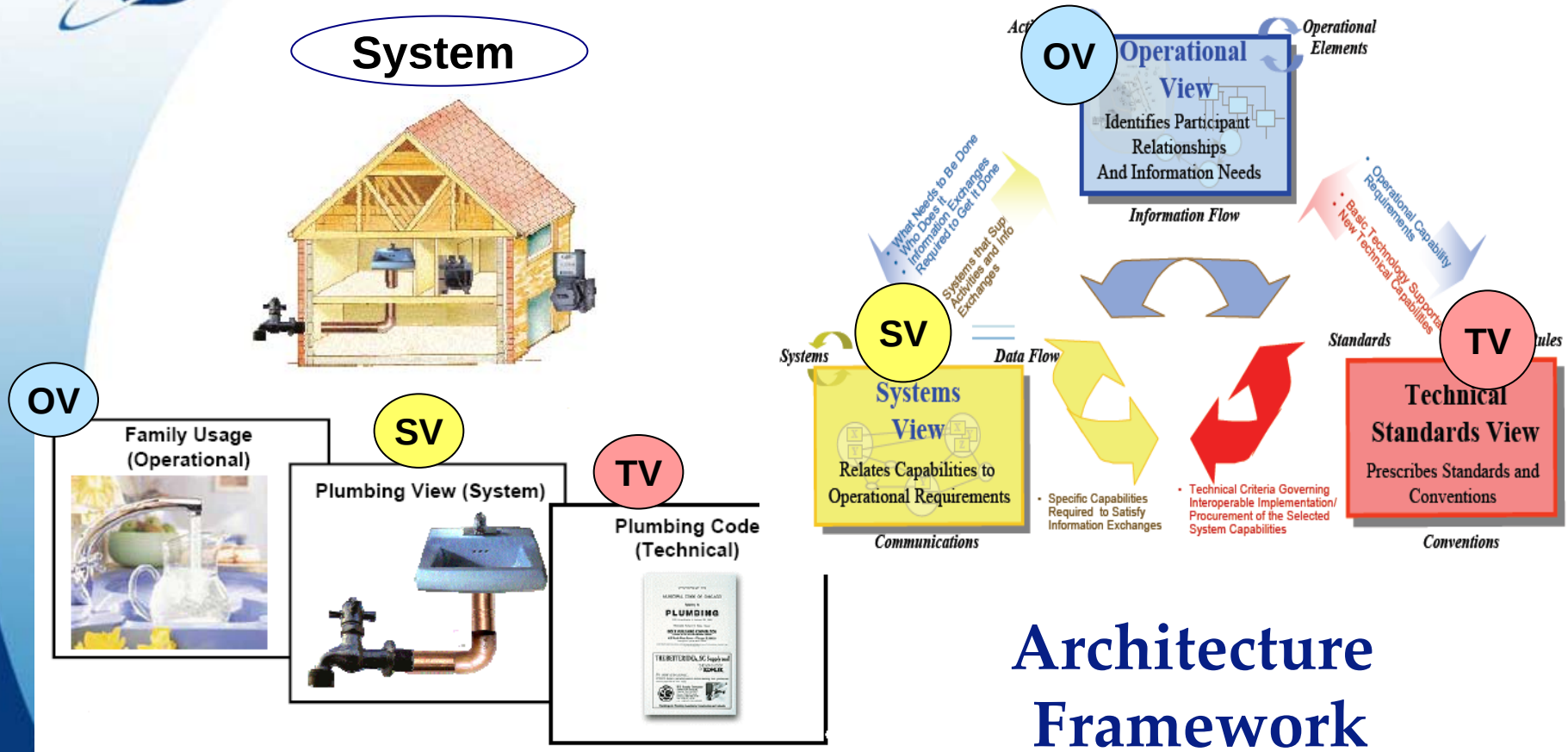
# Capability Engineering Domain of Application



# DOD Architecture Framework



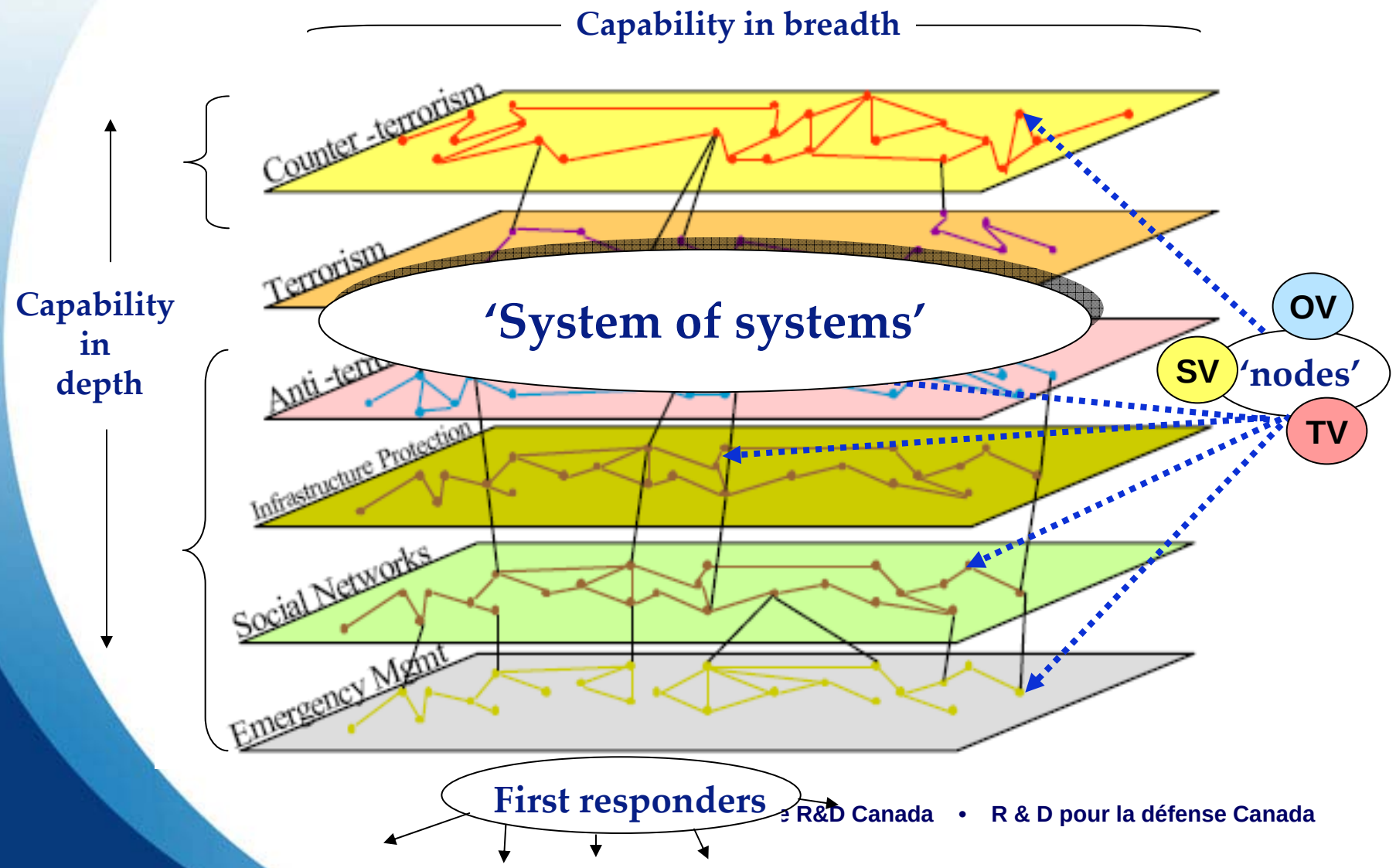
# Capability Engineering Approach….



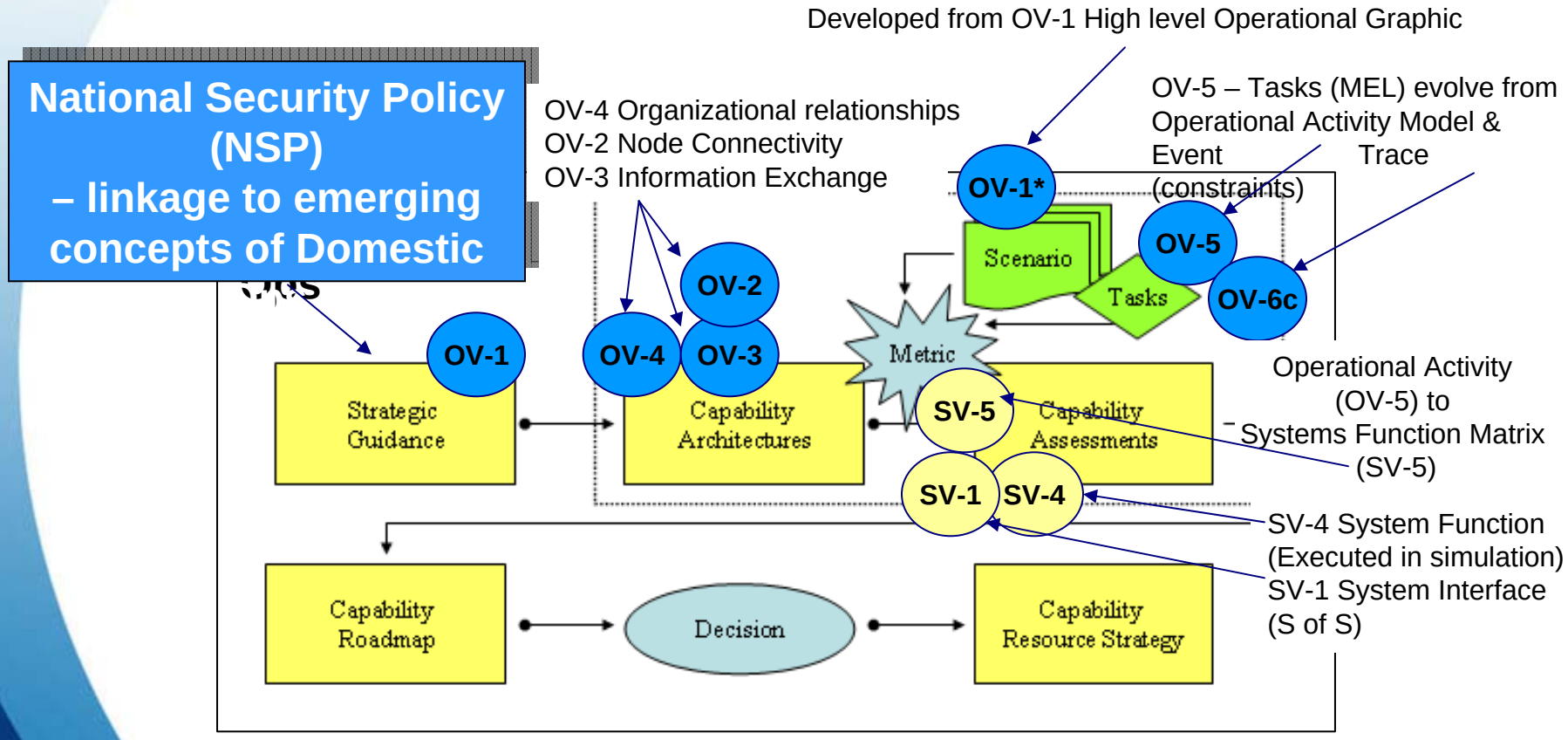

## Architecture Framework

"**structure** of components, their **interrelationships**, and the principles and guidelines governing their design and **evolution over time**"

