Technical Course MSG-162 on “Guideline for Scenario Development”

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ABSTRACT

This paper first sets the context for scenario development given by the Modelling & Simulation (M&S) application areas defined in the NATO Modelling & Simulation Masterplan. The application areas defined herein are support to operations, capability development, mission rehearsal, training and education and procurement. Among these, the area of training and education is the most prominent and the role and creation of scenarios for this area is discussed in the context of NATO collective training. Focusing on M&S, the role and content of scenarios is further specialized and M&S specific requirements on scenarios are derived for different classes of scenarios. After a short introduction to Base Object Models (BOMs) it is demonstrated, how BOMs can be used to specify military scenarios for M&S applications in a formal structure.

1.0 NATO MODELLING & SIMULATION MASTERPLAN (NMSMP) AND M&S APPLICATION AREAS

1.1 NMSMP Overview

The NATO Atlantic Council (NAC) approved the NATO Modelling and Simulation Master Plan (NMSMP) in 1998. The objectives of this plan were to streamline the modelling and simulation community and to establish the NATO Modelling and Simulation Group (NMSG) and the Modelling and Simulation Coordination Office (MSCO). The plan also nominated the NMSG as authority for modelling and simulation standards in NATO.

In 2012, the NMSG approved a new version 2.0 of the NMSMP [1] that is still valid today. This new version was motivated by changes in the security environment, like e.g. asymmetric threats, technological advances, emerging distributed simulation capabilities, and organizational changes within NATO and NATO nations.

The captures NATOs vision on modelling and simulation (M&S) and provides guiding principles for the use of M&S within the alliance. It therefore has a strong impact on NATO M&S application areas by defining governance mechanisms, involved bodies and stakeholders within NATO and the NATO nations. Moreover, it defines the M&S objectives and actions that need to taken by the stakeholders.

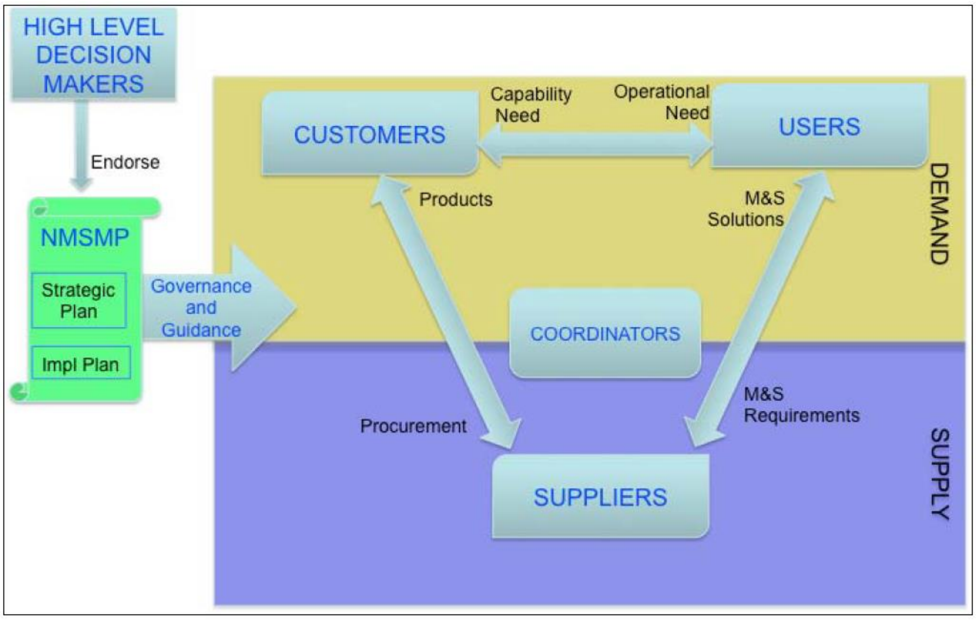

Figure 1: Stakeholders and Roles defined by the NATO Modelling & Simulation Masterplan [1]

This version of the NMSMP comes in two parts, a Strategic Plan to describe the expected long-term development, and an Implementation Plan to guide the evolution of M&S in NATO on short- and medium-term. The NMSMP Strategic Plan captures the NMSG vision of current, developmental and future NATO M&S. It describes the alliance needs in the different M&S application areas and provides common and crosscutting M&S objectives, a definition of key stakeholders and their responsibilities with respect to M&S. The Strategic Plan therefore aims to enable synergy, interoperability and reuse of simulation assets of NATO and contributing nations, and to improve affordability of these assets.

The Strategic Plan defines five different objectives

- To establish a common technical framework. Examples are the support of the development of technical standards like Distributed Interactive Simulation (DIS) or High Level Architecture (HLA), and other standardization efforts.
- To provide coordination and common services. This refers to activities on STO level 2 (NMSG) and level 3 (NMSG Task Groups) and coordination support by the MSCO.
- To develop models and simulations. This refers to the work of numerous task groups that are actively developing models, simulation components and supporting tools.
- To employ simulations. Many demonstrations, technical evaluations and experiments conducted under supervision of the NMSG support this goal.
- To incorporate technological advances. This also is an NMSG activity and there are numerous examples of task groups dedicated to research of emerging technologies (like e.g. MSG-136 on Modelling & Simulation as a Service).

1.2 M&S Application Areas

In addition to the objectives mentioned above, the NMSMP defines five M&S application areas. These are

- Support to Operations including Operational Planning, Analysis and Decision Making
- Capability Development including Defense Planning, Concept Development & Experimentations

- Mission Rehearsal
- Training & Education
- Procurement

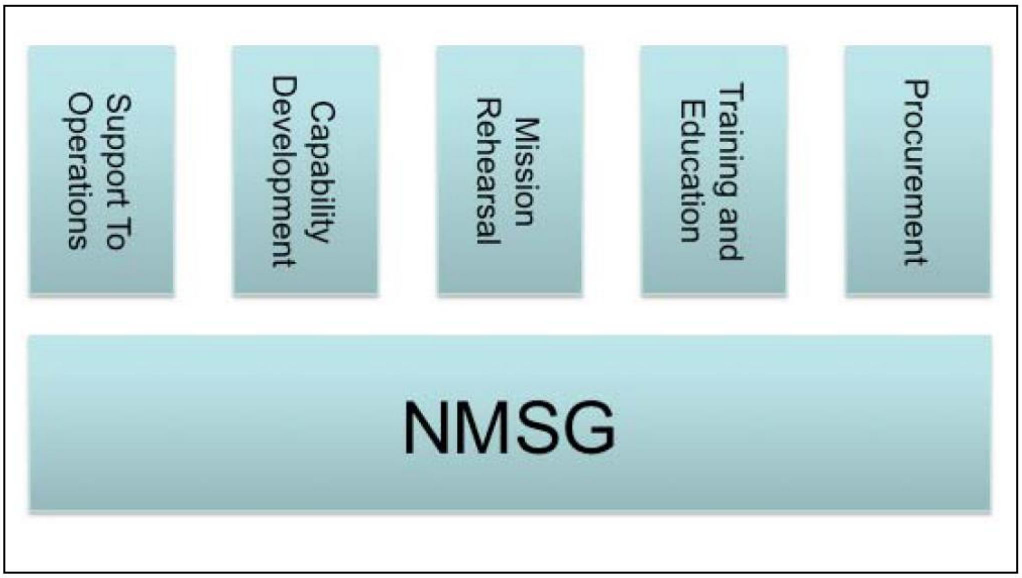

Figure 2: Five M&S Application Areas as defined by the NATO M&S Masterplan [1]

