NORTH ATLANTIC TREATY ORGANISATION

RESEARCH AND TECHNOLOGY ORGANISATION

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RTO TECHNICAL REPORT **TR-MSG-058**

Conceptual Modeling (CM) for Military Modeling and Simulation (M&S)

(Modélisation conceptuelle (MC) pour la modélisation et la simulation (M&S) militaires)

Final Report of MSG-058.

Published July 2012

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The Research and Technology Organisation (RTO) of NATO

RTO is the single focus in NATO for Defence Research and Technology activities. Its mission is to conduct and promote co-operative research and information exchange. The objective is to support the development and effective use of national defence research and technology and to meet the military needs of the Alliance, to maintain a technological lead, and to provide advice to NATO and national decision makers. The RTO performs its mission with the support of an extensive network of national experts. It also ensures effective co-ordination with other NATO bodies involved in R&T activities.

RTO reports both to the Military Committee of NATO and to the Conference of National Armament Directors. It comprises a Research and Technology Board (RTB) as the highest level of national representation and the Research and Technology Agency (RTA), a dedicated staff with its headquarters in Neuilly, near Paris, France. In order to facilitate contacts with the military users and other NATO activities, a small part of the RTA staff is located in NATO Headquarters in Brussels. The Brussels staff also co-ordinates RTO's co-operation with nations in Middle and Eastern Europe, to which RTO attaches particular importance especially as working together in the field of research is one of the more promising areas of co-operation.

The total spectrum of R&T activities is covered by the following 7 bodies:

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

These bodies are made up of national representatives as well as generally recognised 'world class' scientists. They also provide a communication link to military users and other NATO bodies. RTO's scientific and technological work is carried out by Technical Teams, created for specific activities and with a specific duration. Such Technical Teams can organise workshops, symposia, field trials, lecture series and training courses. An important function of these Technical Teams is to ensure the continuity of the expert networks.

RTO builds upon earlier co-operation in defence research and technology as set-up under the Advisory Group for Aerospace Research and Development (AGARD) and the Defence Research Group (DRG). AGARD and the DRG share common roots in that they were both established at the initiative of Dr Theodore von Kármán, a leading aerospace scientist, who early on recognised the importance of scientific support for the Allied Armed Forces. RTO is capitalising on these common roots in order to provide the Alliance and the NATO nations with a strong scientific and technological basis that will guarantee a solid base for the future.

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List of Acronyms

ACIMS	Arizona Center for Integrative Modeling and Simulation
AF	Argumentation Framework
AMRDEC	Aviation and Missile Research, Development and Engineering Center
AV	All View
BCI	BOM Component Implementations
BOM	Base Object Models
BPGS	Best-Practice Guidance Specification
BPMN	Business Process Modeling Notation
C2IEDM	Command and Control Information Exchange Data Model
C-BML	Coalition Battle Management Language
CBML	Cell Behavior Markup Language
CIM	Computation Independent Model
CM	Conceptual Model, Conceptual Modeling
CML	Conceptual Modeling Language
CMMI	Capability Maturity Model Integration
CMMS	Conceptual Model of the Mission Space
COI	Critical Operational Issues
CONOPS	Concept of Operation
COTS	Commercial-Off-The-Shelf
CSDP	Conceptual Schema Design Procedure
CWM	Part of SWAP – Semantic Web Application Program
DAML	DARPA Agent Markup Language
DCMF	Defence Conceptual Model Framework
DEVS	Discrete-Event Systems
DMWG	Data Modeling Working Group
DoD	Department of Defense
DoDAF	DoD Architecture Framework
DSEEP	Distributed Simulation Engineering and Execution Process
EA	Enterprise Architecture
ER	Entity Relationship
ERM	Entity Relationship Modeling
FEDEP	Federation Development and Execution Process
FEDEX	Federation Execution
FFI	Norwegian Defence Research Establishment
FOI	Swedish Defence Research Agency
FORML	Formal Object-Role Modeling Language
GM	Generic Methodology
GM-V&V	Generic Methodology for Verification, Validation
HLA	High Level Architecture
HPKB	High Performance Knowledge Base Program
IDEF	Integration Definition for Function Modeling
IEC	Infomentum Classification Engine

IEEE	Institute of Electrical and Electronics Engineers
INCOSE	International Council on Systems Engineering
IR	Information Retrieval
ISDEFE	Ingenería de Sistemas para la DEFensa de España
ISO	International Organization for Standardization
IST	Information System Theoretic
JC3IEDM	Joint Command Control Communications Information Exchange Data Model
KA	Knowledge Acquisition
KE	Knowledge Elicitation
KIF	Knowledge Interchange Format
KM3	Kernel Meta Meta Model
KRS	Knowledge Representation System
M&S	Modeling and Simulation
MDA	Model-Driven Architecture
MOF	Meta Object Facility
MSCO	Modeling and Simulation Coordination Office
MSG	Modeling and Simulation Group
MSM	Mission Space Model
MSMP	Modeling and Simulation Master Plan
NAF	NATO Architecture Framework
NATO	North Atlantic Treaty Organisation
NDAG	NATO Data Administration Group
NLIAM	Natural Language Information Analysis Method
NIST	National Institute of Standards and Technology
NMM	NAF Meta-Model
NMSG	NATO Modeling and Simulation Group
OCL	Object Constraint Language
OIL	Ontology Interface Layer
OKBC	Open Knowledge Base Connectivity
OMG	Object Management Group
ORM	Object-Role Modeling
OV	Operational View
OWL	Web Ontology Language
OXL	Ontology Exchange Language
PA	Process Activity
PfP	Partners for Peace
PIM	Platform Independent Model
POC	Point Of Contact
PP	Process Phase
PSM	Platform Specific Model
RDECOM	Research, Development, and Engineering Command
RDF	Resource Description Framework
RPR	Real Platform Reference
RTG	Research Technology Group
RTO	Research and Technology Organisation
RUP	Rational Unified Process

SCAMPI	Standard CMMI Appraisal Method for Process Improvement
SEI	Software Engineering Institute
SES	Senior Executive Service
SISO	Simulation Interoperability Standards Organization
SME	Subject Matter Expert
SSDD	System Simulation and Development Directorate
SV	System View
SysML	Systems Modeling Language
TAP	Technical Advisory Panel
TG	Task Group
TOR	Terms of Reference
TS	Technical Standards
UML	Unified Modeling Language
V&V	Verification and Validation
VEA	Microsoft® Visio® for Enterprise Architects
VV&A	Verification, Validation and Accreditation
W3C	World Wide Web Consortium
XMI	XML Metadata Interchange
XML	Extensible Markup Language

MSG-058 Participating Members

Jan-Jelle Boomgaardt *is a senior scientist concerned with Modeling & Simulation at TNO Defence, Security and Safety. He has some 9 years of experience in the field of applied research. The main focus of his research has been on distributed simulation architectures, such as the High Level Architecture (HLA). The M&S field of expertise is supported by his previous 7 years of experience in computer architectures and software engineering.*

Mircea Cernat *was born in Romania, in 1957. He finished the PhD studies in 1996 with the thesis entitled "Study of the solid propellant burning chambers under dynamic loading". He is the Deputy Director for Science at Military Equipment and Technologies Agency, Bucharest (http://www.acttm.ro/en/index.html). Since 1987 he worked in positions linked to education and research, being entitled professor at Military Technical Academy in Bucharest since 2001. In 2006, he graduated the National Defence College and has been involved in several projects linked to defence and security since then. Since 2009 he is also a senior researcher succeeding to manage or to contribute as member in research Groups to several projects regarding weapon systems technology and aerospace engineering. His research topics are focused on applied mathematics to weapon systems and structural mechanics. Since 2005 he has been mandated to represent Romania as voting member in NATO Modeling and Simulation Group (NMSG).*

Nathalie Harrison *is a defence scientist at Defence R&D Canada – Valcartier since 2000. She works in the Electro-Optical Warfare Section where she develops and uses Modeling and Simulation (M&S) processes and tools to study engagements between military platforms, guided weapons and countermeasures. She received a Bachelor's degree in Engineering Physics from Laval University (Quebec, Canada) in 1998. She also received a Master's degree in Electrical Engineering from the same university for her research on virtual reality cryosurgery simulation and modeling of heat transfer in human tissues. Her research interests include: physics-based modeling; verification and validation process and techniques; model exchange; software engineering applied to M&S; Conceptual Modeling and Model-Driven Architecture applied to M&S; and simulation frameworks and synthetic environments.*

Vahid Mojtahed *is a senior scientist and deputy research director at the Swedish Defence Research Agency (FOI). He received a Master of Science in Computer Science and Engineering from Chalmers University of Technology in 1994. He has been working on modeling and simulation for the past 15 years and has led the Swedish conceptual modeling research at FOI since 2001 as well as the FOI research on Semantic Interoperability since 2006. He is also the Swedish representative in NATO's research group on conceptual modeling as well as in NATO's research group on Semantic Interoperability. His research interests are in the area of Conceptual Modeling, Simulation Framework, Semantic Interoperability and Information Operations and Warfare.*

Arne C. Jenssen *is a senior scientist with the Norwegian Defence Research Establishment (FFI). He has received BEng, MSc and PhD degrees in electrical engineering. He has been working with test and evaluation in a naval context for the last decade. These activities comprise substantial efforts in modeling and simulation for evaluation of torpedo and missile defence capabilities.*

Bernardo Martinez Reif *is working for ISDEFE, a company that provides technical engineering support and consulting services to the Spanish Ministry of Defence. He has been involved in several Command and Control and Modeling and Simulation projects since 2003, specially focused in the Data Modeling and Interoperability issues. He has participated also in the NATO Modeling and Simulation Group Technical Activity Program MSG-042 "Framework for Simulation Resources Reusability (FSRR)" and in the Information System Technologies IST-075 "Semantic Interoperability". He received his Bachelor's degree in Computer Science from the Polytechnic University in Madrid, Spain.*

Oscar Jimenez Pascual *is Major of the Spanish Army, specialized in telecommunications, computer science and operational research. He has been working in these fields and, nowadays, he works in the Operational*

Research Department of the Spanish Army, which participates in M&S projects. He also has a degree in Computer Science from the University of Valladolid, a Master of Operational Research from Complutense University (Madrid), and an Executive MBA from Financial Studies Centre (Madrid).

Gregory Tackett *is a member of the US Army Senior Executive Service (SES) and is the Director of the System Simulation and Development Directorate (SSDD) in the Research, Development, and Engineering Command (RDECOM) Aviation and Missile Research, Development, and Engineering Center (AMRDEC). Mr. Tackett has worked for the Department of Defense since 1982 in the field of Modeling and Simulation (M&S) and is a leader in academic and professional initiatives to establish M&S as a recognized profession with a defined body of knowledge and standardized curricula. He has most recently been appointed as the RDECOM M&S Executive Agent. He has a B.S. degree in Physics from Mississippi College, and an Executive MBA from the University of Tennessee.*

Jeroen Voogd *is a member of the scientific staff at the Modeling & Simulation and Gaming Department of TNO Defence, Security and Safety Division. He holds a Ph.D. in Computational Physics from the University of Amsterdam in the field of modeling and simulating (M&S) of biophysical systems on parallel and distributed computing platforms. A recurring theme in his work of the last years is the quality of simulations. This includes verification and validation of M&S assets, as well as quality assurance within TNO.*

William F. Waite *is co-founder and Chairman of The AEgis Technologies Group, Inc., where he directs a staff involved in a wide variety of modeling and simulation (M&S) activities including simulation technologies evolution; simulation systems development; simulation verification, validation, and accreditation; simulation-based studies and analyses; and the development of hardware and software products supporting modern M&S practice. He has more than 30 years of professional involvement in all phases of the M&S life cycle and its application to systems engineering lifecycle. Mr. Waite is currently active in the evolution of the M&S profession, industry, and market. He is also engaged in the further discovery and invention of M&S business practice, emphasizing M&S employment in business enterprise operations.*

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Conceptual Modeling (CM) for Military Modeling and Simulation (M&S)

(RTO-TR-MSG-058)

Executive Summary

Purpose

The aim of this document is to clarify the "Conceptual Model" (CM) concepts; investigate methodologies, simulation and software engineering processes; draft a guidance document on CMs that can be used by different stakeholders; foster the establishment of the guidance document as a SISO standard; identification of the relevant stakeholders of CMs; address the needs of M&S community and provide guidance to implementation; and, provide guidelines for standards in conceptual modeling for M&S.

Scope and Limitations

The scope of this guidance is nominally for NATO military M&S. However, the approach taken herein is to provide comprehensive guidance that can easily be adapted and tailored to individual enterprises. It can be generalized to apply to alternative domains. NATO and national defense establishment M&S communities-of-practice are *de facto* enterprises in this spirit when the investment, development, maintenance, and use of M&S assets are concerned. While the application of this guidance is intended to be broad, its scope is targeted to the CM development process, and only provides limited best-practices pertaining to the rest of the CM life cycle.

Special Issues (Procedures)

Five topics have been identified as critical. They required special work efforts to propose an appropriate solution: Stakeholder Analysis and Context; Scope and Definition; Relationship to Standards; Specification of CM Management Process; Specification of CM Artefacts.

Significant Considerations, Analysis/Results

As in Heisenberg Uncertainty, where a phenomenon is disturbed as soon as one tries to measure it, the referent in a CM is distorted as soon as one tries to represent it. This is one reason so many simulation frameworks have turned out to be unusable or un-reusable while they were modeled as point solutions such as "red against blue", instead of more composable structures, such as "entities and interactions". The conceptual modeling enterprise does not get rid of these biases, as much as it makes the choosing of biases deliberate and well documented.

The CM of a simulation is not simulation space implementation independent. It may appear to be so, without any specific references to the simulation space, but the decisions that were made during the CM design inevitably were informed by the underlying need for a simulation capability or an enterprise interest. The value of this guidance to enterprises is the provision of a broad and flexible process with defined products which can be mapped against current approaches and future plans. Common terminology can also be derived from this guidance to enable better communication of concepts between enterprises.

Decisions and Recommendations, Military/NATO Significance of the Study

- NATO Nations should adopt this guidance as best-practice for their national and international M&S efforts to enable interoperability and reuse.

- The M&S community should incorporate CM development into their M&S development processes, based on the best-practice provided in this guidance.

- Each enterprise should specify its own conceptual modeling process and CM products, using this guidance as a point of reference.

- VV&A of CMs should be integral to the development process. Use of the ISO/IEC 9126 standard on software quality is a starting point for the derivation of CM quality criteria, and use of the (draft) GM-V&V standard is applicable to V&V of CMs.

- Every customization of the guidance should be published to contribute to the body of knowledge of conceptual modeling, to build a valuable experience base for standardization initiatives.

- The M&S community and the Simulation Interoperability Standards Organization, should use this best-practice guidance as a basis to initiate an international standard for CM development.

Modélisation conceptuelle (MC) pour la modélisation et la simulation (M&S) militaires

(RTO-TR-MSG-058)

Synthèse

Objectif

Le but du présent document est de : clarifier les notions de « modèle conceptuel » (MC) ; étudier les méthodologies, les procédés de génie logiciel et de simulation ; rédiger une directive traitant des MC pouvant être utilisée par différentes parties prenantes ; agir en sorte que la directive devienne une norme SISO (Organisation de normalisation en vue de l'interopérabilité en matière de simulation) ; identifier les bonnes parties prenantes aux MC ; répondre aux besoins du monde de la modélisation et de la simulation et lui fournir des directives de mise en œuvre ; et fournir des lignes directrices en matière de normes dans le domaine de la modélisation conceptuelle destinée à la M&S.

Portée et limitations

La présente directive porte, en principe, sur la M&S militaire de l'OTAN. Toutefois, le parti retenu ici est de fournir une directive complète pouvant être facilement adaptée à différentes entreprises. Elle peut être généralisée pour s'appliquer à d'autres domaines. Les collectivités qui assurent la mise en œuvre de la M&S, qu'elles se situent au niveau OTAN ou des établissements nationaux de défense, sont *de facto* des entreprises en ce sens lorsqu'il s'agit de financer, développer, entretenir et utiliser les ressources en matière de M&S. Bien que le domaine d'application de la présente directive soit intentionnellement vaste, sa portée est restreinte à la procédure de développement de modèle conceptuel et elle n'indique que de façon limitée les meilleures pratiques se rapportant au reste du cycle de vie dudit modèle conceptuel.

Questions spéciales (Procédures)

Cinq domaines critiques ont été identifiés. Ils ont nécessité une réflexion spéciale débouchant sur une solution adaptée : environnement et analyse de partie prenante ; portée et définition ; rapports avec les normes ; spécification de procédure de gestion de la MC ; spécification d'artefact de MC.

Considérations importantes, analyse/résultats

De même que, selon le principe d'incertitude de Heisenberg, on perturbe un phénomène dès lors que l'on essaie de le mesurer, le référent dans une MC est altéré dès que l'on essaie de le représenter. C'est l'une des raisons pour lesquelles tant de cadres de simulation se sont révélés être inutilisables ou non réutilisables alors qu'ils étaient modélisés en tant que solutions ponctuelles telles que « rouges contre bleus », en lieu et place de structures plus accommodantes telles qu'« entités et interactions ». L'entreprise de modélisation conceptuelle n'élimine pas tant ces biais qu'elle rend leur choix délibéré et bien documenté.

La MC d'une simulation n'est pas indépendante de la mise en œuvre de l'espace de simulation. Cela peut paraître être le cas, sans aucune référence spécifique à l'espace de simulation, mais les décisions prises lors de la conception de la MC ont été inévitablement influencées par le besoin sous-jacent d'une capacité de simulation ou d'un intérêt d'entreprise. La valeur de la présente directive pour les entreprises consiste en la mise à disposition d’une procédure large et souple comprenant des produits définis qui peuvent être organisés en fonction des méthodologies actuelles et des plans futurs. Une terminologie commune peut également être tirée de la présente directive afin de favoriser l’échange de concepts entre entreprises.

Décisions et recommandations, importance militaire/pour l’OTAN de l’étude

- Les pays de l’OTAN doivent adopter la présente directive en tant que meilleure pratique applicable à leurs efforts nationaux et internationaux en matière de modélisation et simulation (M&S), et ce, en vue de permettre l’interopérabilité et la réutilisation.

- Le monde de la M&S doit intégrer le développement de la modélisation conceptuelle (MC) dans ses processus de développement de M&S en se fondant sur les meilleures pratiques indiquées dans la présente directive.

- Chaque entreprise doit indiquer ses propres procédures de modélisation conceptuelle et produits de MC en utilisant la présente directive comme référence.

- Les VV&A (vérification, validation et acceptation) des MC doivent faire partie intégrante du processus de développement. L’utilisation de la norme ISO/IEC 9126 sur la qualité des logiciels constitue le point de départ d’où vont découler les critères de qualité de la MC, et (le projet de norme ou) la norme GM-V&V (méthodologie générique de vérification et validation) est applicable aux V&V (vérification et validation) des MC.

- Toute personnalisation de la directive doit être publiée afin de contribuer au corpus de connaissances relatives à la modélisation conceptuelle, et ce, pour constituer un précieux socle d’expérience utile aux initiatives en matière de normalisation.

- Le monde de la M&S ainsi que l’Organisation de normalisation en vue de l’interopérabilité en matière de simulation (SISO) doivent utiliser la directive relative aux meilleures pratiques comme point de départ d’une norme internationale en matière de développement de MC.

OVERVIEW

O.1 PURPOSE

This document is intended to have the following consequential effects:

- Clarify "Conceptual Model" (CM) concepts, discuss the terminology, and emphasize the utility to better formalize conceptual models, understand the relationship between conceptual modeling and related concepts (scenario definition, etc.);
- Investigate methodologies, simulation and software engineering processes, initiatives and technologies useful for the establishment and content of conceptual models;
- Draft a guidance document on conceptual models that can be used by different stakeholders (sponsor/user, project manager, subject-matter experts, V&V agents, developers, etc.);
- Foster the establishment of the guidance document as a SISO standard;
- Provide identification of the relevant stakeholders of conceptual models and considering whether a prioritization is needed;
- Address the needs of M&S community, identifying the way conceptual models may contribute to M&S development, and providing guidance to implementation; and
- Provide guidelines for standards in conceptual modeling for M&S; thereby specifying a conceptual model to be (re)usable by users with similar knowledge and to be accepted by the computer science community.

O.2 SCOPE AND LIMITATIONS

The scope of this guidance is nominally for NATO military M&S. However, the approach taken herein is to provide comprehensive guidance that can easily be adapted and tailored to individual enterprises. It can be generalized to apply to alternative domains. NATO and national defence establishment M&S communities-of-practice are *de facto* enterprises in this spirit when the investment, development, maintenance, and use of M&S assets are concerned. While the application of this guidance is intended to be broad, its scope is targeted to the CM development process, and only provides limited best-practices pertaining to the rest of the CM life cycle.

O.3 SPECIAL ISSUES (PROCEDURES)

Five topics were identified as critical to the TR-MSG-058 Task Group's efforts that required special attention to achieve an appropriate outcome to the Groups work-product. Those issues included:

1) Sensitivity to stakeholder analysis and context;
2) Precise specification of study scope and definition of terms;
3) Explication of relationships of conceptual modeling practice and products to existing standards;
4) Specification of conceptual model management process; and
5) Specification of resulting conceptual model documentary artifacts.

O.4 SIGNIFICANT CONSIDERATIONS, ANALYSIS/RESULTS

Two particular considerations assumed special prominence during the effort of the Group's deliberations. In each case the Group made every effort to appreciate the underlying nature and logical entailments of these considerations and to produce analyses and work-product results that were reasonably commensurate both the implications of these considerations and the need for practitioners to deal with those implications in straight-forward pragmatic ways.

The first consideration is the fact of 'ontological relativism' whereby every abstraction of a referent domain by way of conceptualization has inherent systematic biases that depend strongly on the perceptual frame of the modeler and that may so particularize a consequent conceptual model that alternative models, while drawn from the same reality, are not in fact 'complementary' or semantically consistent. Conceptual modeling process and conceptual model product artifacts recommended by the Study Group were particularly conceived and phrased so as to make this risk to re-use and interoperability of conceptual models and consequent simulations apparent and to provide such guidance as could be made prescriptive whereby this risk might be ameliorated.

The second consideration of import addressed by the Group was the question of whether simulation conceptual models should be in some significant way simulation-implementation independent. By designating fully simulation independent abstractions of the referent world as 'conceptual system-reference-models' rather than conceptual simulation-models, the Group proceeded to include both the objective system-space and the simulation-space in its scope. Consequently, the decisions that are recommended to be made during the conceptual model design inevitably will be informed by the underlying need for a simulation capability or an enterprise interest. The value of this guidance to enterprises is the provision of a broad and flexible process with defined products which can be mapped against current approaches and future plans. Common terminology can also be derived from this guidance to enable better communication of concepts between enterprises.

O.5 DECISIONS AND RECOMMENDATIONS, MILITARY/NATO SIGNIFICANCE OF THE STUDY

- NATO Nations should adopt this guidance as best-practice for their national and international M&S efforts to enable interoperability and reuse.
- The M&S community should incorporate CM development into their M&S development processes, based on the best-practice provided in this guidance.
- Each enterprise should specify its own conceptual modeling process and CM products, using this guidance as a point of reference.
- VV&A of CMs should be integral to the development process. Use of the ISO/IEC 9126 standard on software quality is a starting point for the derivation of CM quality criteria, and use of the (draft) GM-V&V standard is applicable to V&V of CMs.
- Every customization of the guidance should be published to contribute to the body of knowledge of conceptual modeling, to build a valuable experience base for standardization initiatives.
- The M&S community and the Simulation Interoperability Standards Organization, should use this best-practice guidance as a basis to initiate an international standard for CM development.

Chapter 1 – BACKGROUND OF MSG-058 EFFORT

Conceptual models are key to the transformation of user needs and requirements to modeling and simulation (M&S) design, implementation and use. Conceptual models form the bridges of understanding between the users of M&S, the military domain experts that have the necessary knowledge that must be represented in M&S, and the software and simulation engineers that implement simulations. Neither a standard practice for conceptual model development nor consensus definition of conceptual model content currently exists. Where conceptual modeling is practiced, it is typically defined on a project-to-project basis. A recommended best-practice including specification of the content of conceptual models for M&S will increase user understanding of the capabilities of those M&S, thus increasing their reusability and interoperability.

The North Atlantic Treaty Organisation (NATO) Modeling and Simulation Group (NMSG) was established within the Research and Technology Organisation (RTO) in 1999, with an objective to favour re-use and interoperability of M&S within the Alliance, and NATO/PfP Nations. So far, within NATO, as within the international M&S community, the interoperability objective has been mainly addressed at the “technical level” using open standards developed by the Simulation Interoperability Standards Organization (SISO), Institute of Electrical and Electronics Engineers (IEEE) or International Organization for Standards (ISO), such as the High Level Architecture (HLA) that was adopted by NATO as early as 1998. Those standards have provided a first step to interoperability and a state-of-the-art way to interconnect simulations and tools to build distributed systems of simulations; but it is recognized that existing standards are neither intended nor sufficient for specification and controlled exchange of semantics and concepts.

Since the beginning of the NMSG activity, it was recognized that HLA was only a preliminary step to satisfy the M&S technical interoperability concern and that the final objective was still to achieve a more ambitious M&S “interoperability level”. This final objective should be to achieve a common understanding and use of information exchanged between simulations for better satisfying military requirements for education, training and operational support. Without conceptual models, history has shown that simulation developers often do not sufficiently understand the military domain to be modelled, implement M&S that do not reflect the intended reality, and thus do not satisfy the user’s needs. Further, conceptual models form the basis of an important step in Verification and Validation – determining that the application domain has been described sufficiently to meet users’ needs while accurately incorporating Subject-Matter Expert (SME) knowledge.

SISO recognized the importance of better defining and advising the M&S community on the importance of conceptual models not only for the interoperability issue but also to form a basis for simulation development, foster re-use, and to support Verification and Validation (V&V) activities. A SISO Task Group was created in 2003 to address the topic of conceptual models with the potential objective of developing a new standard, or more precisely a “guide”, to help practitioners building conceptual models. While this SISO Task Group did not proceed to the publication of such a guide, it nevertheless produced interesting and valuable output that can be exploited to produce a recommended practice guide for the elaboration of conceptual models.

Chapter 2 – OBJECTIVE OF MSG-058 EFFORT

In April 2008, then, the NMSG originated a Task Group (MSG-058) to develop a guidance document on conceptual models, which can be used in the future by NATO to support its M&S requirements. The major objectives of this Task Group, according to its Technical Advisory Panel (TAP) Terms Of Reference (TOR) charter of June 2007, enclosed as Annex A and B respectively are:

1) Clarify the "Conceptual Model" concepts, discuss the terminology, and emphasize the utility to better formalize conceptual models, understand the relationship between conceptual modeling and related concepts (scenario definition, etc.);
2) Investigate methodologies, simulation and software engineering processes, initiatives and technologies useful for the establishment and content of conceptual models;
3) Draft a guidance document on conceptual models that can be used by different stakeholders (sponsor/ user, project manager, subject-matter experts, V&V agents, developers, etc.);
4) Foster the establishment of the guidance document as a SISO standard;
5) Identify the relevant stakeholders of conceptual models and considering whether a prioritization is needed;
6) Address the needs of M&S community, identifying the way conceptual models may contribute to M&S development, and providing guidance to implementation; and
7) Provide guidelines for standards in conceptual modeling for M&S; thereby specifying a conceptual model to be (re)usable by users with similar knowledge and to be accepted by the computer science community.

The Task Group's first objective was to clarify what a conceptual model for M&S is and what it represents. A common understanding from the outset of the effort was that a conceptual model should serve as a frame of reference for simulation development by documenting important entities/concepts, their properties, and their key actions and interactions. That is, a conceptual model should bridge between the requirements and simulation design. The use of simulation in military applications such as training and decision support requires that the simulations are fit for use. V&V can be applied to evaluate if this fitness for use is achieved. The quality of the end-product (i.e., the simulator) is, however, largely dependent on the quality of the intermediate products. To be more specific, a large portion of the problems with the end-product come from a poor understanding of the customer's situation which leads to a low quality of the requirements. Explicitly building a conceptual model is one of the ways to improve the quality of the end-product by allowing for a good starting point for its development. In order for the conceptual model to be able to really improve the quality of the consequent simulation, the quality of the conceptual model itself must be sufficiently high. Building the conceptual model is *the* step in simulation development in which the actual modeling takes place. Therefore validation (determining whether the abstractions taken during the modeling are allowed) of the conceptual model against the stakeholders' purpose is important for the simulation's fitness for purpose. From a project management point of view, the conceptual model is the last step in simulation development where correcting errors, such as having erroneously left out important parts that should be represented in the end-product, is still relatively easy, quick and cheap. If design and implementation starts, correcting mistakes quickly becomes much more costly. Therefore V&V of the conceptual model is an important form of risk mitigation.

Therefore, the Task Group endeavoured to clarify and rigorously define the core terminology associated with conceptual models and conceptual modeling, and the relationship among those terms. Among the issues the Task

Group addressed was clarification of key concepts in respect to which are framed the needs each of these stakeholders in a conceptual model and the level of abstraction at which conceptual models should be expressed to meet various stakeholders' needs. Conceptual Models are one of the key concepts in the development and employment lifecycle of M&S. As such it is related to other concepts such as scenario development, simulation software requirements development, and test plan development. As part of the first objective, the Task Group defined the relationships among conceptual models and these other activities.

The second objective of this Task Group was to investigate methodologies, simulation engineering and software engineering processes, initiatives and technologies useful for the establishment and content of conceptual models. While the objective of this Task Group was not to develop or identify a single standard for the representation of conceptual model content, this Task Group did identify a range of such solutions that can be employed in conceptual models. In order to take advantage of the work covered by others regarding to this issue, it was very important to collect and analyze as much as possible of the documentation available on conceptual models – especially those related to the M&S field. Lesson learnt by them helped to avoid some recurrent problems, to reduce the risk of developing simulation not adapted to the requirements and to get the greatest benefit from the effort of this Task Group. The Task Group explored the potential of a variety of processes and knowledge representation approaches to examine their potential for conceptual modeling. Through this objective, the Task Group synthesized existing practices to identify the state-of-the-art of conceptual modeling. By doing this, the Task Group maximized the reuse of previous effort in the development of a recommended practice.

The third objective of the effort was to provide a tailorable set of guidance to the M&S community on conceptual modeling processes and products. This will guide users through the conceptual modeling effort by explaining how to apply it in practice. The process will be tailorable in that it is intended to be extended and modified by individual programs that apply it. Rather than being a one-size-fits-all rigid, single approach to conceptual modeling, the guidance will provide a starting point that individual programs can apply given their specific needs and resources. The guidance on the conceptual model content will state what should be in the conceptual model, and not mandate a specific format but suggestions for the selection and use of format, methodology, techniques and tools will be provided. The guidance will encompass the conceptual model process, conceptual model content and describe appropriate views on a conceptual model for different stakeholders. For example, the conceptual model process will describe the transformation from the users view, concerned with the problem domain, to the developers view, focused on the M&S domain.

The Task Group's fourth objective was to foster the establishment of the guidance document as a SISO standard. The current policy of NATO for standardization is to use civil standards where appropriate ones exist and to develop its own standards only when no civil standard exists. In the case of conceptual models for M&S or conceptual models in general, no civil standard exists. The requirement for M&S conceptual model is not specific to NATO or to the military domain. Thus it should be helpful to extend this work to a larger M&S community. With respect to this proposal, the Task Group broadened its guidance document to comprehend in its work-product the scope of an M&S standard product, developed through an open consensus-based standards body. The SISO is the best-suited organization for this standardization, since it has a strong background and current focus on military M&S, but also includes M&S practitioners from outside the military domain. Finally, the Task Group collaborated with SISO's Standing Task Group on Conceptual Modeling throughout the period of performance of the effort in order to facilitate to the greatest extent possible the acceptance of the Task Group's work-product as the basis of a successor SISO/IEEE standard.

In addressing the fifth objective, the Task Group identified the key stakeholders in conceptual modeling and their requirements with respect to conceptual models. Stakeholders will include those that are involved in the production of conceptual models and those that rely on conceptual models to perform their jobs.

In response to the sixth objective, the Task Group realized that the value of its eventual work product would be dependent upon the degree to which it provided value to practicing modeling and simulation professionals and to the stakeholders involved in the M&S enterprise wherein it is employed; the Group was anxious to appreciate and to make evident in, auditably traceable form, its perception of the wants and needs of the conceptual modeling stakeholder community, and the specific attributes desired of its effort and of the resulting work-product pursuant to that effort. To this effect, desiderata were compiled from a variety of sources relating to each of the following categories:

- Compliance – Degree of conformance of work-process and work-product to explicit and implicit guidance.
- Completeness – Degree of exhaustion of effort and resulting product with respect to the fundamental need to support enterprise conceptual modeling of military models and simulations.
- Correctness – Degree of appropriateness of operational process and conceptual modeling guidance documentation in subject enterprise environment … roughly the degree to which employment of the published best-practice specification is likely to result in satisfactory conceptual modeling practices and conceptual model artefacts, given requisite completeness.
- Consistency – Degree to which the efforts of the Task Group and its resulting work-product are mutually coherent and based on common precepts and assumptions.
- Utility – Degree to which the employment of the Task Group work-product is useful to stakeholders in generating, using and maintaining conceptual models in the NATO enterprise environment.

In response to the seventh objective, the Task Groups have to ensure that specific requirements (e.g., attributes of the Task Groups operating process and/or resulting product) were derived from task guidance, self-generated concept of operations of the Task Group, and the consensus of product structure, and content agreed upon by the Task Group during its deliberations. These requirements are documented in Annex C. The requirements serve both to:

- Indicate the sensitivities of the Task Group in executing its responsibilities and to provide persistent strategic and tactical guidance for execution of the Task Group effort; and
- Serve both the Task Group itself and the recipients of the Task Group’s work-product, by providing the means for evaluation of the work-product as against necessary and sufficient criteria.

Chapter 3 – MSG-058 PROGRAM OF WORK

The effort described in this chapter constitutes the program of work executed by the Task Group MSG-058, which resulted in the generation of the Study work-product, i.e., recommended best-practice guidance for conceptual modeling for military models and simulations and for the structure and content of the resulting conceptual model documentary artefact.

3.1 INTRODUCTION

Significant diverse and intensive technical effort was required to meet the Task Group objective. Understanding conceptual models for military simulations requires employment of a variety of precepts, technical concepts, and existing circumstances. Generating best-practice guidance for executing conceptual modeling requires appreciation of a wide variety of academic and practical techniques for ontology creation and conceptual model specification. Finally, the creation of useful best-practice guidance requires appreciation of existing M&S management practice, and the standards and techniques associated with specification of both process and product in expected enterprise operational environments.

Elucidation of the effort conducted by the group in executing the subject study illustrates clearly the diverse technical basis for the resulting study conclusions and recommendations. Description of the activities of the Task Group, indication of their necessity or motivational rationale, and description of their intended consequences in accomplishment of the study objective, is intended to provide detailed context for interpretation and appreciation of the study results and recommendations. The effort actually executed by MSG-058 is described explicitly herein for two purposes. First, such a description is intended to demonstrate the practical means whereby the Group met the conditions set forth in the Study TAP and TOR introduced above. Comparison of the account that follows and the prescriptive guidance from reference guidance document illustrates that the ‘way of work’ is in fact compliant with guidance, complete with respect to scope of the guidance, and consistent both internally and with the intentions of the guidance itself. Secondly, the following description of the programme of work actually executed by the Group should provide implicit evidence to the reader of this report and the agent striving to follow the best-practices guidance recommended herein regarding both the quality of the effort and consequent work-product, and the significance and relevance of the subject best-practice guidance proffered below to the reader/user’s needs and interests.

The approach adopted by the Group in addressing all these foundational matters was to first identify particular topics that seemed to entail issues of significance or particular difficulty; to address each of these topics specifically; and to derive there-from concrete elements of the solution of the study problem to be manifest in study conclusions and recommendations. In all cases, the Task Group was careful to consider:

- The diversity in the existing practices and technical postures;
- Commonality in practice or in dealing with potential issues; or
- Innovative approaches considered to be auspicious but not in fact part of the experience of any of the organizations and enterprises of the respective Group members.

3.2 GENERAL DISCUSSION OF EFFORT ELEMENTS

By way of context, comments relating to scope of activity and Concept of Operations (CONOPS) of the Group’s effort, and associated transaction protocols as well as to relationships among components of the Group’s effort are introduced first.

The effort of the MSG-058 consisted of a series of working meetings augmented with the execution of actions identified therein in the intervals between formal working meetings. The effort of each meeting was decided in advance and published as a meeting agenda. Naturally, the differential interests of the Group members and national participation suggested that one or another Group member might lead deliberation for topic areas of special interest or competency; nevertheless, all deliberations were conducted by the committee-of-the-whole, operating as a peer-group, wherein all significant decisions were made as matters of consensus across the entire Group. Group efforts were coordinated by means of collaboration workspace information technology resources, wherein, all records of meetings, decisions, actions, and collateral information, were conscientiously recorded and will be made available for inspection by interested parties in future or related efforts. The use of the collaboration environment was particularly valuable in supporting the compilation of the Group's work-product – whose components' authorship responsibilities were allocated to Group members based on interest and familiarity.

The schedule of Group meetings is indicated in the following figure. That illustration indicates the tactic adopted by the Group to have meetings as frequently as possible, particularly early in the program when disparate practices and complex concepts requiring face-to-face interaction for adequate resolution were at issue.

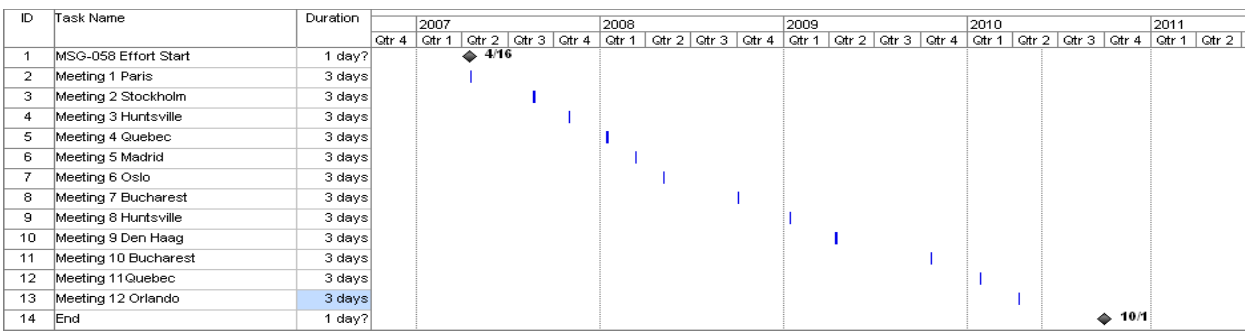

Figure 3-1: Calendar Relationship of Meeting Activities Across Which Effort was Distributed.

A rough indication of the logical and activity-flow relationships among the Group's activities regarding topics of special import is provided in the figure following. These logical relationships and the nature of particular activities are discussed in considerable detail below.