# The Conceptual Problem ‘space’

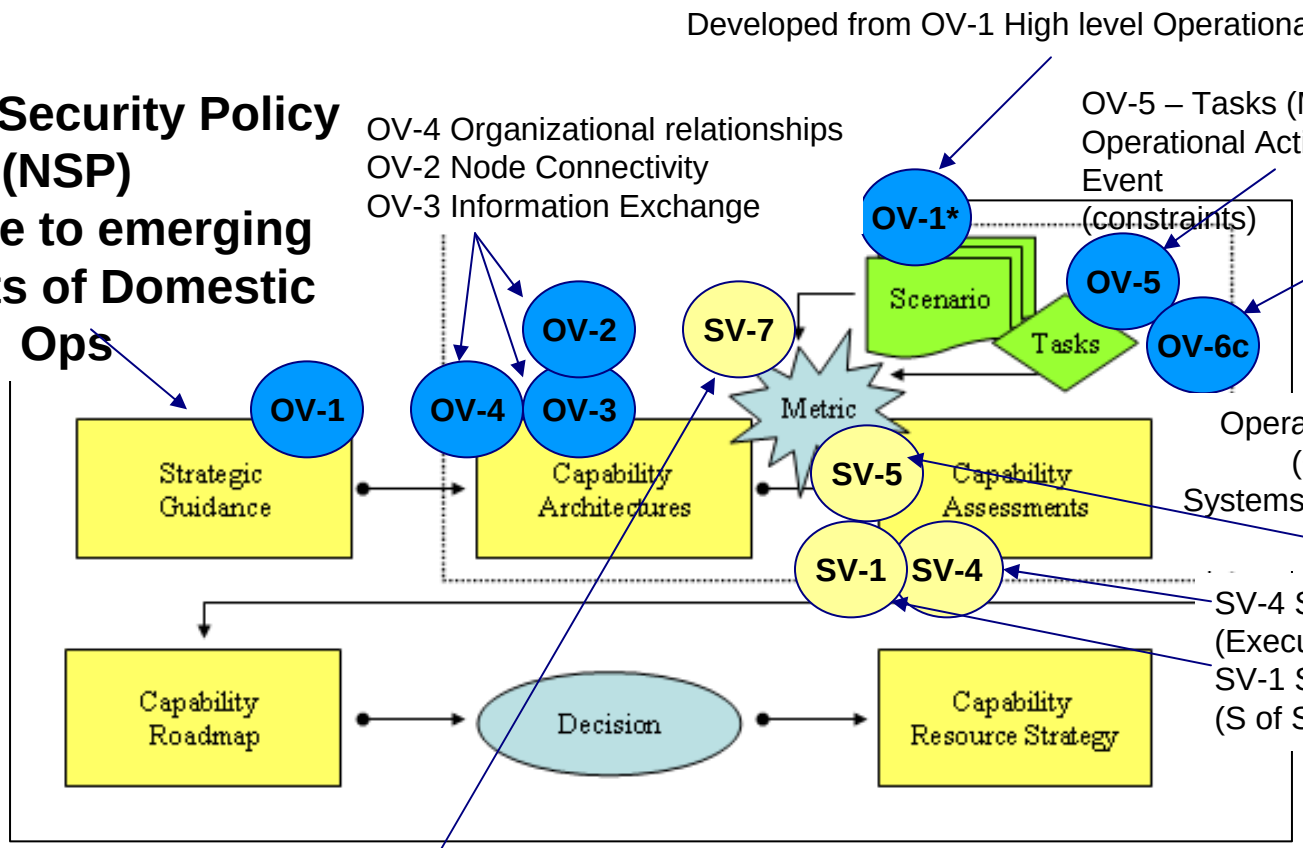


# Capability Engineering-based Experimentation

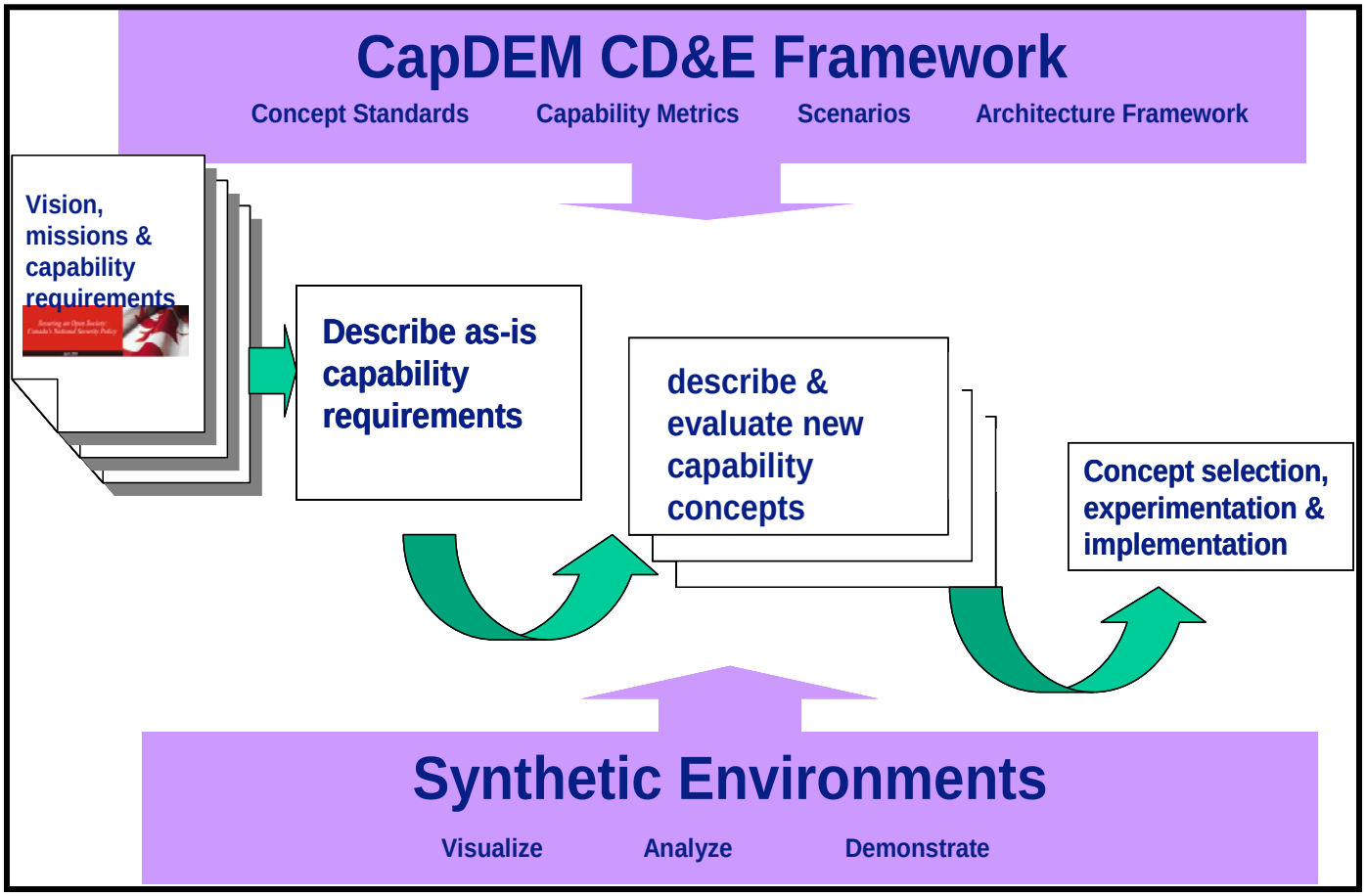


# JSMARTS II – Applying Architecture to Simulation-based Analysis, Design and Experimentation

**National Security Policy (NSP) – linkage to emerging concepts of Domestic Ops**

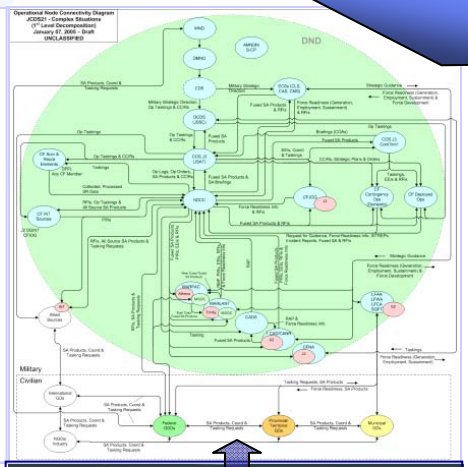