It is obvious that military scenarios are required wherever a simulation system is in use, independent of the application area or specific purpose of the simulation system. An exception from this general rule are simulations of purely technical processes of physical phenomena that are independent of a military situation or operation.

Scenarios however are most prominent and well known in the area of Training and Education (T&E). A lot of experience has been gained by the T&E community over the years and has been documented in several reference documents, one of them beeing the Bi-Strategic Command Directive 075-003 [2].

2.0 NATO BI-SC 075-003 COLLECTIVE TRAINING AND EXERCISE DIRECTIVE

2.1 Overview

The Bi-Strategic Command Directive 075-003, endorsed by the Supreme Allied Commander Europe (SACEUR) and the Supreme Allied Commander Transformation Norfolk (SACT), is a comprehensive guideline on how to plan, execute and assess NATO collective training and military exercise.

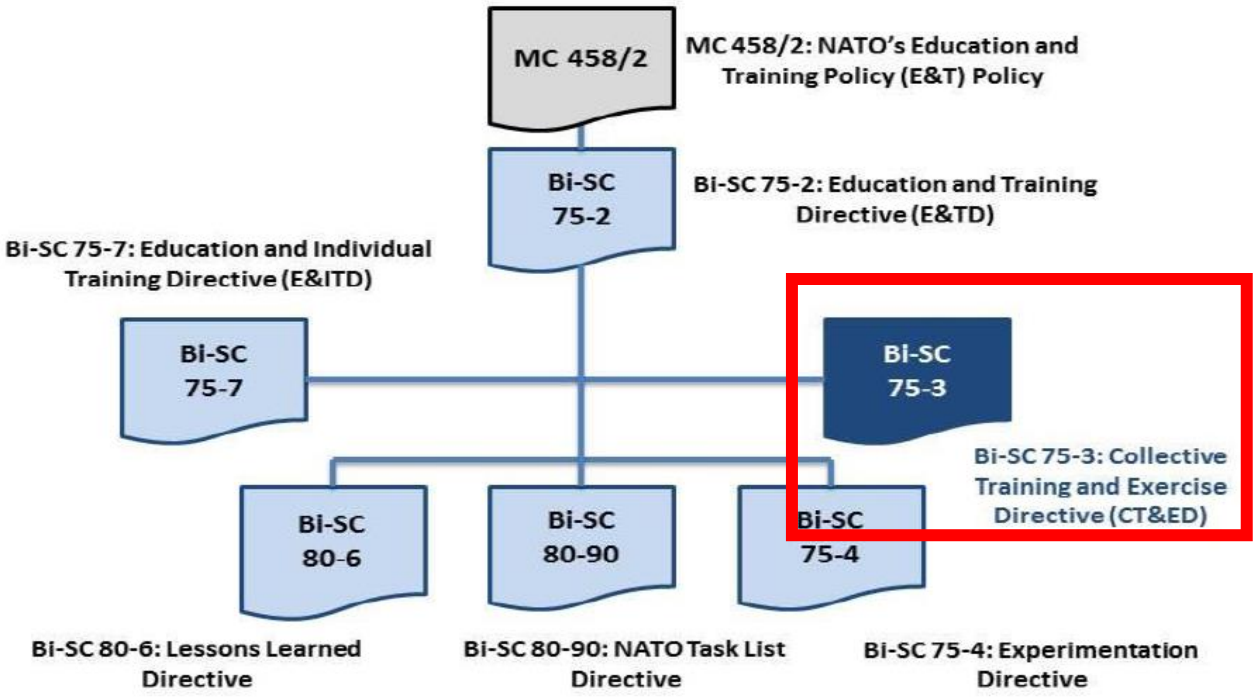

Figure 3: Position of the Bi-SC 075-003 (indicated by red box) in the framework of other documents related to NATO Training & Exercises (from [2])

The Bi-SC 075-003 is embedded in a framework of other documents governing NATO Training & Exercise. It describes the NATO (collective training) exercise process structured into four stages

- Stage 1, Concept and Specification Development. The purpose of this stage is to define the objectives of the training and necessary steps to fulfill these objectives.
- Stage 2, Planning and Product Development. Here all planning activities take place and the resulting plans for the exercise are documented in specific products.
- Stage 3, Operational Conduct. This is the action-training phase where a training audience actually performs in a military training environment setting.
- Stage 4, Analysis and Reporting. In this stage, the results and observations collected during the previous phase are analyzed and documented in a report.

For each of these stages the Bi-SC 075-003 defines the deliverables, the activities required to produce these deliverables, the roles involved and the responsibilities of these roles with respect to activities and deliverables.

M&S typically plays a supporting role in stage 3, although simulation is not directly mentioned in the stage definition of the Bi-SC 075-003. It is obvious that the engineering process of a simulation environment needs to be aligned properly to the exercise process described above. Thus, the described four phases and the contained roles, activities and products have a strong similarity to the well-known Distributed Simulation Engineering and Execution Process DSEEP [3].

2.2 Scenarios in the Bi-SC 075-003

The Bi-SC 075-003 defines scenarios as

"the background story that describes the historical, political, military, economic, cultural, humanitarian and legal events and circumstances that have led to the current exercise crisis or conflict. The scenario is designed to support exercise and training objectives and, like the setting, can be real, fictionalized or synthetic as is appropriate. A scenario will be composed of specific modules essential to the accomplishment of the exercise objectives or of the seminar/academic/ experiment objectives."

The primary purpose of a scenario in the context of NATO collective training therefore is to provide background information for all participants of the exercise. It serves as the "glue" that ties all activities, stakeholders and products of an exercise together.

The Bi-SC 075-003 further structures a scenario into different modules. These modules create a sub-structure of a scenario. They should not be seen as a means to compose a scenario from individual modules or to render standalone modules reusable in different contexts.