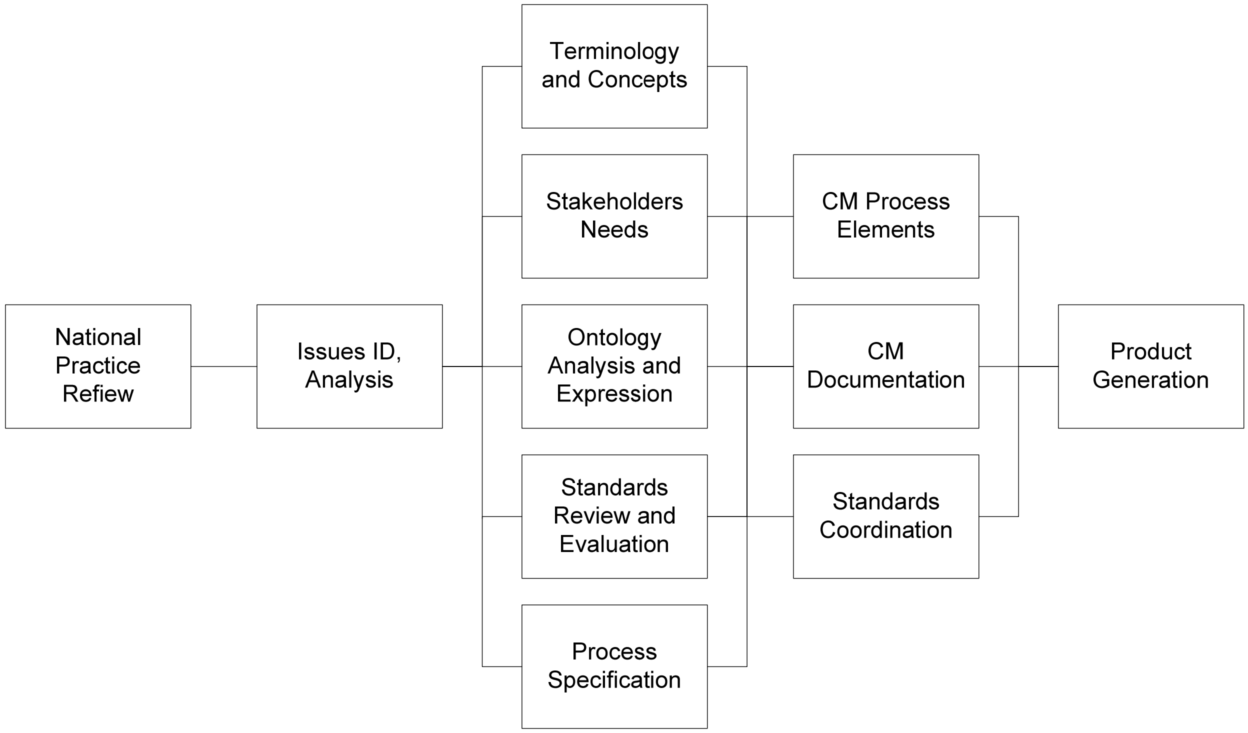

Figure 3-2: Logical and Activity Flow Relationships Among Principal Efforts Comprising the MSG-058 Effort.

Finally, the effort of the Group and its respective domains of interest and resulting meta-products is to be understood in context of the diagram of Figure 3-3 below. There, the Group executes the MSG-058 program by way of Business Process Invention. The Group product document specifies conceptual model process to be conducted by practitioner during Business Process Practice, yielding the conceptual model artefact for the specific mission space and model-simulation intended.

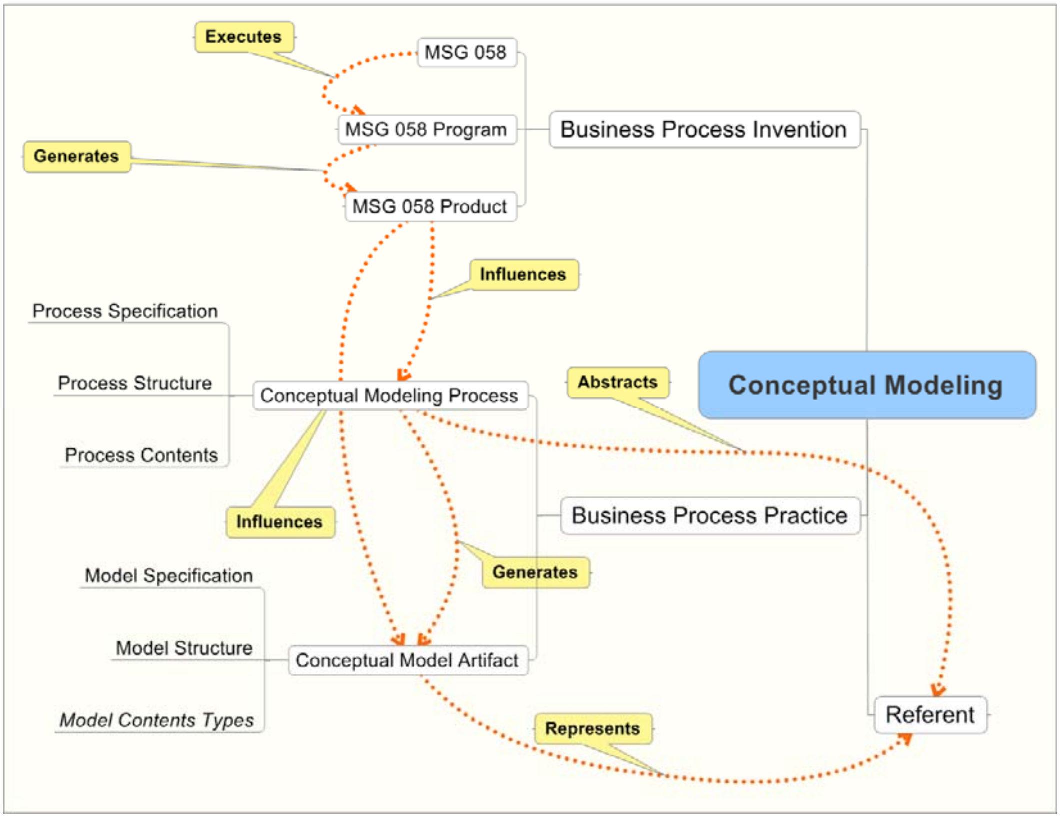

Figure 3-3: Mind-Map Style Illustration of the Scope-of-Effort and Domain-of-Interest of the MSG-058 Task Group.

Specific topic areas of effort undertaken by the Task Group included the following:

- National Conceptual Modeling Practice Expository Briefings.
- Issue Identification and Analysis.
- Stakeholders and Study Scope and Objective.
- Terminology and Concepts.
- Analytical Framework and Ontological Perspective.
- Standards Review and Evaluation.
- Process, Product and their Relationships.
- Process Specification Expression.
- Conceptual Model Process Elements.
- Conceptual Model Documentation.
- Task Group Work-Product Generation.
- Coordination with SISO for Generation of Subsequent SISO/IEEE International Best-Practice Standard.

For each topic area identified above, we will address briefly:

- Introduction and background;
- Current circumstance;
- Approach;
- Risks and risk-amelioratives;
- Relationships;
- Findings; and
- Conclusions and recommendations.

3.2.1 National Conceptual Modeling Practice Expository Briefings

Naturally, members of the Group convened to execute MSG-058 effort brought with them both their personal and their national Institutional preconceptions and practices relevant to conceptual modeling. Therefore, in order to assay the range of interests, competencies, and richness of perception and experience, the systematic review of existing conceptual models practice was considered prudent. Therefore, Task Group member's national representatives briefed in turn their respective practices for conceptual modeling, and those sample practices were compiled into the Group's collaborative environment for future reference.

As expected, the range of preconceptions and styles of operations in conceptual modeling practice proved to be exceptionally diverse. Differentials exist among presumptive academic underpinnings, scope assumed to be included in conceptual modeling, techniques for educing and documenting conceptual models and for their use within the various enterprise environments represented. This diversity, while challenging, was considered by the Group as opportunistic by virtue of its providing a constructively broad scope to the Group's deliberations and establishing a suitably broad basis of implicit requirements for any best-practice work-product developed and recommended by the Group. Consequently, potential risk in task scoping and ecumenical consideration of established preferred practices were considered to be assuaged.

Review of existing practices familiar to the Group proved a profitable initial transaction. It did in fact serve as a suitable basis for framing the work process for the remainder of the program, and particularly reinforced the sense that a consensus-based effort was prudent.

3.2.2 Issue Identification and Analysis

Pursuant the revelation of Task Group members' respective conceptual modeling practices; it was observed that a variety of topics might reasonably be specially designated 'issues' – that is, topics whose deep appreciation and consensus resolution by the Group members would likely be necessary to the successful completing of the MSG-058 effort.

The Group's approach to issue-identification and resolution is described in detail in Annex D. Significantly, however, a deliberate effort was made to identify issues related to each of four perspectives:

1) General and administrative conduct of the Task Group tasking;
2) Constraints associated with the program of work defined in the tasking guidance;
3) Technological considerations arising out of the subject matter entailed in conceptual modelling; and

4) Considerations related to the generation of work-products necessary and sufficient to accomplish the mission of MSG-058.

In each case, actions necessary to resolve such issues, and the identification of the entailments of such resolution to technology, product, program, and meta-process for the Task Group's effort, were identified.

This approach revealed what proved to be nineteen (19) issues deemed worthy of attention in four (4) categories:

1) Circumstance and Analytical Context;
2) Intention;
3) Product Development and Deployment; and
4) Technical Considerations.

Of the total set of issues explicitly identified, five (5) topics were accorded such criticality that special work efforts were conceived and executed for their resolution and the remediation of such risks as were considered to be related thereto. In priority order, these issues were:

- Stakeholder Analysis and Context;
- Scope and Definition;
- Relationship to Standards;
- Specification of Conceptual Model Management Process; and
- Specification of Conceptual Model Artefact.

Each is addressed in the text of this report at a level of indenture no higher than two (i.e., n.m.).

Naturally, early issue identification had profound implications for the establishment of a detailed program of effort by the Group. The Task Group's approach to concern for identification and resolution of critical issues had far-reaching implications for the subsequent effort, and the work-product of which this report and its enclosed best-practice recommendations consist.

3.2.3 Stakeholders and Study Scope and Objective

In the course of the Task Group's deliberations, it became apparent that conceptual modeling must be practiced in context of modeling a simulation enterprise–scope activity. Further, it was clear that the nature of conceptual modeling shared many of the practices related to 'user-needs', and 'requirements' management practices typical of systems engineering disciplines. For both these reasons, the need to be explicit regarding the identification of stakeholder roles, their associated processes, and responsibilities was evident. At the least, the Group's expression of conceptual models best-practice would need to 'speak to' significant stakeholder communities – for which purpose, the Group needed to be appropriately sensitive to those roles.

Consequently, the MSG-058 Task Group devoted considerate attention to identifying and characterizing stakeholder roles, and to including in our analysis such use-cases as seemed prudent both to understand the implications of necessary diversity of stakeholder populations in M&S enterprise environments and to communicate successfully to all parties those entailments.

The results of this analysis are addressed more fully in Section 4.3 Conceptual Modeling Enterprise Stakeholders, below; and further explication is therefore deferred, except to emphasize the degree to which stakeholder analysis and respect for stakeholder diversity and peculiarity are necessary conditions for understanding, let alone employing the best-practice guidance contained herein.

Regarding the study scope and objective, analysis effort addressed primarily the class of conceptual model being considered, and the analytical disciplines considered necessary and sufficient for subject models to be managed over their life cycle.

Conceptual models for simulations relating to military mission space domains were, according to the tasking guidance, the relevant scope. In fact, however, considering the breadth of the adjective ‘military’ in its own referential scope (covering most of the mission space elements considered typical of non-military mission-spaces and certainly passing well beyond simple war-fighting operations to encompass logistics, materiel management, personnel health and safety, operational security, communications, etc.), and considering how generic most of the ideas associated with conceptual models in general and the pragmatic conceptual models guidance eventually derived; the scope of applicability of the Group’s work-product is scarcely proscribed by its ‘military’ appellation.

Likewise, given the interest of conceptual model management (development, documentation, storage, retrieval, re-use, sharing, etc.), during the conceptual modeling life-cycle, together with the not incidental relationships of systems engineering (applied here to simulation systems) and enterprise-context operations across considerable institutional scope (e.g., national and NATO international); very little constraint accrued to the processes recommended, particularly with respect to requirements management and stakeholder sensitivity.

3.2.4 Terminology and Concepts

In many scientific domains, terminology is critical, see Annex I. Practitioners’ shared appreciation of the state of evolution of the field of endeavour, and their fundamental capacity to communicate, collaborate and cooperate depend upon the existence of a well-established vernacular that is shared by the community-of-practice.

Often, such terminology is available through the efforts of past researchers – especially when the discipline is mature (or simple), taught systematically, and appreciated widely across the community. Conceptual modeling is not such a discipline. While its roots in the ‘first-philosophies’ of epistemology and ontology are deep, its explicit practice in modeling and simulation is relatively new. Conceptual modeling terminology is further confounded by the overloading or multiple meanings of such keywords such as: ‘entity’, ‘model’, ‘concept’, ‘relationship’, ‘attribute’, ‘predicate’, etc. Further, the presumption of one or another conceptual technique, schema or notation leads promptly to terminological ambiguity. Finally, in an international working group doing business in English, some challenges to terminological consistency are to be expected.

The approach of the MSG-058 was, from the start, to be scrupulously precise in vocabulary usage, and to record such determinations as seem best in a lexicon that has evolved over the course of the program and that is published as Annex J to the present volume. The structure of that annex is, in fact rather a glossary than a formal definitional lexicon, in which alternative definitions, interpretation, commentary and usages are cited in hopes of communicating not only the sense of terms as used in the report text, but also to communicate to the reader the range of nuance which lexical vocabulary may, under one circumstance or another assume. In doing so, the Task Group hopes both to communicate precisely its own effort, determinations and findings, but also to share with the reader the degree to which nuance and potential ambiguity persist in a subject only lately approaching the maturity which modeling and simulation practitioners desire and deserve.

This explicit convergence on vocabulary usage, combined with the consensus-based protocols characteristic of all the collaborative effort of the Group has resulted in acceptable vocabulary consistency at least within the context of the study. Given that the intention of NATO is to have the present work continued in context of international standards-development bodies, however, concern for lexical precision cannot be ignored. The reader is particularly referred to the Glossary, Annex J, for citations and explication of vocabulary used in the body of this report.

Continued aggressive pursuit of vocabulary and subject-matter semantic consistency in conceptual models best-practice guidance is strongly recommended.

3.2.5 Analytical Framework and Ontological Perspective

Conceptual modeling entails the abstraction of some 'referent' domain' resulting in a description of that domain suitable for managing its 'representation' by artificial means such as by a model or simulation. Pursuing the MSG-058 TAP TOR entails assuming one or another 'analytical frame' from which to address consideration of this process and generation of prescriptive guidance to practitioners. This analytical frame is in effect one or another way of looking at the world. Alternatives of such frames include for instance: ontology, systems engineering, software engineering, and knowledge management; together with a wide variety of tools and techniques for pursuing explication of each frame, such as model driven architecture, Knowledge Acquisition / Knowledge Engineering (KA/KE) assets, systems engineering tools, etc.

The Task Group debated the question of an appropriate analytical frame or prospective from which to proceed, investigating closely a wide variety of options such as was manifest in the knowledge and practices of the member national participants and active individual members. Finally, the Task Group elected an ontology-based perspective, and proceeded to create a systematic process that reflected this foundational perspective, while drawing from multi-disciplinary perspectives to make the best-practice guidance familiar and pragmatically practical to the target practitioner and associated stakeholders.

In short, 'ontology' asks the rhetorical question: What is there? In the present context, more specific formulations might be: What do we care about, or alternatively:

- What is it necessary to represent in a model or simulation in order for the resulting product to serve its intended use; and
- What is necessary to prescribe about the simulation artefact itself for it to be likewise useful? Given this knowledge, the next question that must be addressed is: How can one select, and document the contents of such representations?

Two complimentary risks are associated with the Group's addressing selection of analytical frame. On the one hand, failing to establish an intellectually secure frame leaves the establishment of a conceptual model a proverbial foundation of sand. On the other hand, making the proceedings and consequent product of the Group too explicitly bound to potentially abstruse academic precepts, constructs, and inferences risks alienating potential practitioners. The risk management tactic adopted by the Group was to dig deep and build on firm foundations, and to report those deliberations; but to efface such considerations from the pragmatic process guidance provided in the 'best-practice' prescriptive guidance in the document's Annexes G and H.

To this effect, the subject is explicitly treated separately in Annex E – Explanation of Fundamental Concepts for Conceptual Model Frame-of-Reference. In addition, copious references are provided in Annex K – Bibliography, that document the fundamental ontological perspective upon which many of the Task Group's deliberations were fundamentally based. Nevertheless, this analysis and exposition and the academic-intellectual underpinnings it deploys can be skipped for the sake of convenience or for lack of explicit interest by the reader without detracting from either the comprehensibility or the utility of the concrete best-practice guidance contained herein.

3.2.6 Standards Review and Evaluation

The present document – particularly its operationally concrete and procedurally prescriptive guidance contained in Annex G – Conceptual Modeling Process Activity Description and Annex H – Conceptual Model Product Description – is itself a 'soft' standard, of type usually denoted 'best-practice'. On the other hand, the analysis entailed in deriving such practice and the expression of the practice itself entails consideration of standards of a wide variety of types.

A significant effort by the MSG-058 Task Group was to review standards perceived as potentially relevant to the subject analysis and prescriptive guidance; to analyze the special significance of such candidate standards; and to invoke such standards (individually, by reference, or more often by class) in either the analysis reported herein or the procedural guidance appended.

The strategic approach of the Group was to leverage existing standards instances and standards types to the greatest extent possible in order to reduce redundancy and invoke guidance re-use wherever possible. At the same time, however, we have been scrupulous to avoid recommending specific standards when a class of standards could be cited and the choice of a particular standard left to the discretion of the practitioner.

The subject of standards is detailed in Annex F – Standards, but should be interpreted throughout as an exercise in coaching of the practitioner toward more systematic professional and productive practice commensurate with the mores of his own enterprise environment.

3.2.7 Process, Product and their Relationships

Within this document, there are two primary processes described, to be executed by one or another of two agencies, and resulting in one or another of two significant work-products. In this section, we identify briefly these processes, agents, and work-products and indicate their relationships before proceeding with more detailed descriptions in following text sections. In order to establish a perceptual frame of the set of agents, activities, and products that comprise the development of this document and its included best-practice guidance as well as the execution of that guidance and the generation of consequent conceptual models, the reader is referred to the following Figure 3-4.

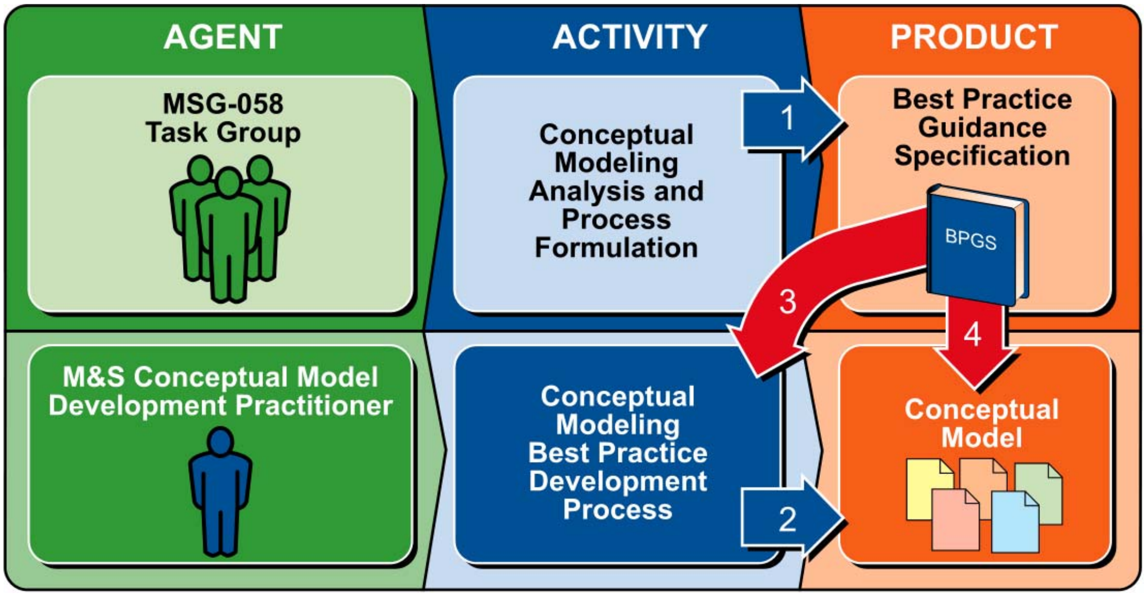

Figure 3-4: Relationships Among Agents, Processes, and Products Associated with Subject MSG-058 Effort and its Consequential Conceptual Modeling Practice.

As indicated in the diagram, the MSG-058 Task Group itself performed the activity of analyzing conceptual modeling and formulating requisite best-practice guidance. The persistent information product resulting from that activity is the best-practice guidance specification contained within this document in Chapters 5 and 6 and in the Annexes G and H. The causal relationship between this activity and its consequent resulting work-product is indicated by the blue arrow numbered 1. Subsequently, the M&S conceptual modeling development practitioner is expected to execute the prescriptive best-practice to produce the conceptual model itself. This productive result is indicated by the blue arrow number 2. Finally, the activity conducted by conceptual modeling practitioners and the work-product produced thereby are shown to be affected by the best-practice guidance specification through influence designated by red arrows 3 and 4 respectively. With this activity and influence relationships in mind, comments follow relating to process and product specification generated by the Task Group.

3.2.8 Process Specification Expression

The MSG-058 Task Group explicitly addressed consideration of the most appropriate form of specification of its guidance to conceptual model stakeholders. Process specification itself admits to a wide variety of schemas, notations, and seminal notions. Since the Group could not provide multiple alternative specifications, and chose not to endorse a single specific notational or conceptual frame for process specification, we resorted to what was held to be a generic or vanilla specification schema – without, however, falling prey to least-common-denominator information content. The meta-process specification schema employed (employed as partial graphic illustrations in the text of Chapters 5 and 6 and defined in detail in association with the Annex G wherein it is employed to communicate the recommended conceptual modeling processes) is considered to be sufficient, complete, consistent, and formally equivalent to most commonly employed process specification schemas and notations, and implementing Commercial-Off-The-Shelf (COTS) tools.

Naturally, the practitioner is encouraged to use schemas, tools, and techniques to specify the objective system processes such as constitute the content of the actual conceptual model as are deemed appropriate to the enterprise context in which execution of conceptual modeling is to be conducted. In that way, considerations such as machine readability, COTS tools availability, and compliance with enterprise process specification standards are well within the discretion of the practitioner-agent for the benefits intended thereby.

3.2.9 Conceptual Model Process Elements

Moving from consideration of meta-process specification practiced in formulating the best-practice instructions proffered below, to the actual prescription of elements of process models considered necessary and sufficient to contain and communicate model and simulation object and process semantic content; the Task Group again, resorted to the use of nominative or generic conceptual primitives that were considered equivalently powerful as specific conventional notations and styles of object and process specification. Supporting on the one hand, object qualia such as: class membership, generalization and specialization, inheritance of attributes, membership and client server associations, etc., and on the other hand, process constructs as sequence and concurrency, causal effect, temporal synchronization, process composition and encapsulation, etc.; the notation used in the subject best-practice specification is considered likewise sufficiently general to serve all needs, and sufficiently suggestive and non-binding to be able to be implemented by the use of such specific process primitives as are to be found in typical practices and tools.

Once again, the practitioner’s discretion to use such constructs and notations as are commensurate with technical, programmatic, and enterprise constraints is protected, while the sufficiency of actual conceptual models to contain necessary and sufficient information is guaranteed.

3.2.10 Conceptual Model Documentation

Consideration of the conceptual model documentation, as discriminated from both the conceptual model generation and its specific information content generated for one or another application, was a matter of particular concern to the Group. That documentation activity is yet another meta-process – that is, one of the operations by the conceptual model management practitioner whereby the conceptual model, having been abstracted from appreciation of the subject mission- and simulation-space, is made manifest in persistent, communicable, achievable, and recoverable form, that can serve as well as a reference information artefact from which model or simulation implementation may proceed and subsequently be verified. Documentation artefacts resulting from practitioners’ efforts were considered to be appropriately subject to best-practice guidance; and providing instruction to practitioners on recommended structural form and general semantic content of such artefacts was felt to be a significant component of best-practice guidance.

In order to influence conceptual model artefacts generated pursuant to election and execution of best-practice guidance by conceptual modeling stakeholders, the Task Group elected to provide to the conceptual modeling practitioner dual forms of guidance (i.e., process and product) whereby one perspective addressed conceptual model development process and the other addressed the resulting conceptual model product document artefact. Having addressed conceptual modeling process elements, as described above, and having resolved to provide guidance to practitioners, the Group determined to address the characteristics recommended for the consequent conceptual model ‘Product’ itself, namely the document (or other form of persistent capture of the conceptual model’s semantic content) expected to be generated by the practitioner in accomplishing his objective conceptual modeling effort.

Since a necessary criterion for completion of conceptual model development and use is the generation of a persistent capture of information relevant to the conceptual model development, contents, life-cycle management, and uses, the Task Group resolved to provide necessary and sufficient guidance for the generation of such documentation. Guidance related to conceptual model product artefacts is 'dual' to process guidance addressed above; and the result of the pursuit of this approach is Chapter 5 and Annex G of this report. In effect, the Task Group determined that if the conceptual modeling practitioner executed the Process Guidance of Chapter 5 in this report; then there would result a documentary product whose desired characteristics are described in Chapter 6 and Annex H of this report. Product Guidance, therefore, contains specification of expected information-content and expositional-structure of the resulting conceptual model documentation itself.

Throughout the Task Group's deliberations and everywhere in its derived prescriptive guidance, emphasis of data contents over expository structure was assumed. Attention to capture of information necessary and sufficient to support the conceptual modeling facet of M&S enterprise operations of the specific M&S community of practice for which the conceptual model is intended was kept clearly in mind and made manifest to the greatest degree possible in recommended practice guidance processes prescribed below. This commitment was modulated with considerable sensitivity to avoiding too restrictive prescription of documentary practice that local or national standards could not conveniently be employed.

The Task Group concluded that by providing complimentary process and product prescriptive guidance, the prospect of successful completion of conceptual modeling practitioners' efforts and the result of appropriate conceptual model documentation might be assured.

3.2.11 Task Group Work-Product Generation

The Task Group was well aware that the results of the effort were expected to be a documentary report serving the following functions:

- Establishing the context of the subject effort by reciting background circumstances and Task Group objectives;
- Providing a recitation of the effort of the Group sufficient to illustrate how their determinations and findings were arrived at, and establishing the credibility of the group process and consequently the relevance of its effort; and
- Capturing prescriptive guidance for M&S conceptual modeling practitioners regarding the generation and documentation of subject conceptual models commensurate with NATO M&S enterprise wants and needs on the one hand and the need for explicit guidance to practitioners occupied in conceptual model management on the other.

According to the "TERMS OF REFERENCE RTG on Conceptual Modeling for M&S MSG-058, RTG-038:", the Task Group was to "Draft a guidance document on conceptual modeling that can be used by different stakeholders (sponsor/user, project manager, subject-matter experts, V&V agents, developers, etc.)", with the admonition that: "The final work will be to provide a tailorable set of guidance to the M&S community on conceptual modeling" … provided as a "Technical Report"… which final report should be a "guidance document freely available to the international community".

The Group's approach to the generation of this work-product was to execute the following process:

- Establish subject matter suitable for inclusion in the product;
- Agree on the expository outline deemed most clearly to accomplish the functions cited above;

- Negotiate voluntary adoption of writing assignments among the Group members according to personal familiarity with the subject matter in respective documentary outline sections, and equitable distribution of workload among the Group participants;
- Complete storyboard specifications of subject-matter exposition, including attention to elements indicated in the NATO Conceptual Model Storyboard template;
- Review in plenary the storyboards and establish consistent plan of explication;
- Draft respective sections;
- Compile and integrate full documentary report; and
- Conduct review of document by all members of the Task Group and determination of consensus support of final work-product.

While small risk was expected relating to consistency, correctness, and lucidity of explanations of the individual sections (due to conscientious record-keeping by the Task Group via its collaborative environment during effort execution and the personal and professional qualifications and competencies of the authority team), the formal composition process implemented served to ensure consistency and economic documentation of the Group effort and its consequent determinations and findings.

One significant decision was to produce one report work-product; within which the subject-recommended best-practice standard was contained. Consequently, Chapter 4 “Conceptual Modeling Best-Practice Guidance Introduction”, Chapter 5 “Conceptual Modeling Process Guidance”, Chapter 6 “Conceptual Model Product Guidance” and their accompanying Annexes G – “Conceptual Modeling Process Activity Descriptions” and H – “Conceptual Model Product Descriptions” are considered appropriate to serve as stand-alone as prescriptive best-practice guidance and to be proffered to the NATO and SISO communities for excision and publication for the reference of conceptual model management practitioners and related stakeholders.

3.2.12 Coordination with SISO for Generation of Subsequent SISO/IEEE International Best-Practice Standard

At the inception of Task Group activity, collaboration with other international standards organizations was anticipated and made explicit in the TOR tasking. In particular, the intention was to: “Foster the establishment of the [Task Group work-product] guidance document as a SISO standard.”

The desired scope of prospective collaboration was specified as “Liaison” in the Terms of Reference and should be established with the following organizations:

- MSG-054 Task Group on “An Overlay Standard for Verification, Validation, and Accreditation (VV&A) of Federations”.
- MSG-052 Task Group on “Establishment of a Knowledge Network for Federation Architecture and Design”.
- The coming Task Group IST-075/RTG-034 on “Semantic Interoperability” (Continuation of the IST group ET-040 on “Ontology fusion”).
- Simulation Interoperability Standards Organization (SISO).
- Other RTO Task Groups as required.

Means for implementing such collaboration process were left to the discretion of the Task Group and were, in fact pursued to the greatest extent allowed by circumstances, resources, and perceived probability of success of the Task Group's subject tasking. Interface was implemented by means of exchange of briefings publications of papers, and meetings at which information was exchanged on current state of effort and expectations for immanent progress.

As a consequence of this collaboration, it is expected that, as desired: "The final report should be a 'guidance document' freely available to the international community."

3.3 CONCLUSION

Based on the process model and activity of the Task Group described in the preceding sections, the contents of Chapters 4, 5, and 6 were generated, which together with their accompanying annexes, constitute the recommended best-practice guidance for conceptual modeling for Military Models and Simulations.

Chapter 4 – INTRODUCTION TO CONCEPTUAL MODELING: BEST-PRACTICE GUIDANCE

In the previous chapter, we addressed the conduct of MSG-058 and identified significant issues and strategies associated with the accomplishment of the Task Group's effort. In following chapters, we present exposition of best-practice guidance process and product finally developed and recommended to the conceptual modeling practitioner and stakeholder community for employment. In this Chapter 4, we establish the conditional determinations and findings upon which that operational best-practice is predicated. The discussion following addresses contextual issues of scope and enterprise context, and the appreciation of the stakeholder community whose wants, needs and collaborative participation are necessary for successful conceptual modeling. Foundational and pragmatic ideas related to specialized vocabulary, the complementary dyadic conceptions of representation spaces, and best-practice notational conventions are introduced in anticipation of the use of this terminology and these concepts in the formal prescriptive guidance to follow in Chapters 5 and 6. Finally, we comment on quality attributes of conceptual models in order to emphasize the necessity to verify and validate simulation conceptual models in much the same way as simulation artefacts themselves are verified and validated as a fundamental component of conceptual model quality management.

4.1 CONCEPTUAL MODELING OPERATIONAL SCOPE

While the scope of this guidance is nominally for NATO military modeling and simulation, the approach taken herein is to provide comprehensive guidance that can easily be adapted and tailored to individual enterprises and can be generalized to apply to alternative domains. Likewise, this guidance is intended to be general enough to serve as a foundation for subsequent establishment of industry standards for conceptual model development and life-cycle management activities.

Throughout MSG-058 deliberations, the Task Group found it convenient to keep in mind two contextual perspectives of conceptual modeling and conceptual models – both simple – each suggestive of the place of conceptual models and modeling in simulation life-cycle development paradigms. Such pictorial paradigms served to remind the Group at once of the intended scope of deliberation and of consequent best-practice guidance as well as the context of its analysis and work-products.

Consequently, it may be useful to consider a general case of conceptual modeling as shown in Figure 4-1, to illustrate that any conceptual model of interest may be of a particularly simple or complex domain or problem space, which can also benefit from these best-practices.

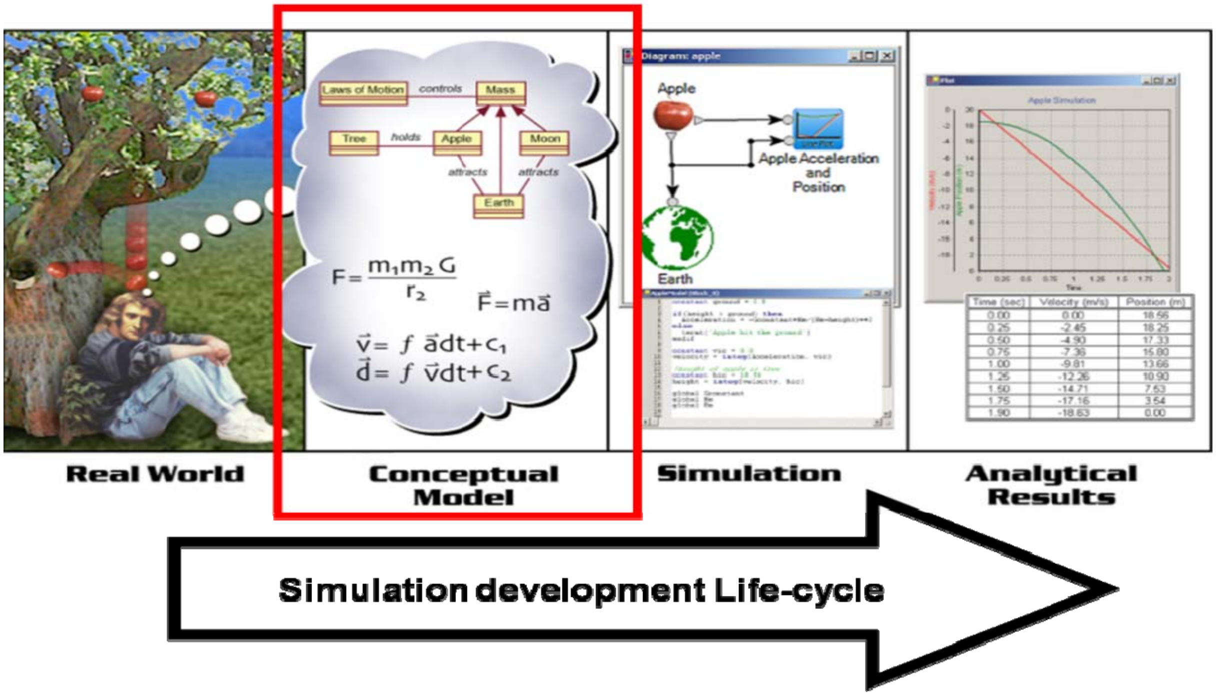

Figure 4-1: Conceptual Model Depicted as Intermediate Artefact Between Real-World or Mission Space Knowledge and Simulation Artefact and as Element in Progressive Simulation Life-Cycle Development Process.

While the application of this guidance is intended to be broad, the scope of this guidance is targeted to the conceptual model development process, and only provides limited best-practices pertaining to the rest of the conceptual model life cycle. And while the development of quality conceptual models enables other life-cycle characteristics such as interoperability and transformation, guidance to execute the additional stages is beyond the scope of this document. Figure 4-2 provides a context for the guidance provided here, as related to the larger conceptual model life cycle.

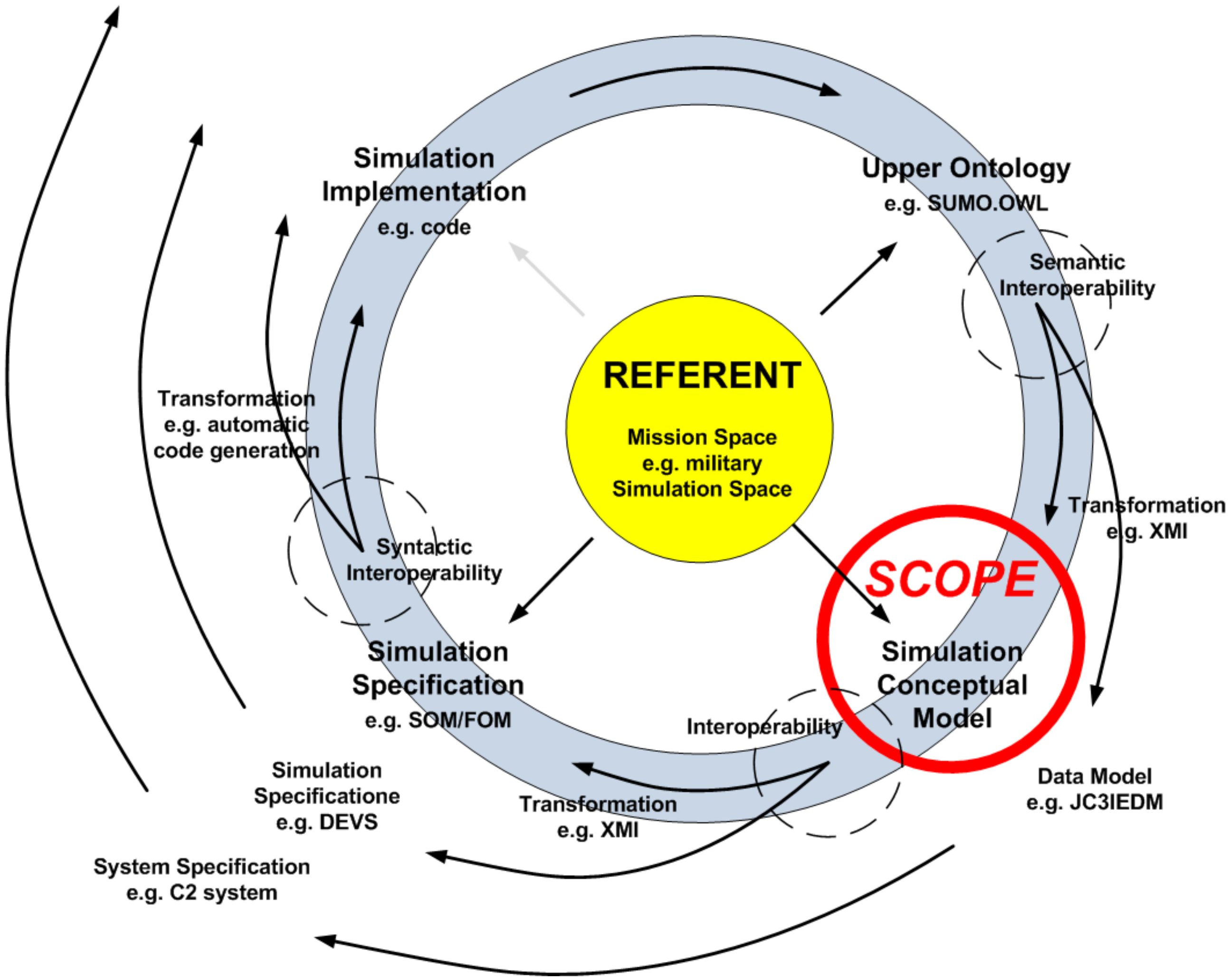

Figure 4-2: The Scope of Best-Practice Guidance in the Conceptual Model Life Cycle.

The approach for explication of this guidance is to discuss the role a conceptual model should have in the M&S development process, propose scope and terms of reference, expand and illustrate new and novel concepts, propose an analytical framework, define a thorough but tailorable process and associated products, and provide Process Activity and product descriptions for reference.

4.2 ENTERPRISE CONTEXT

One particularly significant component of the context of conceptual modeling is the institutional or business practice environment within which the modeling is performed and within which its value is expected to be realized. In the text that follows, we introduce the idea of enterprise context by discussing how modeling and simulation has evolved within the last decades. Next we define ‘enterprise’ and distinguish between ‘local’ operational contexts and enterprise contexts. Several implications that are entailed by enterprise-based conceptual modeling operations, including both:

- The influence of enterprise concepts-of-operations upon conceptual modeling process and the nature of conceptual models themselves; and
- The entailments of conceptual modeling and the use of conceptual model artefacts for the success of the enterprise environment, in which they are contained, will be described.

The very significant perspective of the control of quality of conceptual models over their life-cycle evolution – usually designated verification and validation of the conceptual model – are addressed in a following section in order to address in appropriate detail the specific place of conceptual model quality management in enterprise contexts.

4.2.1 Evolution of Operational Context

Modeling and simulation in general, and conceptual modeling in particular, are being conducted in different environments in recent decades than previously.

Heretofore, M&S (and conceptual modeling) were technical specialties that were conducted by individual staff, largely below the level of visibility of the organization-level management. Conceptual modeling was itself mostly a craft competency; and its conduct was private to the simulation developer or to the small Group of which he was a member. Conceptualization was a personal skill, seldom conducted at even Group level of visibility, and less often documented at all but instead manifest only implicitly in the simulation products produced by individuals or development Groups. Simulation development efforts were modest in size and scope or were organic within one or another user community. Simulations were seldom shared, re-used or operated in combination with other models or simulations; and there was little appetite or motivation for explicit, deliberate, public conceptual modeling practice and products.