# An Integrated Vision?

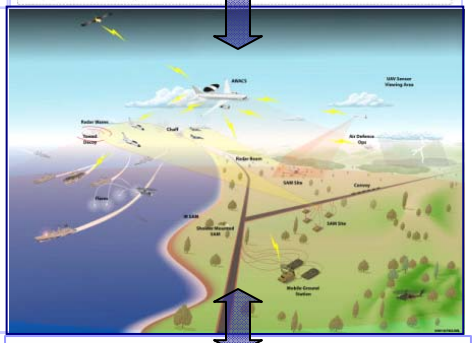


# Convergence of Capability Engineering and Modeling and Simulation

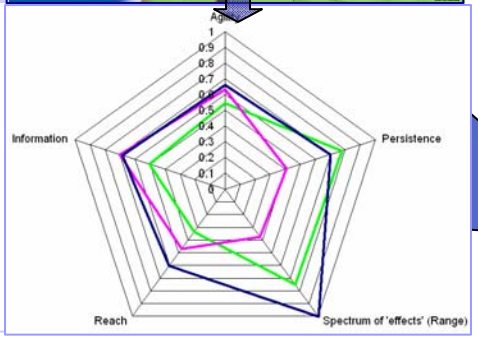
Architecture Design & Analysis

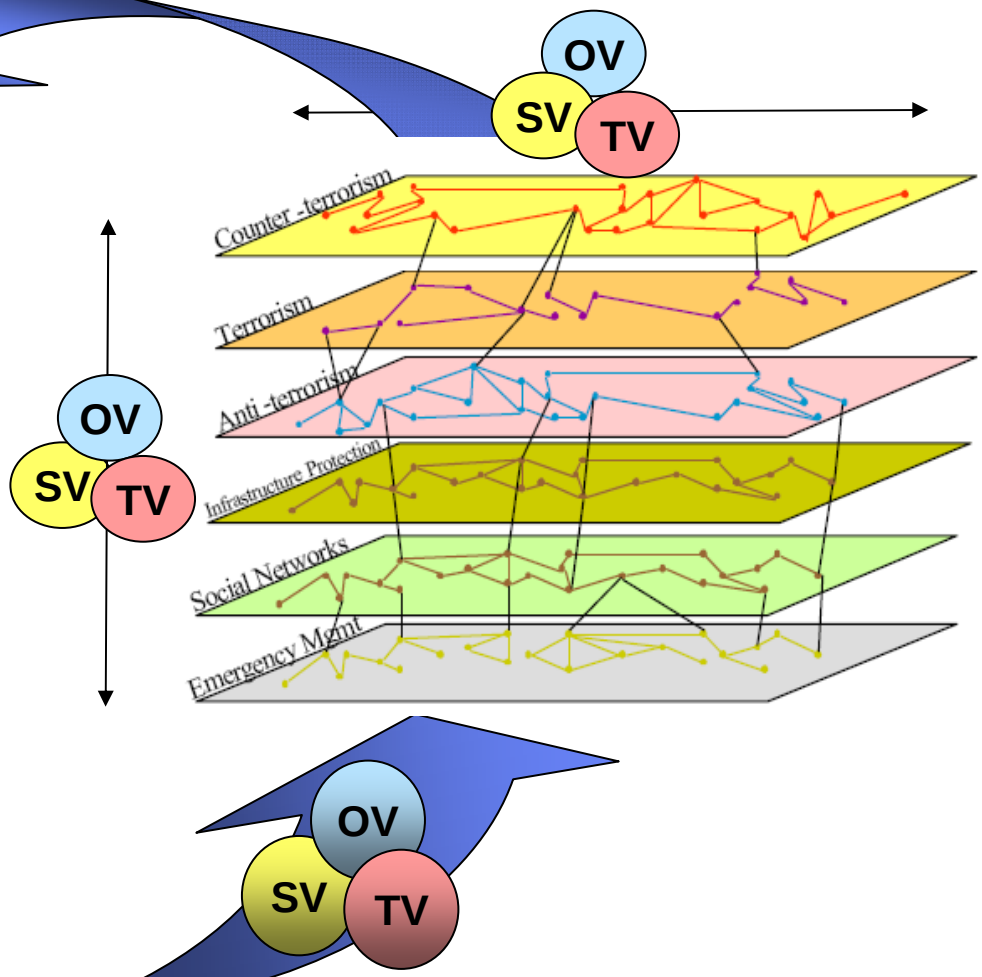


Simulation



Evaluation Metrics

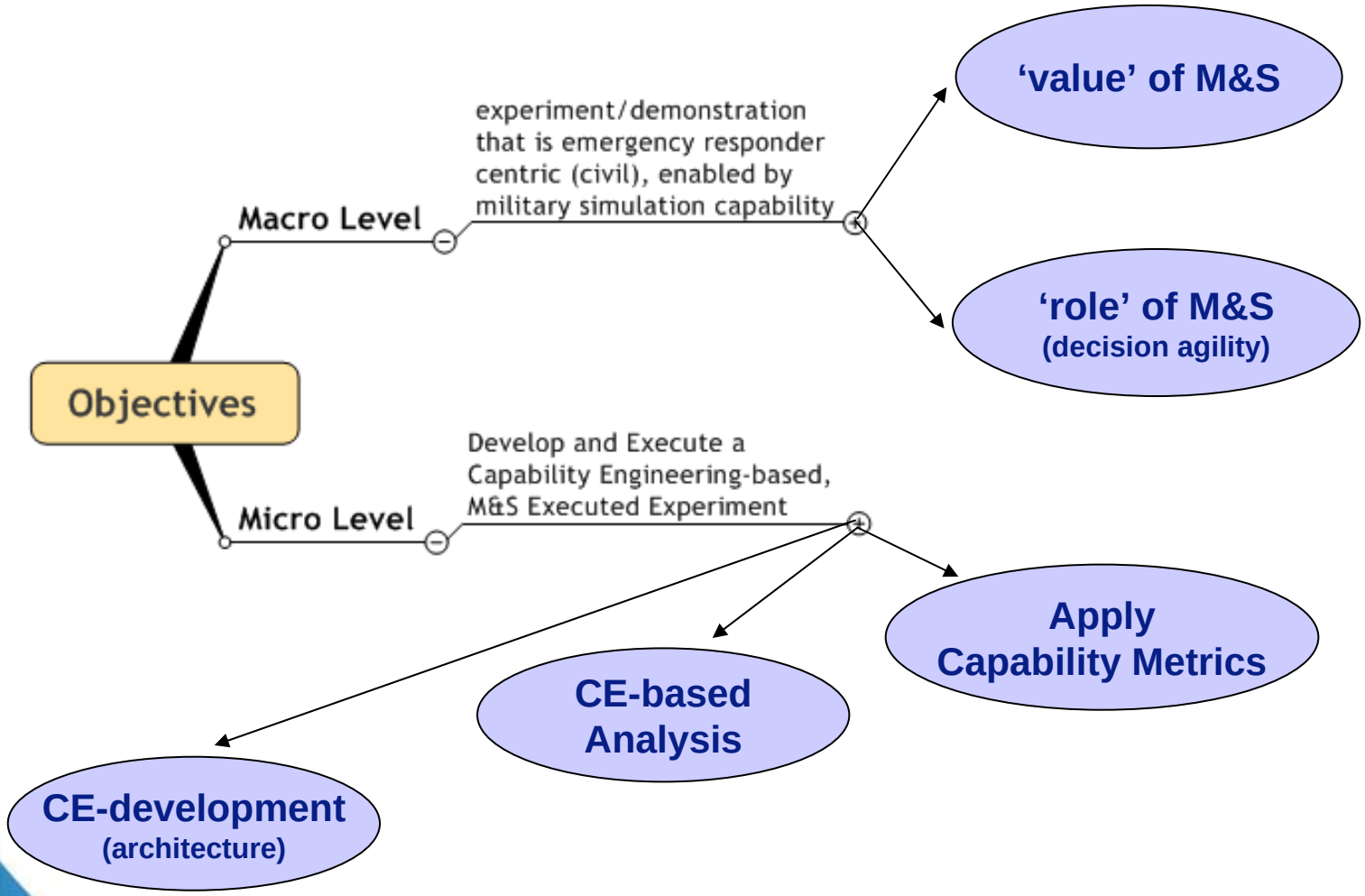