According to this structure, a scenario comprises the modules

- Geo-Strategic Situation containing
  - A generic description of the crisis area
  - The major regional actors
  - A description of the crisis
  - The historical background
  - The political, military, economic, cultural, humanitarian and legal conditions
- Theatre of Operations containing static information like
  - Maps
  - Theatre data
  - Country studies/information
  - Regional/National ORBATS
- Strategic Initiation holding information like e.g.
  - road to crisis
  - UNSC Resolutions, legal basis for operation
  - NAC Request for Advice
  - SACEUR Strategic Warning Order
  - NAC Initiating Directive
  - Strategic CONOPS
  - SACEUR and intermediate Commanders Planning Directives
- Crisis Response Planning Information comprising
  - current intelligence summary
  - friendly forces

  - environmental assessment
  - TOPFAS and LogBase dataset
  - intelligence dataset
  - MEL/MIL (as appropriate for phase II in stage 3)
- Force Activation and Deployment Information including
  - ACTWARN/ACTREQ messages
  - FORCEPREP messages
  - Allied Force List
  - NCRS messages
  - ROEAUTH/ROEIMPL messages
  - MEL/MIL (as appropriate for phase IIIa in stage 3)
- Execution Information containing
  - Road to Crisis (narrative summary incl. MEL/MIL)
  - Current Intelligence Summary
  - Operational Assessment and Reports
  - ORBAT / Transfer of Authority
  - Current SITREPS
  - Area of Interest Common Operational Picture
  - Main Event List / Main Incident List (for exercise execution)

Within its four-staged exercise process the Bi-SC 075-003 locates the development of the scenario information in stage 1 for the Geo-Strategic Situation scenario module and in stage 2 for all other scenario modules.

3.0 SCENARIO DEVELOPMENT PROCESS

The SISO-GUIDE-006-2018 “Guideline on Scenario Development for Simulation Environments” [4] focuses on M&S support for T&E and provides extensive information on different types of scenarios, expected scenario content from the perspective of stakeholders responsible for setting up simulation environments and different maturity levels of scenarios.

It is obvious that for large exercises in the NATO collective training setting of the Bi-SC 075-003 the development if this kind of scenario is a subset of the scenario development activities described in the previous section. In large exercises, typically two separate groups are responsible for scenario development and MEL/MIL development respectively. Although these are separate groups, there must be a strong interaction and interplay between them. The formation of two separate groups hereby results from the different roles of their products. Whereas the scenario is the springboard from which the exercise stems, i.e. the exercise starting point to which all relevant data for the execution of the exercise are tied, the MEL/MIL is the script from which the exercise is controlled.

According to [2] the required input for the scenario development group comes from

- the OSE’s Exercise Guidance

- the OCE's Exercise Planning Guidance
- the EXSPEC Geo-Strategic Situation
- the OSE's aim and objectives
- the OCE's Approved Training Objectives
- all relevant geospatial data

The final scenario product then provides the broad setting as well as detailed background information about locations, groups, people and the environment of the military situation to be trained in the exercise. The scenario therefore includes the PMESII factors

- geographical
- political
- military
- economic
- social
- information
- infrastructure

The MEL/MIL group will then use this scenario as a basis and builds storylines designed to trigger certain decisions and activities for the training audience based on the Exercise and Training objectives.

For exercises supported by simulation systems this must be augmented by capturing some engineering aspects in the scenario which in this case also serves as a source of requirements for the engineers faced with planning and setting up a simulation environment. If the scenario editors neglect this engineering aspect of scenario development, the corresponding scenario product will be incomplete or relevant information may be missing. This can result in severe consequences on the M&S synthetic environment:

- Misunderstandings regarding objectives and scope of a simulation environment
- The conceptual model (and the subsequently developed simulation environment) is not reflecting what the user originally wanted.
- The simulation environment does not fulfil the original requirements or does not answer the questions originally posed.
- The simulation results do not reflect what the user was expecting.

3.1 Types of Scenarios

The development of a simulation environment in support of training and exercise often follows the seven-step Distributed Simulation Engineering and Execution Process (DSEEP) [3]. This process guides a user from the definition and concept phases via development and integration phases finally to the execution and analysis phase. The DSEEP associates different types of scenario products with these phases.

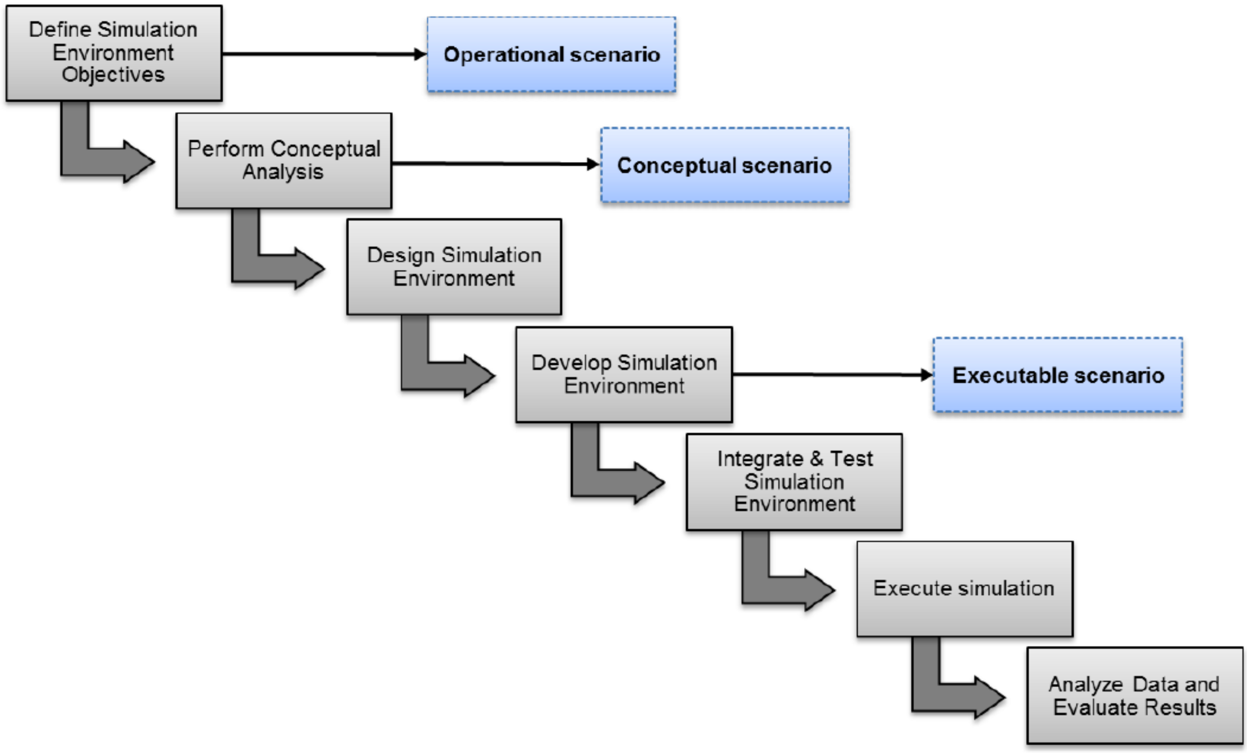

Figure 4: Different types of scenario products are associated to the phases of the Distributed Simulation Engineering and Execution Process (DSEEP) [3]

The Operational Scenario originates from the definition phase and serves as a source of requirements for the simulation environment. The conceptual phase further details this product and integrates it into the conceptual model of the simulation environment. Finally, in the development phase the scenario then is transformed into executable actions for the simulations systems involved, ideally in a machine-readable format.