More recently, M&S has become a significant component of operations within organizations. Consequently, M&S and their attendant conceptual modeling efforts have become both more expensive, and more critically valuable to the organizations within which they are conducted. Expectation of M&S re-use and interoperability, sensitivity to demonstrated M&S credibility through systematic verification and validation, and the persistence and pervasiveness of use of simulations within and beyond organizational boundaries have made deliberate, public, and accountable M&S practice in enterprise context the norm.

4.2.2 Enterprise Definition

For purposes of this discussion, the following definition is provided:

> ***Enterprise*** *n. – One or more organizations under common control. Generally refers to the broadest scope of organization and operational process relevant to the subject discussion rather than to individual components thereof.*

NATO and national defence establishment M&S communities-of-practice are *de facto* enterprises in this spirit when the investment, development, maintenance, and use of M&S assets are concerned. Naturally, the scope of any particular enterprise environment depends upon the circumstances and particularities of the M&S operation in question; but in most cases, questions of strategic investment in M&S policy, practice and implementation has as its scope the entire NATO community. The fundamental need for successful investment in modeling and simulation within NATO is well documented and broadly recognized. In addition, more than a few efforts have been conducted to assess the then-current state, prevalent need, and recognized gaps of business practices for M&S, and the deliberate management of M&S investment to achieve necessary and sufficient state of mission capability. Such efforts have included: NATO M&S Conference [1] and Study Group [2] activity; initiatives by other national defence establishments [3]; efforts by professional societies to analyze the mechanisms of M&S cost-effectiveness [4][5][6][7][8]; and academic research efforts [9][10].

Enterprise-level M&S investment requires structure, persistence and common valuation for consistent execution. To paraphrase a quote [11] from the commercial environment:

> *Stand-alone M&S strategies don't work when DoD's enterprise-wide success depends on the collective value created across the organizations that influence the creation and delivery of value derived from investment in M&S. Knowing what to do requires understanding DoD's ecosystem and leadership's role in it.*

This admonition advances the fundamental premise that commercial businesses exist and thrive (or not) within the context of a business environment much larger than exists within the boundaries of an individual firm; and that to succeed, individual firms must learn to recognize and create value within 'the ecosystem' in which they exist. The article defined a 'business ecosystem' as that set of external organizations to which the success of your organization is closely tied, those for which critical dependencies exist. The key to maximizing value on an enterprise level is, as is implied by an 'ecosystem' viewpoint, understanding who shoulders the costs, and who potentially derives value from the allocation of resources to M&S.

4.2.3 Implications of Enterprise Context for Conceptual Modeling Practice

Enterprise level processes and products are required for all components of the M&S life cycle within the organization, but nowhere more than in the area of conceptual modeling.

From the perspective of enterprise operations, several implications follow for conceptual modeling practice. These influences must be reflected in recommended conceptual modeling best-practice, and constitute, in fact, a substantial set of the requirements for such practice. Among the several requirements driven by the expectation that conceptual models will inhabit an enterprise environment are the following:

- **Stakeholder Community** – Conceptual modeling will be conducted and its value recovered in a community or practice commensurate with the scope and diversity of the enterprise participants. Concepts invoked to develop, understand, share, and reuse conceptual model artefacts with confidence, and with reasonable expectation of accruing the benefits of shared investment require that all stakeholder roles be carefully defined and be appreciated as pertaining across the enterprise scope.

- **Process Consistency, Commonality and Tailorability** – Processes comprising the conceptual model best-practice must be appropriate for execution in a NATO-diverse constituency. Best-practice process elements must be sufficiently consistent that participation in conceptual modeling can be extended across any sub-set of the NATO M&S community. Practice commonality must have a similar domain in order that suitable common ground exist from which NATO M&S constituents may fully appreciate both how conceptual models were achieved and what their contents are, once produced. Conceptual modeling processes and products must, nevertheless, be sufficiently tailorable so that they can be socialized by any particular sub-set of the enterprise to which they will particularly pertain – and they must be sufficiently tailorable as to admit the specific referent subject matter, conceptual constructs, and representational schemas as may be elected by one or another sub-set of the stakeholder community.

- **Product Consistency** – Conceptual model product consistency must be sufficient that the library of conceptual models deployed and used within the NATO M&S enterprise are at least evidently interpretable among stakeholders, and preferably interoperable (to within similarity of mission- and simulation-space referents) across the enterprise. While complete interoperability and exhaustive re-usability are not likely to occur even under the most auspicious circumstances, and while it is certain that no degree of product 'best-practice' results could guarantee such consistency; any element of the prescribed practice that can be established with a view to improving product consistency should be adopted.

- **Product Quality** – Conceptual model product quality across the enterprise is relevant from two complimentary perspectives. On the one hand, consistent quality resulting from the subject guidance is directly correlated to the value of the return on investment in conceptual modeling itself. On the other hand, sufficient and auditably documented product quality across conceptual models will influence greatly both the likelihood of use of the conceptual modeling best-practice guidance and the re-use, sharing, and recovery of utility of the pursuant models themselves.

4.2.4 Consequences of Conceptual Modeling for Enterprise Mission

The use of simulation in military applications such as analysis, acquisition, training and decision support requires that the simulations are fit for use. V&V can be applied to evaluate if this fitness for use is achieved. The quality of the end-product (i.e., the simulation) is, however, largely dependent on the quality of the intermediate products. To be more specific, a large portion of the problems with the end-product come from a poor understanding of the customer's situation which leads to a low quality of the requirements. Explicitly building a conceptual model is one of the ways to improve the quality of the end-product by allowing for a good starting point for its development. In order for the conceptual model to be able to really improve the overall quality, the quality of the conceptual model itself must be sufficiently high. Building the conceptual model is *the* step in simulation development in which the actual modeling takes place. Therefore validation (determining whether the abstractions taken during the modeling are allowed) of the conceptual model against the stakeholders' purpose is important for the simulation's fitness for purpose.

From a project management point of view, the conceptual model is the last step in simulation development where correcting errors, such as having erroneously left out important parts that should be represented in the end-product, is still relatively easy, quick and cheap. If simulation design and implementation starts, correcting mistakes quickly becomes much more costly. Therefore V&V of the conceptual model is an important form of risk mitigation.

The amount of resources put into the V&V effort must be related to the risk (financial risk, loss of lives, etc.) of using a faulty end-product because a faulty conceptual model was used for its development. If almost no consequences exist of using a faulty conceptual model then the V&V effort may be low. If, however, a substantial risk is present, and using M&S results for military application usually has, the V&V effort must be accordingly.

For an enterprise it is advantageous to re-use as much of previous efforts as possible. This means that conceptual models from previous projects should be available for re-use, but it also means that V&V results should be available. One important way of achieving this is to use a set of enterprise-mandated processes and product formats. Then a common approach across projects can be achieved. On enterprise level, a V&V methodology must be chosen that supports this reuse in the sense that the V&V data of previous efforts should be (partially) re-usable.

4.3 CONCEPTUAL MODELING ENTERPRISE STAKEHOLDERS

Stakeholders can be defined as people being affected by a process or product. In this sense conceptual modeling and conceptual models have a number of stakeholders – each with different responsibilities, concerns and interests. They will typically also have different backgrounds and consequentially different perspectives, and therefore often use different “languages” or terminology.

4.3.1 The Importance of Identifying Stakeholders

Explicit identification of stakeholders of the conceptual modeling endeavor will help each stakeholder understand his role in a larger context. It will make him aware of the roles of other stakeholders and thus facilitating necessary communication between stakeholders.

4.3.2 Main Categories of Stakeholders

The primary stakeholder targeted by this guidance is the developer of conceptual models. There are however several other types of stakeholders. These can be referred to by many names. For our purpose we will use the following main categories:

- **Sponsor**: This is a person or organization that sees a need for modeling and simulation in the solving of a problem such as specifying an operational requirement or analyzing a capability. The sponsor will typically initiate and fund a modeling and simulation activity.
- **Producer**: This is a person or organization that will endeavor to satisfy the sponsor’s need. The supplier will undertake activities such as project management and development of the conceptual model. This will typically include subject-matter experts providing mission space knowledge and knowledge engineers eliciting, structuring and documenting knowledge.
- **Consumer**: This is a person or organization that will put the conceptual model to use in order to implement an executable model to satisfy the sponsor’s needs. The users of the simulation model may also be conceptual model consumers, as they will profit from understanding mission domain concepts and their relationships.

In an organization where conceptual model development is a recurring activity, it will, in the long run, pay to employ a repository containing results from past development efforts. In this approach is chosen, there will be need for a:

- **Custodian**: This is the person or organization that ensures that the repository is maintained and policies adhered to.

In order to ensure the quality of the conceptual model, it is recommended to implement a verification and validation process. This will be carried out by an:

- **Evaluator**: The person/organization that validates the conceptual models.

4.3.3 Use Case Description of a Conceptual Model Development Process

Figure 4-3 shows a high level view of the activities and stakeholders typically involved during a conceptual model development process.

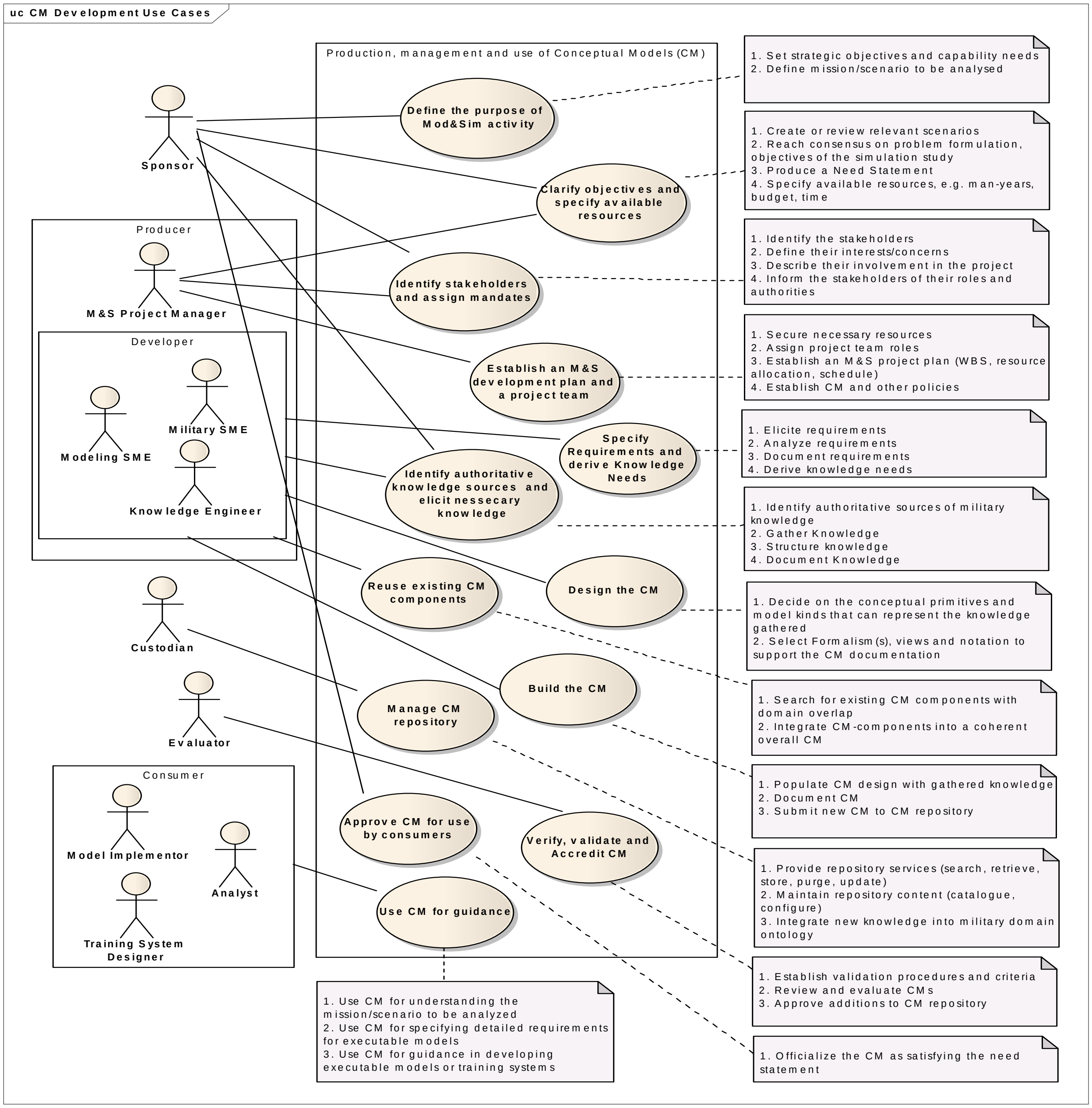

Figure 4-3: High Level Use Case Diagram Illustrating the Main Actors and Interactions During a Conceptual Model Development Process.

4.3.4 Stakeholders Responsibilities

Some of the main concerns of the different stakeholders in the process of conceptual model development and use are summarized in Table 4-1.

Table 4-1: Stakeholders' Concerns.

Stakeholder	Responsibility
Sponsor	• Analysis of combat outcome, system performance, system alternative trade-offs, etc. • Cost-effective training. • Credibility of analysis results. • Making sure the conceptual model represents necessary and sufficient relevant information about operational issues and mission context of interest (correct scope). • Decision-making based on analysis products (introducing a new tactic, procuring a new system, etc.). • Cost of modeling and simulation.
Producer (M&S Project Manager)	• Effective use of allocated resources (e.g., ensuring reuse when appropriate). • Unambiguous communication with customer.
Producer (Knowledge Engineer)	• Understanding of operational issues and mission context. • Translation of operational issues and mission context into a conceptual model. • Unambiguous communication with SMEs and implementers.
Producer (M&S Subject-Matter Expert, Military Subject-Matter Expert)	• Understanding operational issues and mission context. • Provide technical and military know-how at appropriate level of detail.
Consumer (Model Implementer)	• Understanding operational issues and mission context. • Implementation of simulation model. • Verification of simulation model compliance with conceptual model.
Consumer (Analyst)	• Understanding operational issues and mission context. • Producing relevant analysis products.
Consumer (Training System Developer)	• Understanding operational issues and mission context. • Producing adequate training environment.
Custodian	• Provide services for effective reuse of available knowledge and conceptual model components.
Evaluator	• Ensuring validity of conceptual model and compliance with requirements.

4.4 CONCEPTUAL MODEL ATTRIBUTES AND DEFINITIONS

Conceptual modeling has often been practiced as an art form or implied activity in M&S development processes. There was has been little formal structure or definition, and no consistent approach to applying various standards or formalism in previous practice. Conceptual modeling has been defined in several ways in literature, of which copious evidence is provided in Annex K – Bibliography. Most of these definitions are compatible, overlapping, or complimentary, but taken as a whole; they produce considerable ambiguity in regards to the scope of the conceptual modeling process and products. Further, consideration of conceptual modeling in the Military M&S context puts additional constraints and implications on the set of applicable definitions.

4.4.1 Scoping Definitions

Since it is difficult to write a definition of conceptual modeling that is not self-referential, and while Annex J – Lexicon provided a glossary of relevant terms; the following definitions will be used for the purposes of this guidance document:

- A *referent* is a set of fictive or existing systems, entities, phenomena, or processes subjected to modeling and simulation, which a user may want to consider in the context of their own objectives or interest.
- A *model* is a simplified/abstracted representation of a part of reality or a potential reality. It is a physical, mathematical, or otherwise logical representation of a referent of interest.
- A *simulation* is the implementation of a model over time.
- A *concept* is an abstract idea or a mental symbol, typically associated with a corresponding representation in language or symbology, that denotes all of the objects in a given category or class of entities, interactions, phenomena, or relationships between them.
- A conceptual model is a model that abstractly represents a referent.
- An *M&S* conceptual model is a conceptual model intended for realizing a simulation capability.
- A *military M&S* conceptual model is an M&S conceptual model within the military domain.

The relationship between these terms is further illustrated in Table 4-2.

Table 4-2: Relationships Between Defined Terms.

Term	Definition			
	Subject	**Attribute**	**Relationship**	**Object**
Concept	Abstraction	Generalized	Characterizes	Referent
Model	Description	Simplified Explicit	Represents	Referent
Conceptual Model	Model	Abstract	Represents	Referent
Military Conceptual Model	Conceptual Model		Represents	Military Referent
Simulation Conceptual Model	Conceptual Model		Represents Referent in	Simulation
Military-simulation Conceptual Model	Conceptual Model		Represents Military Referent in	Simulation

These basic terms define the content of the conceptual model, which is the set of information that is the collection of abstractions of the represented referents. But it is also necessary to consider the nature of the conceptual model in terms of the characteristics, the composition, and the context of the conceptual model in the relationship of the Conceptual Model Space to the Mission Space and Simulation Space must be defined.

4.4.2 Conceptual Model Characteristics

Any conceptual model will have characteristics of the following categories: Quality Characteristics, Utility Characteristics, Formality Characteristics, and Abstractness Characteristics. Figure 4-4 provides an illustrative list of characteristics in these categories, but is not intended to be exhaustive in its illustration.

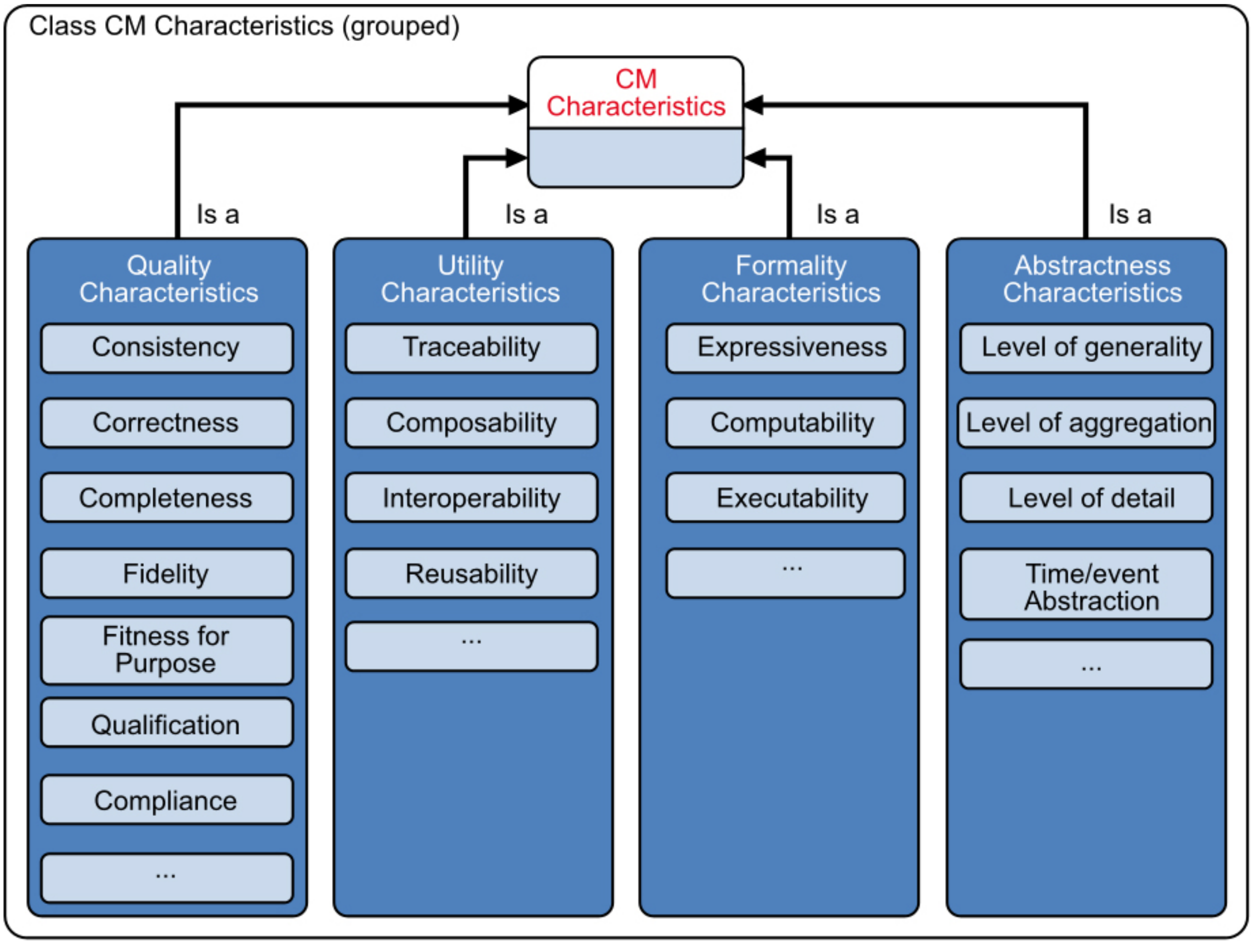

Figure 4-4: Conceptual Model Characteristics.

A practical set of definitions for these illustrative characteristics may be found in the Lexicon to this document. Definitions of the four categories are as follows:

- *Quality* is a totality of features and characteristics of a conceptual model that bear on its ability to satisfy stated or implied needs. It measures how "good" a conceptual model might be for various purposes.
- *Utility* is the property of the relative satisfaction gained by the use of a system expressed in terms of a value and cost. It measures the kinds of purposes for which the conceptual model might provide value.
- *Formality* is compliance with formal or conventional rules.
- *Abstractness* relates to the way the conceptual model abstracts or symbolizes the referent.

These characteristics are inherent to the conceptual model, and are not necessarily explicitly defined, measured, or in some cases even known. But it is this set of characteristics that will determine the use of the conceptual model by the Stakeholders, the re-use of the conceptual model by future Stakeholders, and the V&V Status throughout the conceptual model development and life cycle.

4.4.3 Conceptual Model

Most importantly, the conceptual model has content. And this content is composed, structured, and viewed as shown in Figure 4-5. This figure shows that a conceptual model is composed of Model Kinds, which are similarly composed of Conceptual Primitives. Model kinds use Formalism, and Conceptual Primitives are specified by that Formalism. Notation supports the Formalism and realizes Views, and the Views allow the conceptual model to be presented in appropriate manners to respective Stakeholders.

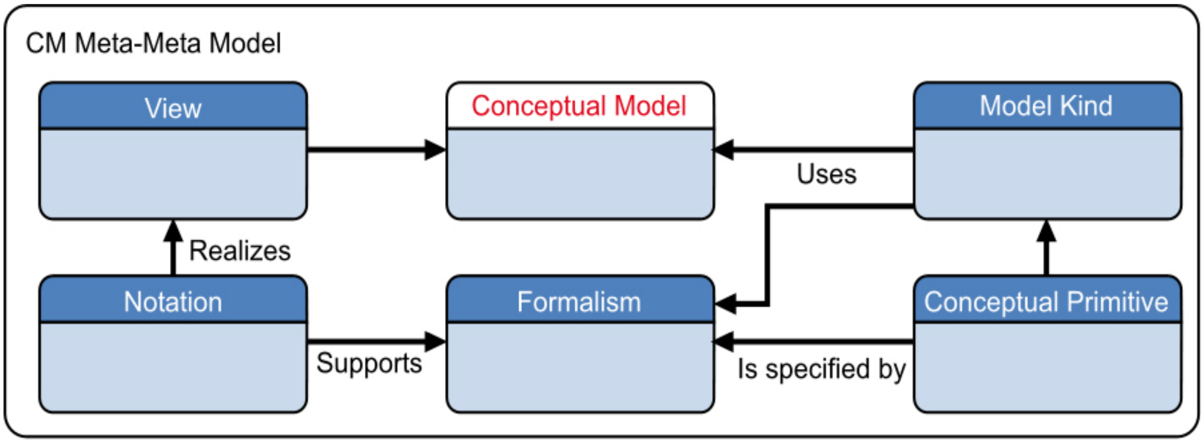

Figure 4-5: Conceptual Model Composition.

These composition terms have standard definitions, per Webster:

- *Primitive* – "an elemental component from which higher-order composites may be composed. Commonly applied to conceptual model constructs".
- *Model Kind* – "a type or alternative classes of models".
- *Formalism* – "the practice or the doctrine of strict adherence to prescribed or external forms".
- *Notation* – "a system of characters, symbols, or abbreviated expressions used in an art or science or in mathematics or logic to express technical facts or quantities".
- *View* – Explication of a subject model-kind instance created using one or another selected notation.

The following are illustrative lists of these composition elements. These lists are not intended to be exhaustive in their illustration.

- Example Primitives: Entity, object, signal, time, event, attribute, message, state, etc.
- Example Model Kinds: Dynamic, static, state machine, structural, behavioral, agent, object-based, process-based, Meta data, entity relation, activity, composition, generalization, collaboration, event trace, sequence, etc.
- Example Formalisms and Suitable Notations: Unified Modeling Language (UML), Conceptual Modeling Language (CML), System Modeling Language (SysML), Integration Definition for Function Modeling (IDEF0), Base Object Models (BOM), BOM++, Conceptual Graphs, Mind Maps, and Business Process Modeling Notation (BPMN).
- Example Views: Class diagram, activity diagram, swim lanes, state diagram, operational view, etc.

A more detailed discussion of the composition of the conceptual model, in terms of the design process, will be given in Chapter 6.

4.5 CONCEPTUAL MODEL PERSPECTIVES AND COMPOSITION

Conceptual Model of a Simulation is predicated for the purposes of this effort as the conceptual model of the Mission Space (i.e., that which is represented within the simulation during its execution) integrated with the conceptual model of Simulation Space (i.e., encompassing the design and implementation of the simulation artefact itself). Consequently, it is important to differentiate between aspects of the conceptual model space, the Mission Space of the referent world, and the Simulation Space where the simulation itself resides. Each of these Spaces will impact the design of the conceptual model in its own fashion.

Figure 4-6 shows the nature of these three spaces, and how they interact through the requirements and design of the conceptual model. Following are examples of requirements which might be applied to the conceptual model components relevant to the two spaces and the composite conceptual model itself.

- Example from conceptual model composite space: The conceptual model shall be machine-readable.
- Example from Mission Space: The conceptual model shall represent World War II trench warfare.
- Example from Simulation (Implementation) Space: The conceptual model shall be at a level of abstraction allowing real-time execution at 1000 Hz on a commercial desktop platform.

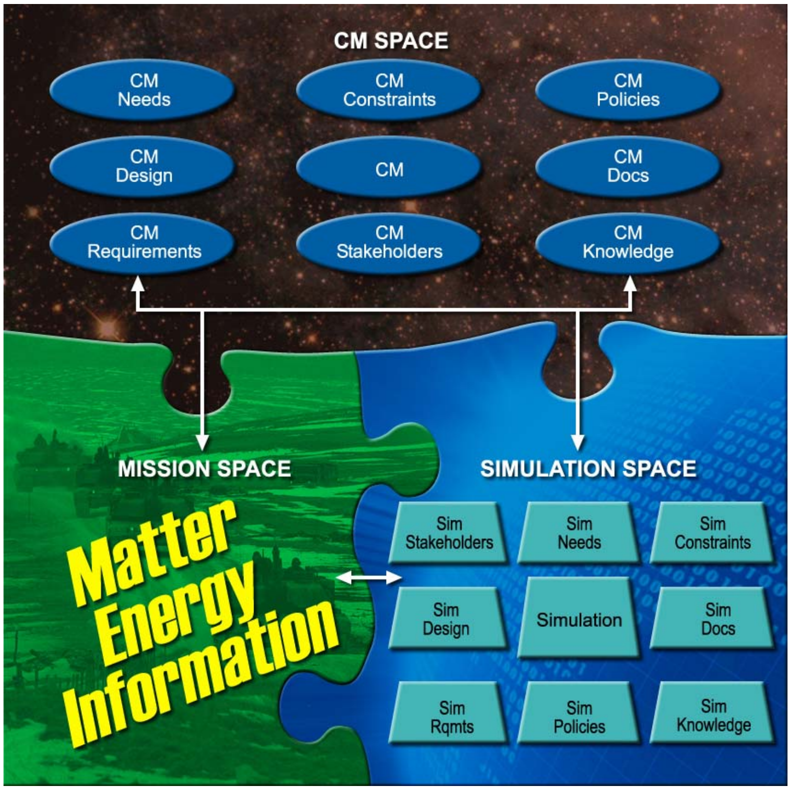

Figure 4-6: Mission Space and Simulation Implementation Spaces Indicated as Disjoint, but Highly Integrated 'Worlds' Whose Natures are to be Included in the Entire M&S Conceptual Model.

Also see Annex I – Conceptual Model Examples.

The diagrams of Figure 4-6 and Figure 4-7 illustrate the notions of the disjoint representation and simulation implementation spaces and their composition into the fully articulated conceptual model artefact.

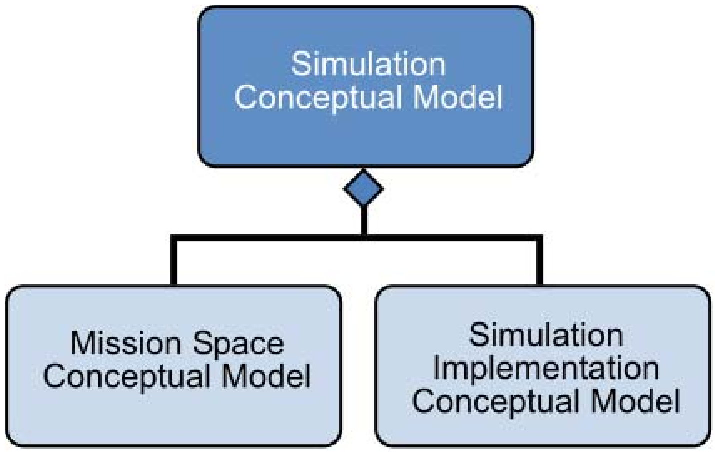

Figure 4-7: Simple Indication of Composition of the Simulation Conceptual Model from Mission Space and Simulation Implementation Space Components.

Typically, the conceptual model is thought to only represent the Mission Space. Although it is often said that the ideal conceptual model is "implementation independent", thus "Simulation Space independent", such is rarely ever the case. Even if the conceptual model does not explicitly mention an implementation, and may be highly portable from one Simulation Space to the next, the original Simulation Space to which the conceptual model was designed will have influenced the structure and content of the conceptual model, sometimes in significant ways. This is also true of the Conceptual Model Space influences, such as Conceptual Model Stakeholders and Policies.

It is, in fact, the frequency of conflation of mission and simulation implementation spaces, and the occurrence of unanticipated pejorative consequences that has motivated the Task Group to adopt this particular partition convention. By making the partition explicit, the degree of machine independence and the artificial implementation of mission space representations by means of undesirably static implementation techniques are believed to be better appreciated and controlled.

4.6 BEST-PRACTICE SPECIFICATION NOTATION

One of the practical determinations and findings of the Task Group related to representational notations whereby specifications of best-practice and resulting conceptual models could be mad manifest; and, whereby the conceptual model itself may be captured, published, archived, retrieved, understood, modified, and maintained in a systematic and deliberate manner without corrupting the semantic content of the model itself. It was abundantly clear from the Team's investigations of current practice and available standards that myriad notational schema were available. It was further determined by the Group that the use of any of any one notational form in expressing best-practice or the requirement for use of any such single form by conceptual model practitioners in executing the recommended best-practice would be found to be technically and socially impractical, however desirable and fit-for-purpose it might seem.

Notwithstanding this determination, it was clear that the Team needed a provisional or ‘nominal’ notation for expressing its guidance; and that the conceptual modeling practitioner would be obliged to select some one specific documentary notational schema in executing the recommended best-practice. In the later case, the Group resolved that practitioners should (could) elect any formulation consistent with the representational capacity required to express their particular conceptual model and commensurate with the norms and requirements of the enterprise environment in which they worked. Naturally, selection from among common standard notations and specification languages is strongly recommended in any case. In the former case, the Group was particularly sensitive to its own use of notational artifice for two reasons. On the one hand, any notation employed herein to specify conceptual modeling process or conceptual model structure and semantic content must be sufficiently expressive and ecumenical so that the best-practice guidance communicated thereby might be clearly intelligible. On the other hand, the Group was anxious not to imply by its own selection and use of notational schema, that our particular choice of schema was particularly preferred for use by practitioners – let alone a required element of the recommended best-practice.

Therefore, the group strove to use the most simple and self-evident notation within the document, and to reserve the best-practice guidance itself to vernacular English in Chapters 5 and 6 and in tabular prescription in annexes tabular prescriptive guidance in Annexes G and H for process and product respectively. The fundamental activity-on-node with control-on-arrow notation with which this guidance is modestly introduced in Chapter 6 for process particularly together with an expression of the degree to which this notational convention is practically a ‘least common denominator’ of several common representational forms, is indicated in the figures following.

Figure 4-8 illustrates the simplified baseline graphical representation for indication of activities and their relationships with other entities in the conceptual modeling practice process Used by the Task Group in following explication.

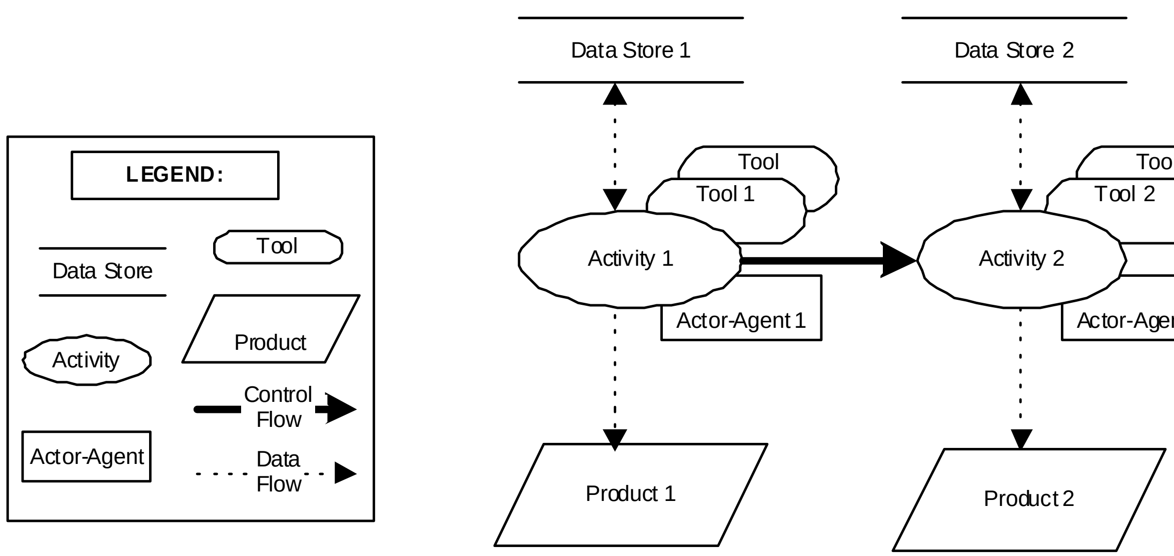

Figure 4-8: Simplified Process Graphical Notation Used in Expressing Conceptual Modeling Best-Practice Process.

Figure 4-9 indicates alternative canonical views with information-preserving transform operations are possible, facilitating use of CASE-supported native representations and guaranteed information sharing.

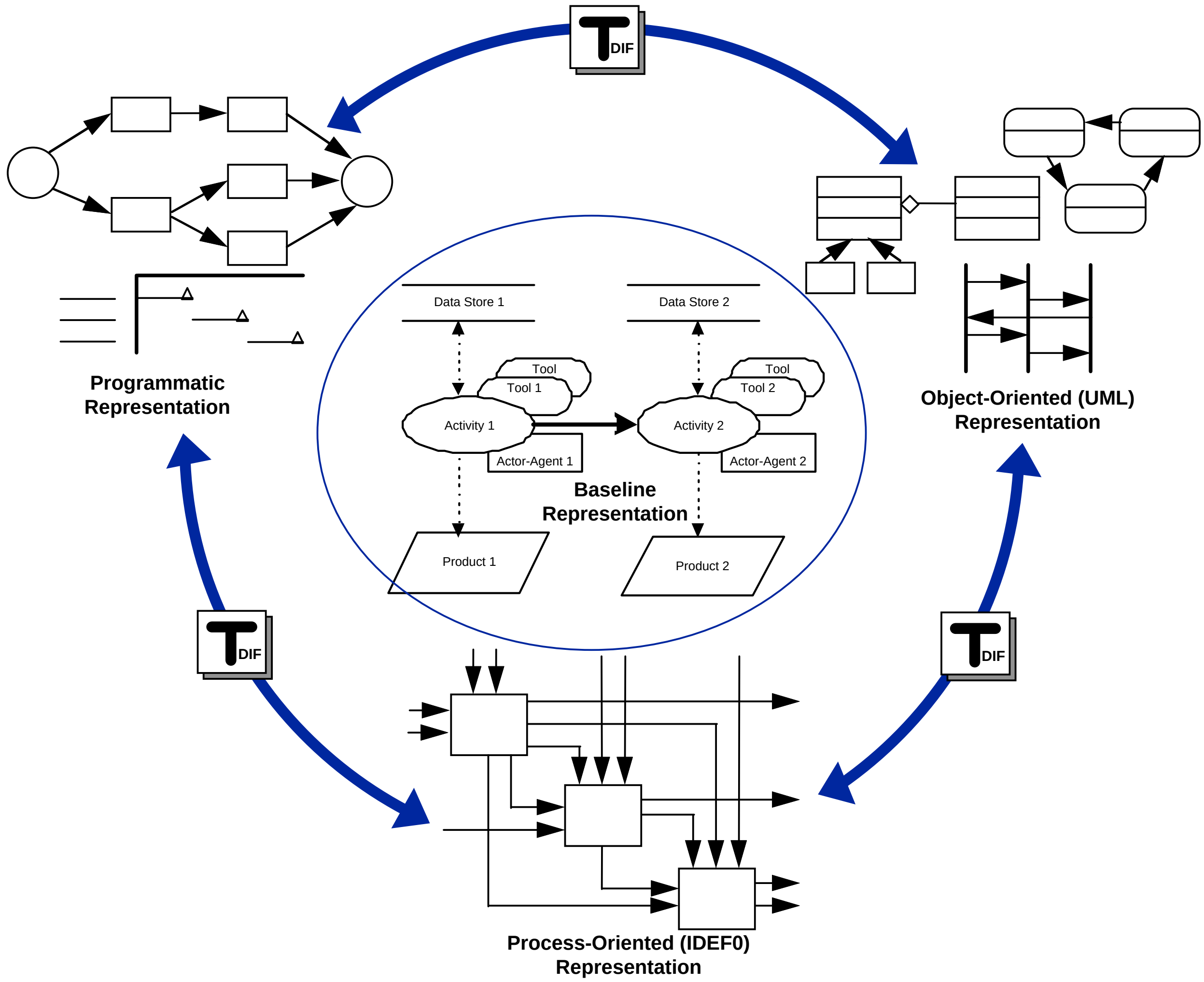

Figure 4-9: Notional Illustration of Relationship of Simplified Process Specification Graphical Notation in Context of Other Canonical and More Powerful Notations.

4.7 CONCEPTUAL MODEL QUALITY (VERIFICATION AND VALIDATION)

In this section some aspects that are relevant for understanding the role of V&V of a conceptual model in the project context are described. Although the complete product life cycle is not described in this report, some aspects of this larger setting may still be useful for a complete understanding. An enterprise that decides to explicitly make a conceptual model clearly has the desire to deliver quality products. Just making a conceptual model, however, is not sufficient for achieving quality. The quality of the conceptual model (and other intermediate products) must be sufficient to allow the development of a quality end-product. V&V helps in determining the quality of the final product and must be applied throughout the whole of the development, and thus also to the conceptual model. V&V of the whole development can be a large undertaking. Here we describe the V&V work with the focus on conceptual model and as if the rest of the V&V work is non-existent. It is important, however, to understand that the result of V&V of a conceptual model is only a part of the overall V&V effort.

4.7.1 Context of Conceptual Model V&V Effort

The V&V work consists of a number of activities that are described in the activities in this guidance. These V&V activities do not all need to be completely finished before a next activity can be started: they may partly be executed in parallel. Process Activities can also be executed iteratively.

The V&V work starts with agreement on a number of elements such as: who performs the V&V work, what resources (time, money, etc.) are available for V&V, and how the results of the V&V work are used. See also the V&V elements in the "Meta data" product in the V&V elements in the "Information Pool" of Annex H, Table H-5. The amount of available resources for V&V must be related to the risk (financial, loss of lives, etc.) of using a faulty end-product because a faulty conceptual model was used for its development. If almost no consequences exist of using a faulty conceptual model, then the V&V effort may be low. If, however, a substantial risk is present, and using M&S results for military application usually has, the V&V effort must be accordingly. The applied V&V methodology should be tailorable such that it delivers the best possible V&V given the risk and available resources.