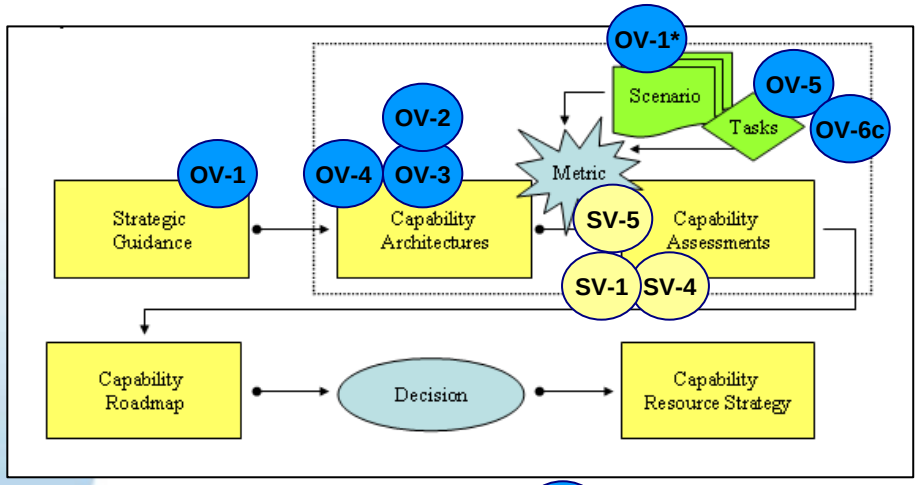

**....exploring Executable Architectures....**

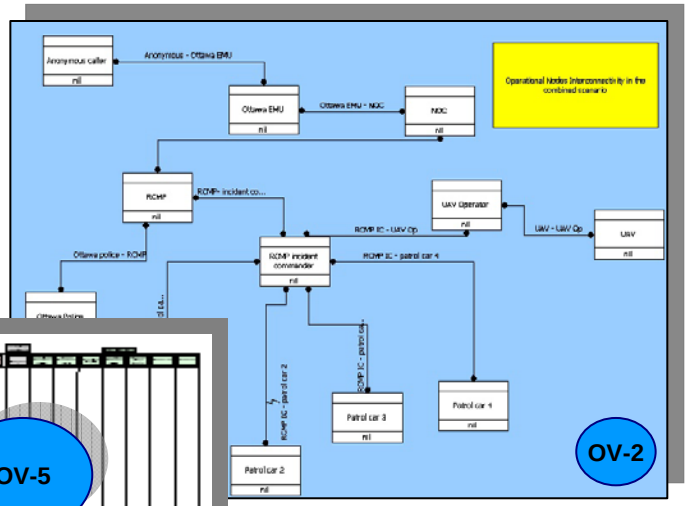
CAE Professional Services, 2005

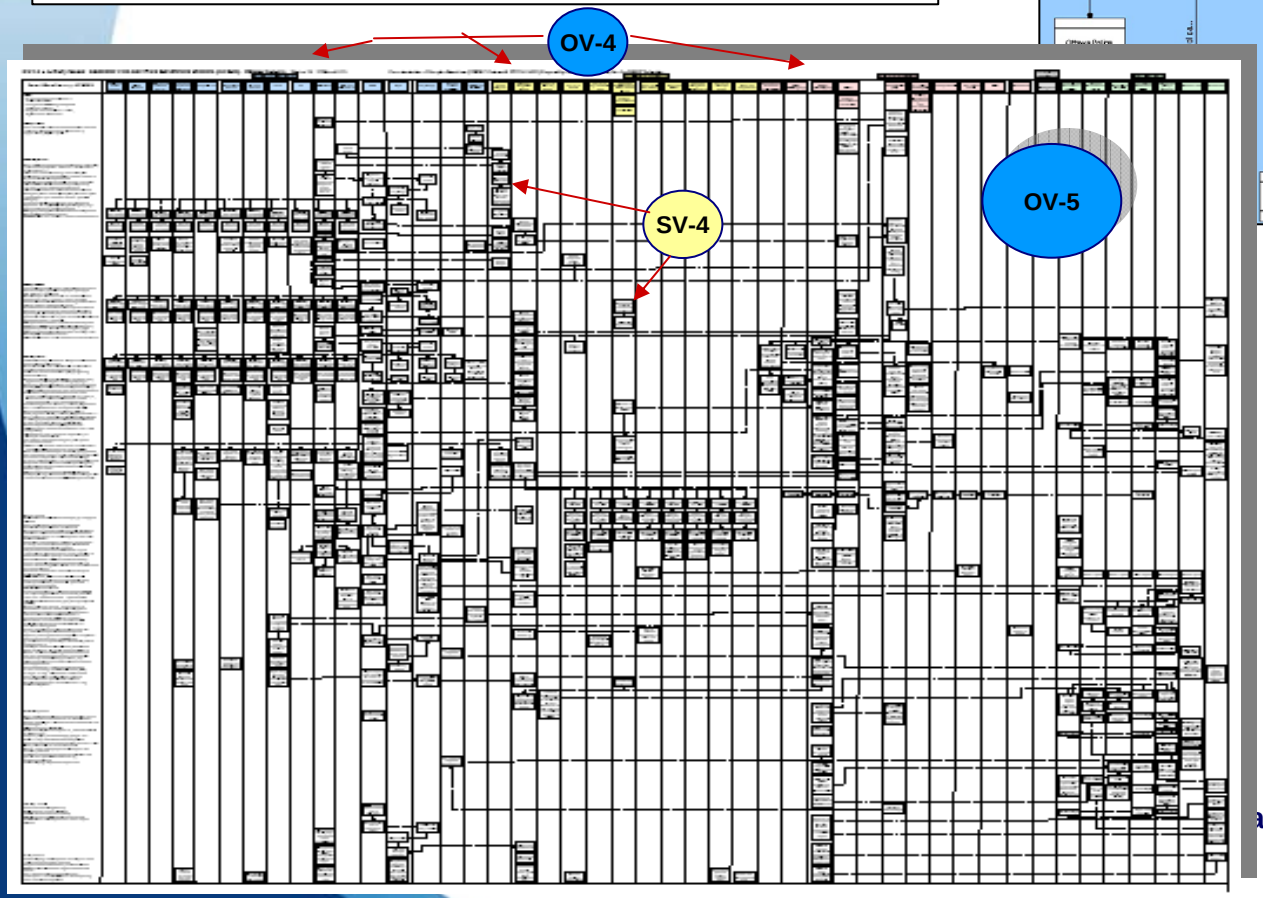
# Capability Engineering Approach applied in JSMARTS 2



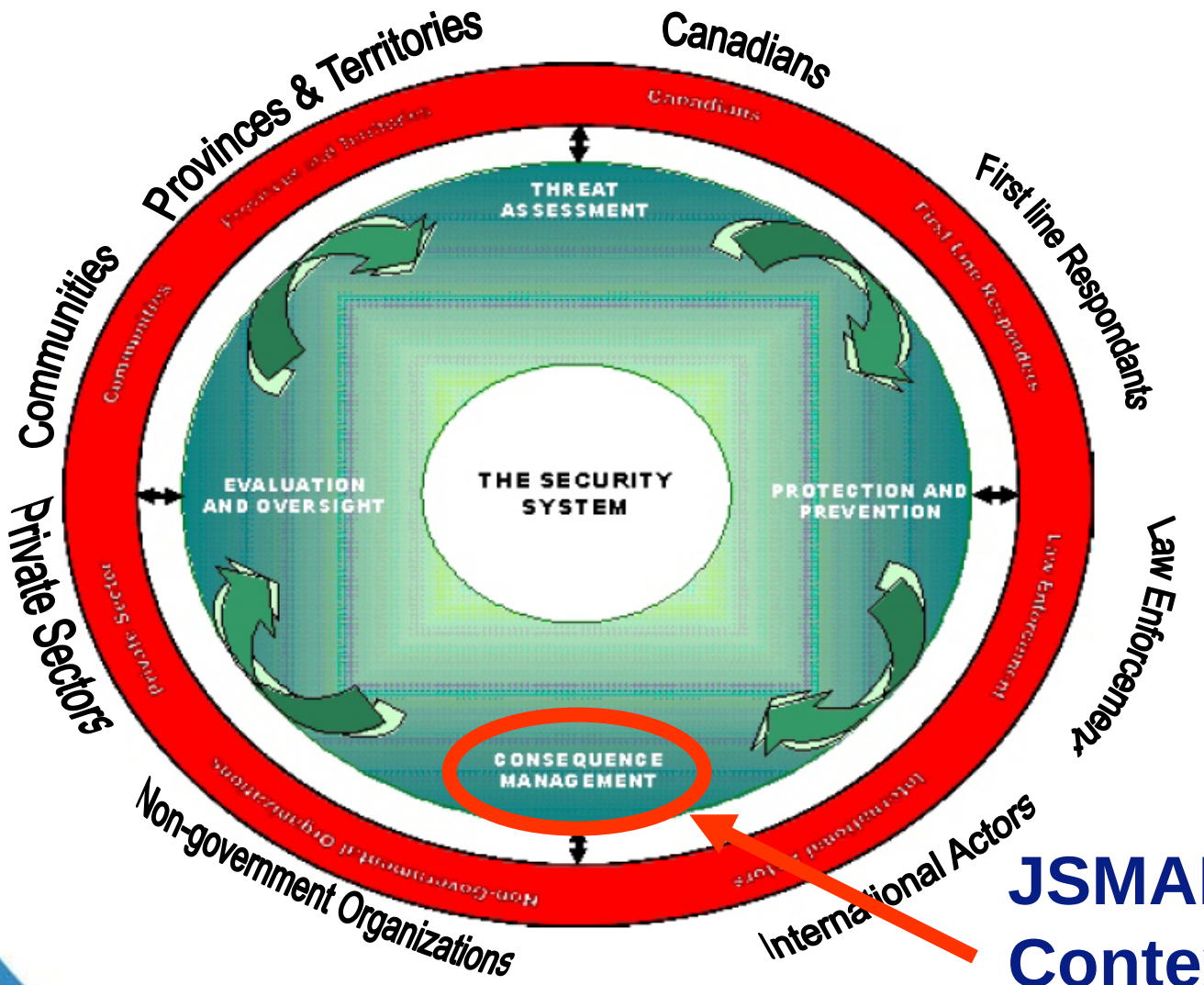
# Capability Engineering – Architecture Development