3.1.1 Operational Scenario

The Operational Scenario contains binding requirements for the development of a specific simulation environment. These requirements derive from authoritative descriptions by subject matter experts (i.e. military users) using their domain specific terminology. They need to describe from their user point of view the parts of the reals world that need to be represented in the simulation environment. This refers to all relevant aspects of the environment, the simulation models and their behavior.

The Operational Scenario thus is very similar to the scenario defined in the Bi-SC 075-003 but focuses on the simulation specific requirements and information. It has less emphasis on information about history and military background information as compared to a Bi-SC 075-003 scenario.

From a theoretical point of view, the Operational Scenario can be characterized as one single point ("instance") in the Application Space.

The concept of Application Space is briefly introduced here. It is the totality of all possible simulation applications. Historically the Application Space is spanned by the simulation applications and can be structured along 5 "dimensions"

- the Simulation Application Mode (e.g. education, training, exercise, research, …)
- the Capability or Activity performed (e.g. defense analysis and planning, operation support, …)
- the Military Level (e.g. technical, tactical, operational, strategic, …)
- the Kind of Mission (e.g. Article-5, Non-Article-5)
- the Staff involved (e.g. CJ1, CJ2, …)

Thus, it is possible to characterize a concrete instantiation of a simulation environment by its intended purpose. This could enable re-use of the simulation environment in total or in parts. Therefore, this concept goes well beyond classical CAX applications and allows to match certain products like e.g. Operational Scenarios to certain points in the Application Space to ease the selection of conceptual models and other products. This extends the concept of re-use to information products other than software components.

The main characteristics of an Operational Scenario are that

- it bridges between operators and simulation engineers
- it is described in terms the (military) user is familiar with
- it is often a combination of a graphical and a textual description
- it should follow an operational planning process
- it is human readable

It should contain the following information

- reasoning, objectives
- relation to higher / lower level scenarios
- historical context, road to war
- PMESII
- types and numbers of major entities
- missions (initial/end state), operations, tasks, effects
- events/actions (TOEL = time ordered event list), MEL/MIL
- plans, orders
- constraints (doctrine, ROE, control measures)
- environmental conditions
- geographic characteristics

3.1.2 Conceptual Scenario

The Conceptual Scenario is closely related to the conceptual model of the simulation environment. In fact there is a strong overlap of the Conceptual Scenario product and the conceptual model and both may be composed from the same parts.

The conceptual scenario can be seen as the handover of scenario development from the (military) user to the M&S subject matter expert (SME). It forms the transition from the purely descriptive approach of the Operational Scenario to the engineer’s constructive point of view and therefore contains a more engineering-like structured description of the scenario content.

Although still being human readable it is (or at least should be) written in a more formalized language which allows the simulation SMEs to derive entity classes and their relationships from it and to finally be able to construct the conceptual model of the simulation environment.

There is no single standard for drafting and documenting conceptual scenarios. Several formal descriptions (e.g. Unified Modelling Language UML [5], NATO Architecture Framework NAF [6], etc.) can be used for this purpose.

The following figure illustrates the relationship between the conceptual model and the Conceptual Scenario, both being documented in one single diagram.

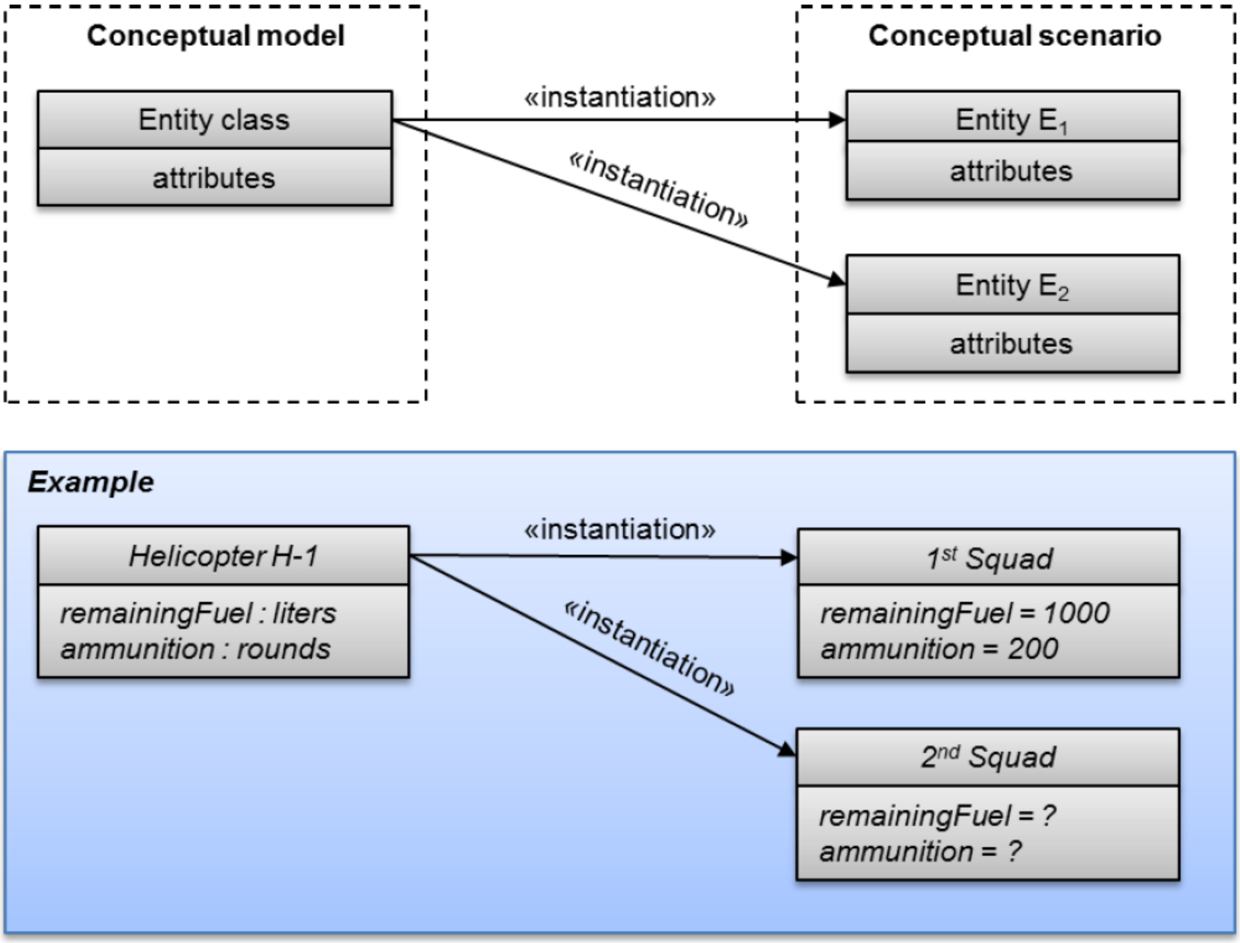

Figure 5: Relationship between the conceptual model and the conceptual scenario (from [4])