4.7.2 Quality Attributes Relevant to Conceptual Model V&V

Three properties must be shown during the V&V work: utility, validity and correctness:

- Utility
  - Assesses the effectiveness and efficiency of the conceptual model in solving the problem statement. Evaluation metrics for utility comprises three areas: value or benefits (measures of effectiveness, measures of performance, etc.), costs (money, time, etc.) and use risks (impact, probability, etc.).
- Validity
  - Assesses the level of agreement of the conceptual model behavioral representation with that of the simuland. Validity metrics are also used to assess the consequences any behavioral discrepancies on the utility of the M&S system.
- Correctness
  - Assesses whether the conceptual model implementation is free of error and of sufficient precision. Correctness metrics are also used to assess the consequences of implementation discrepancies on both the validity and utility of the conceptual model.

4.7.3 Sufficiency Criteria for Conceptual Model V&V

In order for the conceptual model to have utility it must help improve the quality of the end-product within with resources that are in balance with the risk. Building the conceptual model is the step in simulation development in which the actual Modeling takes place. Therefore validation (determining whether the abstractions taken during the Modeling are allowed) of the conceptual model against the stakeholders' purpose is important for the simulation's fitness for purpose. In order to serve its purpose the constructed conceptual model must also be correctly implemented such that its representation is useful and leads to a correct transformation of purpose, via requirements to design and implementation.

A conceptual model that has been V&V-ed with positive results increases the chances of a high quality end-product and can serve as part of a referent for the V&V of that final product. For conceptual models no formal acceptance process (accreditation) is available, it must however be acceptable for the stakeholders (users, developers, etc.) that use the conceptual model in the development process. This must be achieved in two ways. First, the acceptance criteria must be derived from the stakeholders' purpose, and, second, the format in which the results of the V&V effort are delivered must be suited for their purpose.

4.7.4 V&V Compliance Framework

It is important that the V&V effort results in a compliance network linking stakeholders' goals via a set of evidences to justifiable claims.

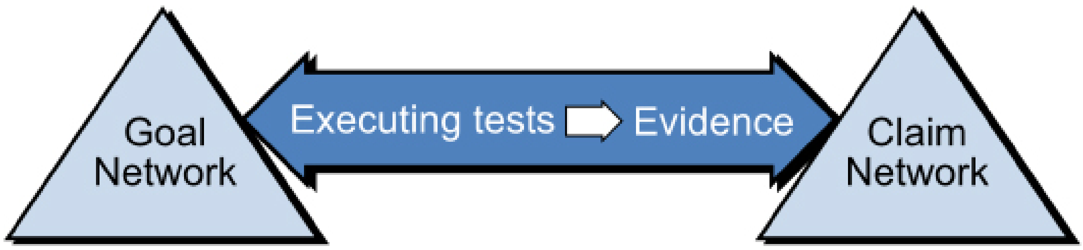

Figure 4-10: The V&V Argumentation Framework (AF) Consists of the Goal Network, Evidence and the Claim Network.

The goal network is used in a top down fashion for reasoning about the decomposition of a top-level objective into smaller goals and, finally, into a set of definitions of tests to generate evidence. Therefore goal networks can be used for planning purposes. V&V goal networks are closely related to and overlap with goal-oriented requirements engineering.

Claim network structures work in the opposite way. A claim network structure aggregates evidence collected in a certain context into sub-claims, and these sub-claims into a single justified top-level claim on the subject of interested. This aggregation is done by means of logical arguments.

The rationale for using both a goal network and a claim network stems from the fact that in practice decomposition and re-composition do not mirror each other for various practical reasons like time, cost and availability of equipment to gather the appropriate evidence.

After completion of the claim network, and thus also the goal network and evidence collection, the results must be communicated to the stakeholders. The results are an acceptance recommendation in the format best suited for the stakeholders' purpose with the V&V results. Since there is no formal acceptance process for conceptual models, the result is not an accredited conceptual model but a recommendation on acceptance.

If all is well the top claim shows that the top goal is justified. For all M&S related products, and indeed possibly all products, the top goal is of the same form: the system must provide utility for the given purpose. Therefore the top goal of the Goal Network is a utility goal. In case of conceptual models the following top goal is proposed:

The Conceptual Model provides utility for the improvement of the quality of the end-product.

This top goal must be decomposed into smaller goals. At first these are likely to be more specific utility goals. At some point the utility goals can be expressed either into criteria for which tests can be devised or into smaller goals that deal with validity and correctness. The validity goals express criteria on the abstractions from reality that are made in the conceptual model since the phase in which the conceptual model is build is the modeling phase. Only those abstractions are allowed that will result in a model that – given its purpose and the way it is used in the final product – result in a behaviour that is indistinguishable from the equivalent behaviour in the real world. The correctness goals state criteria on how the conceptual model is build, expressed in formalism and used in the rest of the development process. The conceptual model must for example be understandable for all relevant stakeholders and be specified without errors in formalisms that are appropriate.

Some of these criteria will be independent of the specific topic and formalisms, but many criteria, and especially those in the validity goals, will be highly dependent on the stakeholder's purpose with the final product. Inspiration for criteria can be found in standards on software quality, namely [ISO/IEC 9126], papers on conceptual model quality such as [Lindland] [Pace] [Teeuw], SMEs and domain specific knowledge that may be available from previous quality evaluation efforts. A good overview of quality frameworks specific for conceptual models is given by [Moody].

4.8 REFERENCES

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Chapter 5 – CONCEPTUAL MODELING PROCESS GUIDANCE

Establishment and implementation of best-practices are critical to ensure that a sound and structured process is followed to produce conceptual models of sufficient quality, and to ensure that conceptual model products are robust and complete. It is particularly important to establish a homogeneous and common process for conceptual model development to enable a structured approach and to build a common vocabulary across the M&S community for the sake of collaboration and reuse.

Based on the research effort described above, and in order to meet the stated objectives of advancing the development of conceptual models beyond current practice, Chapters 5 and 6 (along with corresponding annexes) constitutes NATO Best-Practice Guidance, provided to enable the development of quality and re-useable conceptual models of military models and simulations.

5.1 PROCESS GUIDANCE INTRODUCTION

This chapter provides the MSG-058 Task Group's "Best-Practice Guidance Specification (BPGS)" for the "Conceptual Model Best-Practice Development Process" as indicated in Figure 3-4. This guidance includes descriptions of the Process Phases, Activities, and Activity-Flows required to ensure a quality conceptual model, and quality ancillary products. The products themselves will be described further in Chapter 6.

The desired process guideline is based on these desirable characteristics, which best-practices conceptual modeling process should contain, exhibit, or facilitate:

COMPLIANCE:

- Comply with policies.
- Conform to enterprise precepts and practices.
- Include identification of stakeholders' roles and responsibilities.
- Leverage available standards.
- Leverage systems engineering and information management best-practices.

SUFFICIENCY:

- Provide necessary activities to the conceptual model lifecycle.
- Contemplate multiple formalisms and views.
- Distinguish between Mission Space and Simulation (implementation) Space requirements and needs.
- Exhibit sufficient completeness for subsequent intended use.

'-ITILITIES' – this represents words that end in itilities, such as utilities, capabilities, etc.:

- Give developers flexibility to apply and tailor the process.
- Provide utility and efficiency.
- Allow sufficient expressiveness and flexibility.
- Foster reusability.
- Foster understanding.

QUALITY:

- Exhibit sufficient correctness for intended use.
- Produce quality documentation.
- Enable VV&A.

A five-phase development process is provided commensurate with these required characteristics. That process is shown in Figure 5-1, and its process elements are designated as follows:

- PP1 – Initiate Conceptual Model Development.
- PP2 – Define Conceptual Model Requirements and Knowledge Needs.
- PP3 – Acquire Conceptual Model Knowledge.
- PP4 – Design the Conceptual Model.
- PP5 – Build the Conceptual Model.

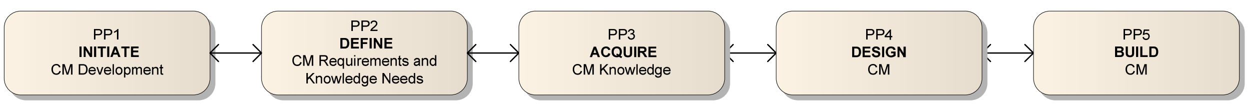

Figure 5-1: Conceptual Model Development Phases.

Each development phase is composed of a corresponding set of Process Activities. The complete collection of activities for the entire process is shown in Figure 5-2. Further guidance on the specific phases and activities is provided in the sections below, and technical descriptions of each Process Activity are provided in the text that follows and, systematically in Annex G.

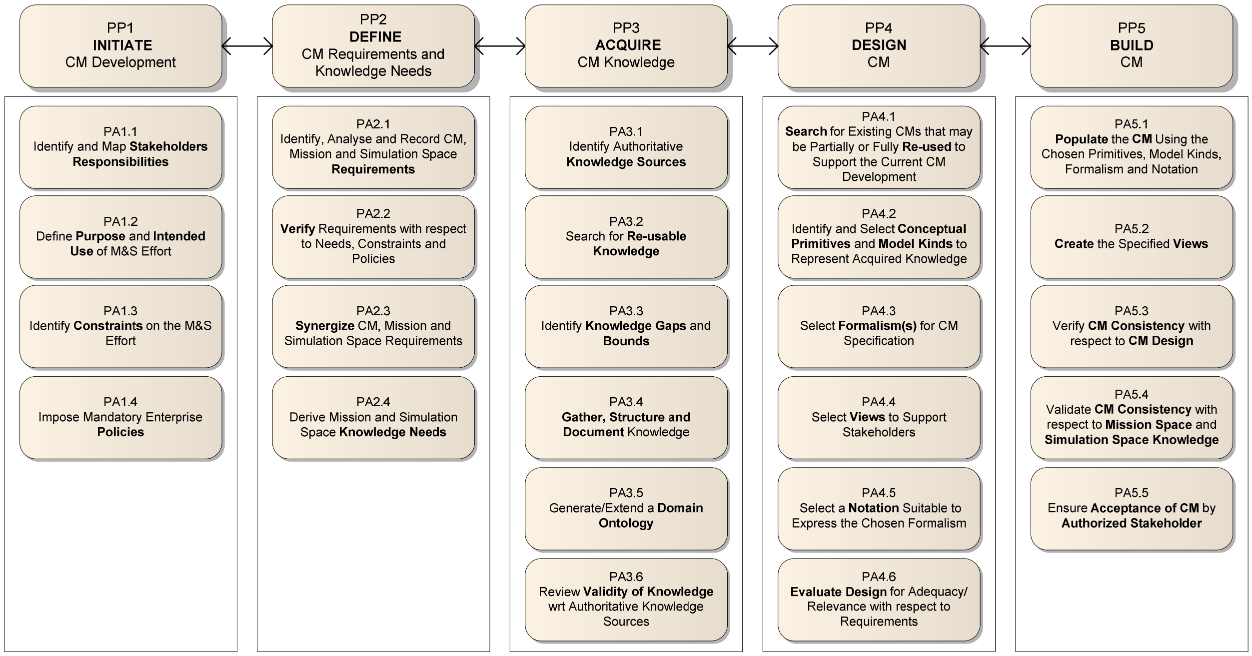

Figure 5-2: Conceptual Model Development Process Exhibiting Devolution of Process Phases to Process Activities.

It is important to note that these Process Phases and Activities need not be executed in the serial order implied by their enumerated listing; although, the ordinality of Process Activities associated with each Process Phase is considered to be logically suggestive. Pragmatically, many of the activities may be executed concurrently, in multiple iterations or out of numerical sequence, contingent such exigencies a team structure and availability of expertise, availability of information, election of spiral or other recursive implementation techniques, or, in fact, any of the circumstances that are the inevitable consequence of enterprise operational style or business practice. The only limitations to task activity sequencing is the necessity to satisfy entry conditions and exit conditions for each activity, as defined in the respective sections of Annex G.

Figure 5-3 illustrates such one such non-linear execution of the global process through the use of a state-transition diagram. In the example in the figure, S1…S13 indicate each state, and it can be seen that the sequence includes execution of multiple phases in parallel, and iterative passes through the process. These states may also involve execution of individual phased Process Activities in different or parallel order.

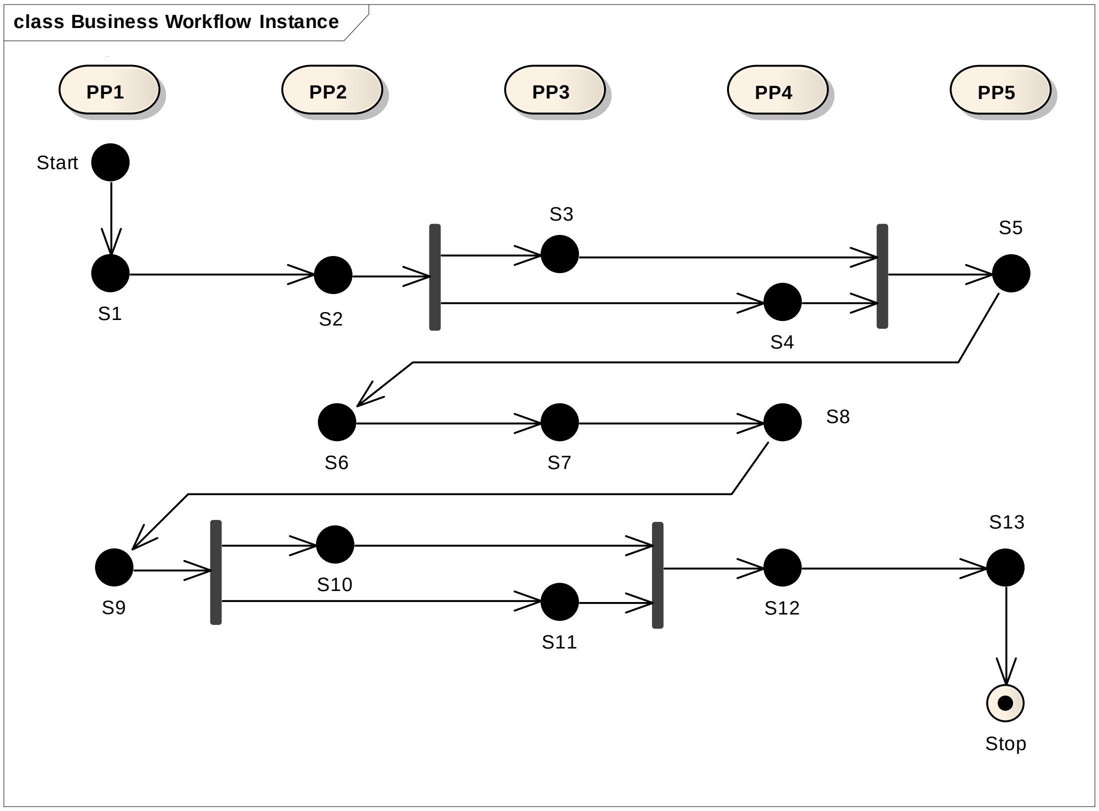

Figure 5-3: Example Conceptual Model Development Workflow.

It is significant to note that the process specification is organized and presented in order to provide the greatest possible discretion to the conceptual modeling execution agent, while encouraging elements that have been determined to comprise best-practice. In that spirit:

- These defined Process Phases and Activities are provided as best-practices in conceptual model development.
- This process may be tailored as needed by the developer.
- The Process Activities may be executed in any sequence allowed by the entry and exit criteria.

5.2 CONCEPTUAL MODEL PROCESS DESCRIPTION

In the sections that follow, discussion of conceptual modeling Process Phases and their component Process Activities are provided. The intention of the text is to provide a plausible explanation and rationale of the entire effort expected to be necessary and sufficient for the creation and management of military simulation conceptual models. Information is provided that is deemed:

- Useful to the practitioner in understanding motivation for particular process components;
- Constructively prescriptive in conducting conceptual modeling;
- Effective in elaborating on special circumstances likely to apply to such execution;

- Liberating to the practitioner in specializing the subject guidance contingent particular circumstances following from enterprise and task peculiarities; and
- Prescriptive of intentions for resulting work-products.

This account is provided as a complimentary and consistent form of guidance which, when taken together with the systematically tabular guidance specification contained in Annex G, is considered necessary and sufficient to inform best-practices.

5.2.1 Process Phase 1 Guidance – Initiate Conceptual Model Development

The conceptual model development activity in this phase is to identify, collect, and document initial needs, constraints, and policies that are most often described in terms of the underlying simulation, and to identify stakeholders and map them to their roles and responsibilities. This phase is critical to the translation of simulation needs, mandates, and constraints into those for the conceptual model itself.

Since it is highly unusual for conceptual models to be developed for their own sakes, rather than in the context of one or more M&S initiatives, the initiation process is often seen as external to the conceptual model process. Yet most senior stakeholders in the enterprise make their greatest conceptual model development contributions at this time. Historically these contributions rarely have been documented within the conceptual model itself, which has often resulted in limited conceptual model reusability or sub-optimum representation due to assumed constraints and mandates that dictate the form and content of the conceptual model.

For example:

> *A Joint Forces Commander recognizes the need to provide transportable helicopter simulators in the field to reduce the number of flight hours required for mission training. He develops an M&S need statement to address the problem, and an Acquisition Executive decides to fund the development of the simulators to meet the need. Due to the urgency of the problem, the Acquisition Executive allocates twenty million dollars to do the development in the nine remaining months of the current year, and tasks an Army Program Office to execute the mission. The Army Program Manager knows that to execute within time and budget, he will not be able to develop a validated flight model, and will have to use a surrogate, which will limit the value of the training in the near-term. He decides to direct the development of a composable architecture so that he can drop in a validated flight model at a later date. He also is constrained to develop the simulators using existing tools and using mandated software development practices. He articulates this to his Group, who are now prepared to develop the conceptual model for the simulation effort.*

In this example, conceptual model development began long before the development Group received their direction, in terms of the constraints, policies, and mandates limiting the simulation development effort. As mentioned above, an ideal conceptual model is said to be implementation independent. And a conceptual model can certainly be developed to support the example above, without specifying application constraints. But even if the conceptual model does not explicitly reference these constraints, those constraints will still bind and shape it, and as will be shown in the next process steps, the conceptual model requirements definition and knowledge acquisition will be highly impacted by the decisions made by the senior stakeholders.

Therefore, in order to translate and document the impacts of the M&S development effort to the conceptual model, the following Process Activities must take place:

- PA1.1 – Identify and Map Stakeholder Responsibilities.
- PA1.2 – Define Purpose and Intended Use of M&S effort.
- PA1.3 – Identify Constraints on the M&S effort.
- PA1.4 – Impose Mandatory Enterprise Policies.

The relationships among these Process Activities and with their products are shown in Figure 5-4.

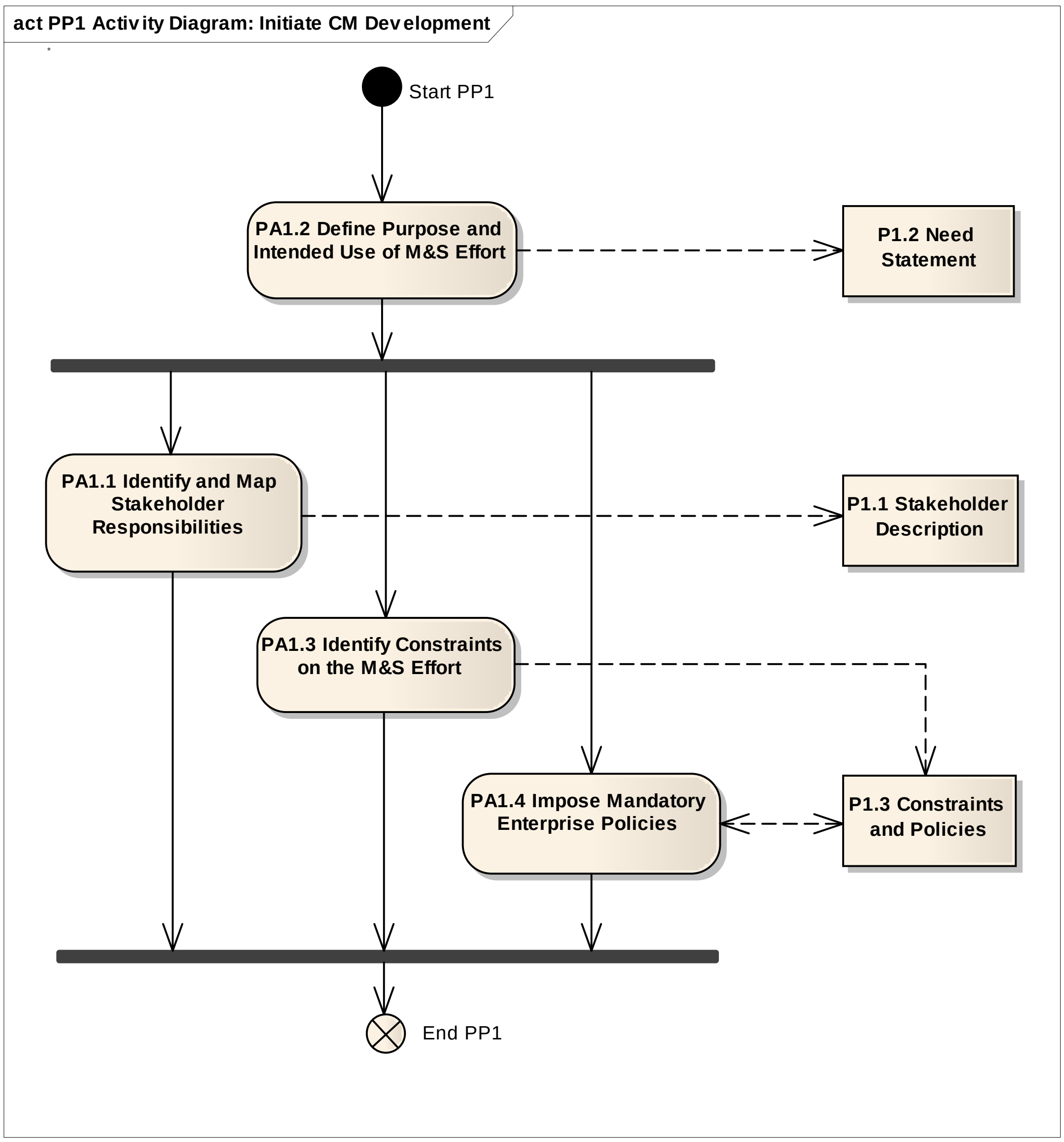

Figure 5-4: Process Phase 1 (PP1) Activity Diagram.

Each Process Activity is described below, and is further specified in Annex G.

5.2.1.1 PA1.1 – Identify and Map Stakeholder Responsibilities

A conceptual model primarily exists for the benefit of its stakeholders. Stakeholders must be identified to support the conceptual model development process: to support requirements development and knowledge acquisition, and to impact the design and build of the conceptual model. Stakeholders and their roles must be known before views can be determined. Stakeholder perspectives will drive terminology and will impact the selection of models and relationships.

This Process Activity involves three kinds of things: Lists of actual points of contact, by name or office; identification of relevant stakeholder roles as described in Section 4.3; and a mapping of the points of contact to the roles.

Points of contact may be generated from lists, employee roles, organizational charts, personnel databases, referrals, resumes, biographies, contract labor categories, or any other programmatic or administrative means.

Roles must be defined by analysis of the PA1.2 defined purpose and intended use of the M&S effort to the stakeholder classes described above, tailored to the particular application.

Mapping of the two will most likely involve M to N mapping, given that many individuals or offices can often have multiple roles in a particular conceptual model development, and many roles include multiple people for any realistically sized effort.

In the example above, the points of contact "Joint Forces Commander" and "Acquisition Executive" might map to "Sponsor", and "Army Program Manager" would likely map to the stakeholder role of "Producer".

This activity produces the P1.1 – Stakeholder Descriptions, which are used to derive conceptual model requirements and conceptual model knowledge needs.

5.2.1.2 PA1.2 – Define Purpose and Intended Use of M&S Effort

This Process Activity may begin upon stated or implied intent to develop a model, simulation, or conceptual model. This intent may come in the form of task orders, mission needs statements, user requirement documents, requests for proposal, statements of work, formal or informal directives, test agreements, oral or written orders, or any combination of like manners of communication.

The purpose of this activity is to compile all these M&S source documents and implied intents into a single set, to deconflict the elements of the set, and to provide this reconciled, definitive description of intent to the conceptual model developers, written in terms of descriptions of needs for the conceptual model.

It may be possible that multiple references to intent cannot be reconciled, as in the example above, where the Joint Forces Commander wants to train pilots but the Army Program Manager is not providing a validated flight model. In that case, even these potentially conflicting or mutually exclusive intents must be documented and highlighted, as they will likely drive complexity into the conceptual model, as the Army Program Manager's decision to develop a composable architecture surely would have done.

This activity produces the P1.2 – Intended Use Statement, which is used to derive conceptual model requirements and conceptual model knowledge needs.

5.2.1.3 PA1.3 – Identify Constraints on the M&S Effort

As in the example, time and resources can constrain the conceptual model design, as can the intended use itself. These M&S constraints in turn constrain the conceptual model development, and impact the reusability and implementation independence.

And as in PA1.2, information pools such as documented resource constraints, senior stakeholder preferences and requirements, planning/budgeting management limitations, legacy M&S preferences and availability, data availability, enterprise preferences, and such, must be collected, integrated, and de-conflicted into a self-consistent set of descriptions of M&S constraints.

This activity, combined with PA1.4, is necessary to produce P1.3 – Constraints and Policies, which is used to derive conceptual model requirements and conceptual model knowledge needs.

5.2.1.4 PA1.4 – Impose Mandatory Enterprise Policies

In this Process Activity, developers collect information from enterprise standard operating procedures, industry and government standards, enterprise executive mandates, law, agency regulations, agency directives, written policy, implied enterprise mandates, and other references relating to Enterprise Policy Mandates. This data must be collected, integrated, and de-conflicted into a self-consistent set of descriptions of policies.

Examples of enterprise mandates include the US Department of Defense mandate to use High Level Architecture (HLA), some industries standardizing on UML, or even a small business's decision to use a proprietary software tool for competitive advantage. This activity is where the enterprise has tailored the intended use and constraints to its own interests, and that tailoring gets reflected in the initial state of the conceptual model.

This activity, combined with PA1.3, is necessary to produce P1.3 – Constraints and Policies, which is used to derive conceptual model requirements and conceptual model knowledge needs.

Listed below are the points of emphasis:

- The INITIATE phase of conceptual model development is a critical and often overlooked set of activities that must be understood and documented.
- These activities are necessary to document stakeholder roles, conceptual model requirements, policies, and mandates.
- This phase sets the initial state of the conceptual model.
- In mature enterprises, much of this initial state is quite repeatable from one conceptual model activity to the next, and might generate documents that are highly reusable in subsequent efforts.

5.2.2 Process Phase 2 Guidance – Define Conceptual Model Requirements and Knowledge Needs

Overview of Process Activities and Products – The second Process Phase in the conceptual model development process consists of four Process Activities in a simple sequence as shown in Figure 5-5. This Process Phase takes two input products (P1.2 – Need Statement and P1.3 – Constraints and Policies) and produces two output products (P2.1 – Conceptual Model Requirement Specification and P2.2 – Conceptual Model Knowledge

Acquisition Needs). A preliminary product is used to record requirements during the Process Phase execution before they have been synergized and verified.

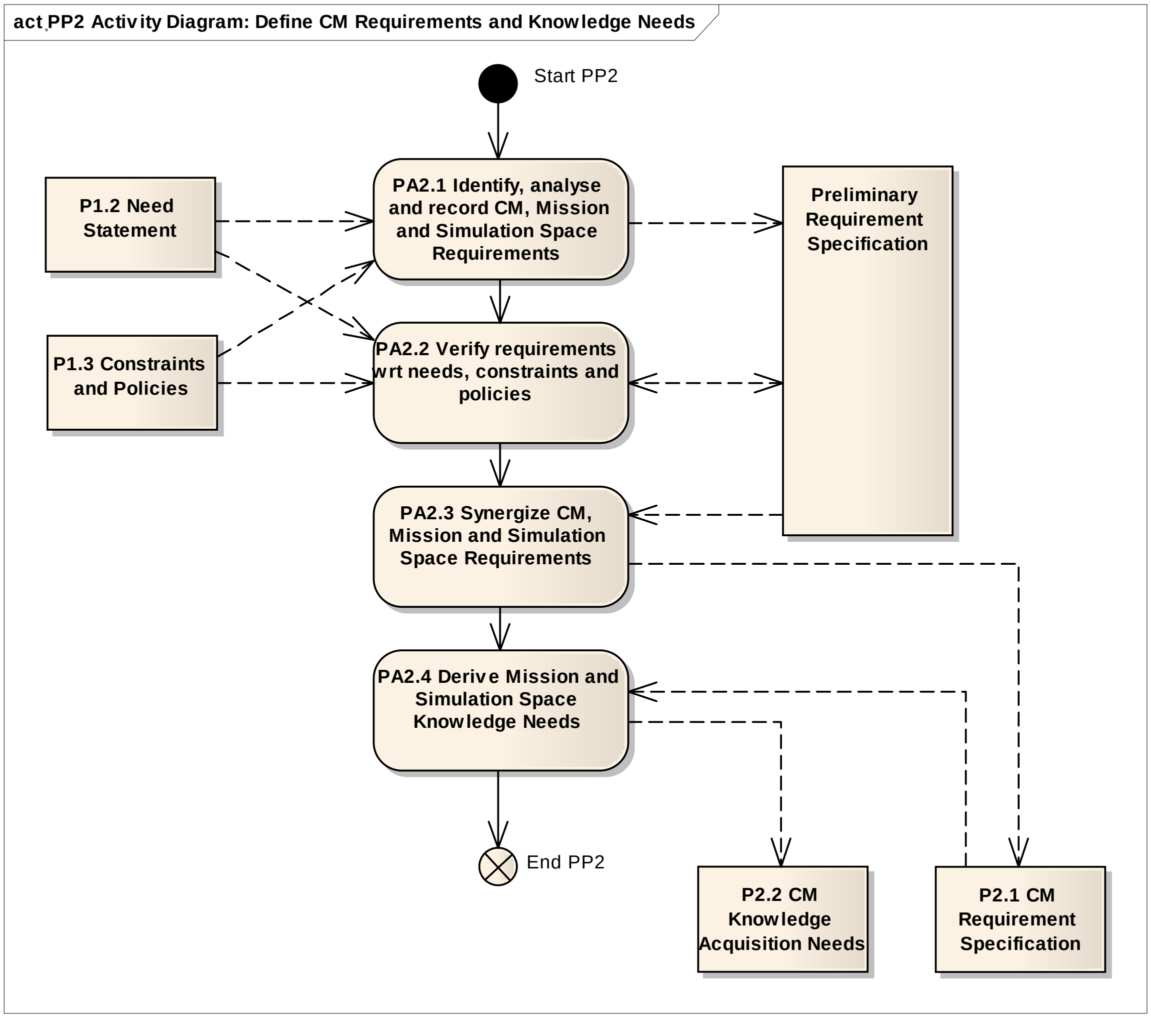

Figure 5-5: Process Phase 2: Define Conceptual Model Requirements and Knowledge Needs.

5.2.2.1 PA2.1 – Identify, Analyze and Record Conceptual Model, Mission and Simulation Space Requirements

Process Activity 2.1 refers to requirements grouped into three "Spaces": Conceptual Model Space, Mission Space and Simulation Space. The concepts of these "Spaces" are explained in Chapter 4, Section 4.1 Scope and Definitions and an example are presented in Annex I.

This Process Activity refines the need statement by detailing the implications of the needs in a more explicit set of requirements. It can be described as a kind of translation process from qualitative and informal statements in the "language" of the client (needs) to more quantified and precise statements of content and attributes of the required conceptual model (requirements).

Analyzing the requirements is a process of reviewing and evaluating the requirements to ensure that they are complete, consistent and correct.

Typical requirements originating from the conceptual model space may include:

- The views needed of the conceptual model by different stakeholders.
- The level of formality needed by stakeholders.
- Mandatory tools, documentation formats, notations, etc.
- Mandated conceptual model characteristics.
- What policy to follow to validate the conceptual model.
- What acceptance criteria to apply in validation.

In order to prepare the acceptance of the results of the V&V effort by the stakeholders used in PA5.5 (Ensure Acceptance of Conceptual Model by Authorized Stakeholder), it must be determined what information the stakeholders require for their acceptance decision-making process.

Typical requirements originating from the mission space may include:

- Definition of what parts of the mission space to be included in the conceptual model (Scope).
- Questions to be answered by the modeling and simulation effort (Critical Operational Issues (COIs)).
- Level of realism and detail needed in order to address the COIs (Abstractness characteristics).
- How the degree of satisfaction of operational issues are to be measured (Measures of effectiveness).

Typical requirements originating from the simulation space may include:

- Intended use of the model (e.g., training, feasibility study, trade-off studies, performance analysis).
- Implementation strategy and choice of fundamental technology.
- Explicit performance constraints (e.g., real-time requirements, Monte Carlo simulation requirements).
- Requirement to interface with existing software, hardware equipment or human operators.

5.2.2.2 PA2.2 – Verify Requirements with Respect to Needs, Constraints and Policies

Process Activity 2.2 shall ensure that the requirement specification satisfies important quality criteria. As `described in Section 4.7 V&V, an AF is built during the V&V work. For the first part of the AF a goal-oriented approach is taken. Starting with the top goal, criteria are derived in a hierarchical fashion. A part of those criteria deal with the requirements of the conceptual model space, the mission space and the simulation space. The requirements are to be verified against the criteria in that part of the AF.

Typical quality criteria are:

- **Completeness**: All needs, constraints and policies are covered by one or more requirements.
- **Traceability**: Every requirement statement can be referred to a corresponding need, constraint or policy statement.
- **Correctness**: All needs, constraints and policies have been interpreted as the sponsor intended.
- **Un-ambiguity**: The requirement is given a form that avoids misinterpretation.

Other possible criteria are consistency, adequacy, measurability, pertinence, feasibility, comprehensibility and good structuring.

Completeness ensures that all requirements implicit in the need statement and applicable constraints and policies are accounted for. Traceability ensures that no requirement that is *not* implied by these inputs has found its way into the requirement specification product. That is, there should be no element of invention at this stage. The requirement specification shall simply be an accurate reflection of preceding products.

The process of verifying the requirements may however reveal inconsistencies, inaccuracies or omissions in the input products. It is therefore a good opportunity to clarify and adjust Phase 1 products before weaknesses are propagated to downstream Process Phases.

5.2.2.3 PA2.3 – Synergize Conceptual Model, Mission and Simulation Space Requirements

Conceptual model space, mission space and simulation space requirements may in some cases be incompatible. There may therefore be a need for harmonizing any conflicting requirements. This is taken care of in Process Activity 2.3.

5.2.2.4 PA2.4 – Derive Mission and Simulation Space Knowledge Needs

Process Activity 2.4 shall produce a description of the knowledge needed by the developers of the conceptual model. These needs must be based on the conceptual model requirement specification and should identify relevant knowledge:

- Used by military personnel in the execution of their profession (tactics, techniques and procedures).
- About the scientific basis for military technology.
- About construction and performance of military technology.
- About simulation methods and technologies.

Note that only the knowledge *needs* are described at this stage, not the knowledge itself (which is the task of Process Phase 3). It is important to be careful in limiting the knowledge needs to what is strictly necessary for the conceptual model to be constructed. It is easy to be carried away by the wealth of information available and making the knowledge acquisition task more onerous than necessary.

Some aspects that should be considered when deriving knowledge needs are:

- The entities and behaviours that must be described by the model.
- The granularity or level of detailed needed in describing the phenomena to be modelled.
- Which simplifying assumptions can be allowed and what causal relationships must be included in the model.

When assessing these aspects the knowledge needed must finally be dictated by what questions the model is supposed to answer, that is the purpose of the model.

For example:

> *A simulation model shall be used to evaluate the effectiveness of flare countermeasures against infrared homing anti-ship missiles. In such a setting we may need the following type of knowledge:*

- *Missile flight trajectory, agility and speed.*
- *Missile seeker sensitivity, field of view and tracking ability.*
- *Missile seeker countermeasure discrimination ability.*
- *Countermeasure blooming profile, intensity and duration.*
- *Countermeasure alternative tactics for deployment.*
- *Ship IR signature.*
- *Ship maneuverability.*
- *Ship alternative maneuvering tactics.*
- *Environmental conditions influencing background IR radiation.*
- *Environmental conditions influencing IR radiation propagation.*
- *Environmental conditions influencing flare movement.*

Listed below are the points of emphasis:

- Bring any hidden assumptions into the open by spelling them out explicitly in the form of requirements and so reduce room for alternative interpretations.
- The knowledge acquisition needs should be limited to what is strictly needed.
- Leverage earlier requirements and knowledge specifications.

5.2.3 Process Phase 3 Guidance – Acquire Conceptual Model Knowledge

The Phase 3 in the NATO conceptual modeling process, called “Acquire Conceptual Model Knowledge”, will begin by taking the two products generated in Phase 2, which are P2.1 – Conceptual Model Requirement Specification and P2.2 – Conceptual Model Knowledge Acquisition Needs, as input. These inputs will be used to identify the authoritative knowledge sources for a particular piece of knowledge. Thus Phase 3 is where the knowledge required for description of a certain mission space will be acquired. This phase will, after gathering, structuring and documenting and review the validity of that acquired knowledge with respect to the authoritative knowledge sources, produce a product called P3.1 – Validated Knowledge. This product will serve as the foundation for designing and building the final conceptual model.

Given that a conceptual model repository already exists, this phase will begin by looking for reusable knowledge that may already be in the conceptual model repository and can be completely or partially usable for this new need. If not, the lack of knowledge is identified, along with the gaps that must be filled. But before that knowledge can be acquired the authoritative knowledge sources should be identified. After that, the required knowledge will be gathered, structured, and documented, and finally analyzed for necessity and sufficiency. After that, enough knowledge should exist to either generate a Domain Ontology for this particular mission space or to extend the existing Domain Ontology. The last activity in this phase will be to review the validity of the acquired knowledge with respect to the authoritative knowledge sources.

The third phase in the conceptual model development process consists of six Process Activities as shown in Figure 5-6.

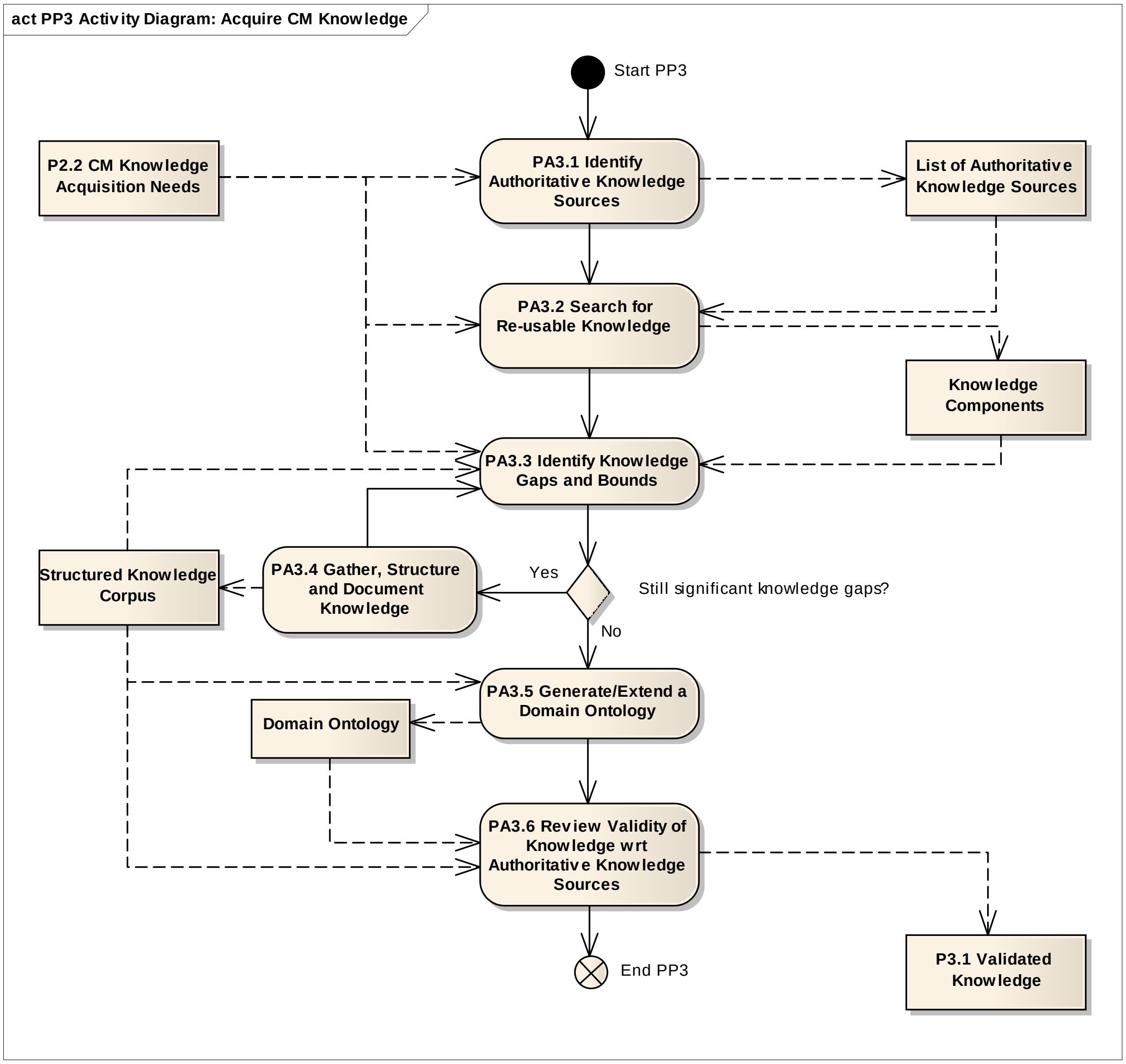

Figure 5-6: Process Phase 3 Activity Diagram: Acquire Conceptual Model Knowledge.