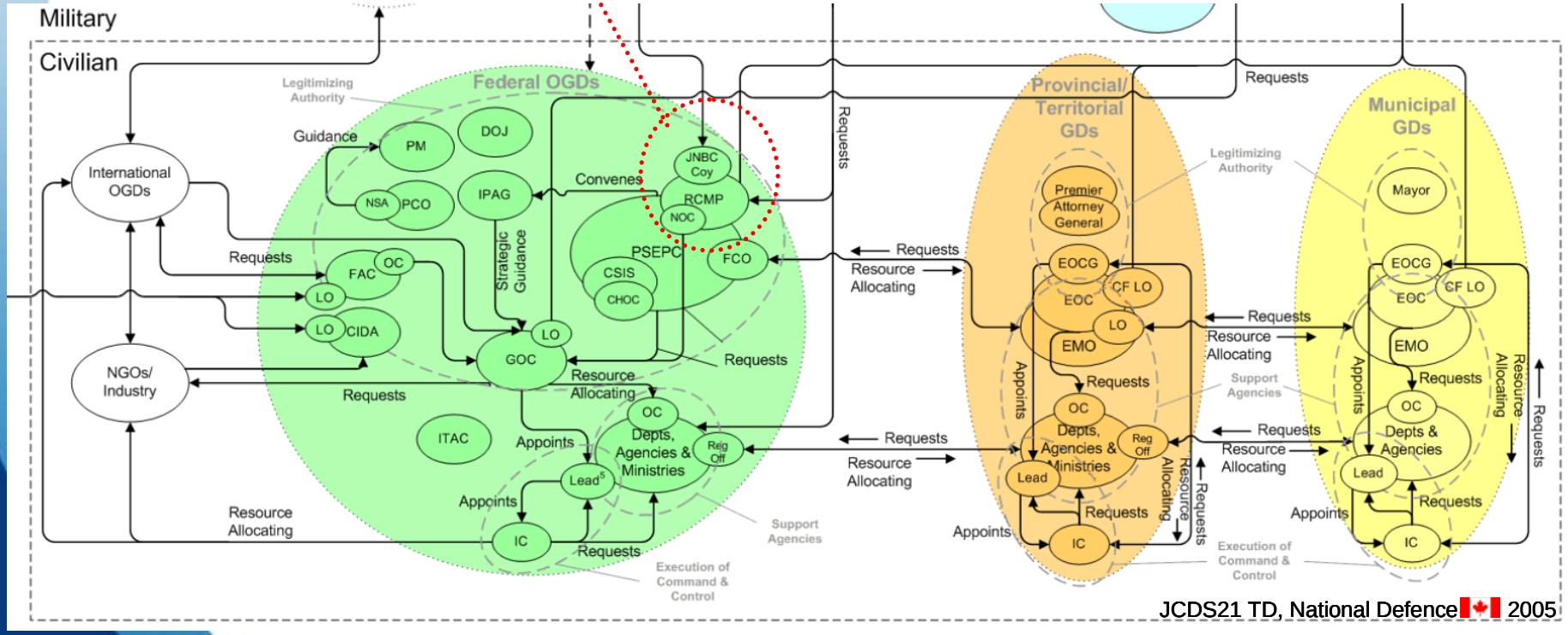
# Example:OV1- JSMARTS ll

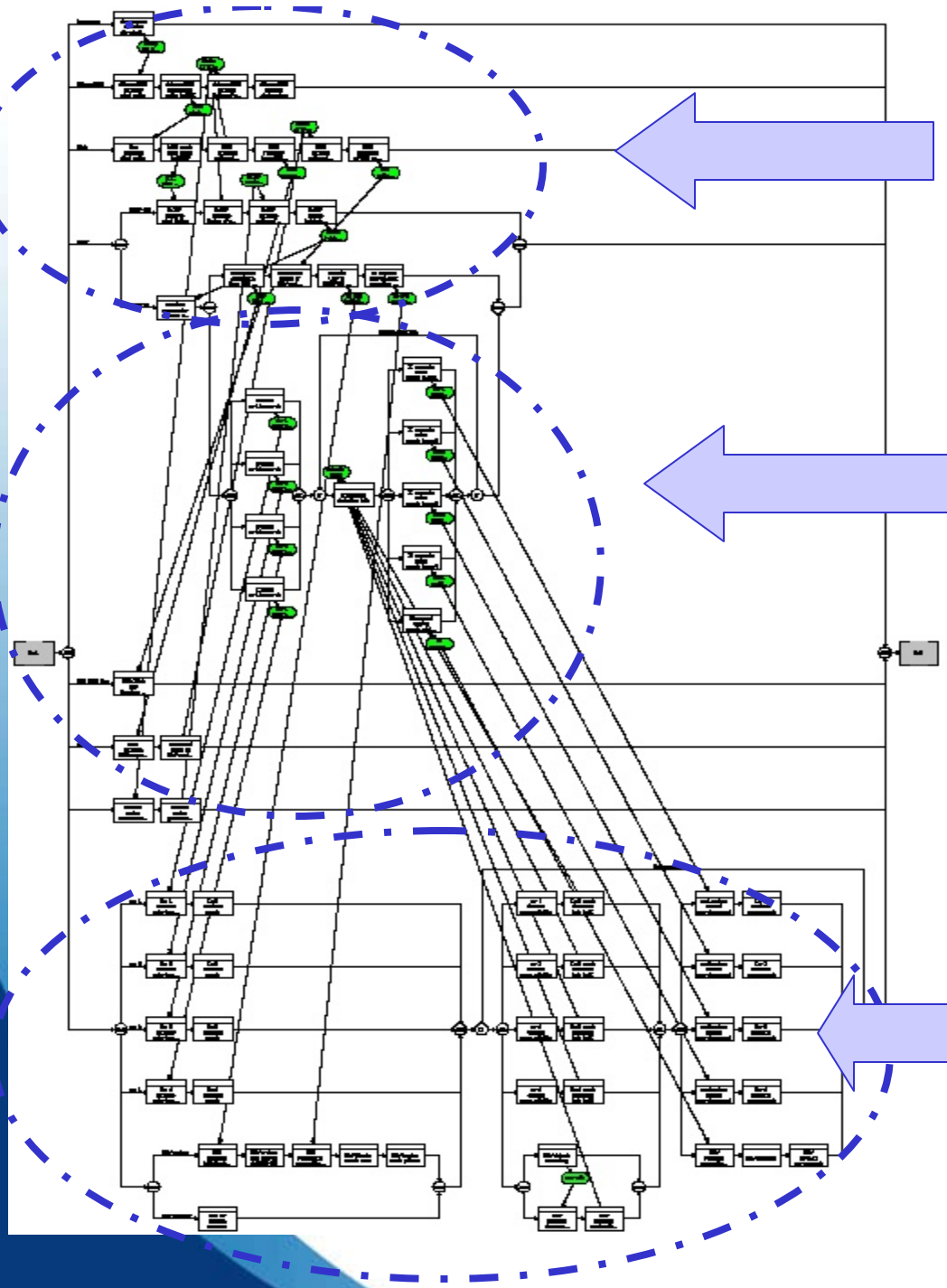



**JSMARTS II Context**

# …Complexity and Architecture…(OV-2)

RCMP link to CF JOG via Joint Nuclear Biological Chemical Company



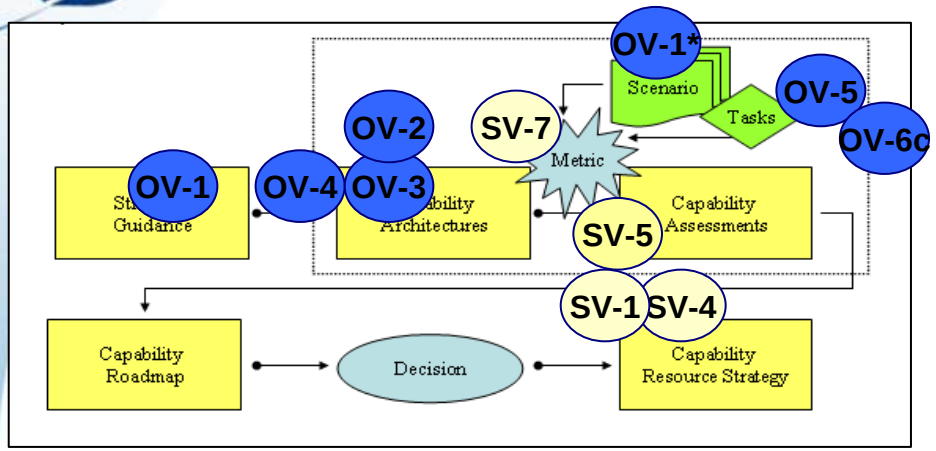


Events leading up
to the set up of a
Incident command post

Events in command
Post and the IC's
interaction with various operational
nodes

Events related to sensors
- four police cars
- one UAV

# Capability Engineering- First Round Analysis



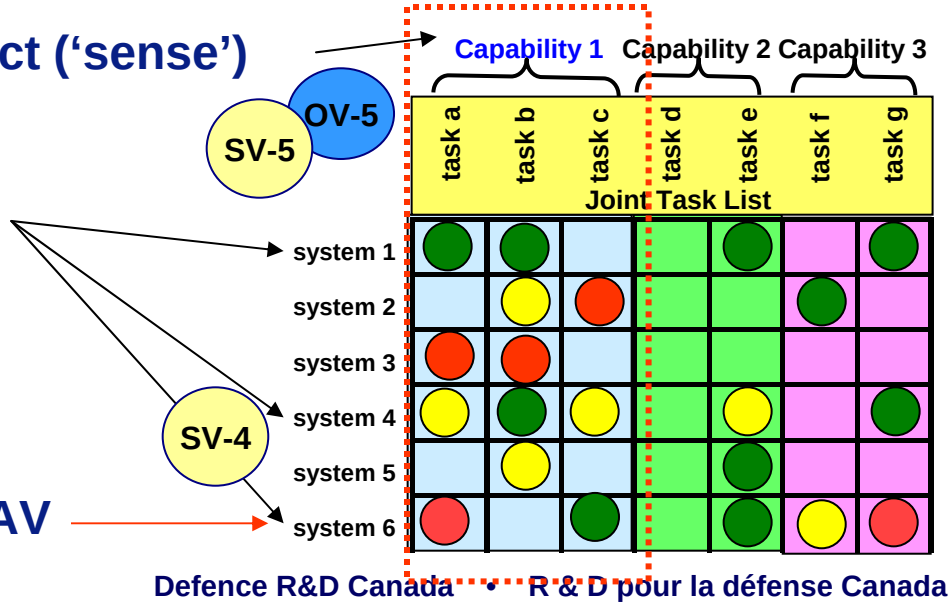