Here a UML-like diagram is used to document both, the conceptual model at the „class level" and the Conceptual Scenario. The latter shows concrete instances of conceptual model classes.

3.1.3 Executable Scenario

Progressing further along the development process [3] in the next step the simulation environment needs to be set up. This corresponds to a concretization of the conceptual model on a particular simulation environment instance. It also involves another handover of the scenario from the M&S experts to software developers and simulation system operators.

The Executable Scenario therefore serves the purpose to prepare, initialize and execute the simulation environment. Thus, it must be a technical description of the scenario, ideally documented in a machine-readable format. It selects all the entities for a particular run, allocates them to simulation environment federates, sets initial values of states and parameters and thereby is the pre-requisite for the execution of a simulation environment.

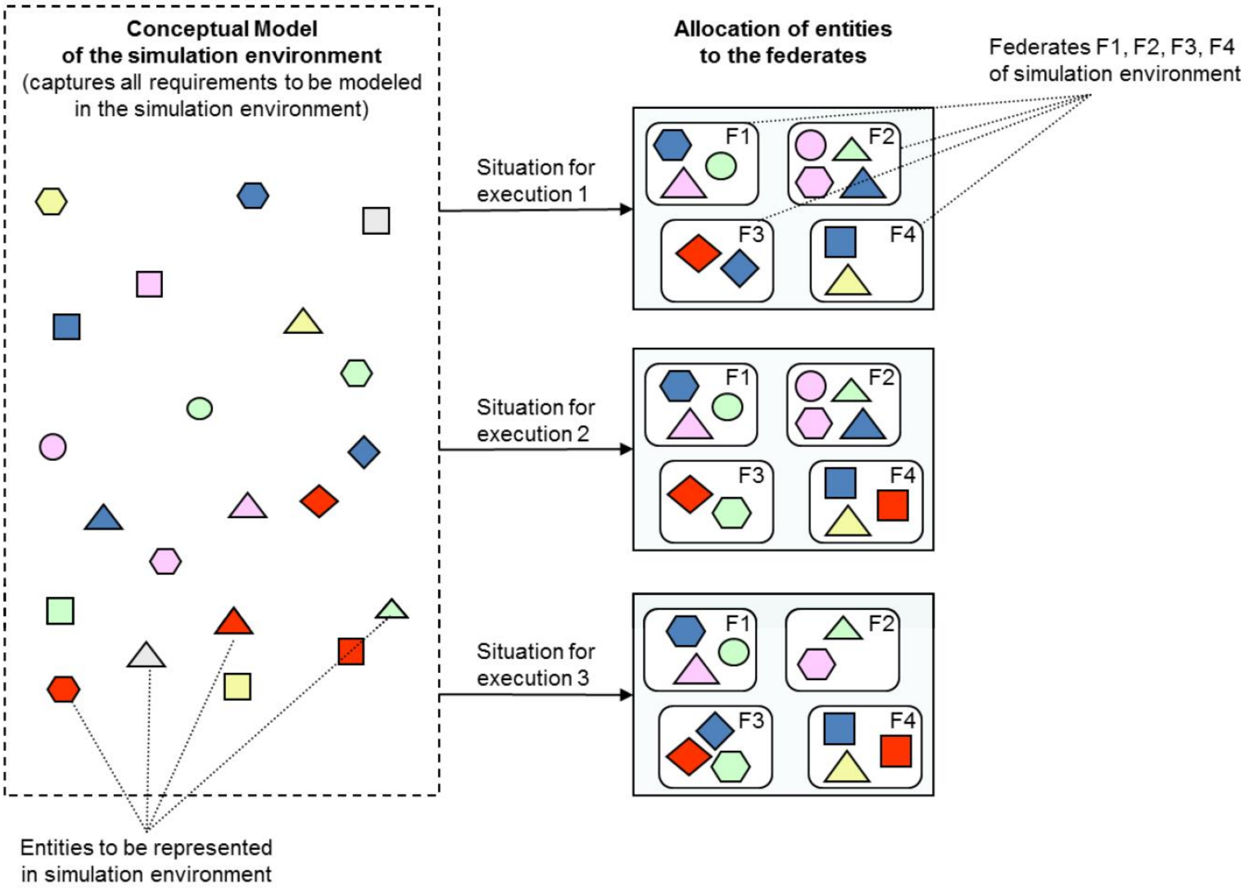

Figure 6: Transition from the conceptual level/scenario to the execution level/scenario (from [4])

Figure 6 illustrates this transition from the conceptual level and corresponding Conceptual Scenario to the execution level and Executable Scenario.

3.2 Content of Scenarios

As they derive from each other, obviously all three types of scenarios described in the previous section must contain the same content, although at different level of detail and documented in different formats. Thus, the content of a scenario forms an “orthogonal” dimension to the time/detail dimension of the scenario type. Figure 7 illustrates this relationship and shows the main content of a scenario, i.e. the initial state, the course of events and conditions for termination. This content is described in more detail in the following sections.