5.2.3.1 PA3.1 – Identify Authoritative Knowledge Sources

This activity is about identifying authoritative knowledge sources to fetch correct and authoritative information that describes a certain domain. Knowledge Acquisition (KA) belongs to the initial phases of almost any kind of system development process. There is no specific methodology for identifying appropriate sources for KA but the important issue here is to rely only on authoritative knowledge sources, those authorised by some organisation/authority beforehand (who this person or agency should be is beyond the scope of this report). These sources can be anything from books, web information, papers, regulations documents, pictures, maps, and case studies, but perhaps most important of all interviews with SMEs. Having a deeper understanding of the problem domain and (preferably) having experience of the particular area are necessary qualities for success.

5.2.3.2 PA3.2 – Search for the Reusable Knowledge in the Conceptual Model Repository

A successful result of this activity requires that good work is done in previous phases to identify the purpose, need, and requirements that are posed on the acquired information. This list of needs and requirements will be the foundation for building the necessary queries to the conceptual model repository. Keep in mind that several qualitative properties are critically important to search and find either the reusable knowledge component (part of a conceptual model) or a complete conceptual model fulfilling a specific need. One is to try to model knowledge in smaller components that makes reusability easier. The other property is to have a degree of formalisation and semantic description that makes it possible to compose smaller components for building the needed conceptual model. The third is to have good Meta data addressing artefacts in the Conceptual Model Repository; this makes it possible to easily find the knowledge which corresponds to the need.

5.2.3.3 PA3.3 – Identify Knowledge Gaps and Bounds

This activity concerns whether the knowledge retrieved from an existing conceptual model repository is in accordance with the requirements; here the reusability of already gathered conceptual models or components will be examined to see if they can be used for the new purpose. The outcome aids in identifying what is missing. This activity will be considered only if the result of the previous activity (search for the reusable knowledge in the conceptual model repository) has been that the knowledge components have been found that only partly fulfils the need. These are then compared with the requirements to make certain that either the set of requirements are fulfilled or alternately, if knowledge corresponding to a specific requirement is missing, further knowledge acquisition will be taken care of in the next activity.

5.2.3.4 PA3.4 – Gather, Structure and Document Knowledge

Information sources for military activities can be anything from instructions, books, military doctrines, military scenarios, and case studies to military experts, Subject-Matter Experts, etc. However, the information that is needed for a certain purpose is often not documented anywhere and is only available through SMEs. Since there is no easy way to access this knowledge and it is often expensive to gather, recount, and store. This activity is about gathering, structuring and documenting this important knowledge. Certain military knowledge is often not documented anywhere and is only available through SMEs. The art of gathering this information from SMEs is usually called *Knowledge Elicitation (KE)* and is considered to be one of the greatest challenges of KA. Another challenge is to capture and obtain tacit knowledge – things that the expert does routinely, without much thought and considered obvious by the expert. The more knowledge an expert possesses, more is often considered obvious and it is usually more difficult for him to recount what they know.

5.2.3.5 PA3.5 – Generate/Extend a Domain Ontology

The previous activity has captured and documented new knowledge about a certain military activity that did not already exist in the conceptual model repository. It means new knowledge most likely will introduce new military concepts, properties, relations, and constraints which should be stored in some kind of knowledge base for future use and reuse. This activity covers structuring, tagging, and storing the gathered information either as new domain ontology or as an extension to an existing one.

5.2.3.6 PA3.6 – Review Validity of Knowledge with Respect to the Authoritative Knowledge Sources

This activity is about evaluation of the validity of acquired knowledge with respect to authoritative knowledge sources. This occurs by examining whether the result of the knowledge acquisition phase is acceptable to the owner of the mission space (the SME). It is about checking with the experts, whose realities have been captured and documented, to see if the documented knowledge is correct and completely represents the activity. This is preferably performed by a VV&A agent.

A challenge of knowledge acquisition is that it often begins with the gathering of information from descriptions about a certain domain, through books, papers, tutorials, etc. All stored information is static while reality is dynamic and in constant change, which, if nothing is done, results in information that has been correctly gathered, but over time, becomes out-dated. Another challenge may appear when several experts have to be involved, where each expert might use different terminology or emphasize different things. A method for solving this can be to have one expert write something and then use a system of peer-review to iteratively refine the data. However a good methodology for keeping the generated conceptual models updated over time is required.

5.2.4 Process Phase 4 Guidance – Design Conceptual Model

The objective of this phase is to translate the conceptual model requirements into a conceptual model design preparing to build the actual conceptual model.

The conceptual model design explicitly trades off and balances conflicting requirements, such as the stakeholders understanding and involvement in the simulation development process and enterprise mandated policies.

It may seem artificial to explicitly separate the design and the building. However, a conscious conceptual model design makes the producers aware of their own bias relative to the stakeholders' bias.

The conceptual model design is basically a top-down selection of conceptual primitives, model kinds, views, formalisms and notations. The selection can be influenced by the bottom-up choice of reusing existing conceptual model artefacts. The design must be submitted to an evaluation against the conceptual model requirements for typical quality criteria like completeness and fitness for purpose.

The conceptual model design is divided in six activities:

- PA4.1 – Search for Existing Conceptual Models that May be Partially or Fully Re-Used to Support the Current Conceptual Model Development.
- PA4.2 – Identify and Select Conceptual Primitives and Model Kinds to Represent Acquired Knowledge.
- PA4.3 – Select Formalism(s) for Conceptual Model Specification.
- PA4.4 – Select Views to Support Stakeholders.
- PA4.5 – Select a Notation Suitable to Express the Chosen Formalism.
- PA4.6 – Evaluate Design for Adequacy/Relevance with Respect to Requirements.

As shown in Figure 5-7, conceptual primitives, model kinds, formalisms, views and notations are implicitly entangled, but they are artificially separated to make the producers aware of the interrelation of design choices and their consequences on meeting the stakeholders' expectations and the conceptual model characteristics requirements. This separation is necessary to be intentionally selective on the conceptual model design options. It is an investment against the risk of uninformed use of conceptual model components.

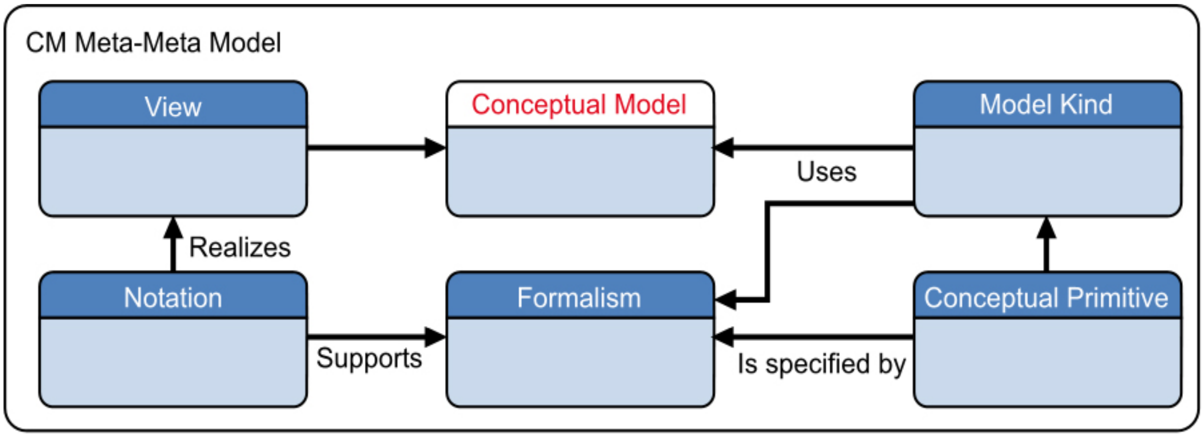

Figure 5-7: Conceptual Model Components.

The activity diagram in Figure 5-8 shows how the activities are interrelated.

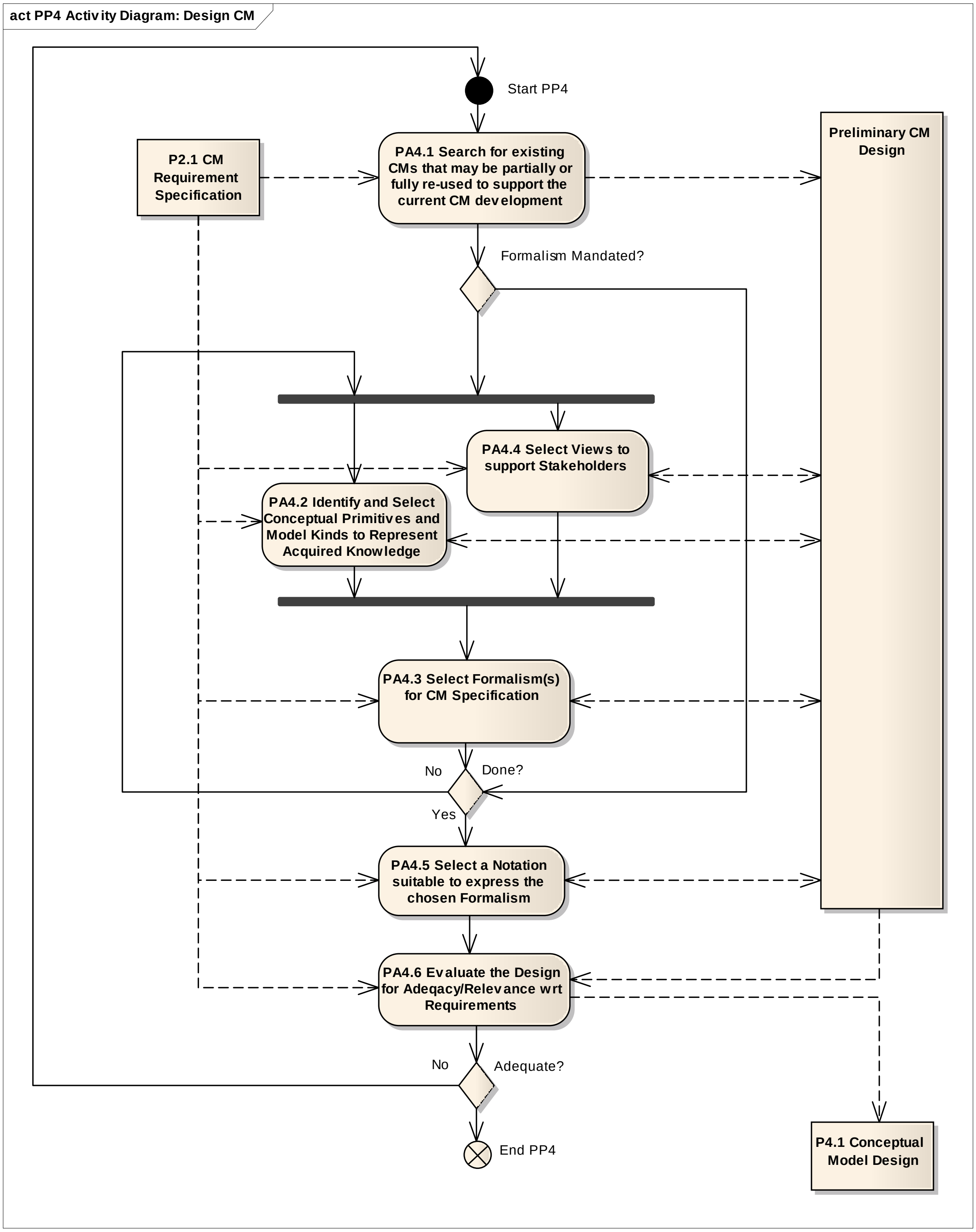

Figure 5-8: Process Phase 4 (PP4) Activity Diagram.

There is no mandatory order in PA4.1 to PA4.5. They all input to the preliminary design for evaluation in PA4.6 and for acceptance by the stakeholders as the Product 4.1 – Conceptual Model Design. Several preliminary design and evaluation cycles are usually required to finally pass the evaluation. Experience will allow passing the evaluation with fewer cycles.

Annex I presents several examples of different conceptual model designs. The example in Annex I, Section I.5 specifically emphasizes on the iterative conceptual model design process.

5.2.4.1 PA4.1 – Search for Existing Conceptual Models that May be Partially or Fully Re-Used to Support the Current Conceptual Modeling Development

In this Process Activity, the producer of the conceptual model is searching for existing partial conceptual models with the intention of reusing it for the conceptual model design. Typical search criteria are driven by mandated enterprise policies, the obligation for stakeholder's involvement and relevant common practice. Even if the producer cannot find an appropriate conceptual model design that suits all of these criteria, a conceptual model design that has been used successfully might be a good starting point. Future iterations are likely to refine search criteria and hint of other existing designs.

Motivations for reusing conceptual model designs are to avoid discussions that have been settled in the past and endorse common practice within a relevant community.

5.2.4.2 PA4.2 – Identify and Select Conceptual Primitives and Model Kinds to Represent Acquired Knowledge

In this Process Activity, the producers select suitable conceptual primitives that will capture the knowledge elements and the model kinds that will organize the conceptual primitives.

The producers do not need to know the exact knowledge content to be modelled, but need to have a rough idea of the domain area and the type of knowledge. For example, decision support knowledge may require action-related conceptual primitives while system knowledge may require function-related ones.

The producers need to analyze the conceptual model characteristic requirements from P2.1 – Conceptual Model Requirement Specification to derive the implications on conceptual primitives and model kinds.

The producers need to know about the conceptual primitive and model kind options either from the literature or from experience. There is a critical need to further develop the body of knowledge necessary to categorize the conceptual primitives and model kinds in terms their implications on conceptual model characteristics on the other conceptual model components. For example, it would be useful to understand how characteristics such as expressiveness, computability or level of detail influence the choice of conceptual primitives and model kinds.

Each time the conceptual primitives and model kinds are updated; they influence other conceptual model components, the existing conceptual model artefact and its Meta data, including its characteristics and its validation status. Conversely each time other conceptual model components and requirements change, the conceptual primitives and model kinds will be influenced.

5.2.4.3 PA4.3 – Select Formalism(s) for Conceptual Model Specification

In this Process Activity, one or more formalisms are selected to be enforced in the build phase. A formalism is the constraint of form over content. A formalism can be more or less formal. The formality is the amount of constraints imposed on the form. Informal representations such as loose or structured natural language would not be considered as a conceptual model (e.g., glossaries, dictionaries, thesaurus, and hierarchies). A formal representation imposes an artificially defined formalism. A more formal formalism clearly defines concepts with semantics, theorems and proofs that enable inferences. A higher level of formality fosters some conceptual model characteristics such as consistency, interoperability, reusability, computability and executability.

Several formalisms may be required to bridge the gap between different stakeholders. For example, decision-makers, simulation end-users, simulation developers and machines may feel more comfortable to retrieve meaningful and valuable input from a particular paradigm or a particular level of formality. The conceptual model design is meant to cope with contradictory requirements such as expressiveness for human understandability (e.g., Mind Map or UML) and computability or executability for machine readability (e.g., Web Ontology Language (OWL)).

The formalisms are carefully chosen according to the policies, the characteristics and the stakeholders' requirements from P2.1 – Conceptual Model Requirement Specification. In an iterative and incremental design process, the choice of formalism is driven by and influences the other conceptual model components, the existing conceptual model artefact and its Meta data, including its characteristics and its validation status.

The producers need to know about the formalism options either from the literature or from experience. There is a critical need to further develop the body of knowledge necessary to categorize the formalisms in terms their implications on conceptual model characteristics and on the other conceptual model components.

5.2.4.4 PA4.4 – Select Views to Support Stakeholders

In this Process Activity, views are selected to fit the purpose of the different stakeholders. Views are the graphical user interfaces of the conceptual model. When selecting views, the producers are always biased by their own way of "seeing" the problem. It is of utmost importance to make an elective choice of views that support the stakeholders' requirements.

A complete conceptual model design generally includes multiple views. For example, Department of Defense Architecture Framework (DoDAF)/NATO Architecture Framework (NAF) includes an Operational, System and Technical views. UML offers Design, Process, Component, Deployment, Use Case views.

A view can be represented by several model kinds. For example, the UML Process view represents dynamic aspects using State, Activity, Sequence and Collaboration diagrams.

Although views are prescribed by P2.1 – Conceptual Model Requirement Specification, many other latent views can emerge from available conceptual primitives and model kinds if a stakeholder requires it. In an iterative and incremental design process, the stakeholders' representation requirements and the views can evolve as the conceptual model is being built.

The producers need to know about the view options either from the literature or from experience. There is a critical need to further develop the body of knowledge necessary to determine which views are appropriate fit which stakeholders' representation requirements and which conceptual primitives and model kinds make meaningful views.

If formalisms have been selected in the preliminary conceptual model design, they may impact on the discretionary specification of views. There may be more than one way of presenting a view and a specific formalism may impose specifications on the view.

5.2.4.5 PA4.5 – Select a Notation Suitable to Express the Chosen Formalism

In this Process Activity, suitable notations are elected to express the formalisms, the conceptual primitives, the model kinds and the views selected in the preliminary conceptual model design. The choice is driven by P2.1 – Conceptual Model Requirement Specification. For example, in Annex I, Section I.2, the Use Case view was expressed using a custom pictogram notation instead of the UML notation to meet an expressiveness requirement. Introducing the UML notation to non-initiated decision-makers could have added an overhead if not a misunderstanding.

The producers need to know about the notation options either from the literature or from experience. There is a critical need to develop the body of knowledge necessary to explicitly categorize the notations in terms of supported formalisms, conceptual primitives, model kinds, and views.

In an iterative and incremental design process, the selected notations need to be adapted when the requirements and the conceptual model design change.

5.2.4.6 PA4.6 – Evaluate Design for Adequacy/Relevance with Respect to Requirements

In this Process Activity, the stakeholders verify whether the conceptual model design meets the criteria that are manifest in the conceptual model requirements. Their criteria are also part of the V&V argumentation framework. Typical topics that must be specified and transformed into criteria are whether all views needed by the stakeholders are available and for each view whether the chosen formalism is capable of expressing the conceptual model. For example, there must be one or more model kinds that present and completely cover the user's view. There must also be one or more views that present and completely cover the designer's view.

Listed below are the points of emphasis:

- It is not necessary to wait until the requirements are perfect before starting to design the conceptual model and it is not forbidden to start building the actual conceptual model to express the intent as the effort progresses in order to help progressing through the requirements. This conceptual modeling guidance supports the creative process of evolving a conceptual model. Trying to express in building a preliminary conceptual model is part of the iterative design.
- The conceptual model design always starts with an informal mean to express ideas. It evolves each time the mean induces ambiguity or constrains what needs to be expressed. The evolution is from less formal to more formal. The process of evolving a conceptual model design is essential to the stakeholders self and mutual understanding. The conceptual model design process is a learning process; the process of becoming aware of self and others' understanding, bias and expectations. There is more to it than just what is recorded in the actual conceptual model artefact. The journey serves as much as the end destination.
- It is important to be intentionally selective on the conceptual model components (conceptual primitives, model kinds, views, formalisms, and notations) to reduce the risk of uninformed use of components.
- The producers have the discretionary choice of conceptual model components, but they also have the responsibility to justify their choice.

- Because the conceptual model components are tightly entangled, this five-unknown system of equations can only be solved iteratively until the requirements are all satisfied and the design is reconciled in a coherent conceptual model component combination. It is advised to select conceptual model components and try building a preliminary conceptual model. If the design becomes too constraining, it is time to redesign toward another level of conceptual model characteristics.
- Specific modeling tools are helpful to design coherent conceptual model component combinations. It is not rare that the tool influences the design choices, which may affect the conceptual model characteristics.
- It is important to remind that although the coherence of the conceptual model component combination is a necessary condition, the conceptual model design must be driven by the requirements, mostly stakeholders' representation requirements and conceptual model characteristics requirements.
- It is important to document which requirements cannot be met within the constraints of the design and to update the effective conceptual model characteristics accordingly in the conceptual model Meta data.
- It is not rare to feel the need to invent new conceptual model components when encountering expressiveness limitations. This is why general modeling languages allow creating profiles (e.g., UML, SysML) and common standards emerge from specific communities. It is useful to look at related community conceptual models, as a reference since they are likely to suit similar needs. It is not wrong to invent new conceptual model components when nothing satisfying already exists. It would be useful to develop the body of knowledge to determine the common design patterns (appropriate conceptual model component combinations) typically used by the M&S community.

5.2.5 Process Phase 5 Guidance – Build Conceptual Model

The Conceptual model development Process Phase described here is the final stage of the five-step process and entails the completion of the subject conceptual model by means of its compilation and qualification for its intended use.

The components of Phase 5 (PP5) Process Activities, their inputs, and resulting products are indicated in diagram of Figure 5-9 below.

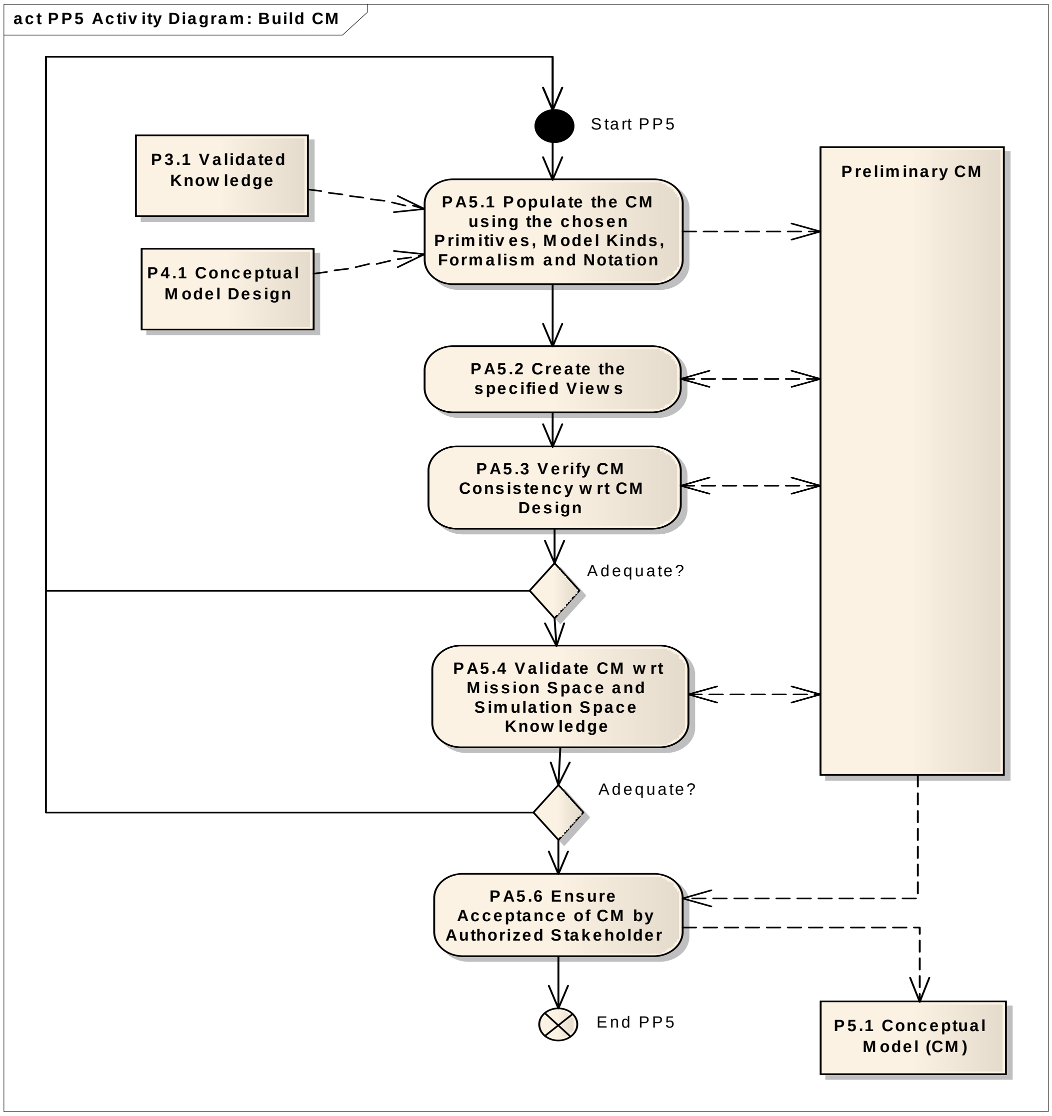

Figure 5-9: PP5 Activity Diagram: Build Conceptual Model Indicating Process Activities, Process Flow, and Artefact Generation.

Depending primarily on the results of proceeding activities including work-products (i.e., P3.1 – Validated Knowledge and P4.1 – Conceptual Model Design), and resulting in a single work-product result (i.e., P5.1 – Conceptual Model); Phase 5 consists of five (5) Process Activities (PA5.1 through PA5.5) whose contextual circumstances, execution, and consequent results together with inter process flows will be elaborated in the commentary that follows and in detailed formal specification in Annex G, Tables G-23 through G-28.

Some guidance relevant to the entire PP5 – Conceptual Model development phase includes the following elements considered prudent for any such product build effort:

- Confirm entrance criteria are satisfied and that all necessary resources are likely to be available in time.
- Establish Group composition, roles and responsibilities.

- Establish expectations for the execution of all Process Activity elements. Plan effort and manage to resources, schedule, and product deliverables.
- Confirm exit criteria with conceptual model product customer/user.

5.2.5.1 PA5.1 – Populate the Conceptual Model Using the Chosen Primitives, Model Kinds, Formalism, and Notation

Several considerations relevant to the execution of PA5.1 relate to: input assets, preparation for effort execution, conduct of the activity itself, and the nature of resulting effort.

Overall program management agent for conceptual model effort is presumed to provide:

- A full specification of characteristics of an acceptable conceptual model product; and
- A complete set of validated knowledge of both the mission space and the simulation space.

Nevertheless, conceptual model build Task Group should be prepared to communicate liberally with Process Phase 3 and 4 execution agents to request clarification of information provided in work-products P3.1 and P4.1 and to request additional information determined necessary to complete the model specification as build population proceeds.

In preparation for formal task activity, anticipation of circumstances likely to arise during the effort is prudent. Building of a conceptual model entails a variety of determinations that may not be fully prescribed by design guidance but which are likely to affect the efficiency and quality of conceptual model product. In each of these cases, provisional determinations by the conceptual model build Group are recommended.

Build strategy refers to the election of style of operation by the Group, election of alternative design options not otherwise bound by requirements, and establishing such stylistic conventions as may facilitate cooperation and efficiency of the Group. Build versions may be spiral so that a succession of products is generated progressively converging on the desired result. Alternatively, parallelization techniques such as partitioning the mission space, allocating model constructs (i.e., primitives or model kinds) to Group members of the group may be convenient.

Election of alternative options for Primitives, Model kinds, Formalisms and Notation which may persist, consistent with P4.1 – Conceptual Model Design specified constraints may be necessary. These determinations and such style conventions to be shared across the Group should be established by consensus before significant build composition effort is begun. Checking the implications of such determinations during first spiral reviews will reassure the Group of the wisdom of its choices.

Prefatory interpretation of sufficiency criteria for the expected product, cast in terms of easily observable and confirmable product characteristics and evidently correlated to requirements specification elements will provide insurance against shortfalls in product quality in areas such as detail and completeness (scope, entities, entity-attribute and entity-relationships) as specified.

Selection and prompt access to sufficient tools is prerequisite to start of work. Selection of such tools should be made carefully with consideration for:

- Familiarity and competence of Task Group;
- Power to meet conceptual design capture and specification; and
- Facility to generate views and published data products acceptable to customer user stakeholders.

Finally, establishment of Product Document management process and information storage and retrieval sufficient to contain the evolving conceptual model work-product, control of its authoritative configuration and containing commentary on tactical decisions – just as is prudent for requirements or code management under other circumstances.

During execution, conduct of Group reviews of work progress, product convergence according to build strategies, and product quality should compliment normal program reviews and control mechanisms. Cultivation of consistency of vision across the conceptual model build Group is a powerful mechanism to maintain consistency of product, and collaboration among Group members.

Work-product capture in tool consistent with Model Design guidance in form suitable for use as publication or transmission of database as Product P5.1. For this purpose, preliminary coordination with Stakeholder recipient is prudent.

5.2.5.2 PA5.2 – Create the Specified Views

Assuming the requirements for conceptual model design are satisfied, and tools that sufficiently articulate and powerful, the generation, capture, and publication into document or database archive under configurable control should be straightforward. In order not to be disappointed in this expectation, view generation should be included in product reviews during PA5.1.

5.2.5.3 PA5.3 – Verify Conceptual Model Consistency with Respect to Conceptual Model Design

The practice of system, software, or simulation verification is of course too extensive in its scope and detail and too myriad in its alternative strategies, tactics and techniques to be specified here. With respect to the range of options available for verification of the preliminary conceptual model, the most important considerations are consistency, and sufficiency – otherwise wide discretion is allowed to the conceptual model build group commensurate with ‘good practice’ contingent that such process as is elected is declared and documented together with the results of its execution.

Sufficiency of verification consists in a complete, documented, persistent, and traceable confirmation that all the attributes required by the conceptual model design of P4.1 are present in the subject conceptual model. Naturally deliberate and professional requirements management beginning with conceptual model design and proceeding through the process of model build is desired in avoiding (or, alternatively in detecting) such errors of omission.

Consistency in verification entails that attributes of the Conceptual Model are in fact self-consistent (presumably in accordance with Conceptual Model Design) and that, in particular, no pathological attributes of the Conceptual Model not addressed in the Design are present that will interfere with the acceptability of the conceptual model in supporting its intended use and in meeting the need for which it was conceived and created. Such errors of commission are more difficult to identify without a consistent representational schema in the design, conscientious attention to build discipline, and thorough testing and customer use. Execution or inspection of the conceptual model in representation of use cases that may have been used in its design as well as with such *cases that were not used in its design* will likely be helpful.

5.2.5.4 PA5.4 – Validate Conceptual Model with Respect to Mission Space and Simulation Space Knowledge

See above, recognizing the distinction between verification and validation, and interpreting the above in relation to the appropriate referent – that is, Validated Knowledge of Product P3.1.

5.2.5.5 PA5.5 – Ensure Acceptance of Conceptual Model by Authorized Stakeholder

Whereas verification and validation are technical determinations of goodness of fit or similarity between artefact (here a conceptual model) and one or another referent (here design requirements, and Validated Knowledge respectively); accreditation is an administrative decision regarding the degree to which an asset (here the conceptual model) is acceptable for its intended use. On this account, accreditation processes entail articulate collaboration between the accreditation agent stakeholder and the proponent of the asset in question. Several considerations pertain to this circumstance.

First of all, unambiguous identification and acquiescence of the identity of the accreditation agent is necessary. If the authoritative accreditation agent (or agents) is not clearly identified, due, for instance, to the relatively large number of agents with a significant ‘stake’ in the conceptual model, an inefficient decision process is to be expected at best. Note that multiple accreditation agents for alternative intended uses are not uncommon for either simulations or conceptual models.

Clarity of agreement on intended uses and re-confirmation of accreditation exit criteria in advance of the accreditation application is prudent if only to remove inconsistency between acceptability of the conceptual model asset due to migration or evolution of the use or changes in staff appointees.

It is incumbent upon the conceptual model build agent to have designed and execute factory acceptance tests and if desired user delivery tests whose results have been suitably documented, interpreted and reported in anticipation of the preparation of submission of accreditation request. Coordination of accreditation reviews; support of the accreditation decision process itself; documentation of the consequences and its delivery with the completed Product P5.1 prepared in compliance with associated guidance completes PA5.5, PP5 and conceptual model development.

5.3 CONCEPTUAL MODELING PROCESS CONCLUSION

In preceding text, a linearized account of recommended best-practice guidance for conceptual model development and management process is provided. That account is intended to be interpreted together with the more terse but systematic specification provided in Annex G as constituting recommended best-practice conceptual modeling process. Every effort was made by the Task Group to produce necessary and sufficient guidance; in forms that are comprehensible, consistent, and sufficient for guidance of practice throughout the conceptual modeling process and practically; while leveraging the minimal sufficient binding on the conceptual modeling practitioner in favor of allowing liberal elective of style, an convention commensurate with the challenge of the effort and the cultural, technical and business practice constraints of the enterprise environment in which effort is effected.

Chapter 6 – CONCEPTUAL MODEL PRODUCT GUIDANCE

Having addressed in Chapter 5 and its associated Annex G the process intended by the MSG-058 Task Group to be executed by the "M&S Conceptual Model Development Practitioner" agent. We proceed to discuss the expected results of completion of the "Conceptual Modeling Best-Practice Development Process", namely the Conceptual Model itself.

6.1 PRODUCT GUIDANCE INTRODUCTION

This chapter provides the MSG-058 Task Group's "Best-Practice Guidance Specification (BPGS)" for the "Conceptual Model" Product as indicated in Figure 3-4. These products include the conceptual model itself, as well as intermediate documents produced in the course of following the conceptual model development process. The intermediate products are critical to document and transfer information from one Process Phase to the next, and are also very valuable references for later simulation development, and for conceptual model management throughout the life cycle, including VV&A.

This guidance details the intents and ideas behind these products and how they relate to different phases of the conceptual model development process. It defines the main products the process should generate, what ideas, views and information should be contained in each of them, their structure and their format.

The complete set of products associated with conceptual model development is as follows. They are numbered with respect to the Process Phase within which each one is developed:

- P1.1 – Stakeholder Description.
- P1.2 – Need Statement.
- P1.3 – Constraints and Policies.
- P1.4 – Conceptual Model Meta Data.
- P2.1 – Conceptual Model Requirements Specification.
- P2.2 – Conceptual Model Knowledge Acquisition Needs.
- P3.1 – Validated Knowledge.
- P4.1 – Conceptual Model Design.
- P5.1 – Conceptual Model.

Each of these products will be discussed in more detail in subsequent text, and technical descriptions of each are provided in Annex H.

This product set has been designed such that all information transfer between conceptual model development phases is contained within the set of documents. Further, these documents are the input and output of specific phases. This relationship is shown in the context of the development process in Figure 6-1.

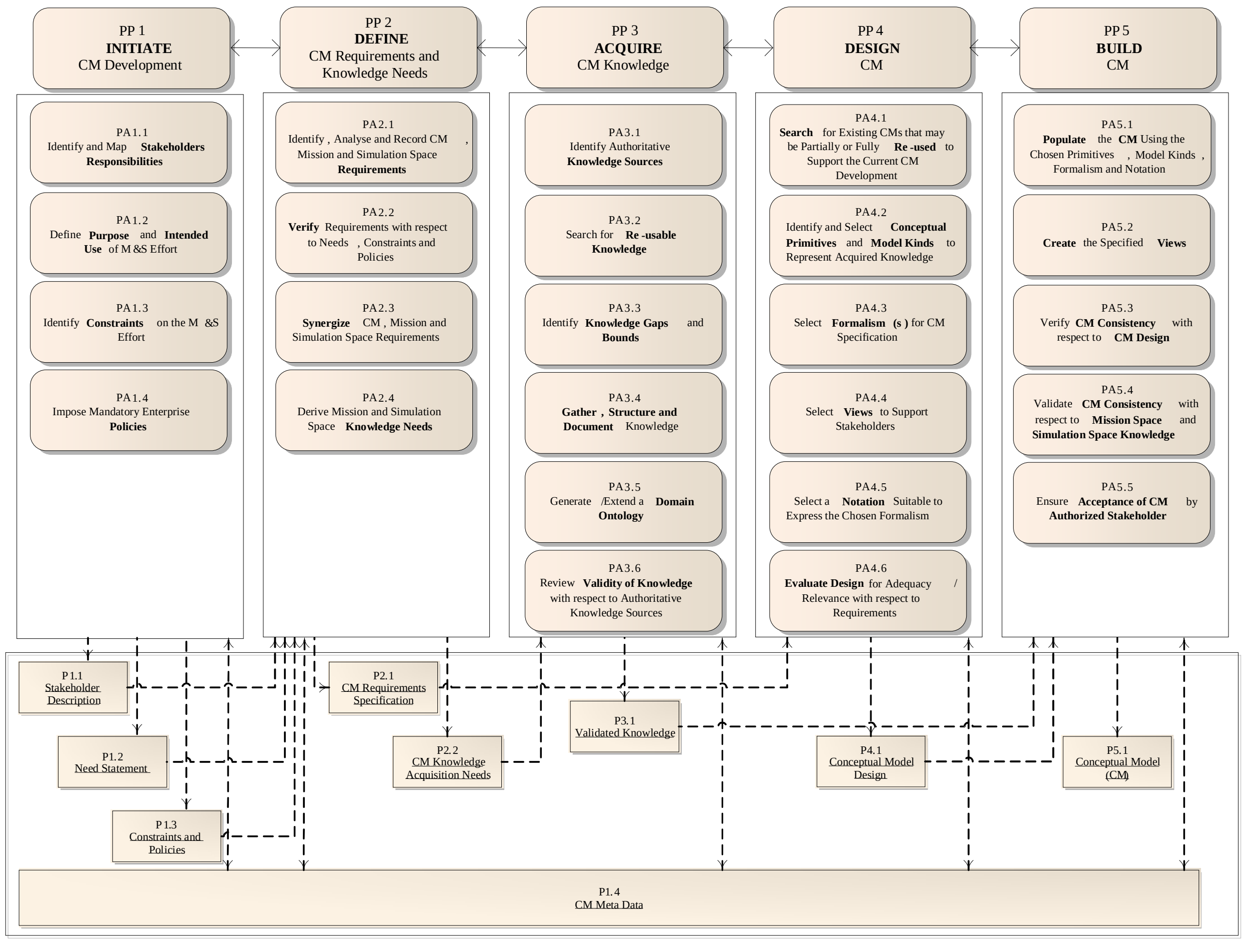

Figure 6-1: Conceptual Model Process and Product Relationships.

From this figure, it can be seen that Stakeholder Descriptions, Needs Statement, and Constraints and Policies are generated in the 1st phase and provide input to the 2nd phase, but do not continue to influence subsequent phases. This means that all relevant content of these products must be translated into the Conceptual Model Requirements Specification and Conceptual Model Knowledge Acquisition Needs documents during the 2nd phase. Likewise, the Conceptual Model Requirement Specification must be translated into the Conceptual Model Design in the 4th phase to provide input to the fifth and final phase, whereas the Conceptual Model Knowledge Acquisition Needs are translated into Validated Knowledge in the 3rd phase and made available directly to the 5th phase. Conceptual Model Meta Data is modified and used throughout every phase.

Listed below are the points of emphasis:

- The provided products are provided as best-practice in conceptual model development.
- These products may be tailored as needed by the developer.
- Product development will be as allowed by the previously described process.
- Intermediary products should be preserved as valuable artefacts for the conceptual model life cycle.