**The PURPOSE of architecting is to produce ACTIONABLE information**

**Limited Operational Capability**

**Detect ('sense')**

**New 'System of systems'**

**Addition of UAV**



# M&S Experiment Design

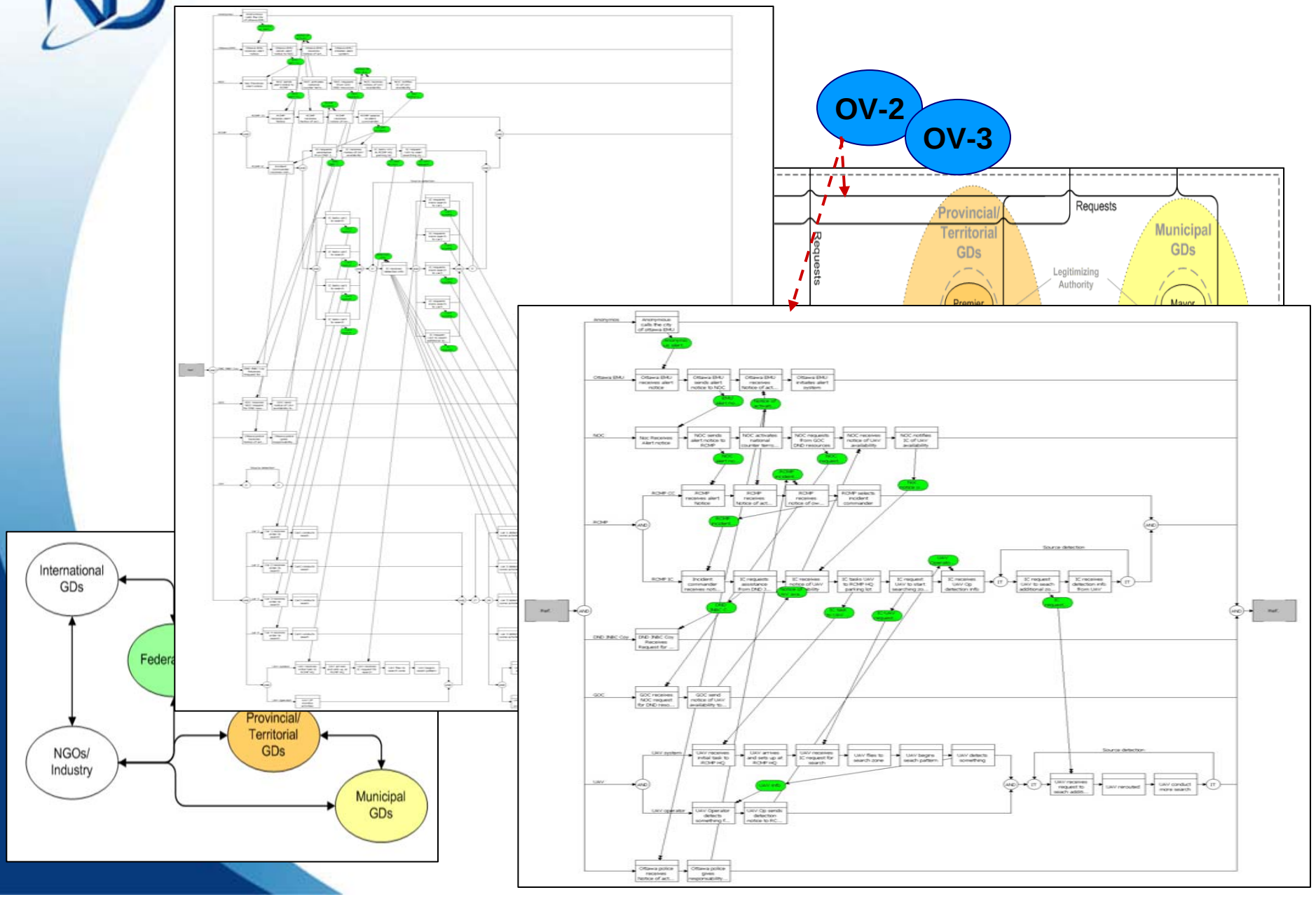
**Technical Task**

- Search, detection & localization of radiation point source
  - Measure radiation from air & ground vehicles
  - Engineer M&S & C4 elements for CE experiment

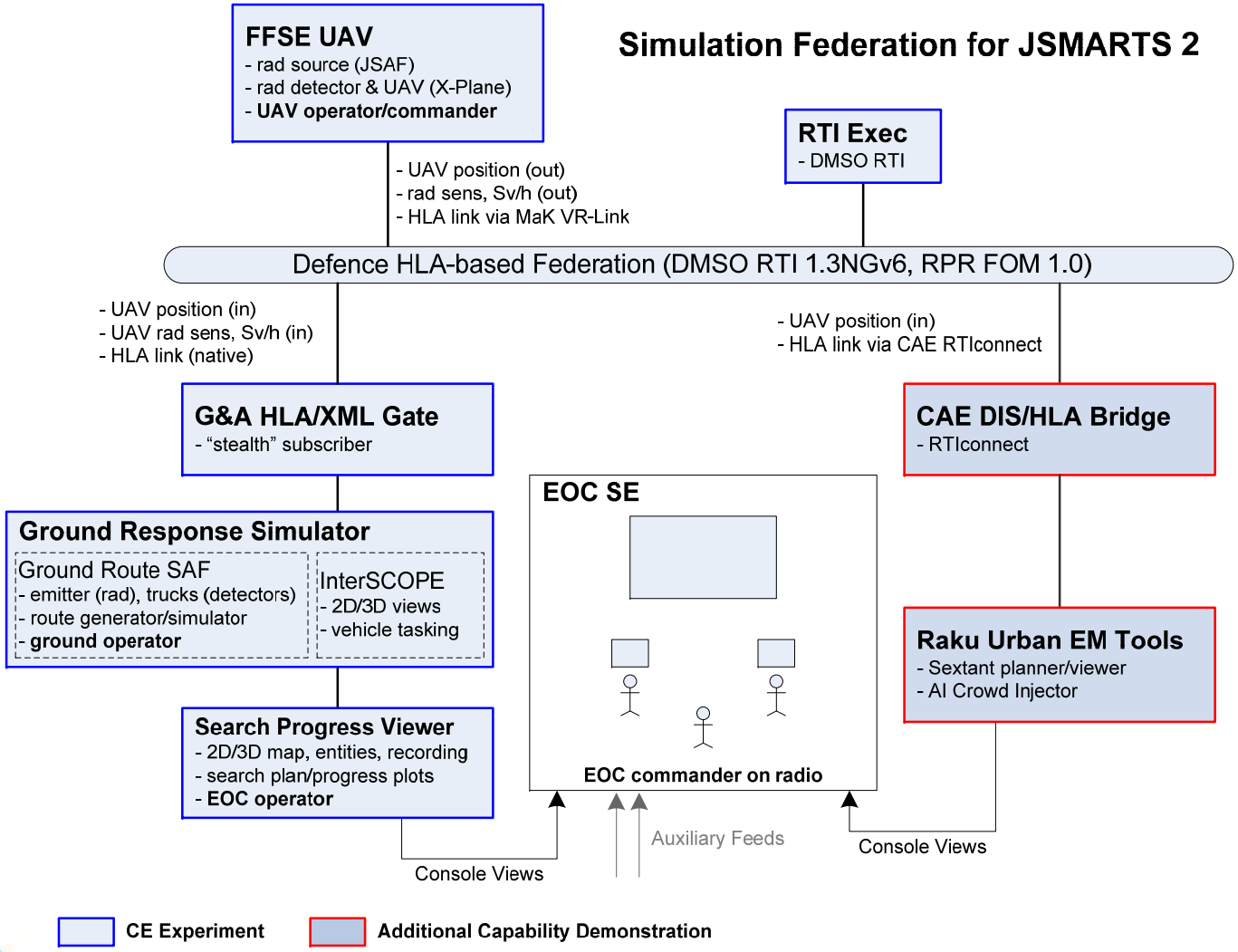
**Solution**

- Select from existing useful M&S baseline simulations
  - UAV, Road Vehicles, Urban Crowd models
- Need distributed simulation of 3 main federates at 2 sites
  - Choose HLA/DIS federation & secure network
  - Integrate 12 simulation processes
- Design EOC SE for CE experiment & demonstration