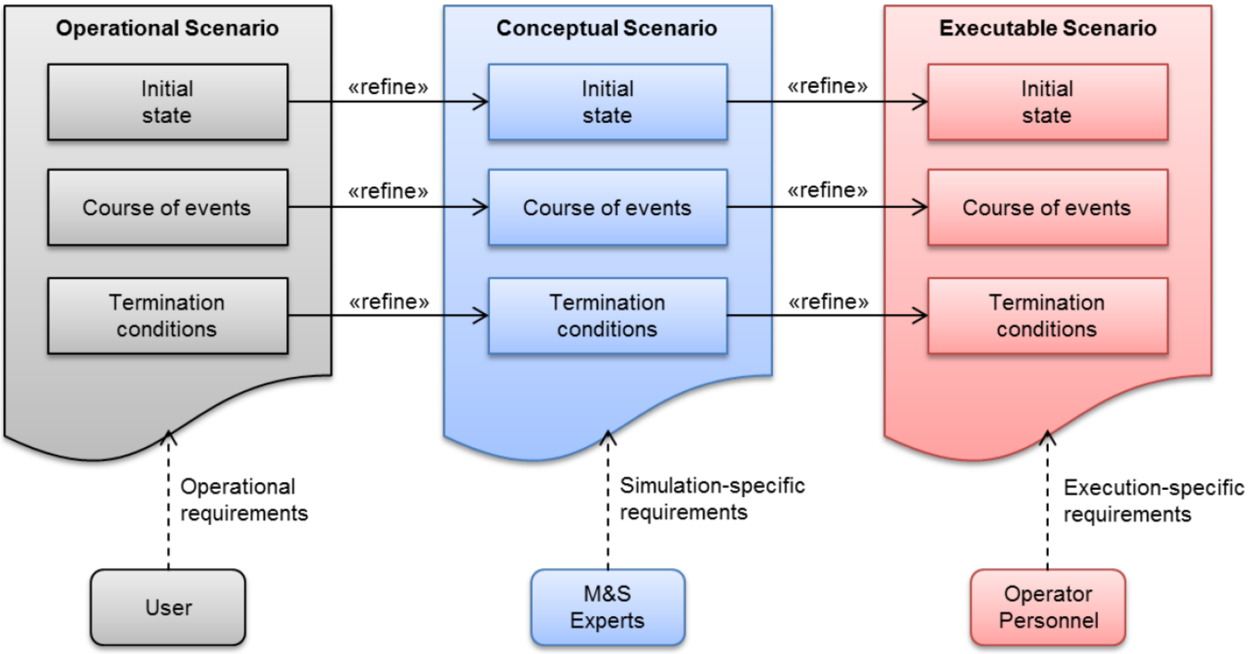

Figure 7: The different types of a scenario share the same content in different levels of detail and in different documentation formats (from [4])

3.2.1 Initial state

The SISO-GUIDE-006-2018 [4] suggests the following content and structure for the initial state described in a scenario

- Mission Statement
  - Contains high-level essentials of a scenario, e.g. background situation, intended outcome
  - Is formulated in domain-specific terms
  - Should communicate concisely the current situation as well as the intended end state
- Objects and Units
  - A list and description why participation in the scenario is required
  - Description content (e.g. according JC3IEDM), e.g. Identifier, Number/Count, Textual Description, Capabilities, Behavior, States, Attributes
- Forces and Force Structure, i.e. ORBAT including command and control hierarchies, communication networks, communication channels
- Geography
  - Area of interest, e.g. as rectangular bounding box
  - Resolution requirements, e.g. for terrain and imagery (by region)
  - Special requirements, e.g. real buildings or geo-typical buildings, need for building externals as well as interiors, vegetation, roads, ditches, etc.
  - Environmental conditions, e.g. day/night/dawn, rain/fog/snow/dust
  - Additional information, e.g. need for dynamic terrain, tolerances for terrain correlated for use

across constructive and virtual federates, etc.

- Date and Time of the Scenario, both in scenario time and local time
- Surrounding Conditions
  - Political situation
  - Military situation
  - Economic situation
  - Social situation / Cultural aspects
  - Information
  - Infrastructure
- Rules of Engagement, to ensure the correct (i.e. intended) behavior of all participating personnel operating live and virtual systems, as well as constructive systems participating in the simulation execution

3.2.2 Course of Events

The SISO-GUIDE-006-2018 [4] suggests the following content and structure for the course of (pre-planned) events described in a scenario

- Communication Events, e.g. reports, orders, internal or injected by EXCON
- Interaction Events, either directed between objects, e.g. attacks, or undirected, e.g. detonation
- State change Events, these are similar to interaction events but involve only one single object
- Environmental Events, e.g. the onset of rain

3.2.3 Termination conditions

Finally, in a scenario must specify the conditions for the termination of the simulation execution to prevent the simulation to run forever and to provide every operator involved in the simulation execution a clear condition when to stop executing actions and simulation software applications. This is especially relevant for closed-loop simulation where no human operator dynamically interacts with the simulation environment and the same stop-condition needs to be configured into all simulation systems involved. But of course clearly stated termination conditions are also highly desirable in spatially distributed simulation exercises which take place simultaneously in different locations.

3.3 Maturity of Scenarios

The SISO-GUIDE-006-2018 [4] categorizes the maturity of scenarios into three levels. Maturity here is understood in the sense of the Capability Maturity Model Integration (CMMI) as the “Degree of process improvement across a predefined set of process areas in which all goals in the set are attained”. In some cases no written specification of a scenario is drafted, which can be categorized as “Level 0” and will be neglected here. Therefore, the levels of scenario maturity are defined as

- Level 1. A non-standardized scenario specification exists. This typically refers to scenario specification in free-text formats. A scenario description at level 1 has the benefits that
  - A written scenario specification exists at all, at least in a non-standardized way.
  - A basic traceability of requirements and improved understandability of the simulation environment becomes possible.

There are however a number of drawbacks of specifying a scenario at level 1 only.

- Familiarization effort for involved parties (user, M&S experts, system operators, etc.) is quite high
- Ensuring completeness of the scenario specification is complicated (due to missing checklists)
- Comparability of scenario specifications is low as each scenario is specified differently
- Reuse is hampered due to low comparability of scenario specifications and thus limited possibilities for efficiently searching and finding suitable existing scenarios

- Level 2. A standardized scenario specification exists. Standardized in this context refers to a specification that is structured according to a standard or agreed guideline or template. This includes open standards (preferred) as well as "local" standards (accepted). By specifying a scenario at level 2 the following benefits result
  - Initial familiarization efforts are minimized.
  - Access to scenario documentation becomes easier for all persons working on these scenarios (includes the M&S experts, V&V experts, other readers of the scenario specification)
  - Quality management activities (e.g. evaluation of completeness of a scenario specification) are simplified.
  - The development of a "good" scenario specification (even for unexperienced scenario creator) is simplified.
  - It is a prerequisite for the formal specification of a scenario.

  The drawbacks of specifying a scenario at level 2 only are that

  - No single standard is available; rather multiple standards exist from which the scenario editor must choose.
  - None of the existing standards serves all purposes and was specifically designed for scenario specification.

- Level 3. A formal scenario specification exists. Formal here refers to a machine-readable specification format, e. g. XML Schema [7], UML [5] or OWL [8]. The obvious benefits of a scenario specification at level 3 are
  - The elimination or at least reduction of ambiguities.
  - The option for automated processing of scenario specifications.
  - The utilization of tools like e. g. automated consistency checks (e.g., overlapping positions; geographic boundaries) or automated initialization of all simulation systems and other member applications
  - The reduced risk of errors due to manual misconfiguration or human errors
  - An improved reproducibility
  - A semi-automated or fully automated cross-checks with other information products (e.g. FOM)
  - The simplification of re-use

Unfortunately, at the time of writing no standard format for specifying a scenario at maturity level 3 is available.