6.2 CONCEPTUAL MODEL PRODUCT DESCRIPTION

In the sections that follow, discussion of the desired conceptual modeling product and its component elements are provided. The intention of the text is to provide a plausible explanation and rationale of the entire work-product expected to be necessary and sufficient to constitute a military simulation conceptual model.

In particular, information is provided that is intended to address:

- Motivation for conceptual model component artefacts.
- Considerations relevant generation of specific conceptual model components not wholly addressed in the preceding process specification.
- Data-item description of conceptual model components, including explication of:
  - Information content recommended for the subject data component;
  - Data format suggestions for syntactic specification of information;
  - Manifestation in forms that are suitably consistent, manageable, persistent, accessible, and re-usable; and
  - Relationships among conceptual model information artefacts.
- Fundamental utility, special value with respect to quality, cost effectiveness, 'ilities', etc.
- Special sensitivities associated with generation, administration and use of conceptual model component elements.

This account is provided as a complimentary and consistent form of guidance which, when taken together with the systematically tabular guidance specification contained in Annex H, is considered necessary and sufficient to inform best-practice results.

6.2.1 Product 1.1 Guidance – Stakeholder Description

The Stakeholder Description product component is a document-mapping stakeholder to roles and responsibilities in the conceptual modeling effort throughout the entire enterprise life cycle. The purpose of this product is to identify the stakeholders of a particular conceptual modeling development effort and their respective roles and responsibilities to enable staffing/tasking of the conceptual modeling development effort, derivation of stakeholder-related requirements and stakeholder-related knowledge needs, and identification of subject-matter expertise for knowledge acquisition, capture, administration, and use.

At a minimum, the product includes relevant conceptual model development responsibilities identified and grouped into roles, and stakeholders identified organizationally, mapped to responsibilities and roles. It is desirable to also include stakeholder identities by name, and point of contact information, when known. Stakeholder candidate classes are thoroughly described in Section 4.3.3 of this document, and the Process Activity to generate this product is described in Section 5.2.1.1.

Stakeholder role specification within the enterprise is indicated in the Figure 6-2, wherein composition of role specifications and types of role functions are generally indicated. (see Lexicon/Glossary, Annex J for terminology definitions) Naturally, alternative concepts of role specification are admissible, but should be prescriptively defined in relevant documentation along with accompanying role descriptions.

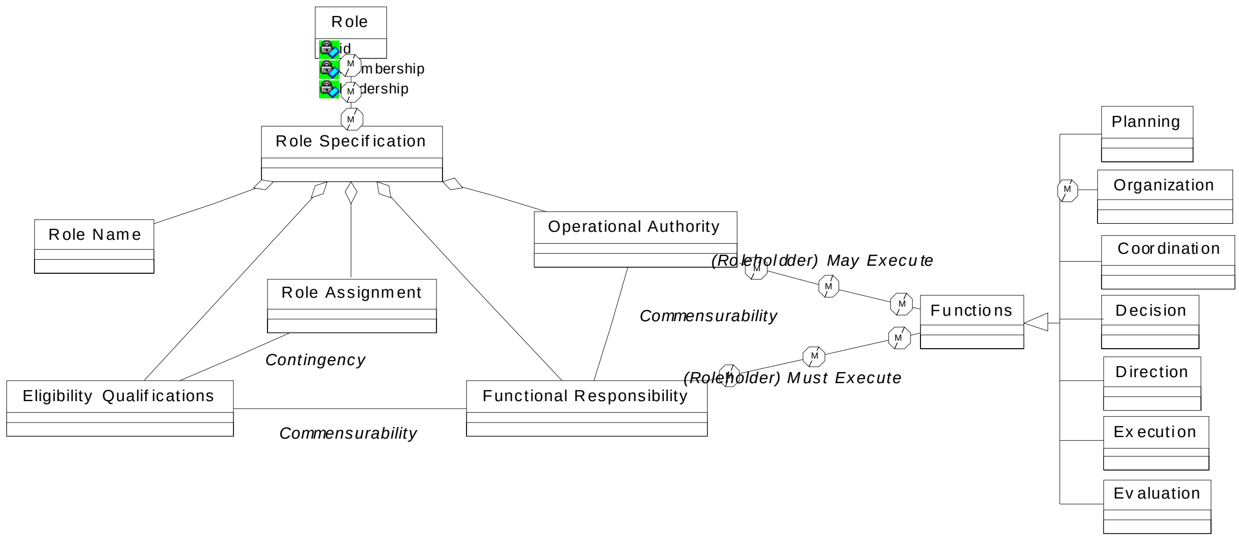

Figure 6-2: Components of a Role Specification and Relationships to Role Functions.

Information content suggested as minimally sufficient for documentation of conceptual modeling roles actually employed within the enterprise is suggested in Figure 6-3. Note the obvious distinction between role specification and role-holder agent or individual. This segregation particularly facilitates the establishment of organizational postures for the conceptual modeling agents with the enterprise in anticipation of or commensurate with appointment of, or changes-to particular role-holder assignments.

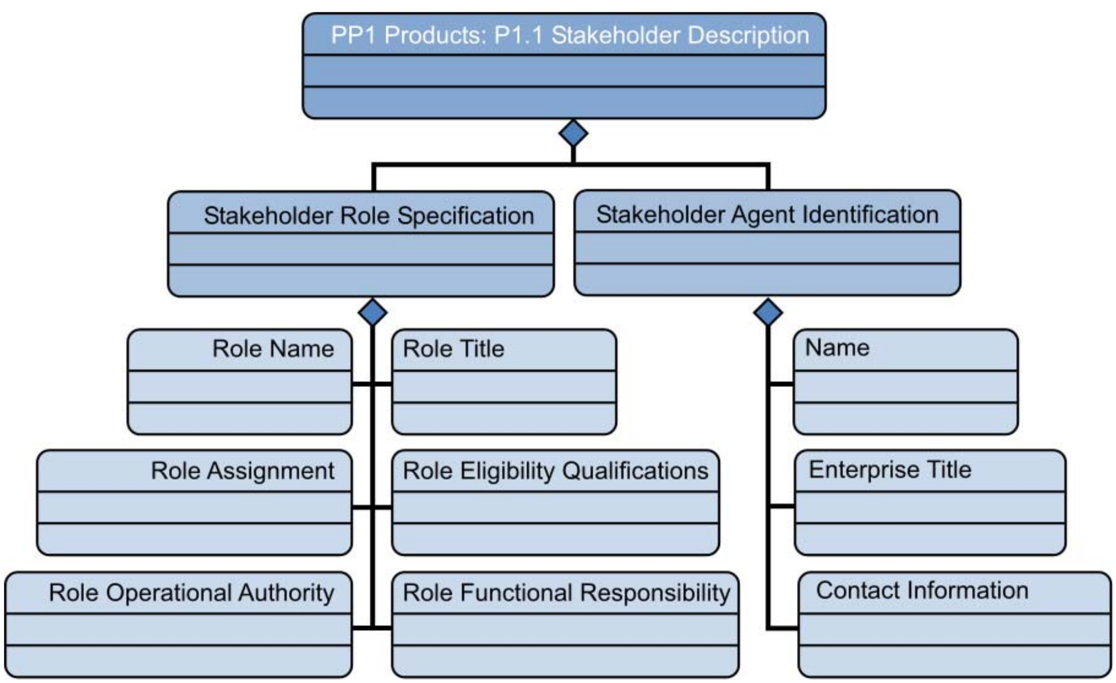

Figure 6-3: Suggested Role Specification and Stakeholder Role Assignment Information Taxonomy.

As indicated in Section 4.3.3, the fact of the usual diversity and particular nature of stakeholder postures relative to conceptual modeling within the enterprise is a matter of considerable sensitivity. Difficulties arising from failure to appreciate the existence, necessity and inter-relationships among these roles commonly afflict conceptual modeling efforts and denigrate the consequent value of conceptual model products. Systematic investment in stakeholder role specification as a formal part of the conceptual model product is considered well worth its relatively modest cost.

6.2.2 Product 1.2 Guidance – Need Statement

The Need Statement product is a document that defines the intended use of the conceptual model, derived from the purpose and intended use of the M&S within the expected enterprise environment. This product serves as the source from which to generate the derived set of conceptual model requirements and knowledge. The Process Activity to generate this product is described in Section 5.2.2.4.

Publication of conceptual model needs statement is motivated by the criticality of preservation of audit traceability from intended use of prospective simulation implementations through expected uses of the conceptual model itself throughout the simulation enterprise life cycle. In tracing these related needs and intended uses, it is important to consider the conceptual model and the consequent simulation generated there-from as distinct product entities. Sequentially, the need for the simulation typically arises first; then, the need for the conceptual model to support the life cycle of that simulation is made manifest. Thereafter, conceptual model requirements may be generated based both on simulation needs and other potential utility of the conceptual model in the enterprise environment. Conceptual model requirements emerge and the conceptual model is itself developed and published. Thereafter, simulation requirements may be finalized, manifesting components of the conceptual model – from which the simulation itself is developed. While this sequence of events is not always adhered to, and while spiral or concurrent simulation development within an enterprise environment often admits to contemporaneous conceptual model and simulation product evolution; the value of audit traceability of the respective process and build threads by means of maintenance of conceptual model needs statements for successive block-builds is difficult to overestimate.

For purposes of reference for each of the components of the conceptual model product suite, the canonical causal sequence of ‘needs’, ‘requirements’, ‘design’ and ‘implementation’ may be considered applicable. The Task Group, while aware of this taxonomy, has not considered it necessary to address each stage of maturity evolution for each component product, but have, instead, selected the elements of such a matrix that most need explication, and for which best value may be attained for their explicit inclusion in the subject best-practice. In future guidance, consideration to completion of this best-practice-to-product-component may be found to deserve exhaustive coverage. Meanwhile, for reference to the entire matrix of possibilities as well as indication of matrix loci actually treated in detail in the best-practice guidance, the following table is offered.

Table 6-1: Array of Maturity Stages versus Conceptual Model Suite Component Product Addressed in Detail in the Subject Best-Practice Explication.

	DESCRIPTION	NEED	REQUIREMENTS	DESIGN	IMPLEMENTATION
Stakeholders	Section 6.2.1 Product 1.1	Section 6.2.2 Product 1.2			
Policy	Section 6.2.3 Product 1.3				
Meta Data	Section 6.2.4 Product 1.4	Section 6.2.4 Product 1.4	Section 6.2.4 Product 1.4		
Knowledge		Section 6.2.6 Product 2.2			Section 6.2.7 Product 3.1
Model			Section 6.2.5 Product 2.1	Section 6.2.8 Product 4.1	Section 6.2.9 Product 5.1

Conceptual model data-item specification is may be liberally adjusted in order to conform to enterprise conventions. In fact, many forms of needs statements are available; from which tailored adaptations can serve for conceptual models. As usual, what is imperative is that for any given conceptual model development within any given enterprise environment, the conceptual model needs statement specification formulary should be prescriptively agreed-upon among the stakeholder community and preserved longitudinally across successive conceptual model and simulation block-build cycles. Practically, sensitivity to the simulation – user's vernacular and preconceptions are recommended.

6.2.3 Product 1.3 Guidance – Constraints and Policies

The creation and use throughout the conceptual modeling process of an information-product documenting the strategic business-practice rules-of-the-road, manifest as operational constraints, policies and practices, is motivated by the need for conceptual modeling to exist as a component of the overall M&S enterprise environment in which it is conducted. Such operational guidance may exist pursuant to: organizational regulations; technical standards; enterprise conventions; stakeholder preferences; or contingency conditions relating to availability of information, staff or materiel resources, While such constraints and policies are present in every management context, their being made explicit and their being acknowledged by the entire conceptual modeling stakeholder community is particularly valuable in conduct of conceptual modeling programs. This special sensitivity results from the facts that:

- Conceptual modeling is poised as it is among stakeholder communities (particularly between simulation users and simulation developers);
- That the success of enterprise wide initiatives such as re-use and interoperability depend so strongly upon the deliberate and successful completion of conceptual modeling efforts; and
- That conceptual modeling is typically not administered with sufficient rigor to forestall the misapprehensions the can so easily arise in early phases of simulation development life cycle.

Naturally, documentation of such strategic guidance admits to any of a variety of forms of capture; and, since there is little precedent for such practice, some liberty is expected on the part of conceptual modeling agents in creating useful product of this type. In general, an explicit ‘living document’ kept under configuration control in the enterprise collaboration environment and available to all stakeholders for reference should suffice.

The Process Activity to generate this product is described in Sections 5.2.1.3 and 5.2.1.4. A more detailed technical description of this product is provided in Annex H, Table H-4.

6.2.4 Product 1.4 Guidance – Conceptual Model Meta Data

Meta data is generally used to describe the data it is referring to, and provides information about a certain item’s content, such as: means of creation, purpose of the data, time and date of creation, creator of data, what standards used, etc. The Conceptual Model Meta Data will address a conceptual model, acting as its identifier. Conceptual models are stored in a conceptual model repository for future use together with Meta data specifying how they have been produced, i.e., when, where, by whom, from what, using what tool, and so on. This Meta data is necessary to ensure traceability and reusability of the Conceptual Model. As shown in Figure 6-4, the Conceptual Model Meta Data is not part of Conceptual Model, but it is delivered as an end-product along with the conceptual model itself.

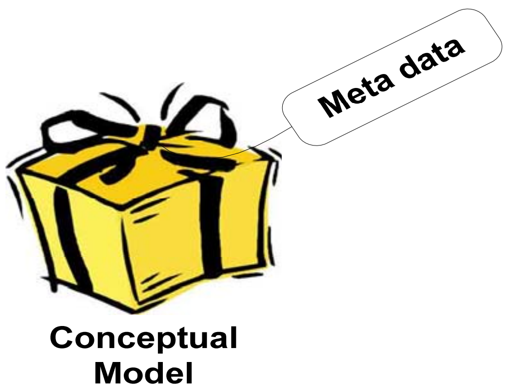

Figure 6-4: Conceptual Model Meta Data Must Always be Attached to the Conceptual Model.

The main role of a Meta data template is to facilitate reusability. Meta data provides information enabling inferences to be drawn regarding their reuse potential for supporting the extension and creation of models and simulations. Thus, it is important to include a minimum but sufficient degree of descriptive information about the conceptual model in its Meta data. An abstract view of the Meta data part of the conceptual model template is presented in Figure 6-5.

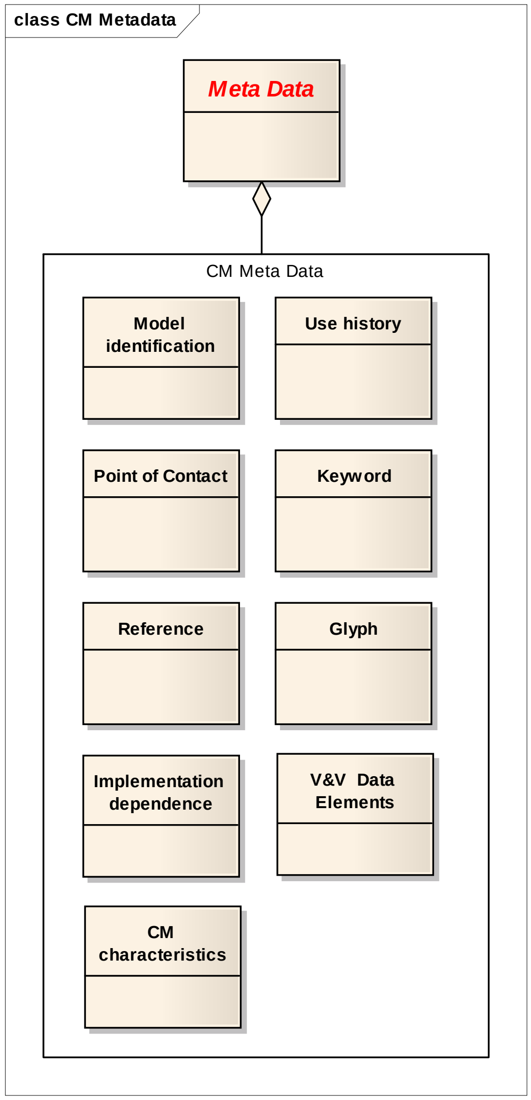

Figure 6-5: Conceptual Model Meta Data.

The Meta data template can accommodate a number of meta features of the conceptual model, for example: Name, Type, Version, Modification Date, Security Classification, Release Restriction, Purpose, Application Domain, Description, Use Limitation, Use History, V&V Data Elements, Keyword, Implementation Dependencies, Point Of Contact (POC), Reference and Glyph.

- **POC:** Holds information about an organization or a person having a particular role with respect to the conceptual model.
- **Model Identification:** Can accommodate information related to the identification of a conceptual model such as: Name, Type, Version, Modification Date, Security Classification, Release Restriction, Purpose, Application Domain, Description, and Use Limitation.
- **Use History:** Provides a description of where this conceptual model has been used.

- **Reference:** Specifies a pointer to additional sources of information such as locations in XML documents and references to ontologies (both domain and middle level) which are used by the conceptual model.
- **Implementation Dependencies:** Maintains a log of all dependencies determined during the development of this conceptual model, such as domain ontologies or any other new concept introduced by the process during the implementation of this conceptual model.
- **Key Word:** Holds information about the key words of this conceptual model for future use. It helps users in searching for this conceptual model.
- **Glyph:** Is responsible for holding the image of conceptual model, which can be used to visually represent a conceptual model in a tool palette or a web repository.
- **V&V Data Elements:** The V&V process can produce an enormous amount of data. These data are collected under a label called V&V Data Elements and placed in the product "Conceptual Model Meta data". In the table below a list of data items is presented together with the Process Activities where that data is produced.

Table 6-2: V&V Data Elements in the Conceptual Model Meta Data.

Meta Data V&V Data Elements	PA That Produces V&V Meta Data
V&V Requirements Specification (VV&A Intended use, VV&A Requirement, VV&A Constraint)	1.1, 1.4
V&V Precondition Specification (Conceptual Model Intended Use, Conceptual Model Use Risk, Conceptual Model Requirement, Conceptual Model Constraint, Conceptual Model itself if available)	1.3
Conceptual Model System of Interest	1.2, 3.4
V&V Experimental Frame	1.3, 1.4
V&V Goal Network	1.2, 2.1, 3.4, 4.3, 4.4, 4.5
V&V Results	2.2, 3.6, 4.6, 5.3, 5.4
V&V Claim Network	5.5
Acceptance Recommendation	5.5

Table 6-2 shows the Meta data elements and the Process Activity that produces the Meta data. A short description of each element in the V&V Data Elements is given below:

- V&V Requirements Specification
  All requirements that are placed upon the V&V products or effort to be delivered and restrictions placed upon their realisation. It is sub-divided into:
  - V&V intended use
    An account of how the Stakeholders intend to utilise a V&V product(s) or effort.

- V&V requirements
  A statement of necessary attributes, capabilities, characteristics, or qualities a V&V product or effort shall possess in order to have value to the Stakeholders. This could for instance be a requirement on the usage of specific formats or templates for V&V products.

- V&V constraint
  The constraints placed on the execution of the V&V effort.

- V&V Precondition Specification
  The prerequisite information for the execution of a V&V project. Many of the items in this specification can be in the form of references to other products produced in this conceptual modeling guidance. The following V&V preconditions are required to properly execute a V&V project:

  - Conceptual model intended use
    An account of how the conceptual model stakeholders intend to utilise the conceptual model.

  - Conceptual model use risk
    An account of a risk associated to the (intended) utilisation of a conceptual model.

  - Conceptual model requirement
    A statement of necessary attributes, capabilities, characteristics, or qualities a conceptual model shall possess in order to have value to the stakeholders.

  - Conceptual model constraint
    A restriction placed upon the realisation of a conceptual model.

  - Conceptual model itself if (parts of it) are already available.

- Conceptual Model System of Interest
  The Conceptual Model System of Interest specifies the referent system, which is usually a part of the real world. This information can be in the form of references to product P3.1 – Validated Knowledge.

- V&V Experimental Frame
  The V&V Experimental Frame indicates how the conceptual model is to be evaluated in order to obtain results that can be used as evidence for criteria.

- V&V Goal Network
  The V&V Goal Network structure provides the technical vehicle to systematically develop a set of precise and well-argued criteria and how evidence for their support can be obtained. Criteria specify from the Stakeholders perspective a set of requirements that, when proven properly, result into a positive acceptance recommendation for the conceptual model and its deployment.

- V&V Results
  The collection of obtained V&V data that are used as foundation to build evidence for the criteria.

- V&V Claim Network
  The V&V Claim Network structure provides the technical vehicle to systematically develop a well-argued set of items of evidence and acceptance claims. These acceptance claims are a declaration of an assertion for the conceptual model and its deployment on whether or to what extent its results can effectively be utilized (i.e., value) with acceptable consequences (i.e., cost and use risk).

- Acceptance Recommendation
  The Acceptance Recommendation is a Stakeholders oriented presentation of the V&V claim network and other relevant V&V project information, which together comprise all the pieces of information needed for an adequate acceptance decision-making on the conceptual model and its deployment.

6.2.5 Product 2.1 Guidance – Conceptual Model Requirements

For purposes of the present document, a specific and very significant distinction is made between 'wants' and 'needs' on the one hand and 'requirements' on the other. The rationale for that distinction illustrates the motivation for specification of Conceptual Model Requirements as a necessary component of a conceptual model product suite. Whereas formal definitions for these terms are provided in the glossary, the fundamental distinction has to do with the relationship of these terms to stakeholders in the first place and the conceptual model design and implementation on the other. So, for instance, a 'want' or 'need' is related to the state of expectation or intention of one or another of the stakeholders. Individually or collectively, stakeholders may have anticipatory preferences for that which is produced as the conceptual model proper based on their intended use for it in context of their role within the enterprise. Thus, wants and needs as discussed in Section 6.2.2 (Product 1.2 Guidance – Need Statement) above are proximate to stakeholders' preferences and may, or may not, be wholly self-consistent, complete, or informative as a basis for creating or judging the sufficiency of the conceptual model artifact *per se*. Wants and needs in this view are desiderata. In the same vein, a 'requirement' is related to the necessary and sufficient attributes of the conceptual model as determined appropriate for the enterprise at large. Requirements both prescribe and proscribe the characteristics of the conceptual model which, if present, guarantee the model to be adequate for its several intended uses. As such, requirements must be monolithic within the enterprise and must manifest the potentially disparate stakeholders' wants and needs in positive-definite, observable form. As in any systems engineering or product development life cycle, stakeholders' wants and needs are transposed into product attribute requirements in accordance with the product life-cycle management strategies (such as waterfall, spiral, etc.). Discriminating between needs and requirements is considered best-practice in conceptual model development; and documenting each separately, while preserving audit traceability between the two guarantees the appropriate causal influence of stakeholders needs upon requirements and consequently (and subsequently) upon conceptual model artifact qualities.

Specification of requirements, therefore, is useful in guiding the conceptual model design and implementation agents. Published requirements serve as a basis for evaluation of the quality of the resulting conceptual model quality as built. Preservation of requirements as a formal component product of the conceptual modeling process guarantees that causal dependencies of design upon stakeholders needs may be understood in the event of conceptual model product evolution, re-use, or expected interoperability with other such models.

Expression of requirements is, in context of these best-practice recommendations, left materially to the discretion of the requirements development and documentation agent within the enterprise. Observations relevant to alternative expressional modes together with the identification of some determinative factors for choosing particular forms of expression from within those modes are intended to be suggestive rather than prescriptive.

Conceptual model requirements are certainly an information product whose function is to provide a necessary if not positively sufficient binding upon the characteristics of the desired conceptual model proper. As such, the scope of requirements is expected to extend at least across the static and dynamic set of observable attributes of conceptual models proper (see Section 4.4.2 Conceptual Model Characteristics). Requirements 'Characteristics' – (see Figure 4-4 Conceptual Model Characteristics); such as scope, quality, utility, formality, abstractness, consistency and special value with respect to quality, cost effectiveness, '-ilities', etc.; are expected to be included in the requirements regime. Note that the 'observability' of required characteristics documented is significant insofar as the confirmation by observation of the values of those characteristics as manifest in the conceptual model product with the values proscribed in requirements specifications will constitute much of the verification of that conceptual model product. There are a few special sensitivities in requirements documentation that associated with generation, administration and use of conceptual model component elements. In particular, the conceptual model stakeholder team should be aware of completeness challenges associated with the relevant generation of specific conceptual model components not wholly addressed in the preceding process specification.

As an information product, requirements specifications should be systematic with respect to representational schema elected for use within the enterprise. Such elective, but necessary conventional determinations may include data-item description of conceptual model components, including explication of:

- Information content;
- Form of requirements specification – Manifestation in forms that are suitably consistent, manageable, persistent, accessible, and re-usable;
- Relationships among conceptual model information artefacts; and
- Data format.

In the same way that information schemas may be left to the discretion of the conceptual model requirements management agent and contingent upon enterprise stylistics or conventional standard the choice of information management artefacts, e.g., classical textual, database, or related forms of expressions, and the choice of CASE/COTS tools whereby to facilitate the generation, publication, reconciliation, valuation storage, retrieval, and re-use are considered discretionary just in case such determinations are explicit, documented as intended practice within the enterprise environment, and complied with by enterprise stakeholders.

Finally, requirements are intended to have the logical standing of imperatives or 'shalls' within the enterprise. Compliance to requirements specifications is expected to be explicit, complete and auditably traceable, contingent, of course, that mechanisms exist within the enterprise for prompt, systematic, and convergent identification, documentation resolution, and identification of exceptions to published requirements.

6.2.6 Product 2.2 Guidance – Conceptual Model Knowledge Acquisition Needs

The purpose of this product component is to document and to communicate to the conceptual Model producer what knowledge must be acquired in order to design and build a conceptual model that will serve its intended purpose. Conceptual model knowledge acquisition needs describe the scope and level of detail of knowledge needed by the Conceptual Model developer to produce a conceptual model satisfying the client's need statement. Conceptual model knowledge acquisition needs guide the conceptual model developer in collecting the necessary knowledge and limit knowledge acquisition to the minimum sufficient knowledge set.

Given that the establishment of the context within which the bulk of direct conceptual model population will occur, the following effort will generate information to be contained in the subject data product:

- Analyze the requirement specification in order to derive knowledge needs.
- Document knowledge needs. Information content of this product describe:

- The entities and activities in the mission space the modeler must understand in order to represent them correctly and with appropriate detail; and
- The simulation technique, tools and legacy assets the modeler must understand in order to represent implementation requirements and constraints correctly.

Contingent review the conceptual model requirement specification in order to identify knowledge needed for developing a conceptual model with sufficient fidelity to satisfy its purpose; information covering the following domains for which specific needs exist will be specified:

- Technologies applied in mission space entities and their capabilities and limitations.
- Physical theories underpinning these technologies.
- Military tactics, techniques and procedures.
- Candidate simulation technologies.
- Legacy simulation models and their capabilities and limitations.

Criteria for sufficiency of the subject product include an exhaustive list of knowledge elements needed to design and build the desired conceptual model as has been documented in P2.2.

6.2.7 Product 3.1 Guidance – Validated Knowledge

Validated knowledge constitutes the authoritative information that is available, necessary, and sufficient for the conceptual model development agent to understand the mission space and simulation space and from which to construct the subject simulation conceptual model.

6.2.7.1 Overall

Validated Knowledge is a product of the NATO conceptual modeling Process Phase 3, known as Acquire Conceptual Model Knowledge. This product is a validated piece of knowledge, developed in response to an identified need and/or requirement from the previous phases. It will be acquired from authoritative knowledge sources, and will then be structured, documented, and validated with respect to that authoritative knowledge source. This product will be the sole and most important product produced during Phase 3. The next phase, Design the Conceptual Model, will use this to design the conceptual model, i.e., this product will serve as the foundation for designing and building the final conceptual model.

6.2.7.2 The Generation Process

The conceptual modeling process is iterative, in which some parts and steps are sometimes conducted in parallel. By the end of every phase, one or more products are generated which may be used as input for the next or another coming phase. Moreover, within one phase some activities may also generate one or more intermediate products which may be used as input for the following activities in the same phase. That is the case for Process Phase 3, where the end result will be P3.1 – Validated Knowledge.

In the previous phases, the needs and requirements for the knowledge were completed and the authoritative knowledge sources for the particular knowledge which is requested were identified. But of course before putting any effort into acquiring the required knowledge, one should search in some existing conceptual model repository to look for knowledge which may already be available for reuse. So the next activity in the process will start looking for the corresponding reusable knowledge for that particular conceptual model which may already exist in an existing conceptual models repository, knowledge that can be either partly or completely usable for this new need. If not, the lack of knowledge and the gaps which must be filled are identified.

As previously mentioned, the conceptual modeling Process Phase 3 is about acquiring sufficient and necessary knowledge about a particular conceptual model by applying knowledge acquisition methodologies. These methodologies and the corresponding techniques help to ensure that the correct and necessary data is gathered from the correct sources. When data is obtained (and is presumed to be in raw text format, all other formats of data, such as voice, video, etc., can also be converted to raw text) it is assumed to be unstructured and the first step is to analyze and structure it for further use. The data is therefore processed by knowledge analysis and formalization methodologies employing the appropriate tools. By using these tools, the data is structured and focused according to some world view (e.g., ontology). Smaller sections of this structured data can now be called *knowledge instances*. The knowledge instances are useful for some purposes, but they are not reusable since they are specific to the used *data* (e.g., scenario data, or the result of interviewing one specific SME for a particular case). To get reusable components, modeling tools and methodologies must be applied to the knowledge instances in order to get more abstract and reusable components. To make certain that no information is misinterpreted the ontologies (as a knowledge base) are necessary. These components can now be called *knowledge components* and can, with the aid of more methodologies and tools, be composed to form one or more *conceptual models*. All of these products (Scenario Data, Interview Results, Knowledge Instances, Knowledge Components, Conceptual Models, etc.) should be stored in a conceptual model repository for future use, together with Meta data specifying how, when, where, by whom, from what, using what tool, etc., they have been produced. This Meta data is necessary to ensure traceability. Now, there should be enough information to either generate a domain ontology for this particular mission space or extend/update an existing one. Finally the validity of the acquired knowledge, with respect to the authoritative knowledge sources, will be reviewed before this product can be produced.

6.2.7.3 The Validation Process

The last activity in this phase of the conceptual modeling Process, PA3.6 – Review Validity of Acquired Knowledge with respect to the Authoritative Knowledge Sources, discusses and examines the validity of recently created knowledge with respect to authoritative knowledge sources, and is through that guarantee that the end-product can be said to live up to the requirements. This activity may be initiated as soon as the activity PA3.5 – Generate/Extend a Domain Ontology, is done and the acquired knowledge is ready for review.

For the validation of the conceptual model, it is necessary to determine whether all the abstractions used in modeling are suitable/sufficient for the given purpose and end-product usage. All quality requirements must be specified in the V&V goal model of the AF, and a precise description must be available of what evidence is needed. Part of that description is what data must be "measured" in the conceptual model and a description of the reference data to which it is to be compared. Also the quality of the "measurement" and the quality of the reference data are specified. For each piece of required evidence, it must be considered if the available reference data is of sufficient quality. The reference data may measure real-world data, theories, SME opinions, etc. But for each of those types of reference data, the quality must be considered.

If SME is used as reference data the conceptual model will be reviewed and examined (preferably performed with assistance of a VV&A agent) by that SME, whose reality has been captured and documented, to see if the documented knowledge is correct and completely represents the activity. That is to say, examining whether the result of the knowledge acquisition phase is acceptable to the owner of the mission space. An ontology expert may also examine if the generation or integration of the ontology is done correctly.

When the acquired knowledge or the ontology is validated, Phase 3 is completed and the Product 3.1 is considered being ready for use, i.e., the artefact is qualified to go to the next phase of conceptual modeling process.

6.2.7.4 Significant Inputs, Tools, Methods and Roles

To produce P3.1 – Validated Knowledge, some inputs are required:

- The Knowledge Needs and the Requirements List from the previous phases.
- A list of the authoritative knowledge sources for the required knowledge is also advantageous.
- An existing conceptual model repository with reusable knowledge. Also domain ontologies in a knowledge base are very much appreciated but not mandatory.

This product is a result of a knowledge development process and thus support of appropriate tools, methods, and techniques from the knowledge development area is very much appreciated. Such things could include:

- Methodologies for acquisition of data, information, and knowledge.
- Methodologies for documentation, representation, and formatting the acquired knowledge.
- Tools for knowledge acquisition, representation, formalization, etc.
- Tools for managing and maintaining ontologies as well as ontology reviewing tools.
- V&V methodologies, e.g., GM-VV as well as V&V tools.

Some of the roles and their areas of responsibility used when generating this important product have been identified as:

- Knowledge engineer, to provide experience in acquiring, gathering and compiling information;
- SME, to provide the domain and task knowledge;
- Analysis and formatting expert; experienced in the appropriate formatting analysis method and technique;
- Ontology expert; experienced in mapping and interpreting information held in the ontology, as well as being skilled in how to further develop and extend ontologies; and
- VV&A-agent for validating the result.

6.2.8 Product 4.1 Guidance – Conceptual Model Design

Just as in text Section 6.2.5 above, the Task Group felt the necessity to distinguish with particular precision the distinction between 'needs' and 'requirements'; at this point in the exposition, we feel the incumbent responsibility to distinguish between 'requirement' and 'design'. Both requirements and designed presage the artefact (namely the conceptual model *per se*) itself. They are, however, individuated in several ways that make the creation and persistent management of requirements and design(s) separately valuable to the conceptual modeling enterprise. Definitions such as are provided in the Glossary appended are suggestive of these salient distinctions; but, for purposes of this document the following discriminates are cited as particularly relevant:

- Requirements generally address specific attributes of the subject system; while designs address collective/composite/holistic characteristics.

- Requirements are derived (devolved) from user/stakeholder needs; while design strategies, tactics and features are generated to be compliant with existing requirements – in this phase of system evolution, design discretions permitted insofar as requirements compliance is assured.
- Requirements consist primarily in attribute specification; while designs, while respecting required attributes must be implementation specific.
- Requirements entail necessary conditions; while designs entail sufficient conditions.
- Requirements address structure and functional necessary attributes; while designs address in addition compositional relationships among both structure and functions.
- Requirements are insofar as possible implementation indifferent; while designs are of necessity implementation specific.
- Requirements must proscribe prospective systems to the degree that they are sufficient to support some prospective design; while designs must be sufficient to support all necessary requirements.
- Requirements serve as a basis for user verification; while Design specifications must serve as a basis for construction verification.
- Finally, requirements are similar to the Aristotelian final cause or telos, e.g., ‘that for the sake of which’; while design is more nearly related to Aristotelian material cause (e.g., ‘that out of which’), and formal cause (e.g., ‘the form … the account of what is to be’).

Motivation for conceptual model design – as for any system design artefact – is to establish constraints upon the subject product that, when observed, improve the fundamental utility, quality, cost effectiveness, ‘ilities’, etc., of the work-product. The design should in effect bind the conceptual model product in such a way as to guarantee accomplishment of requirements. Product design should be sufficient to guide and control implementation agents possessing a clear appreciation of the enterprise context of the intended product to complete a satisfactory product. Design should contain explicitly or by inferential implication from requirements, etc., everything short of conceptual model instance semantic content. That information is, of course, contained in mission space and simulation space Meta data. Conceptual model product design should constitute a plan or scheme conceived in the mind and intended for subsequent execution; addressing: architecture, notational schemas, data formats, and documentary tools. Finally, conceptual model design may contain any information considerations relevant to the generation of specific conceptual model components not wholly addressed in the preceding process specification.

Naturally, documentation of conceptual model design admits to any of a variety of forms of capture; and, since there is little precedent for such practice, some liberty is expected on the part of conceptual modeling agents in creating useful product of this type. In general, an explicit ‘living document’ kept under configuration control in the enterprise collaboration environment and available to all stakeholders for reference should suffice.

The Process Activity to generate this product is described in Section 5.2.4 as Process PP4. A more detailed technical description of this product is provided in Annex H, Table H-9.

6.2.9 Product 5.1 Guidance – Conceptual Model

The conceptual model *per se* is, in this exposition, the final component of the conceptual model development process. Having proceeded through the conceptual model development process described in Chapter 5 and detailed in the process specification of Annex G, and having generated product artefacts above described in this chapter, in accordance with the product specification of Annex H there remains only to comment upon the populated resulting simulation conceptual model.

The conceptual model product itself is clearly the conceptual model design, populated with mission space and simulation space data generated, compiled and validated in preceding tasks. Seen as such it is merely the practical compilation of information previously gathered consistent with the wants and needs of simulation stakeholders, in context of the subject simulation enterprise environment. It is, therefore one – if the last – information product of the suite of artefacts resulting from the conceptual modeling effort. Nevertheless, as the culmination of that effort it is distinctive and particularly noteworthy.

Just as the conceptual model design above constitutes the descriptive and prescriptive specification of the conceptual model; the simulation conceptual model itself, constitutes the *de facto* design of the resulting simulation's representation capabilities and implementation characteristics. Insofar as the conceptual model has been generated by a suitably systematic devolution beginning with simulation user needs and proceeding through collection and qualification of Meta data, specification schema, and information product design stages, it manifests the fundamental information necessary and sufficient for the creation of a satisfactory simulation. Insofar as the conceptual model development process has been conducted with due regard to the enterprise context in which such simulations are to be developed and used, it establishes a sound basis for collaborative business practice throughout the enterprise and over its practical duration.

The Process Activity to generate this product is described in Section 5.2.5 as Process PP5. A more detailed technical description of this product is provided in Annex H, Table H-10.

Chapter 7 – CONCLUSIONS AND RECOMMENDATIONS

This best-practice guidance is intended to lay the foundation for practical and effective conceptual model development, to serve as a baseline for individual enterprise tailored implementations, and to set the vector for future standardization and conceptual model life-cycle management.

7.1 OBSERVATIONS AND INFERENCES

Conceptual modeling begins, most often unconsciously, at the very beginning of the first idea; long before the official conceptual modeling effort starts. Notes and drawings scrawled in the corner of a napkin already begin the abstraction process, and in doing so, provide the first bias. As in Heisenberg Uncertainty, where a phenomenon is disturbed as soon as one tries to measure it, the referent in a conceptual model is distorted as soon as one tries to represent it. This is one reason so many simulation frameworks have turned out to be unusable or un-reusable while they were modeled as point solutions such as “red against blue”, instead of more composable structures, such as “entities and interactions”. The conceptual modeling enterprise does not get rid of these biases, as much as it makes the choosing of biases deliberate and well documented.

The conceptual model of a simulation is not simulation space implementation independent. It may appear to be so, without any specific references to the simulation space, but the decisions that were made during the conceptual model design inevitably were informed by the underlying need for a simulation capability or an enterprise interest.

Current practice in simulation development rarely includes an explicit conceptual modeling effort. This fact was the primary motivation for the development of this guidance. But study of ongoing enterprises has revealed a few shining examples of deliberate conceptual modeling practices that are encouraging in the commonality of their underlying principles, even as they took varied approaches in the conduct and description of their efforts. The value of this guidance to these and future enterprises is the provision of a broad and flexible process with defined products which can be mapped against current approaches and future plans. Common terminology can also be derived from this guidance to enable better communication of concepts between enterprises.

Once the community is able to produce a critical mass of conceptual model products from a diverse set of enterprises, refining best-practices through a variety of experiences, the methods of standardization and reuse, along with evolution towards automation and machine readability, can bring about substantial efficiencies in the conceptual model and M&S development and their respective life-cycle management efforts.

7.2 RECOMMENDATIONS

The following comprise the recommendations distilled from the experience of the MSG-058 Task Group and which are proffered for consideration in conducting NATO M&S conceptual modeling activity in expected collaborative enterprise environments:

- NATO Nations should adopt this guidance as best-practice for their national and international M&S efforts to enable interoperability and reuse.
- The modeling and simulation community should take this opportunity to deliberately incorporate conceptual model development into their respective M&S development processes, based on the best-practice provided in this guidance.