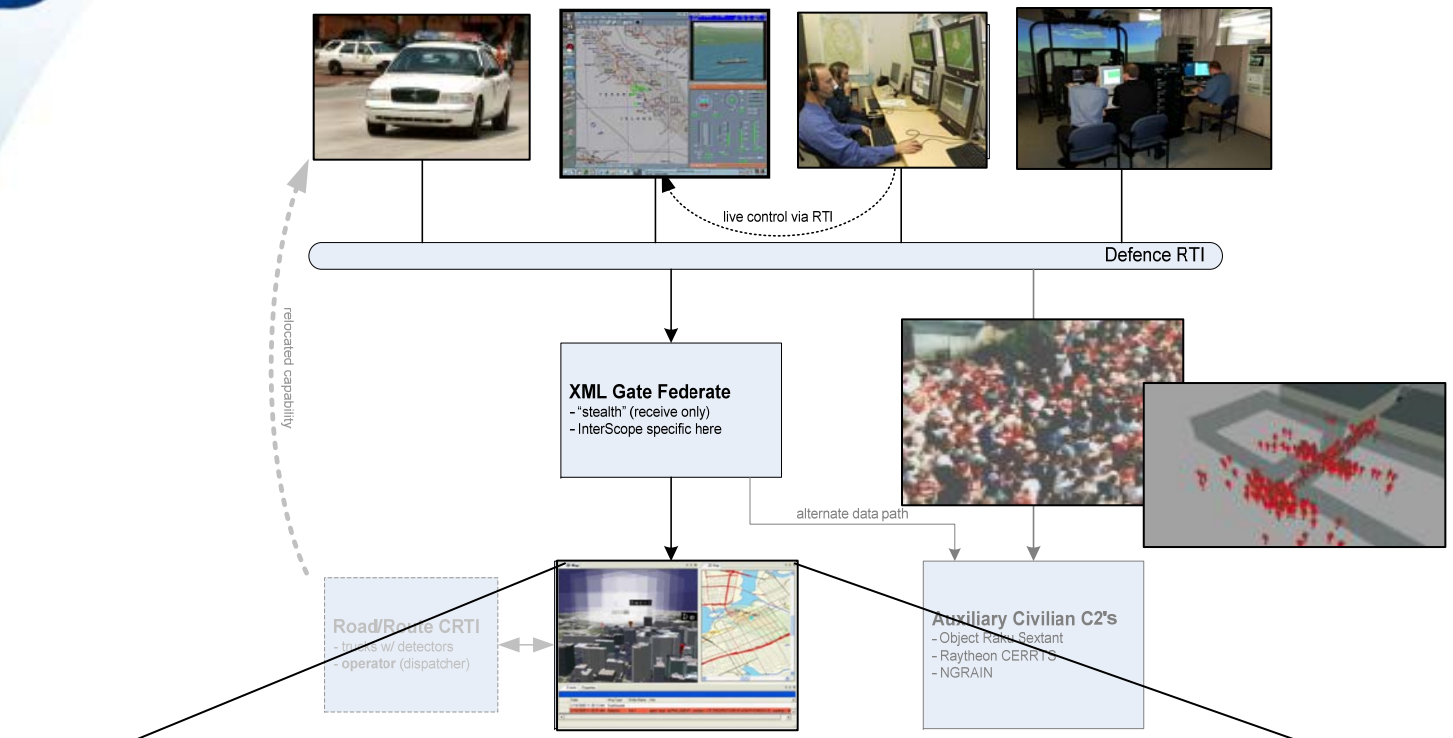
# Mapping the Operational Architecture



# Simulation Federation

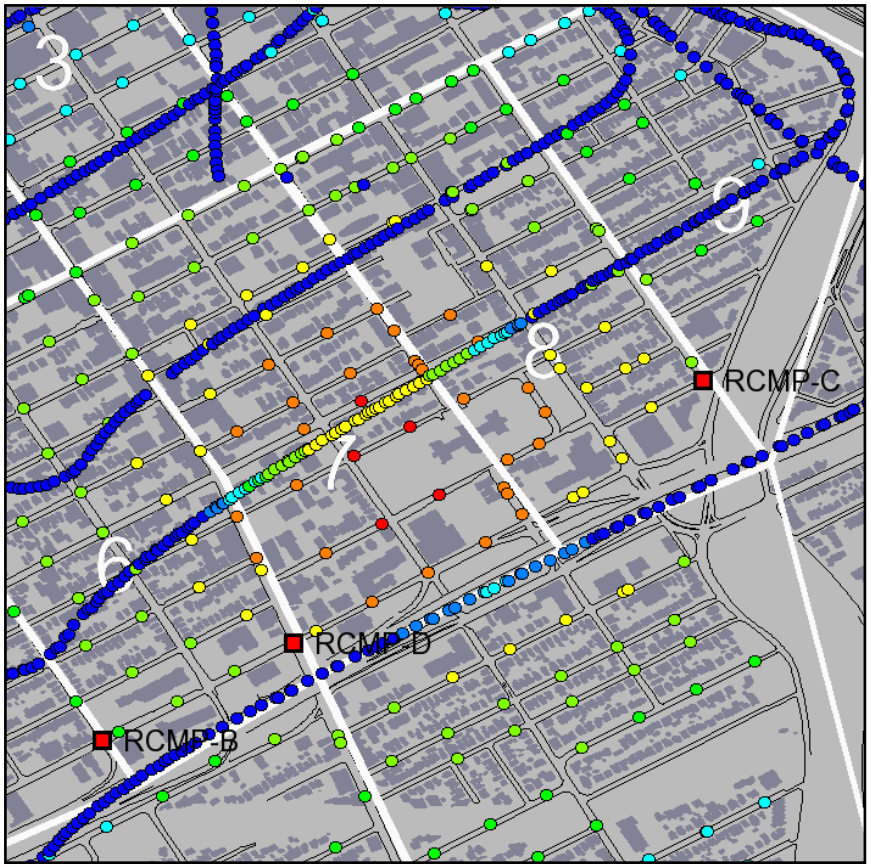


# Operational Architecture in Simulation

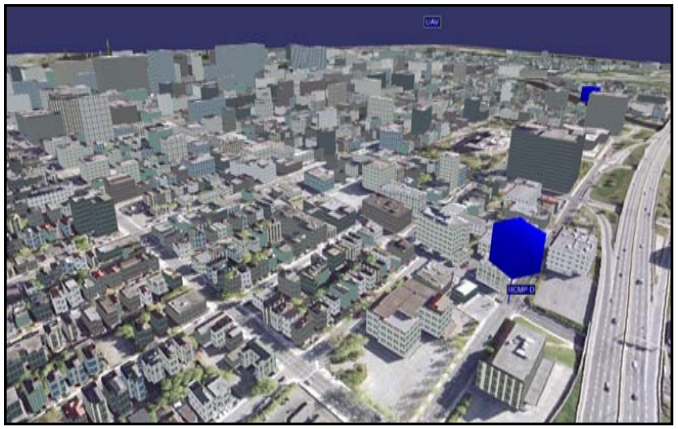


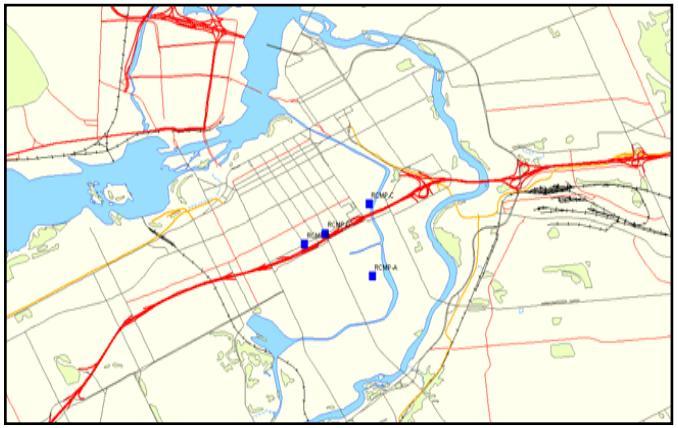

# Ground Sim. & Search Views

Search Progress View



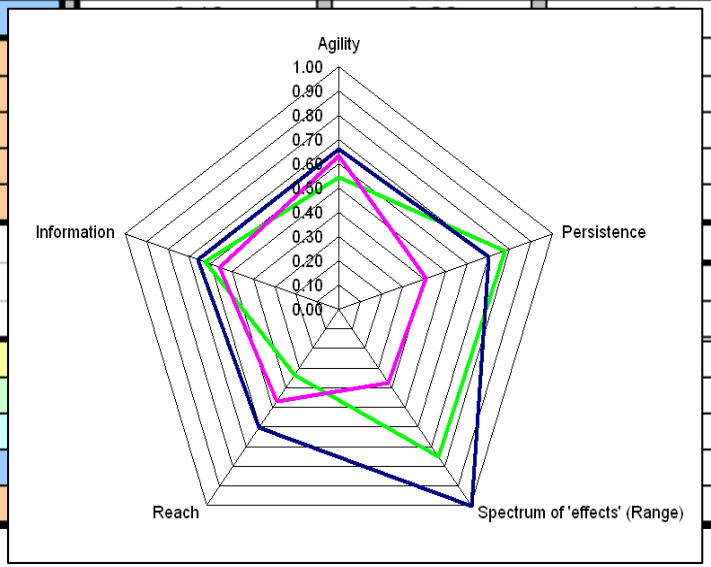

Ground Simulation Views





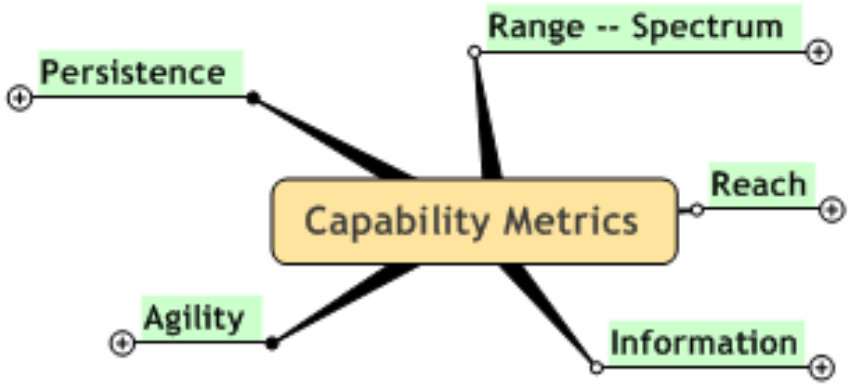
# Representative application of Capability Metrics

| MOEs and Capability Metrics | MOE Measures for 3 Options | | |
|---|---|---|---|
| | Ground-based | UAV | Combined |
| speed of response | 0.45 | 0.65 | 0.55 |
| speed in decision making | 0.67 | 0.60 | 0.80 |
| survivability | 0.63 | 0.48 | 0.68 |
| Duration | 0.90 | 0.20 | 0.90 |
| Effect Sustainment (requirements for support - based on duration of effect) | 0.93 | 0.67 | 0.77 |
| Environmental Limitations | 0.40 | 0.20 | 0.30 |
| Reliability | 1.00 | 0.33 | 0.80 |
| Extent of effects achievable | 0.60 | 0.40 | 1.00 |
| Concurrent Effects | 0.80 | 0.37 | 1.00 |
| Where | 0.30 | 0.30 | 0.40 |
| When | | | |
| Precision | | | |
| Quality | | | |
| Security | | | |
| Timeliness | | | |
| Sharing (Collaboration) | | | |
| | | | |
| | | | |
| | | | |
| **Agility** | | | |
| **Persistence** | | | |
| **Spectrum of 'effects' (Range)** | | | |
| **Reach** | | | |
| **Information** | | | |

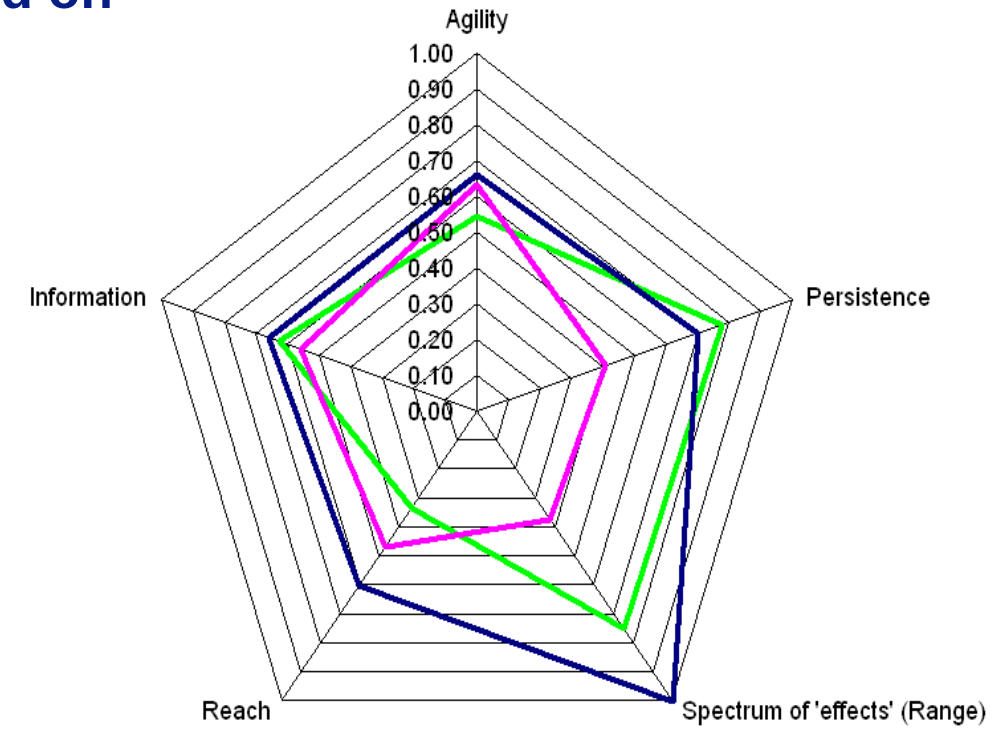



58 MOPs were developed and mapped to the Capability Metrics in terms of their respective ability to achieve ‘improved detection and containment’ as a desired “effect”