4.0 SCENARIO SPECIFICATION USING BASE OBJECT MODELS

As there are no unique standards for the specification of a scenario, different standards originally designed for other purposes may be used. One of these standards is defined by the SISO-STD-003-2006 Base Object Model (BOM) Template Specification [9] and explained in more detail in the SISO-STD-003.1-2006 Guide for Base Object Model (BOM) Use and Implementation [10]. After a short introduction, a walk-through example explains the application of this standard for the specification of scenarios.

4.1 Introduction to Base Object Models

In the field of Modelling & Simulation, interoperability is usually categorized into different levels.

- Level 6, Conceptual Interoperability
- Level 5, Dynamic Interoperability
- Level 4, Pragmatic Interoperability
- Level 3, Semantic Interoperability
- Level 2, Syntactic Interoperability
- Level 1, Technical Interoperability

Middleware and data exchange solutions for distributed simulation like the Distributed Interactive Simulation (DIS) and the High Level Architecture (HLA) allow interoperability at level 2 to 3 only. These specifications only rule the technical exchange of data and define the semantic of exchanged data (in the case of DIS; for HLA applications in addition an agreement on a Federation Object Model (FOM) is needed) and thus do not enforce interoperability at higher levels.

Base Object Models (BOMs) define a standardized methodology to access also higher interoperability levels, thereby improving reusability, composability, adaptability, aggregation and multi-resolution modelling. In addition to a description of the relevant entities and events like in the DIS/HLA, a BOM also contains a formalized description of dynamics and behavior of the related entities. A BOM comprises the parts Model Identification, Conceptual Model and Model Mapping.

4.1.1 Model Identification

The Model Identification component of a BOM relates the BOM to metadata information relevant for search, retrieval and traceability of the BOM and the entities and events described therein.

Metadata may be manifold and among other information may contain

- Name and Type of the BOM
- Versioning information and modification timestamps
- Security classification and release restrictions
- Purpose and description of the application domain
- Description of the contained models and use limitations

4.1.2 Conceptual Model

This component forms the core of the BOM and contains

- The Entity Types and Event Types relevant for the BOM. These are very similar to the content of a FOM in an HLA federation. In fact, a FOM can be derived from the Entity and Event Type information in a BOM. This part of the BOM describes the object types involved in the model and the relevant events that will be exchanged between the objects, will be internally used by objects to control their behavior or will be injected from external sources to influence the model.

- The Patterns of Interplay. This part captures the dynamics and interactions between the different objects. This goes well beyond the concept of a FOM and couples Entity Types together in complex action patterns often involving multiple senders and receivers of several different events.
- The State Machines. These describe the internal dynamics of entity types by defining several different states and events to trigger transitions between them. The concept of state machines is well known in informatics.

4.1.3 Model Mapping

The Model Mapping component of a BOM forms the link between BOM Entity Types and FOM object classes and their properties. This allows traceability between the conceptual description of an entity type in a BOM and its concrete implementation in a HLA federation by an object class. An explicit model mapping is necessary because there in general is no 1:1-mapping of BOM Entity Types and HLA object classes, i.e. several object classes in concrete realization of a HLA federation may be necessary to implement a single BOM Entity Type.

4.2 Walk-Through Example Scenario Specification

To illustrate the use of BOMs in the specification of a scenario we present a simple walk-through scenario. We choose a small air defense scenario where a single hostile helicopter is detected and intercepted by a ManPAD Team comprising a commander, an observer and a gunner.

Thus, the BOM Model Identification may look as stated in Table 1.

Key	Value
Name	Air defense of a maneuvering unit using ManPADs
Type	BOM
Version	1.0
Modification Date	2012-12-10
Security Classification	Unclassified
Purpose	Analysis of the operational effectiveness of man portable air defense (ManPAD) systems for defending a maneuvering unit against airborne attacks.
Application Domain	Analysis
…	…

Table 1: Model Identification of an example scenario (from [4])

Further analysis shows that the following entity types can be identified for the conceptual model.

- Commander Entity

- Observer Entity
- Gunner Entity
- Hostile Object Entity
- Firing Entity
- Target Entity
- Missile Entity

It should be noted here that two separate conceptual entities are required to represent the different roles of the hostile helicopter. The first of them, the Hostile Object Entity, is used to represent any unidentified object detected by the observer and reported to the commander. The other one, the Target Entity, represents any object ordered by the commander to be intercepted by the gunner. This strict separation of conceptual roles allows an application of the BOM to a wide range of air defense scenarios where many objects are present in the airspace and different objects are targeted. It thus broadens the concept (and the represented scenario) from a specific intercept of a single helicopter to a much broader application area.

UML swim lane diagrams like Figure 8 may then represent the patterns of interplay.