- Each enterprise should specify its own conceptual modeling process and conceptual model products, using this guidance as a point of reference.
- VV&A of conceptual models should be integral to the development process. Use of the ISO/IEC 9126 standard on software quality is a starting point for the derivation of conceptual model quality criteria, and use of the (draft) GM-V&V standard is directly applicable to V&V of conceptual models.
- Every customization of the guidance should be published to contribute to the body of knowledge of conceptual modeling, to build a valuable experience base for standardization initiatives. Especially important is the documentation of decisions on the mapping of formalisms/views/model-kinds/ primitives, and identification of formalisms that are well suited to particular applications or domains. It would also be useful to develop the body of knowledge to determine the common design patterns and appropriate conceptual model component combinations typically used by the M&S community. Improving the conceptual modeling body of knowledge also involves the development of metrics to evaluate fitness for purpose of a conceptual model design.
- The M&S community and the Simulation Interoperability Standards Organization (SISO) in particular, should use this best-practice guidance as a basis to initiate an international standard for conceptual model development.
- As this guidance was limited in focus to conceptual model development, further work should be initiated to develop best-practice guidance for the entire conceptual modeling life cycle, including design for reuse, collection of conceptual models for repositories, configuration management, verification and validation of conceptual models, and advancing state-of-the-art in development of automated tools.

Annex A – TAP

Activity	MSG-058	Conceptual Modelling for M&S												2007
Activity REF. Number	RTG-038													June 2007 IS
Principal Military Requirements	2							UU						May 2010
Military Functions				4										
Panel and Coordination	MSG							IST						
Location and Dates	Multiple													P-I
Publication Data	TR							2010			50			UU
Keywords	M&S		Interoperability					M&S Re-use			VV&A			

I. BACKGROUND AND JUSTIFICATION

Current M&S standards have provided a first step to interoperability and a state-of-the-art way to interconnect simulations and tools to build distributed systems of simulation but it is recognized that existing standards are not meant for exchange of semantics and concepts. The final objective of the TG is to achieve a common understanding and use of information exchanged between simulations for better satisfying military requirements for education, training and operational support. Conceptual models are key to the transformation of user needs and requirements to M&S design, and eventually implementation. The purpose of this NMSG TG is to develop a guidance document on Conceptual Models, which can be used in the future by NATO to support M&S requirements.

II. OBJECTIVE(S)

Major objectives of this Task Group are to:

- Clarify the "Conceptual Model" concepts, discuss the terminology, and emphasize the utility to better formalize Conceptual Models, etc.;
- Investigate methodologies, simulation and software engineering processes, initiatives and technologies;
- Draft a guidance document on conceptual modelling that can be used by different stakeholders; and
- Foster the establishment of the guidance document as a SISO standard.

III. TOPIC TO BE COVERED

The first step will be to clarify what a conceptual model for Military M&S is and what it represents. A common understanding is that conceptual models should serve as frames of reference for simulation development by documenting important entities/concepts, their properties, and their key actions and interactions: a conceptual model should bridge between the requirements and simulation design. The second step will consist to investigate methodologies, simulation and software engineering processes, initiatives and technologies useful for the establishment and content of conceptual models. The final work will be to provide a tailorable set of guidance to the M&S community on conceptual modeling. This will guide users through the conceptual modeling effort by explaining how to apply it in practice. If possible a future guidance will be proposed to the international community for standardization via the SISO (Simulation Interoperability Standards Organization).

Deliverables and/or end product:

The final report should be a “guidance document” freely available to the international community.

IV. DELIVERABLE

Technical Report.

V. TECHNICAL TEAM LEADER AND LEAD NATION

Co-Chair: Mr. William F. Waite, United States.

Lead Nation: United States.

VI. NATIONS WILLING/INVITED TO PARTICIPATE

Canada, France, Netherlands, Norway, Romania, Spain, Sweden, Turkey, United Kingdom, United States.

VII. NATIONAL AND/OR NATO RESOURCES NEEDED

Nations should provide funding for their own participation (manpower and traveling resources).

VIII. RTA RESOURCES NEEDED

RTA will publish the final report and electronic support through its RTO Wise.

IX. ADDITIONAL INFORMATION

Limited Participation Technical Team: No.

Comments: This activity will be co-chaired by the USA and Romania.

Annex B – TERMS OF REFERENCE

RTG on
Conceptual Modelling for M&S
MSG-058, RTG-038

I. ORIGIN

A. Background

The NMSG was established within the Research and Technology Organisation (RTO) in 1999, with an objective to favour re-use and interoperability of M&S within the Alliance, and NATO/PfP Nations. So far, within NATO, like in the international M&S community, the interoperability objective was mainly addressed at the "technical level" using open standards developed by SISO (Simulation Interoperability Standards Organization), IEEE (Institute of Electrical and Electronics Engineers) or ISO (International Organisation for Standardisation) such as the HLA that was adopted by NATO as early as 1998. Those standards have provided a first step to interoperability and a state-of-the-art way to interconnect simulations and tools to build distributed systems of simulation but it is recognized that existing standards are not meant for exchange of semantics and concepts.

Since the beginning of the NMSG activity it was recognized that HLA was only a preliminary step to satisfy the M&S technical interoperability concern and that the final objective was still to achieve a more ambitious M&S "interoperability level". This final objective should be to achieve a common understanding and use of information exchanged between simulations for better satisfying military requirements for education, training and operational support.

In the mean time SISO recognized the importance of better defining and advising the M&S community on the importance of Conceptual Models not only for the interoperability issue but also to form a basis for simulation development, foster re-use, and to support V&V activities. A SISO Task Group was created in 2003 to address the topic of Conceptual Models with the potential objective of developing a new standard, or more precisely a "guide", to help practitioners building Conceptual Models. For various reasons this SISO Task Group did not fully achieve its goals. Nevertheless it produced some interesting and valuable output that can be exploited to produce a recommended practice guide for the elaboration of Conceptual Models.

The purpose of this NMSG Task Group is to develop a guidance document on Conceptual Models, which can be used in the future by NATO to support its M&S requirements.

B. Military Benefit

Conceptual models are key to the transformation of user needs and requirements to M&S design, and eventually implementation. Conceptual models form the bridge of understanding between the users of M&S, the military domain experts that have the necessary knowledge that must be represented in M&S, and the software and simulation engineers that implement simulations. Without Conceptual Models, history has shown that simulation developers often do not sufficiently understand the military domain to be modelled and implement M&S that do not reflect the intended reality, and thus do not satisfy the user's needs. Further, Conceptual Models form the basis of an important step in Verification and Validation – determining that the application domain has been described sufficiently to meet users' needs while accurately incorporating subject-matter expert knowledge.

In addition to playing a key role in the development of individual simulations, Conceptual Models are also a key to facilitating the valid and effective composition of M&S into federations. While technical interoperability of simulations has been thoroughly researched and solutions have been implemented (for example, the High Level Architecture for M&S), these do not address higher levels of interoperability (semantic, pragmatic, and conceptual).

Neither a standard practice for Conceptual Model development nor consensus definition of Conceptual Model content currently exists. Where conceptual modelling is practiced, it is typically defined on a project-to-project basis. A NATO Task Group (TG), working in conjunction with SISO, is in the unique position to develop a standard that will be used by multiple Nations, thus meeting the reusability and interoperability goals. A recommended practice including specification of the content of Conceptual Models for M&S will further increase user understanding of the capabilities of those M&S, thus increasing their reusability.

II. OBJECTIVE

Major objectives of this Task Group are:

- Clarify the "Conceptual Model" concepts, discuss the terminology, and emphasize the utility to better formalize Conceptual Models, understand the relationship between conceptual modelling and related concepts (scenario definition, etc.);
- Investigate methodologies, simulation and software engineering processes, initiatives and technologies useful for the establishment and content of Conceptual Models;
- Draft a guidance document on conceptual modelling that can be used by different stakeholders (sponsor/user, project manager, subject-matter experts, V&V agents, developers, etc.); and
- Foster the establishment of the guidance document as a SISO standard.

The TG's first objective will be to clarify what a Conceptual Model for Military M&S is and what it represents. A common understanding at this starting moment is that the Conceptual Model should serve as a frame of reference for simulation development by documenting important entities/concepts, their properties, and their key actions and interactions. That is a Conceptual Model should bridge between the requirements and simulation design.

The TG will clarify and rigorously define the core terminology associated with conceptual models and conceptual modelling, and the relationship among those terms. The TG will identify the key stakeholders in conceptual modelling and their requirements with respect to conceptual modelling. Stakeholders will include those that are involved in the production of conceptual models and those that rely on conceptual models to perform their jobs. Among the issues the TG will address what key concepts each of these stakeholders needs in a conceptual model and the level of abstraction at which conceptual models should be expressed to meet various stakeholders' needs.

Conceptual modelling is one of key concepts in the development and employment lifecycle of M&S. As such it is related to other concepts such as scenario development, simulation software requirements development, and test plan development. As part of the first objective, the TG will define the relationships among conceptual modelling and these other activities. The second objective of this Task Group is to investigate methodologies, simulation and software engineering processes, initiatives and technologies useful for the establishment and content of Conceptual Models. While the objective of this TG is not to develop or identify a single standard for the representation of conceptual model content, this TG will identify a range of such solutions that can be employed in conceptual modelling.

In order to take advantage of the work covered by others regarding to this issue, it will be very important to collect and analyze as much as possible of the documentation available on conceptual modelling, specially those related to the M&S field. Lesson learnt by them can help to avoid some recurrent problems, to reduce the risk of developing simulation not adapted to the requirements and to get a better profit of this TG.

The TG will explore the potential of a variety of processes and knowledge representation approaches to examine their potential for conceptual modelling. Among these will be simulation-specific methodologies as the HLA FEDEP general software engineering processes; prior conceptual modelling initiatives as the CMMS – Conceptual Models of the Mission Space, and emerging technologies such as ontology languages. Through this objective, the TG will synthesize existing practices to identify the state of the art of conceptual modelling. By doing this, the TG will maximize the reuse of previous effort in the development of a recommended practice.

The third objective is to provide a tailorable set of guidance to the M&S community on conceptual modelling. This will guide users through the conceptual modelling effort by explaining how to apply it in practice. The process will be tailorable in that it is intended to be extended and modified by individual programs that apply it. Rather than being a one-size-fits-all rigid, single approach to conceptual modelling, the guidance will provide a starting point that individual programs can apply given their specific needs and resources. The guidance on the Conceptual Model content will state what should be in the Conceptual Model, and not mandate a specific format but suggestions for the selection and use of format, methodology, techniques and tools will be provided.

The guidance will encompass the conceptual modelling process, Conceptual Model content and describe appropriate views on a Conceptual Model for different stakeholders. For example, the conceptual modelling process will describe the transformation from the users view, concerned with the problem domain, to the developers view, focused on the M&S domain.

The TG's fourth objective is to foster the establishment of the guidance document as a SISO standard. The current policy of NATO for standardization is to use civil standards where appropriate ones exist and to develop its own standards only when no civil standard exists. In the case of conceptual modelling for M&S or conceptual modelling in general, no civil standard exists. The requirement for M&S Conceptual Modelling is not specific to NATO or to the military domain. Thus it should be helpful to extend this work to a larger M&S community. With respect to this proposal, the TG will open its guidance document to an M&S standard product, developed through an open consensus-based standards body. The SISO is the best suited organization for this standardization, since it has a strong background and current focus on military M&S, but also includes M&S practitioners from outside the military domain. Thus, the TG will propose to SISO the creation of a standard development group (a PDG, Product Development Group) in charge of developing a balloted standard.

Two models of interaction between this NMSG TG and the SISO PDG are possible:

1) The TG guidance document can provide the first draft of the future SISO product which can benefit from the input of a larger M&S community; or

2) The TG will work along with a SISO PDG to develop the product.

The decision rests with the SISO membership and the SISO Standards Activity Committee on whether they wish to apply the resources immediately to exercise the second option. In either case, the TG will be involved in the SISO PDG activity and could provide a part of the leadership of the group thus protecting its own interests. This working mode between NATO Task Groups and SISO Product Development Groups has already been employed in the VV&A (Verification, Validation and Accreditation) and Coalition Battle Management Language (C-BML) activities. Even if the first cooperative approach is used, and SISO does not choose to take the product forward as a SISO product, NATO will be provided with a guidance document as proposed in the third objective at the end of the TG activity.

Main deliverables of the Task Group will be:

- A draft guidance document;
- Interim publications at some conferences (when required); and
- A final report.

III. RESOURCES

A. Membership

Co-Chair: Mr. William F. Waite, United States.

B. Nations Willing/Invited to Participate

Canada, France, Netherlands, Norway, Romania, Spain, Sweden, Turkey, United Kingdom, United States.

Task Group members must have a working knowledge of the simulation design and development. An initial list of Nations, which have expressed a willingness to participate, is given above.

Other Nations can express willingness to participate in this activity. It is recommended that USA and Romania co-chair this activity.

National and/or NATO resources needed:

- Member Nations will supply manpower (including travelling expenses) resources. It is important that the group be supported by the NATO Modelling and Simulation Coordination Office (MSCO).

RTA resources needed:

- Technical report publication services.
- RTO Web Space via the RTO Wise.

IV. SECURITY LEVEL

The security level will be Unclassified/Unlimited.

V. PARTICIPATION BY PARTNER NATIONS AND OTHER NATIONS

This activity is open to PfP.

VI. LIAISON

Liaison should be established with the following organisations:

- MSG-054 Task Group on "An Overlay Standard for Verification, Validation, and Accreditation (VV&A) of Federations";
- MSG-052 Task Group on "Establishment of a Knowledge Network for Federation Architecture and Design";
- The coming Task Group IST-075/RTG-034 on "Semantic Interoperability" (Continuation of the IST group ET-040 on "Ontology fusion");
- Simulation Interoperability Standards Organisation (SISO); and
- Other RTO Task Groups as required.

VII. REFERENCE

The deliverables should be "Unclassified – Approved for Public Release (unlimited distribution)".

Annex C – TAP/TOR REQUIREMENTS

REQUIREMENT	COMPLIANT
Comply with TAP-TOR guidance language … as interpreted	X
Sufficiently serve all relevant stakeholders	X
Be demonstrably and fully relevant to (but not strictly limited to) best-practice…	X
Modeling and simulation life-cycle	X
Defence industry enterprise	X
Facilitate broad-based M&S standards evolution	X
Conceptual Model has to be something useful to the M&S community to understand clearly those aspects of the reality that must be implemented in a simulator	X
Conceptual model has to be enough open to get that it will be reusable by anyone that face similar problems in the same domain of knowledge	X
The guidelines have to become in a standard for conceptual model in M&S	X
Guidance to address the conceptual model needs of NATO military M&S (4) Stakeholders, while keeping in mind that the related processes and technology solutions may be applicable to a larger audience (non-military, non M&S). We must be enough specific (military / M&S) to produce a useful and applied guidance document but nothing more specific than that. If the specification does not bring clarity, useful / applicability of the guidance, we must admit it.	X
Priorities in topic discussion be addressed	X
[Address needs of 4] stakeholders	X
Final product should be as… general as possible	X
Relevant to military M&S but not proscribe practices that would preclude uses within other areas (as for instance, Enterprise modeling)	X
Consider adoption/tailoring of the 4-actor view of stakeholders	X
Primary emphasis on the needs of the [simulation] developer	X
Ensure stakeholders, use cases, definitions and applications are applicable to the military and M&S areas	X
If we discover during the process that we must give specific guidance that limits the scope to military or M&S, we will constrain ourselves only to the minimum degree necessary to address the specific case	X
Other than military and M&S areas we have no other scope constraints	X
Convey M&S as prime concern versus information systems in general	X
Cover military as primary concern versus other domains	X

REQUIREMENT	COMPLIANT
Identify specific stakeholders in the [military and M&S] domains to capture their requirements on conceptual models but try not to limit the conceptual model for only those domains	X
Scope driven from stakeholder's needs	X
Focus on defence establishment	X
Focus on M&S development	X
Stakeholder roles to be advanced somewhere between 4 of NMSG -042 and Colonel Smith	X
Use of generally accepted practice in the computer science establishment	X
[address] Definition of conceptual model	X
[address] How conceptual model can address military simulation shortcomings	X
[include] General evaluation of conceptual model use cases versus actual technology use cases	X
[provide] Guidance to implementation of conceptual models	X
[provide] Guidance to possible standards	X
Conceptual model [practice and artefact] has to be something useful to the M&S community to understand clearly those aspects of the reality that must be implemented in a simulation	X
Conceptual model [practice and artefact] has to be open enough that it will be accessible by anyone who face[s] similar problems in the same domain of knowledge	X
Guidance [has] to become a standard for conceptual modeling in M&S	X

Annex D – ISSUES

In order to identify and subsequently resolve issues (i.e., topics whose deep appreciation and consensus resolution by the Group members would likely be necessary to the successful completing of the MSG-058 effort) the Task Group resolved to systematically review the prospective study and establish, by consensus, topic areas considered deserving attention. The first step in this process was to discuss potential difficulties in areas of:

- General and Administrative conduct of the effort;
- Elements of the Programme of Work; and
- Matters of Technology that were likely to challenge the Group in successfully completing its assignment, and considerations related to the intended Work-Product.

In doing so, as completely and systematically as possible, our intention was as follows:

- Ensure that each national participant nominated at least one issue topic of particular concern;
- Ensure that at least one topic was nominated for consideration by each individual participating in the study;
- Arrange that each topic was ‘adopted’ by some one individual, who would be depended upon to pursue resolution throughout the study process; and
- Arrange that each adoption allowed individuals with special intensity of concern for a topic to influence the Group’s treatment of that topic issue to their particular satisfaction.

This intention for issue management activity is indicated in the following figure, where abbreviated topic titles associated with General and Administrative, Programme of Work, Technology and Work-Product specification, generation, and publication respectively.

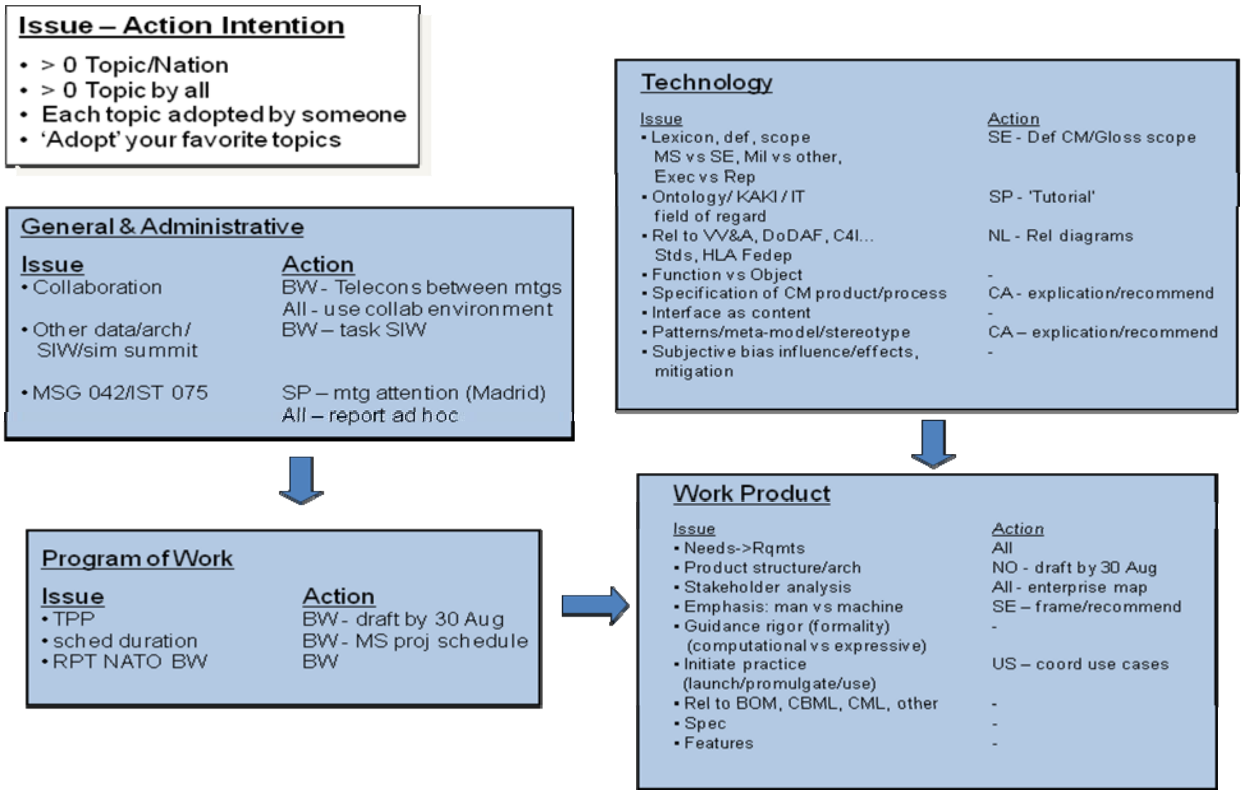

Figure D-1: Outline of Scope and Influence Among Topic Issues Identified by the Task Group in Anticipation of Initiation of Detailed Programme of Work.

It was further resolved by the Task Group that for each issue topic, the designated agent, would provide a definition, indicate stakeholder needs, specify the scope of concern of the topic, and establish other such attributes of the identification and specification of the issue, together with recommendations of actions whereby the effect of each issue in areas of Technology, Work-Product, Programme of Work, and meta-process would be made a matter of record and so duly respected by the team during the consequent effort. This intention is indicated diagrammatically in the following figure.

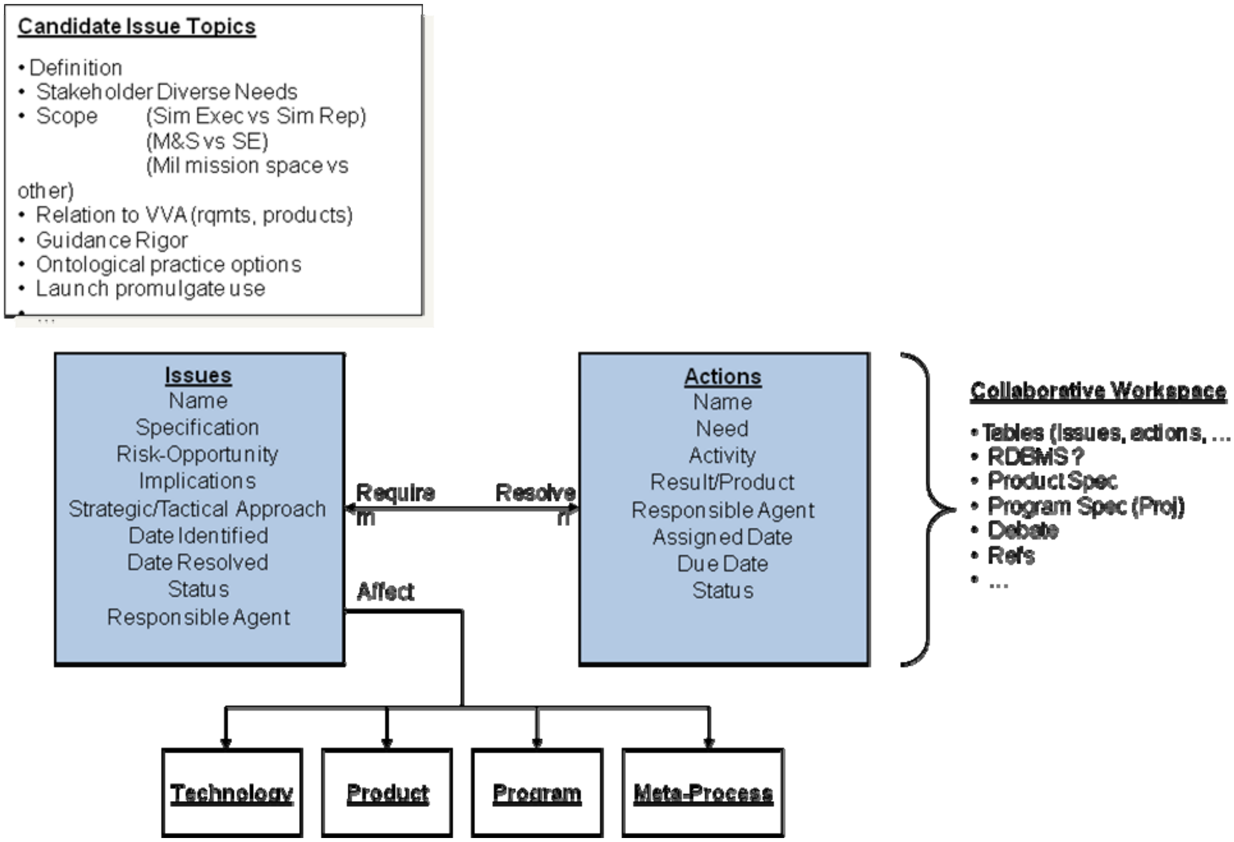

Figure D-2: Schematic of Specification of Topical Issue, Resolution Action and Influence.

Finally, the suite of issues so identified were reviewed by the Team in order to establish a priority list and to identify the highest priority issue topics in order that the sensitivity of the study Task Group might continue to be focused on a consensus basis throughout the duration of the effort. The list that follows indicates the 5 most important topical issues identified by consensus of the group.

1) Stakeholder Analysis and Context;
2) Scope and definition;
3) Relationship to standards;
4) Specification of Conceptual Model Management Process; and
5) Specification of Conceptual Model Artefact.

The following table provides the details of the priority vote-ordering of the total list of topical issues considered.

Table D-1: Total List of Candidate Topic Issues, With Team Vote Compilation of Significance of Each.

Circumstances and Analytical Context:	Score 1-5
Stakeholder Analysis and Context (20)	1,1,1,2,1,1,1,1,2→11
Effort Analytical Frame (e.g. ‘Conceptual model’ versus ‘Ontology’ … DODAF, MDA versus ontology …system eng, software eng, ? engineering… OWL / Rules … ‘ontology’ pragmatic selection of operating locus within the manifold of knowledge management → capture as ‘operational strategy’)	2,3,2,3,3,2,2,2,1,→20
Intention:	
Product influence-utility scope … “Scope” – M&S? Military? Versus SE? Executable versus Representation? Order (CM / Mil / M&S vs. CM / M&S / Mil)	1,2,1,1,1,2,1,1,1,→11
Guidance rigor (22)	3,1,3,3,2,1,2,2,3,→20
Style of influence (e.g. CMMI?)	
Authoritative standing	
Enforcement strategy	
Product Development and Deployment:	
Product needs/requirements discrimination (18)	4,3,3,4,1,2,3,4,3,→27
Work- Product content structure/architecture (19)	1,5,3,3,1,3,1,2,4→23
Exposition	
Lexical analysis and documentation (10)	
Reference analysis and documentation	
Specification of Conceptual Model Management Process	1,1,1,1,2,2,1,1,2,→12
Process content	
Expository schema	
Subjective bias/influence/effects (ontological relativism) mitigation (17)	
Specification of Conceptual Model Artefact (14)	1,1,1,1,1,1,1,1,2,→10
Specification requirements	
Expository Schema	
Conceptual Model contingency with respect to detail of conceptual model, its relationship to simulation lifecycle evolution, it multiplicity of views, its computability and its creditability.	
Prototyping with Guidance-Product	3,4,3,1,3,4,4,3,3,→28

Circumstances and Analytical Context:	Score 1-5
Product Development and Deployment (cont'd):	
Identify/enlist trial-horse sample problems	
Establish preliminary guidance	
Execute prototype	
Abstract lessons learned	
Document effort	
Deployment/employment of guidance	5,3,3,1,4,2,2,3,4,→27
Recommendations	
Initiate practice (23)	
Deployment Campaign	
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Technical Considerations:	
Ontology (11)	2,2,1,1,4,1,1,2,3,→17
Function versus Object (13)	4,4,2,5,1,2,4,5,2,→29
Emphasis man vs. machine (21)	5,2,1,2,4,1,2,4,2,→23
Interface (only) vs. Context (15)	2,3,2,5,3,3,4,3,1,→26
Patterns/meta-model/stereotype (16)	2,3,2,5,4,3,2,2,4→27
Relationship to Standards … DODAF, etc. others	2,1,2,1,3,1,1,1,1,→13
Relationship to VV&A (12)	1,2,2,2,2,3,3,3,2,→20
Relationship to BOM, CBML, CML, other (24)	2,2,2,2,3,3,2,2,1,→19
Intellectual Property management	3,5,4,3,4,5,3,4,5→36

Annex E – EXPLANATION OF FUNDAMENTAL CONCEPTS FOR CONCEPTUAL MODEL FRAME-OF-REFERENCE

In order to better understand and incorporate into the best-practice guidance specified in detail in following annexes, the Task Group undertook an analysis of fundamental concepts for conceptual model composition and specification. This analysis addressed particularly the differences and similarities between a variety of commonly used conceptual models, formalisms and ontologies. This analysis had as its objective the following:

- Give appropriate and necessary definitions. Discuss the differences and the benefits of *natural languages, artificial languages, and machine languages.*
- Discuss the possibility to verify the models by rules and constraints – if they have formal representations.
- Explain how to transform an informal conceptual model into a formal or semi-formal model.
- Discuss Machine Readability – e.g., to make an ontology 'machine-readable' we need to select a formal, machine-processable implementation language.
- Show the steps towards making the human-readable information also machine-readable. (One of the accepted ways of expressing such machine readable conceptual models is UML (Unified Modeling Language). UML is being used for far more than simply conceptual modeling. Additionally, UML class diagrams (conceptual models) can be categorized as *semi-formal* ontologies themselves. (Semi-formal because they are not directly machine-readable.) However, tools are being developed that enable automatic transformation from UML class diagrams to ontology formalisms like DARPA Agent Markup Language (DAML), OWL, etc.).

E.1 OVERVIEW

To determine what can be a good conceptual frame for a set of elements for capturing the semantic contents necessary and sufficient for a conceptual model, we have reviewed a number of methods known to the Task Group to be relevant and representative for use for conceptual modeling. We identified and studied sixteen (16) different methods/templates and have noted their properties, their most important information elements, parameters, etc. The results of this analysis revealed, as expected, the common factors among them from which we could select attributes of the consequent conceptual model specification prescriptive guidance to follow.

Given this analysis, a synthesis step followed. Having found the denotative name for information elements, their information content, and justification of their necessity; we allocated those elements to our nascent conceptual modeling process and product. Taken together with the options are their representation/specification, and the degree their quality should be certified; we proceeded to successfully generate a table of semantic contents necessary and sufficient for a conceptual model, along with their qualifying attributes and other necessary information.

For the purpose of this analysis/synthesis, the following terminology is relevant:

- A 'Behavior' is the means an Actor uses to actuate Events.
- An 'Actor' is the subject of action.
- An 'Event' is an action composed of Activities.

- A ‘Control’ defines what can occur within an Activity.
- ‘Information’ details the capabilities of a Behavior, Actor, Event, or Control.

Using this vernacular, a process is specified (in the present context), thus:

Using <Behaviors>, an <Actor> actuates <Events> composed of <Activities> that are directed by <Controls> and richly described by <Information>.

… where the text indicated within carets as reserved words are used below in tabulating the model schema characteristics in tabular form for each model schema analyzed.

E.2 ANALYSIS

Analysis of conceptual schema alternative styles follows, given the primitives established above. In each case, we identify the schema, and characterize it systematically in order both to:

- Appreciate its intrinsic nature and the systematic relationships among alternative typical relevant schema; and
- Provide evidence to the effect that the use of the normative precept above is sufficient for any conceptual model specification.

E.2.1 Method: BOM [1]

Properties educed from examination of the standard in accordance with the strategy outlined in Section E.1 above include the following:

I. Patterns of interplay:
   A. Identifies a sequence of actions.
II. State machines:
   A. Identifies the behavior states expected to be exhibited by one or more conceptual entities.
III. Event type (Conceptual events):
   A. Describes the types of events that are the result of, or triggered from, actions relevant in a pattern of interplay.
   B. Two types:
      1. Triggers.
      2. Messages.
IV. Entity type (Conceptual entities):
   A. Types of conceptual entities that represent senders and receivers of information in a pattern of interplay.
   B. Object classes.
   C. Interaction classes.

A table compiling the canonical allocation of conceptual components evident in the standard to the vernacular conceptual model characteristics reserved words, therefore, is:

Using *Behaviors*	**An *Actor***	**Actuates *Events***	**Composed of *Activities***	**Directed by *Controls***	**Richly Described by *Information***
State machines	Entity type	Event type	Patterns of interplay		
	(Object class)	(Triggers)			
	(Interaction class)	(Messages)			

E.2.2 Method: BOM++ [2]

Properties educed from examination of the standard in accordance with the strategy outlined in Section E.1 above include the following:

I. Patterns of interplay:
  A. Identifies a sequence of actions.
  B. Identifies the behavior states expected to be exhibited by one or more conceptual entities.
II. Event type (Conceptual events):
  A. Describes the types of events that are the result of, or triggered from, actions relevant in a pattern of interplay.
  B. Two types:
    1. Triggers.
    2. Messages.
III. Entity type (Conceptual entities):
  A. Types of conceptual entities that represent senders and receivers of information in a pattern of interplay.
  B. Extended through use of Namespace Qualified Extensions.

A table compiling the canonical allocation of conceptual components evident in the standard to the vernacular conceptual model characteristics reserved words, therefore, is:

Using *Behaviors*	**An *Actor***	**Actuates *Events***	**Composed of *Activities***	**Directed by *Controls***	**Richly Described by *Information***
State machines	Entity type	Event type	Patterns of interplay		
	(Object class)	(Triggers)			
	(Interaction class)	(Messages)			

E.2.3 Method: BPMN [3]

BPMN is particularly conceived to meet the following criteria:

- Designed to be usable to business community; and
- Must generate executable processes through a BPMN model, coupled with some additional information.

Properties educed from examination of the standard in accordance with the strategy outlined in Section E.1 above include the following:

I. Activities:
   A. Work that is performed within a business process.
   B. Can be atomic or non-atomic (compound).
   C. Activities that are a part of a Process Model are:
      1. Sub-Processes:
         a) A compound activity included within a Process:
            (1) Can be broken down into a finer level of detail (a Process) through a set of sub-activities.
            (2) Enables hierarchical process development.
            (3) Two types:
               (a) Embedded.
               (b) Independent (reusable).

II. Task:
   A. An atomic activity that is included within a Process.
   B. Used when the work in the Process is not broken down to finer level of Process Model detail.
   C. Can be looped.

III. Events:
   A. Something that "happens" during the course of a business process.
   B. Affect the flow of the Process.
   C. Usually have a trigger or a result.
   D. Can start, interrupt, or end the flow:
      1. Start:
         a) Indicates where a Process will begin.
      2. Intermediate:
         a) Occur after a process has been started and before a process is ended.
      3. End:
         a) Indicates where a process will end.

IV. Gateways:
   A. Modeling elements that are used to control how Sequence Flows interact as they converge and diverge within a Process:
      1. Exclusive Gateways (decisions):
         a) Locations within a business process where the Sequence Flow can take two or more alternative paths.
         b) Only one of the possible outgoing paths can be taken when the Process is performed:
            (1) Two types decision mechanism:
               (a) Data.
               (b) Events.
               (c) A branching point in the process where the alternatives are based on events that occurs at that point in the Process, rather than conditions.
      2. Inclusive Gateways:
         a) Where there is more than one possible outcome.
      3. Complex Gateways:
         a) Where there more advanced definitions of behavior can be defined.
      4. Parallel Gateways:
         a) Places in the Process where multiple parallel paths are defined.

V. Connectors:
   A. Sequence Flow:
      1. Used to show the order that activities will be performed in a Process.

2. Source and target must be Events, Activities, and Gateways.

B. Conditional.

C. Default:

1. Exits an Exclusive or Inclusive Gateway may be defined as being the default path.

D. Message Flow:

1. Used to show the flow of messages between two entities that are prepared to send and receive them.

E. Association:

1. Used to associate data, information and artefacts with flow objects.

VI. Swim-lanes:

A. Used to partition and organize activities.

B. Pool:

1. Represents Participants in an interactive (B2B) Business Process Diagram.

C. Lane:

1. Represents sub-partitions for the objects within a Pool.

VII. Artefacts:

A. Provide the capability to show information beyond the basic flow-chart structure of the Process:

1. Data Objects:

a) Used to show how data and documents are used within a Process.

2. Groups:

a) Used to highlight certain sections of a Diagram without adding additional constraints for performance, as a Sub-Process would.

3. Annotations:

a) Provide additional information about a Process.

b) A modeler or tool can extend BPMN by defining new Artefacts.

A table compiling the canonical allocation of conceptual components evident in the standard to the vernacular conceptual model characteristics reserved words, therefore, is:

Using *Behaviors*	**An *Actor***	**Actuates *Events***	**Composed of *Activities***	**Directed by *Controls***	**Richly Described by Information**
		Event	Process		Gateways
			– Activity		Connector
			– Sub-process		– Sequence flow
			(embedded)		– Conditional
			(reusable)		– Default
			– Task		– Message flow
					– Association
					Swim-lanes
					– Pool
					– Lane
					Artefacts
					– Data objects
					– Groups
					– Annotations

E.2.4 Method: CML (OneSAF) [4]

Properties educed from examination of the standard in accordance with the strategy outlined in Section E.1 above include the following:

I. Elements:
   A. Real/abstract things making up and acting in the battle-space.
   B. Belong to a Category.
   C. Have Characteristics.
   D. Issue Events.
   E. Stimulate Behaviors.
   F. Behaviors change state of Elements.
   G. Two sub-classes of Elements:
      1. Piece.
      2. Players.
      3. Those things explicitly represented:
         a) Tanks, infantry, etc.
         b) Markers.
      4. Things implicitly represented:
         a) Tactical positions, Psyops, etc.
      5. Game-space:
         a) Environment.
         b) Establish physical battle-space whereas Elements have a location.
      6. Zone:
         a) Abstract spaces where inhabitants do not have a location:
            1) Satellites providing intelligence.

A table compiling the canonical allocation of conceptual components evident in the standard to the vernacular conceptual model characteristics reserved words, therefore, is:

Using *Behaviors*	**An *Actor***	**Actuates *Events***	**Composed of *Activities***	**Directed by *Controls***	**Richly Described by *Information***
Behaviors	Elements	Events		Game-space	Category
	– Piece			Zone	Characteristics
	– Player				

E.2.5 Method: CommonKADS [5]

Properties educed from examination of the standard in accordance with the strategy outlined in Section E.1 above include the following:

I. Communication Model:
   A. Needs and desires with regards to other agents (e.g., a user interface or interfaces with other systems).
II. Knowledge Model:
   A. Knowledge and reasoning requirements.

B. Specifies data and knowledge structures for an application:
   1. Domain knowledge.
   2. Task/Inference Knowledge:
      a) The objectives of an app, together with how to achieve these.
      b) Tasks>Sub-tasks>Elementary inferences.
      c) Therefore, a task is composed of a number of combined inferences, documented in an inference diagram.

A table compiling the canonical allocation of conceptual components evident in the standard to the vernacular conceptual model characteristics reserved words, therefore, is:

Using *Behaviors*	**An *Actor***	**Actuates *Events***	**Composed of *Activities***	**Directed by *Controls***	**Richly Described by *Information***
Communication model	Agent	Task	Sub-task	Communication model	
			Elementary inferences	Knowledge model	
				– Domain	
				– Task/ inference	

E.2.6 Method: DCMF (KM3) [6]

Properties educed from examination of the standard in accordance with the strategy outlined in Section E.1 above include the following:

I. Model element:
   A. Primary active object, as well as objects that are part of actions.
   B. Can be:
      1. EntityType.
      2. RoleinAction.
      3. RoleInOrganizationType.
      4. Action Type.
II. Attribute:
   A. Describes an optional, measurable characteristic of a model element.
III. State:
   A. Set of attributes with values associated with a model element.
   B. Specifies conditions under which an activity starts and ends.
IV. Rules:
   A. Description of changes to model elements.
   B. Rules are pairs:
      1. Activity role.
      2. Atomic formula:
         a) Statement about the state or attributes of a role.

A table compiling the canonical allocation of conceptual components evident in the standard to the vernacular conceptual model characteristics reserved words, therefore, is:

Using *Behaviors*	An *Actor*	Actuates *Events*	Composed of *Activities*	Directed by *Controls*	Richly Described by *Information*
	Element		Activity	State	Attribute
				Rules	

E.2.7 Method: DCMF (M2CM) [7]

Properties educed from examination of the standard in accordance with the strategy outlined in Section E.1 above include the following:

I. Meta data:
  A. Provides information regarding their potential for reuse in extending and creating conceptual models:
    1. POC (Point Of Contact):
      a) Holds information about an organization or a person having a particular role with respect to Conceptual Modeling.
    2. Model Identification:
      a) Accommodates information related to the identification of Conceptual Modeling:
        (1) Name.
        (2) Type.
        (3) Version.
        (4) Modification Date.
        (5) Security Classification.
        (6) Release Restriction.
        (7) Purpose.
        (8) Application Domain.
        (9) Description.
        (10) Use Limitation.
    3. Use History:
      a) Describes how Conceptual Modeling was used.
    4. Reference:
      a) Pointer to additional sources of info:
        (1) T. ex., Locations in XML documents.
        (2) References to ontologies.
    5. Implementation Dependencies:
      a) A log of all dependencies determined during Conceptual Modeling development:
        (1) T. ex., Domain ontologies.
    6. Key Word:
      a) Contains information about keywords (used for searching).
    7. Glyph:
      a) Contains an image of Conceptual Model.
      b) Sub-parts:
        (1) Notation.
        (2) Views.
        (3) Dynamic.
        (4) Static.