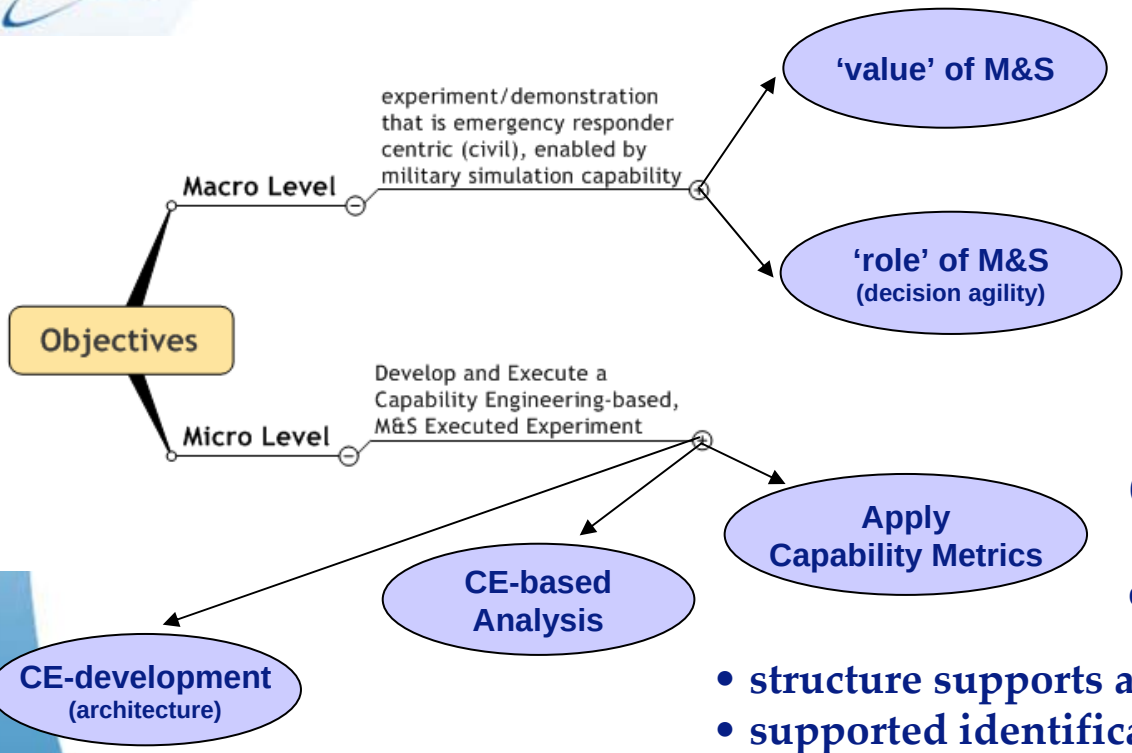
# Preliminary Results -- Methodology




- evaluated using Value-Focused Thinking (VFT)
- objective and subjective measures
- Capability Metrics based on measuring attainment of "effects"
- 58 measures in total



# JSMARTS Results – Initial 'perspectives'




- 'shift' in perception of M&S *value*
- military M&S and distributed simulation structure transferable to non-military domains

- initial assessments evolved (UAV utility)
- additional insights into overall Situation Awareness

- structure supports analysis
- supported identification of limitations in experiment

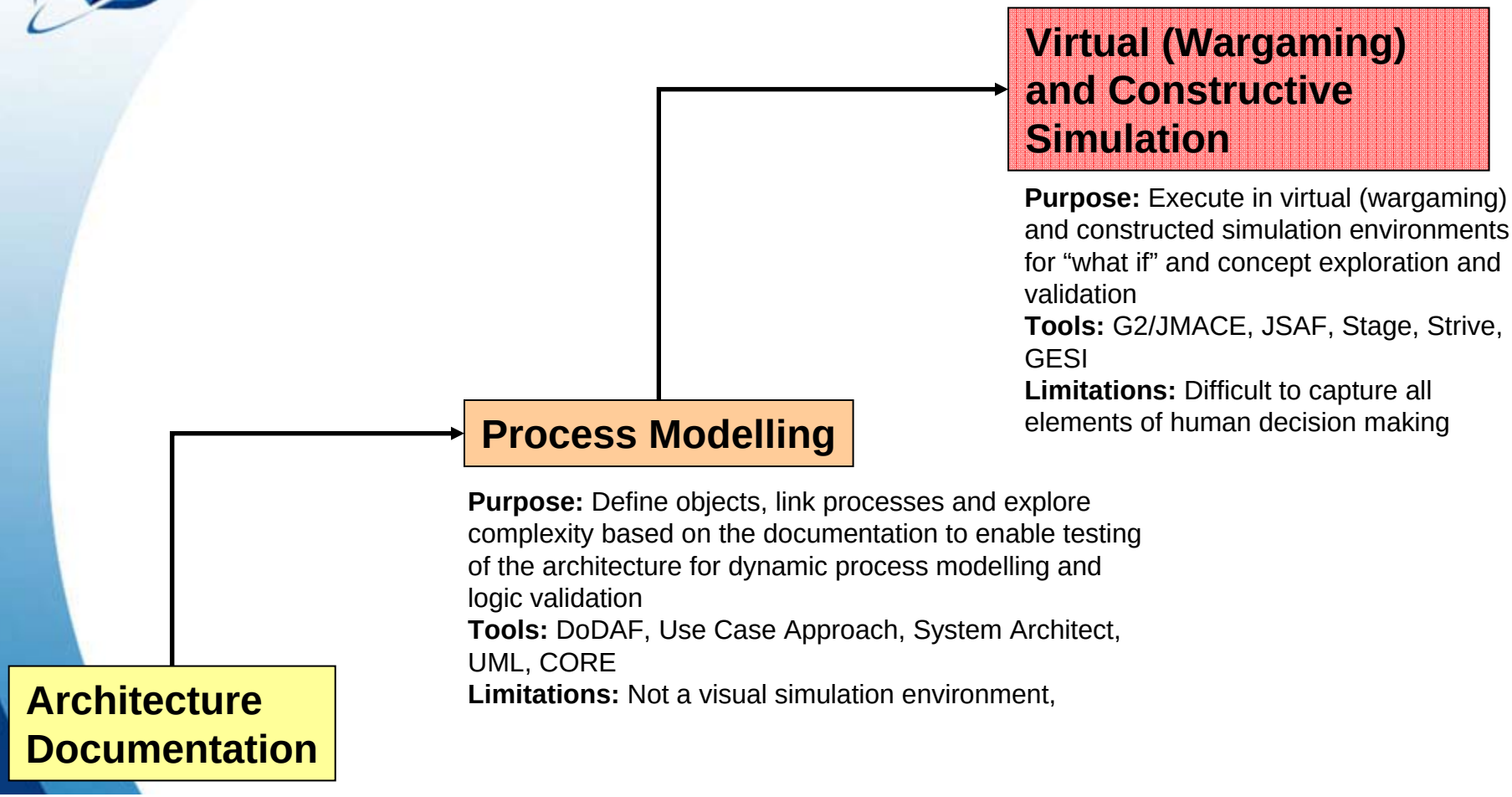
- CE-based architecture development supports M&S execution
- DoDAF products 'fit'

**…convergence of Capability Engineering and M&S-based analysis…'*it works*'….**

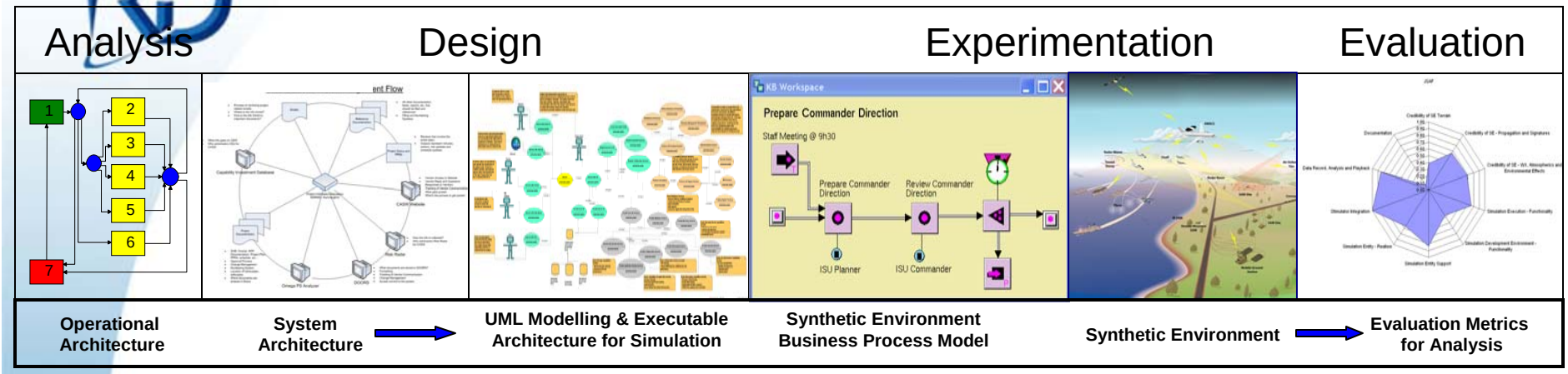
# SE Conclusions and Way Ahead

- Six week Experiment
- Established enhanced distributed simulation capability among GOC, Academia, and Industry.
- Established the basis of Public Security CONOPS development.
- Capability Engineering analysis with distributed simulation proves the philosophy of CapDEM.
- Way Ahead
  - Enhance the Synthetic Environment simulation capability with more realistic representation of the physical environment.
  - Conduct a comprehensive concept evaluation
  - Coordination with Public Security Organizations for the enhancement of prediction capability.

# Approach Limitations?



# Way Ahead – Approach Automation?




**Receive Client Objectives**

**Conduct Requirements Gathering**

-Structured interviews
- Literature Review

**Create Architecture Products**

-Smartdraw
-MS Office (Visio, PowerPoint, Word, Excel)
- System Architect, Artisan, CORE
- Case Complete, DOORS, UML

**Develop Modelling Plan**

**Create Models**

-Executable architecture (UML, XML, Tau G2, Artisan, CORE)
-MS Office (Visio, PowerPoint, Word, Excel)

**M&S Synthetic Environment**

-JSAF, STAGE, VR-Forces, STRIVE, STK

Articulate models in a synthetic environment

**Evaluation**

Metric development and evaluation

**Capability Engineering Design Approach (CEDA)**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