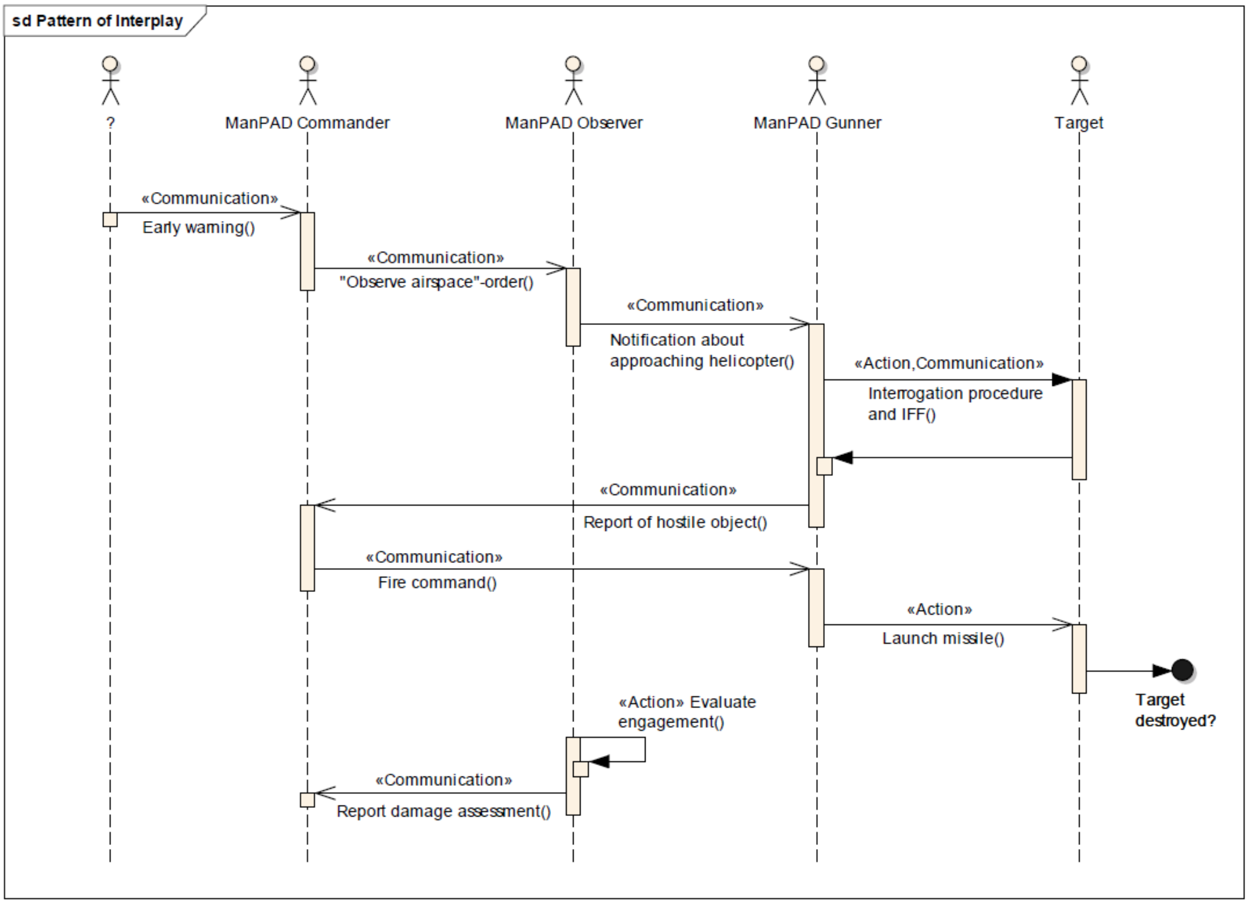

Figure 8: UML swim lane diagram to represent a part of the pattern of interplay in the example scenario (from [4])

This diagram clearly shows the expected interaction between the conceptual entities using conceptual events. The diagram also shows that two different types of events will be present, the "communication" event type and the "action" event type. Creating formal diagrams like these will also reveal important aspects of the scenario which otherwise might be overlooked to specify, thus preventing gaps in the specification. The above diagram for example introduces another entity that initiates the pattern of interplay. It also raises the question who will decide on the target destruction and which action should be taken if the target was not destroyed. In addition, the "engagement evaluation" action and the "report damage assessment" communication are not linked to the other action in the diagram and therefore immediately raise the question how these actions should be triggered.

The dynamics can further by characterized by the specification of state machines for each entity type; we only give two examples for the ManPAD commander and the observer in Figure 9.

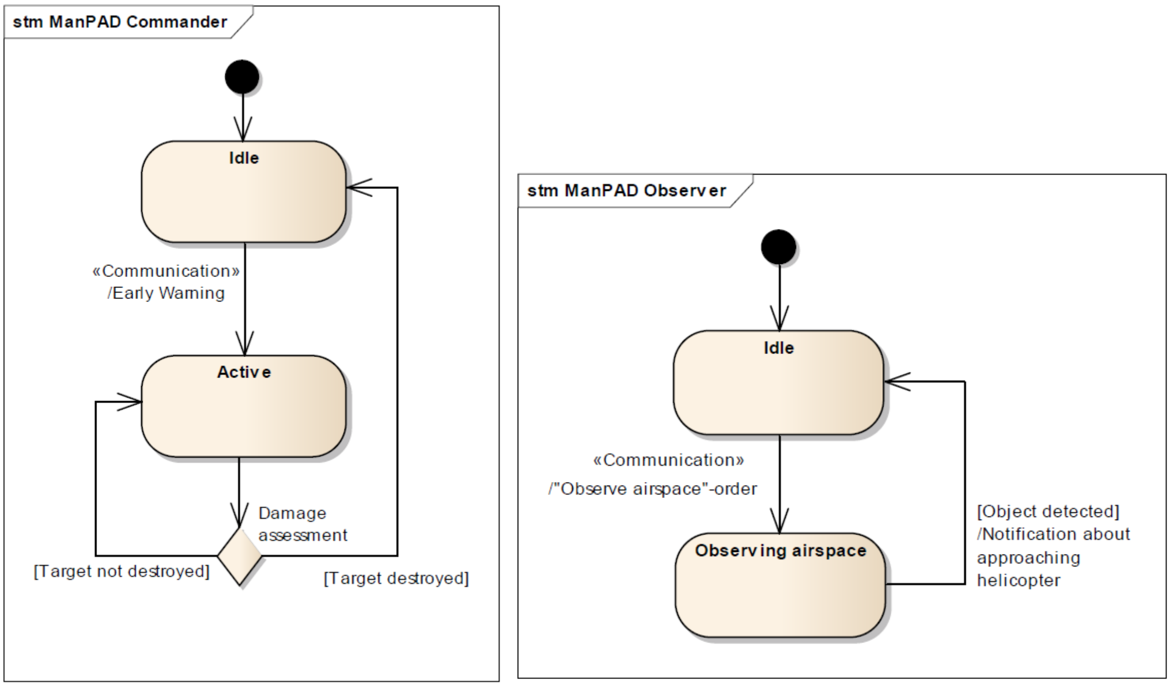

Figure 9: UML state diagrams for two entity types in the example scenario (from [4])

The ManPAD commander entity resides in an "idle"-state until he receives an early warning message, which places him in an "active"-state. Not shown here, the "active"-state contains actions to communicate orders to the observer and the gunner and receive reports from these entities. After a negative damage assessment, the commander entity remains in the "active" state whereas a positive assessment (target destroyed) places him in the "idle"-state again. A similar state and activity cycle holds for the ManPAD observer.

5.0 SUMMARY

In this paper, different application areas of Modelling & Simulation are explained in accordance with the NATO Modelling & Simulation Masterplan. Special attention is given to NATO collective training and the scenario definition process is introduces as defined by the Bi-Strategic Command Directive 075-003. When training is augmented or supported by simulation systems, additional aspects of scenarios become important to bridge the gap between military users, simulation subject matter experts and simulation system developers and operators. These stakeholder groups require additional information, leading to Conceptual and Executable Scenario categories in addition to Operational Scenarios. These can further be characterized by their maturity level and can be documented following different standards. Base Object Models (BOMs) provide one way to document scenarios and capture relevant aspects. This type of scenario documentation is explained via a walk-through example.

6.0 REFERENCES

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[9] SISO-STD-003-2006 "Base Object Model (BOM) Template Specification"

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