II. Static:
  A. Role could possibly be filled using DCMF-O, in particular JC3EIDM:
    1. Action:

        a) Describes military actions on the lowest granular level or higher level aggregation.
    2. Context:
        a) Context in which action occurs.
    3. Reporting:
        a) Contains all data and information.
    4. Rule of Engagement:
        a) Associated with actions.
    5. Candidate-Target List:
        a) Associated with actions.
    6. Objects:
        a) Type:
            (1) Static and persistent.
        b) Item:
            (1) Dynamic and likely to change over time.
    7. Action Capability:
        a) Capability of an object to perform a function or achieve an end.
    8. Location:
        a) Specific place for any item in the sphere of operations.
        b) Geometric shapes needed to plan, direct, and monitor operations:
            (1) Related to object-item concept.
            (2) T. ex, Boundaries.
            (3) Corridors.
            (4) Restricted Area.
            (5) Minefields.
    9. Affiliation:
        a) All objects possess an affiliation:
            (1) T. ex Political Nation.
            (2) Ethnic group.

III. Dynamic:
  A. Role could possibly be filled using DCMF-O, in particular BOM++:
    1. Captures activities, actions, and decisions performed by the atomic knowledge components of the Conceptual Model.
  B. Pattern of Interplay:
    1. Represented by one or more pattern actions needed to accomplish a specific purpose or capability.
  C. State Machine:
    1. Describes the possible states of the conceptual entities as well as the transitions between them.
  D. Entity Type:
    1. Provides a mechanism for describing the types of conceptual entities used to represent senders and receivers identified within a Pattern of Interplay and to carry out the role of conceptual entities identified within the state machine.
  E. Event Type:
    1. Provides a mechanism for describing the types of conceptual events used to represent and carry out:
        a) Pattern actions.
        b) Variations.
        c) Exceptions.

A table compiling the canonical allocation of conceptual components evident in the standard to the vernacular conceptual model characteristics reserved words, therefore, is:

Using *Behaviors*	**An *Actor***	**Actuates *Events***	**Composed of *Activities***	**Directed by *Controls***	**Richly Described by *Information***
State machine	Entity type	Event type	Pattern of interplay	Ontology stack	Meta data
				(Action) (Context) (Reporting) (Rules of Engagement) (Candidate-Target List) (Objects) (Action Capability) (Location) (Affiliation)	(POC) (Use history) Reference (Implementation Dependencies) (Key word) (Glyph) (Model ID) – Name – Type – Version – Modification date – Security Classification – Release restriction – Purpose – Application domain – Description – Use limitation

E.2.8 Method: DRDC [8]

Properties educed from examination of the standard in accordance with the strategy outlined in Section E.1 above include the following:

I. Elements:
   A. Entities.
   B. Entity Attributes.
   C. Functions/Actions.
   D. Relationships/Interactions.
II. Assumptions.
III. Functions/Actions.
IV. Constraints (restraints) / Bounds / Limitations (restrictions).
V. Domain Specific Algorithms.

A table compiling the canonical allocation of conceptual components evident in the standard to the vernacular conceptual model characteristics reserved words, therefore, is:

Using *Behaviors*	**An *Actor***	**Actuates *Events***	**Composed of *Activities***	**Directed by *Controls***	**Richly Described by *Information***
Functions/ actions	Elements			Entity attributes	Attributes
				Relationships/ interactions	Assumptions
				Constraints/ bounds/ limitations	Domain specific algorithm

E.2.9 Method: Entity Relationship [9]

Entity Relationship perspectives are characterized by the following:

- Role of an entity in a relationship is the function that it performs in the relationship.
- The information about an entity or a relationship is obtained by observation or measurement, and is expressed by a set of attribute-value pairs.
- An attribute can be formally defined as a function which maps from an entity set or a relationship set into a value set or a Cartesian product of value sets.
- Another conceptual approach is provided by Entity-Relationship (ER) Modeling (ERM) Although ER models can be useful once the design process is finished, they are less suitable for formulating, transforming or evolving a design. ER diagrams are further removed from natural language, cannot be populated with fact instances, require complex design choices about attributes, lack the expressability and simplicity of a role-based notation for constraints, hide information about the semantic domains which glue the model together, and lack adequate support for formal transformations. Many different ER notations exist that differ in the concepts they can express and the symbols used to express these concepts. For such reasons we prefer ORM for conceptual modeling. In addition to ORM, VEA supports IDEF1X (a hybrid of ER and relational modeling) as a view of ORM.

Properties educed from examination of the standard in accordance with the strategy outlined in Section E.1 above include the following:

I. Entity:
   A. A “thing” which can be distinctly identified.
II. Relationship:
   A. An association among entities.

A table compiling the canonical allocation of conceptual components evident in the standard to the vernacular conceptual model characteristics reserved words, therefore, is:

Using *Behaviors*	**An *Actor***	**Actuates *Events***	**Composed of *Activities***	**Directed by *Controls***	**Richly Described by *Information***
	Entity			Attribute/ value pairs	Attribute/value pairs
				Relationships	

E.2.10 Method: KAMA [10]

Properties educed from examination of the standard in accordance with the strategy outlined in Section E.1 above include the following:

I. Core meta-model (KAMA Foundation):
   A. KAMA Behavior:
      1. Missions.
      2. Tasks.
      3. Activities.
      4. Events.
      5. States.
      6. Data Items.
      7. Command/Control Units.
   B. KAMA Relationships.
   C. KAMA State Machine:
      1. Expresses the behavior of a conceptual model entity.

A table compiling the canonical allocation of conceptual components evident in the standard to the vernacular conceptual model characteristics reserved words, therefore, is:

Using ***Behaviors***	An ***Actor***	Actuates ***Events***	Composed of ***Activities***	Directed by ***Controls***	Richly Described by ***Information***
KAMA state machine			KAMA behavior	KAMA behavior	Attribute/value pairs
				KAMA relationships	KAMA relationships

E.2.11 Method: Mind Maps [11]

Properties educed from examination of the standard in accordance with the strategy outlined in Section E.1 above include the following:

I. Central focus of an image or graphic representation of the problem or information being mapped is placed in the center of a page (BOI’s or Basic Ordering Ideas):
   A. Associate and connect ideas with lines, arrows, and symbols:
      1. Ideas are allowed to flow freely without judgment.
      2. Key words are used to represent ideas.
      3. One key word is printed per line.
      4. Key word ideas are connected to the central focus with lines.
      5. Color is used to highlight and emphasize ideas.
      6. Images and symbols are used to highlight ideas and stimulate the mind to make other connections.

A table compiling the canonical allocation of conceptual components evident in the standard to the vernacular conceptual model characteristics reserved words, therefore, is:

Using *Behaviors*	An *Actor*	Actuates *Events*	Composed of *Activities*	Directed by *Controls*	Richly Described by *Information*
N/A	N/A	N/A	N/A	N/A	N/A

E.2.12 Method: Topic Maps [12]

Properties educed from examination of the standard in accordance with the strategy outlined in Section E.1 above include the following:

- I. Topics:
  - A. Are related to each other by associations, which are typed n-ary combinations of topics:
    - 1. Associations are the general form for the representation of relationships between topics in a topic map. An association can be thought of as an n-ary aggregate of topics. That is, an association is a grouping of topics with no implied direction or order, and there is no restriction on the number of topics that can be grouped together.
  - B. May also be related to any number of resources by its occurrences.
  - C. Represents information using:
    - 1. Associations (representing relationships between topics):
      - a) Each topic involved in an association has a role type.
    - 2. Occurrences (representing information resources relevant to a particular topic):
      - a) Used to represent or refer to information about a concept represented by a topic.
      - b) Can be used either to store string data within the topic map, or to reference any kind of Web-addressable resource external to the topic map.
- II. Topics (representing any concept):
  - A. A topic is a machine-processable representation of a concept:
    - 1. Topics have:
      - a) Four principal forms of identity.
      - b) Can have zero or more of each of these forms of identity, and thus can be identified within a topic map system by a number of different ways:
        - (1) Identity as a topic resource in a serialized topic map:
          - (a) When a topic map is represented in a serialized form for interchange, each topic is assigned a URI identifier that is unique across that topic map.
          - (b) These URIs are used principally for deserializing references between topics.
          - (c) Such identifiers are referred to as source locators.
        - (2) Identity as a human-readable label:
          - (a) Names act as labels for human consumption:
            - (i) Can be either text or a reference to some non-textual representation (for example, an icon, a sound clip, an animation clip, and so on.).
              - (a) Can have any number of topic names.
            - (ii) The scope mechanism allows for the case of homonyms (where a single word is used to refer to two or more different concepts).
        - (3) Identity by reference:
          - (a) When a topic is used to represent a resource that already has its own unique URI, that URI can be used as part of the identity of the topic.
          - (b) Known as a subject locator in the topic map standard.
        - (4) Identity by description:
          - (a) Topics can be used to represent a concept that does not have its own unique URI:

(i) Many of the things that a topic can represent could never have a unique URI because they are not things that a computer can resolve a reference to:
   (a) For example, a person may have any number of database records about himself or online biographies or pictures, but none of those addressable resources are the person – they are merely some form of descriptor for the person.
(ii) The resource that the subject identifier resolves to is known as a subject indicator.

(b) Subject identifiers (URIs) identify the subject the topic is about:
   (i) The key difference between a subject identifier and subject locator is that a subject identifier requires human interpretation of a resource to determine the concept that a topic represents, whereas a subject locator simply points to the concept that the topic represents.

III. Scope:
   A. Used in the topic map standard to refer to a constraint or a context in which something is said about a topic. The way in which such statements about topics are made is by adding a name to the topic; specifying an occurrence for a topic; or creating an association between topics (in which case the statement applies to all of the topics in the association):
      1. Can be attached to any name, occurrence, or association in a topic map to qualify a statement, but still express it.
      2. Is defined by a collection of topics that can be assigned to a name, an occurrence, or an association. The default scope (where no set is assigned) is known as the unconstrained scope and simply means that the name, occurrence, or association is always valid.

IV. Topic Merging:
   A. In any given topic map, each subject described by the topic map must be represented by one and only one topic in the topic map. This means that it is the responsibility of the topic map processor to attempt to identify the situation in which two topics represent the same subject and to process them so that only one topic remains. This is the process of merging.

A table compiling the canonical allocation of conceptual components evident in the standard to the vernacular conceptual model characteristics reserved words, therefore, is:

Using *Behaviors*	**An *Actor***	**Actuates *Events***	**Composed of *Activities***	**Directed by *Controls***	**Richly Described by *Information***
N/A	N/A	N/A	N/A	N/A	N/A

E.2.13 Method: Operational Conceptual Modeling Language (OCML) [13]

Operational Conceptual Modeling Language has the following attributes:

- Description at: http://technologies.kmi.open.ac.uk/ocml/;
- Allows the specification and operationalization of functions, relations, classes, instances and rules; and
- Includes mechanisms for defining ontologies and problem solving methods, the main technologies developed in the knowledge modeling area.

Properties educed from examination of the standard in accordance with the strategy outlined in Section E.1 above include the following:

I. Relations:
   A. Allow the OCML user to define labeled n-ary relationships between OCML entities.
II. Functions:
   A. Defines a mapping between a list of input arguments and its output argument.
III. Classes.
IV. Instances.
V. Rules:
   A. Forward: forward rule comprises zero or more antecedents and one or more consequents.
   B. Backward.
VI. Procedures:
   A. Define actions or sequences of actions which cannot be characterized as functions between input and output arguments.
VII. Constructs:
   A. Functional:
      1. Specifies an object in the current domain of investigation:
         a) Can be:
            (1) Constant.
            (2) Variable.
            (3) String.
            (4) Function application.
            (5) Can also be constructed by means of a special term constructor.
   B. Control terms:
      1. Specify actions.
      2. Describe the order in which actions are executed.
      3. Can be expressed as:
         a) Sequential.
         b) Iterative.
         c) Conditional control structures.
   C. Logical expressions.

A table compiling the canonical allocation of conceptual components evident in the standard to the vernacular conceptual model characteristics reserved words, therefore, is:

Using *Behaviors*	**An *Actor***	**Actuates *Events***	**Composed of *Activities***	**Directed by *Controls***	**Richly Described by *Information***
	Classes		Procedures	Relations	
	Instances			Functions	
	Functional construct			Rules	
				Control terms	

E.2.14 Method: Object Process Methodology (OPM) [14]

See for reference: http://www.opcat.com/products_opm.htm.

Properties educed from examination of the standard in accordance with the strategy outlined in Section E.1 above include the following:

I. Object Process Diagrams (OPD):
    A. Formal graphic model.
II. Object Process Language (OPL):
    A. Natural language (English sub-set/controlled vocabulary) generated in RT in response to human input in OPD.
    B. OPD are developed and then OPL is generated from it.
III. Three building blocks:
    A. Objects:
        1. Things that exist.
        2. Physical or informational things:
            a) What are the states of the object?
            b) Which processes create, destroy, and modify the object?
            c) Which processes does it instrument?
    B. Processes:
        1. Things that transform objects by changing their states or creating or consuming objects.
        2. Processes are peers of Objects.
        3. Objects may contain processes and processes may contain objects:
            a) Which objects instrument and initiate the process?
            b) Which of the three functionalities does it fulfill: create, destroy, or modify the states of an object?
    C. States:
        1. Lower level entities since states are expressed inside of objects:
            a) What object does it belong to?
            b) Which process triggered the change of the state?
            c) What are the source and destination states?
IV. Two parts of OPM ontology:
    A. Entities.
    B. Links, which can be:
        1. Structural – express static, time-independent relations between pairs of entities.

A table compiling the canonical allocation of conceptual components evident in the standard to the vernacular conceptual model characteristics reserved words, therefore, is:

Using *Behaviors*	**An *Actor***	**Actuates *Events***	**Composed of *Activities***	**Directed by *Controls***	**Richly Described by *Information***
	Object	Processes	Processes	States	

E.2.15 Method: Object-Role Modeling (ORM) [15]

Object Role Modeling may be characterized as follows:

- Early versions of object role modeling were developed in Europe in the mid-1970s (for example, binary relationship modeling and Natural Language Information Analysis Method (NLIAM)). The version discussed here is based on the author's formalization of the method, and incorporates extensions and refinements arising from research conducted in Australia and the United States. The associated language Formal Object-Role Modeling Language (FORML) is supported in Microsoft® Visio® for Enterprise Architects (VEA), part of Visual Studio® .NET Enterprise Architect.

- The information system's life-cycle typically involves several stages: feasibility study; requirements analysis; conceptual design of data and operations; logical design; external design; prototyping; internal design and implementation; testing and validation; and maintenance. ORM's Conceptual Schema Design Procedure (CSDP) focuses on the analysis and design of data. The conceptual schema specifies the information structure of the application: the types of fact that are of interest; constraints on these facts; and perhaps the derivation rules for deriving some facts from others.

A table compiling the canonical allocation of conceptual components evident in the standard to the vernacular conceptual model characteristics reserved words, therefore, is:

Using *Behaviors*	**An *Actor***	**Actuates *Events***	**Composed of *Activities***	**Directed by *Controls***	**Richly Described by *Information***
					Conceptual schema

E.2.16 Method: UML [16]

Properties educed from examination of the standard in accordance with the strategy outlined in Section E.1 above include the following:

I. Structure Diagrams:
   A. Class Diagram:
      1. Shows how the different entities (people, things, and data) relate to each other.
   B. Object Diagram.
   C. Component Diagram:
      1. A physical view of the system, meant to show the dependencies that the software has on the other software components.
   D. Composite Structure Diagram.
   E. Package Diagram.
   F. Deployment Diagram:
      1. Shows how a system will be physically deployed in the hardware environment.

II. Behavior Diagrams:
   A. Use Case Diagram:
      1. Illustrates a unit of functionality provided by the system.
   B. Activity Diagram:
      1. Show the procedural flow of control between two or more class objects while processing an activity.
   C. State Machine Diagram:
      1. Models the different states that a class can be in and how that class transitions from state to state.

III. Interaction Diagrams:
   A. Sequence Diagram:
      1. Shows a detailed flow for a specific use case or even just part of a specific use case.
   B. Communication Diagram.
   C. Timing Diagram.
   D. Interaction Overview Diagram.

IV. Other important concepts:
   A. A UML profile is a specification that does one or more of the following:
      1. Identifies a sub-set of the UML meta-model.

2. Specifies "well-formedness rules" beyond those specified by the identified sub-set of the UML meta-model.
3. "Well-formedness rule" is a term used in the normative UML meta-model specification to describe a set of constraints written in UML's Object Constraint Language (OCL) that contributes to the definition of a meta-model element.
4. Specifies "standard elements" beyond those specified by the identified sub-set of the UML met-model.
5. "Standard element" is a term used in the UML meta-model specification to describe a standard instance of a UML stereotype, tagged value or constraint.
6. Specifies semantics, expressed in natural language, beyond those specified by the identified sub-set of the UML meta-model.
7. Specifies common model elements, expressed in terms of the profile.

B. Stereotype:
1. A stereotype defines how an existing meta-class may be extended, and enables the use of platform or domain specific terminology or notation in place of, or in addition to, the ones used for the extended meta-class.
2. A stereotype denotes a variation on an existing modeling element with the same form but with a modified intent. Stereotypes are effectively used to extend the UML in a consistent manner.

Language Unit	Purpose
Actions	(Foundation) modeling of fine-grained actions
Activities	Data and control flow behavior modeling
Classes	(Foundation) modeling of basic structures
Components	Complex structure modeling for component technologies
Deployments	Deployment modeling
General Behaviors	(Foundation) common behavioral semantic base and time modeling
Information Flows	Abstract data flow modeling
Interactions	Inter-object behavior modeling
Models	Model organization
Profiles	Language customization
State Machines	Event-driven behavior modeling
Structures	Complex structure modeling
Templates	Pattern modeling
Use Cases	Informal behavioral requirements modeling

A table compiling the canonical allocation of conceptual components evident in the standard to the vernacular conceptual model characteristics reserved words, therefore, is:

Using *Behaviors*	**An *Actor***	**Actuates *Events***	**Composed of *Activities***	**Directed by *Controls***	**Richly Described by *Information***
General behaviors	Classes		Actions	Behavior diagrams – Use case diagram Activity diagram State machine diagram	Structure diagram – Class diagram
Interactions			Activities	Interaction diagrams – Sequence diagrams – Communications diagrams – Timing diagram – Interaction overview diagram	
State machines				Profiles	
				Stereotypes	
				Use cases	

E.3 REFERENCES

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Annex F – STANDARDS

F.1 INTRODUCTION

As indicated in Section 3.2.6 "Standards Review and Evaluation" of the accompanying text, the Team invested significant effort reviewing standards potentially relevant to conceptual modeling in hopes of leveraging existing standards and standards types to the greatest extent possible in developing the best-practice guidance contained herein.

An indication of the scope and evaluative interest in such standards is provided in Table F-1 following. Based on an initial review of the standards indicated therein, the Team selected nineteen (19) standards of particular interest to conceptual modeling and for further analysis and commentary.

Table F-1: Standards with Applicability in NATO Modeling and Simulation Domain.

STANDARD	Standard Development Organization	Status	Functional Area	Define Application Objectives	Perform Conceptual Analysis	Design Federation	Design Simulation	Develop Simulation	Develop Federation	Plan, Integrate and Test Application	Execute Application and Prepare Outputs	Analyze Data and Evaluate Results
CMMI	Carnagie Mellon University	Published	Business Process Management	X								X
BOMs	SISO	Published	Conceptual Modeling		X	X	X		X			
CML	OneSAF PMO	Published	Conceptual Modeling	X	X	X	X	X	X			
IDEF0	IEEE	Published	Conceptual Modeling		X							
IDEF5	KBS	Published	Conceptual Modeling		X	X	X	X	X			
OWL-Web Ontology Language	W3C	Published	Conceptual Modeling		X							
Simulation Conceptual Modeling RP	SISO	Concept	Conceptual Modeling		X	X	X					
UML	OMG	Published	Conceptual Modeling		X	X	X	X				
DCMF	Open Source	Published	Data Engineering		X	X	X					
IDEF1X	NIST	Published	Data Engineering		X		X	X				

STANDARD	Standard Development Organization	Status	Functional Area	Define Application Objectives	Perform Conceptual Analysis	Design Federation	Design Simulation	Develop Simulation	Develop Federation	Plan, Integrate and Test Application	Execute Application and Prepare Outputs	Analyze Data and Evaluate Results
OKBC	DARPA	Published	Data Engineering		X	X	X					
RDF	World-Wide-Web Consortium (W3C)	Published	Data Engineering			X	X	X	X			
XML	W3C	Published	Data Engineering					X	X		X	
C-BML	SISO	Draft	Data Mediation		X			X	X	X	X	
CMSD	SISO	Draft	Data Mediation					X	X	X	X	
JC3IEDM	MIP	Published	Data Mediation			X	X	X	X			
OpenFlight	MultiGen-Paradigm	Published	Data Mediation				X	X	X			
SEDRIS	ISO	Published	Data Mediation				X	X	X	X	X	
DFAD	U.S. DoD	Published	Data Production Format				X	X	X	X	X	
DTED	U.S. DoD	Published	Data Production Format				X	X	X	X	X	
DEVS	SISO	Concept	M&S-Miscellaneous				X	X				
SCORM Sim	SISO	Concept	M&S-Miscellaneous			X	X	X	X	X	X	
SRML	SISO	Draft	M&S-Miscellaneous				X	X				
HLA FEDEP	SISO/IEEE	Published	M&S-Process	X	X	X	X	X	X	X	X	X
SEDEP	EUCLID	Published	M&S-Process	X	X	X	X	X	X	X	X	X

STANDARD	Standard Development Organization	Status	Functional Area	Define Application Objectives	Perform Conceptual Analysis	Design Federation	Design Simulation	Develop Simulation	Develop Federation	Plan, Integrate and Test Application	Execute Application and Prepare Outputs	Analyze Data and Evaluate Results
Link 11 Simulations	SISO	Draft	M&S-Representation				X	X	X			
Link 16 Simulations	SISO	Published	M&S-Representation				X	X	X			
MOD-5/S IFF	SISO	Concept	M&S-Representation				X	X	X			
RPR FOM	SISO	Published	M&S-Representation			X	X	X	X			
MSDL	SISO	Draft	M&S-Scenarios		X			X	X	X	X	
CSPI	SISO	Draft	M&S-Simulation Inter-Operability					X				
DIS	SISO/IEEE	Published	M&S-Simulation Inter-Operability				X	X	X	X	X	
HLA	SISO/IEEE	Published	M&S-Simulation Inter-Operability		X (OMT)	X (OMT)		X	X	X	X	
TENA	US DoD	Published	M&S-Simulation Inter-Operability			X	X	X	X	X	X	
CORBA	OMG	Published	Software Engineering					X	X	X	X	
MDA	OMG	Published	Software Engineering		X	X	X	X				
RUP	IBM	Published	Software Engineering			X	X	X	X			
Software QA Plans (1220)	IEEE	Published	Software Engineering				X	X				

STANDARD	Standard Development Organization	Status	Functional Area	Define Application Objectives	Perform Conceptual Analysis	Design Federation	Design Simulation	Develop Simulation	Develop Federation	Plan, Integrate and Test Application	Execute Application and Prepare Outputs	Analyze Data and Evaluate Results
Software Reuse Data Model (1420)	IEEE	Published	Software Engineering				X	X				X
UML	OMG	Published	Software Engineering			X	X	X	X			
DoD Architecture Framework	US DoD	Published	Systems Engineering	X	X	X						
MOD Architecture Framework	UK MOD	Published	Systems Engineering	X	X	X						
SysML	OMG/INCOSE	Published	Systems Engineering			X	X	X	X			
GM-V&V	SISO	Concept	V&V	X	X		X	X		X	X	X
REVVA1	EUCLID	Published	V&V	X	X	X	X	X	X	X	X	X
V&V Information Exchange	ITOP	Published	V&V		?					X	X	
VV&A Overlay to FEDEP	SISO/IEEE	Draft	V&V	X	X	X			X	X	X	X
VV&A RPG	US DoD	Published	V&V	X	X	X	X	X	X	X	X	X

F.2 RELEVANT STANDARDS CHARACTERIZATION

In the tables that follow, selected standards identified in Table F-1 above are described in considerable detail. The intention of the Task Group in providing this description is to provide users of the best-practice guidance contained formally in Annexes G and H below to leverage to best advantage – contingent enterprise and technical constraints and motivations – some of the several standards that are known by the Group to be relevant to both the specification of conceptual models themselves and to the expression of best-practice within enterprise contexts.

Standards described in detail in the tables following include:

- Based Object Model (BOM).
- Conceptual Modeling Language (CML).
- Capability Maturity Model Integration (CMMI).
- Defence Conceptual Modeling Framework (DCMF).
- Discrete Event Systems (DEVS).

- Department of Defense Architecture Framework (DoDAF).
- Generic Methodology for Verification, Validation (GM-VV).
- Integrated Definition Methods (IDEF0).
- Integrated Definition Methods (IDEF5).
- Joint Command Control Communications Information Exchange Data Model (JC3IEDM).
- Kernel Meta Meta Model (KM3).
- Model Driven Architecture (MDA).
- NATO Architecture Framework (NAF).
- Open Knowledge Base Connectivity (OKBC).
- Web Ontology Language (OWL).
- Resource Description Framework (RDF).
- Rational Unified Process (RUP).
- Systems Modeling Language (SysML).
- Unified Modeling Language (UML).

Table F-2: Based Object Model (BOM).

ATTRIBUTE	COMMENTS
Organization:	Simulation Interoperability Standards Organization (SISO)
Definition:	The BOM is a component-based standard for describing a reusable piece part of a federation or an individual federate. Specifically, the BOM specification offers ontology for characterizing elements of a simulation and relationships among conceptual entities within a simulation environment as a language neutral interface. BOMs can be used to document the interface for one or more of the following piece part elements: 1) Object classes; 2) Interaction classes; 3) Patterns of interplay; 4) State machines; and 5) Events. BOMs provide developers and users a modular approach for defining and adding new capabilities to a federate or federation, and in quickly composing object models such as HLA FOMs and SOMs through BOM Assemblies.
Intended Use:	Base Object Models (BOMs) provide a key mechanism in facilitating interoperability, reuse, and composability. BOMs are specifically identified in the IEEE 1516.3 HLA Federation Development and Execution Process (FEDEP) as a potential facilitator for providing reusable model components used for the rapid construction and modification of federates and federations. The open standardization of BOM representations is considered essential for encouraging their development, distribution and use. The BOM concept is based on the assumption that piece-parts of simulations and federations can be extracted and reused as modeling building-blocks or components.

ATTRIBUTE	COMMENTS
Intended Use (cont'd):	The interplay within a simulation or federation can be captured and characterized in the form of reusable patterns. These patterns of simulation interplay are sequences of events between simulation elements. The implementation of the pattern using HLA object model constructs is also captured in the BOM.
Community of Usage:	Primary in Military Modeling and Simulation domain but even across government and non-government applications worldwide.
Significant Attributes:	The BOM framework as documented in the BOM specification and the BOM guidance document is intended to influence the following six capabilities within the M&S community: Interoperability – The application of Extensible Markup Language (XML) and XML Schemas prescribed for BOMs provides a mechanism for defining and validating context, and facilitates understanding of the data being exchanged. Furthermore, the flexibility offered by BOMs allows for greater application of simulation interoperability within other domains. Reusability – The Meta data cataloged within a BOM such as intent-of-use, integration history, behavioral information, and potential visual information will facilitate greater reuse of components. Composability – BOMs will facilitate the ability to rapidly compose simulations and simulation environments both statically (design time) and dynamically (at run-time). Adaptability – Mega-BOMs produced by BOM compositions can be used to represent the standard data exchange interface for systems and simulations. Aggregation – The application of BOMs can be used for supporting two types of aggregation: Pattern Aggregation and Entity Aggregation. Pattern Aggregations reflect the coupling of interface groupings that can be identified prior to an exercise. Entity Aggregations reflect the coupling of multiple entities into a single inclusive group, which can be accomplished during a Federation Execution (FEDEX). Multi-resolution Models – At the Federate Capability Level, BOMs can be used to represent the behavior states needed for modeling a conceptual entity of one or more patterns of interplay. Federates can choose from an assortment of BOM Component Implementations (BCIs) of varying resolutions which can be swapped out dynamically during an exercise, assuming the proper precautions are taken to ensure validity and consistency.
Relevance to Our Work:	See FOI-R—2363—SE (BOM and DCMF), BOM++, a Semantically Enriched BOM.
Relevance of Form for Our Product Specification:	High: • Its Meta data port (Model Identification) can be re-used. • BOM fulfils some of basic requirements on a Conceptual model such as; reusability composability and syntactic interoperability. • BOM structure and mechanism (like pattern of interplay and state Machine) as well as BOM Assembly can be source of inspiration.
References:	http://www.boms.info/. "Simulation Interoperability Standards Organization (SISO) Base Object Model (BOM) Template Specification SISO-STD-003-2006", 31 March 2006 Copyright © 2004 – 2006 by the Simulation Interoperability Standards Organization, Inc., P.O. Box 781238, Orlando, FL 32878-1238, USA.

ATTRIBUTE	COMMENTS
References (cont'd):	Simulation Interoperability Standards Organization (SISO) Guide for Base Object Model (BOM) Use and Implementation SISO-STD-003.0 DRAFT-V0.12, 26 October 2005, Prepared by: SISO Base Object Model Product Development Group Keywords: Automation, Behavior, BOM, Components, Composability, Conceptual Model, FEDEP, Interoperability, Meta data, Patterns, Requirements, Reuse Copyright © 2004 – 2005 by the Simulation Interoperability Standards Organization, Inc., P.O. Box 781238, Orlando, FL 32878-1238, USA.

Table F-3: Conceptual Modeling Language (CML).

ATTRIBUTE	COMMENTS
Organization:	U.S. Army, OneSAF Program
Definition:	CML is the OneSAF conceptual modeling language.
Community of Usage:	CML is used within the OneSAF development enterprise as an implementation independent and computationally amenable tool to increase efficiency and security of transformation of information about the real world into simulation computational structures.
Significant Attributes:	CML consists of meta-class components and inter class relationships which, when instantiated, constitute a pictorial and text specification of the military mission space conceptual model. The existence of well-defined component class types, and intended interclass relationships provides a meta model, whereby the conceptual model practitioner may instantiate conceptual model artefacts that will be reduced to computational implementation in accordance with the pre-existing correlations between conceptual model components and computational component artefacts. CML class and relationships were expressly selected to facilitate representation of military mission-space scenarios. The use of CML has been observed to yield the following benefits: "1) improves KAKE and developer productivity; 2) provides a common frame of reference for all shareholders; 3) minimizes requirements creep by limiting KAKE to relevant issues; and 4) provides a sufficiently detailed description of the modeling solution to minimize misinterpretations and reinterpretations of the requirements."
Relevance to Our Work:	CML and its associated employment process are ostensibly highly relevant to the subject effort, having been specifically designed to serve for conceptual model specification for military models and simulations. The language further has been used and tailored/optimized to this purpose in context of the OneSAF simulation development environment. Specializations within CML related to capturing military mission space representation are specifically relevant to the current work. On the other hand, language features and associated process specializations that are peculiar to OneSAF simulation representation and/or implementation paradigm (such as simulation time advance mechanization, data modularization protocols, object class declarations and visibility, etc.) are likely not suitable for the present effort.

ATTRIBUTE	COMMENTS
Relevance to Our Work (cont'd):	(NOTE that notwithstanding the assertion that CMS is "implementation independent", several features – many implicit in the CML itself – seem to entail implementation-specific presumption.)
Relevance of Form for Our Product Specification:	Notational form for within CML is suggestive and relevant in many ways for military mission space representation. On the other hand, the notation is not either an industry standard nor does it evidently support translation to alternative notations. It is, in fact particularly specific to time management, data flow, and control flow specifically elected from a wider range of options for use in OneSAF simulation implementation. The notation as -is is not suitable for use in the documents resulting from this task. It may be appropriate and sufficient as a notation for implementation of the best-practice guidance being developed, if-and-only-if its intended application environment is sufficiently similar to that of OneSAF.
References:	"Conceptual Modeling in OneSAF Software Development", briefing provided by Greg Tackett in cooperation with the U. S. Army OneSAF Program Office.

Table F-4: Capability Maturity Model Integration (CMMI).

ATTRIBUTE	COMMENTS
Organization:	Carnegie Mellon, Software Engineering Institute (SEI)
Definition:	CMMI is not a process (M1 level). It is a process improvement approach (M2 level) that provides organizations with the essential elements of effective processes.
Intended Use:	It can be used to guide process improvement across a project, a division, or an entire organization. CMMI helps integrate traditionally separate organizational functions, set process improvement goals and priorities, provide guidance for quality processes, and provide a point of reference for appraising current processes. Two models exist. The CMMI for Development is a reference model that covers the development and maintenance activities applied to both products and services. Organizations from many industries, including aerospace, banking, computer hardware, software, defence, automobile manufacturing, and telecommunications, use CMMI for Development. This document is a reference model that covers the acquisition of needed capabilities. Capabilities are acquired in many industries, including aerospace, banking, computer hardware, software, defence, automobile manufacturing, and telecommunications. All these industries can use CMMI-ACQ.
Community of Usage:	It is difficult to quantify how many organizations have adopted CMMI because any organization can use CMMI for process improvement without having to register with the SEI or otherwise identify themselves to the public.

ATTRIBUTE	COMMENTS
Community of Usage (cont'd):	However, there have been over 55,000 people who have attended Introduction to CMMI training, and CMMI has been adopted in many industries (e.g., software, finance, and manufacturing) in countries around the world (e.g., United States, Australia, Japan, Brazil, and Russia).
Significant Attributes:	The CMMI model is composed of these main components: process areas, goals and practices. It also includes other components such as notes, examples, amplifications (domain specific notes and examples) and references. Some components are required, other are expected or informative. A process area is a cluster of related practices in an area that, when implemented collectively, satisfy a set of goals considered important for making improvement in that area. A specific goal describes the unique characteristics that must be present to satisfy the process area. Generic goals are called "generic" because the same goal statement applies to multiple process areas. A generic goal describes the characteristics that must be present to institutionalize the processes that implement a process area A specific practice is the description of an activity that is considered important in achieving the associated specific goal. The specific practices describe the activities that are expected to result in achievement of the specific goals of a process area. Generic practices are called "generic" because the same practice applies to multiple process areas. A generic practice is the description of an activity that is considered important in achieving the associated generic goal. A generic practice elaboration appears after a generic practice in a process area to provide guidance on how the generic practice should be applied uniquely to the process area. A sub-practice is a detailed description that provides guidance for interpreting and implementing a specific or generic practice The typical work-products are sample output from a specific practice. Levels are used in CMMI to describe an evolutionary path recommended for an organization that wants to improve the processes it uses to develop and maintain its products and services. CMMI supports two representations. The staged representation (maturity levels) offers a systematic way to approach process areas one stage at a time. Achieving each stage ensures that an adequate process infrastructure has been laid as a foundation for the next stage. In the continuous representation (capability levels), an organization can choose to improve different processes at different rates. A CMMI level can be officially certified following a rating activity of appraisals. The Standard CMMI Appraisal Method for Process Improvement (SCAMPI) provides benchmark quality ratings relative to CMMI models.
Relevance to Our Work:	Since the CMMI models have been designed in a generic manner to improve processes, some of its components (process areas, goals, practices, etc.) are directly applicable to our conceptual modeling process guidelines. The CMMI for Development is privileged because M&S is a developmental activity within the targeted organizations.

ATTRIBUTE	COMMENTS
Relevance to Our Work (cont'd):	The notion of maturity levels is also very useful to scale the Conceptual Model process specification to various organizational needs and to guide them toward our strategic vision (Level 5). This representation is privileged because it is easier to understand.
Relevance of Form for Our Product Specification:	The M2 level of language of the CMMI makes it appropriate to serve as an example for our Conceptual Model Process Spec.
References:	http://www.sei.CMu.edu/CMmi/, CMMI for Development, Version 1.2, CMMI Product Group, *Technical Report*, CMU/SEI-2006-TR-008, August 2006, 573 pp.

Table F-5: Defence Conceptual Modeling Framework (DCMF).

ATTRIBUTE	COMMENTS
Organization:	FOI – Swedish Defence Research Agency
Definition:	DCMF is a framework developed to understand and describe activities and processes in military operations. These descriptions will then be the foundation for developing conceptual models in a formal way. Those models are primarily used for simulation model development. The framework consists of a number of components which together support developers in the task of creating high quality conceptual models out of unstructured data. Examples of Framework's components are a specified modeling process, ontologies and specifications of the format of the models.
Intended Use:	The overall objectives for DCMF is to capture authorized knowledge of military operations; to manage, model and structure the obtained knowledge in an unambiguous way; and to preserve and maintain the structured knowledge for future use and reuse. The premier aim of doing so is to enable semantic and substantive interoperability of the future simulation models built on these descriptions. Another long-term goal with DCMF is reusability which will reduce costs and enhance the quality in the development of conceptual models. Our vision is that DCMF will evolve enough to become a standard for the development of simulation models within the Swedish Armed Forces.
Community of Usage:	FOI and Swedish Armed Forces.
Significant Attributes:	MSMs – Mission Space Models – which are the final result of the DCMF process, and the kernel of both DCMF and CMMS they are defined as simulation and implementation independent functional descriptions of the real-world processes, entities, and environmental factors associated with a particular set of missions.

ATTRIBUTE	COMMENTS
Significant Attributes (cont'd):	These descriptions would be able to serve as a frame of reference for simulation development by capturing the basic information about the important entities involved in any mission, and their key actions and interactions. It is to say these are for all stakeholders in the M&S process a common description of what is to be simulated and serve as a bridge between the military experts and the developers. The military experts own the mission process and are an authoritative source when validating the content of the conceptual models. MSMs also serve as a platform for communication among stakeholders working with these simulation models. Already within the Modeling and Simulation Master Plan (MSMP) developed by the US DoD the CMMS concept was presented as an essential requirement for interoperability and reusability of knowledge in the military domain. On top of that the DCMF initiative has tried to put some more concrete requirements. To summarize, the DCMF requirements for how the final conceptual models should be are as follows: • Well documented; • Readable and usable for a person as well as a machine; • Composable; • Traceable the whole way back to the original sources; and finally • Useable as a basis for simulation models.
Relevance to Our Work:	The framework provides: • A definition for a Conceptual Model; • A process for delivering high quality Conceptual Models; • A structure/template for the procedure Conceptual Models; • A formalism over Conceptual Models; • A list of potential stakeholder; and • A list of different roles and their interactions.
Relevance of Form for Our Product Specification:	At least a source of inspiration and an example of the way we can develop the Defence Conceptual Modeling Framework.
References:	FOI-R—1754--SE. FOI-R—2362--SE. 05F-SIW-038.

Table F-6: Discrete Event Systems (DEVS).

ATTRIBUTE	COMMENTS
Organization:	Arizona Center for Integrative Modeling and Simulation (ACIMS)

ATTRIBUTE	COMMENTS
Definition:	Discrete Event Systems (DEVS) formalism specification is a notation language (M1 level) specific to discrete event models.
Intended Use:	EVS is to be used as a standard notation for discrete event system Modeling.
Community of Usage:	Discrete event system modellers.
Significant Attributes:	The DEVS model components are: inputs, outputs, states and events.
Relevance to Our Work:	DEVS is not directly applicable to MSG-058 work because it specifies a Modeling language (M1 level) instead of providing guidance on how to specify a language. Furthermore, it is specific to the discrete event formalism, which makes it a Modeling language of a lower level of abstraction that is already well defined and outside the scope of the Task Group. However, DEVS could be stated as an example of well-known low-level conceptual modeling language.
Relevance of Form for Our Product Specification:	Due to its scoped target, the DEVS specification can be very formal. Its form is not appropriate to the MSG-058 product specification.
References:	ACIMS – www.acims.arizona.edu. DEVS Standardization Group – http://www.sce.carleton.ca/faculty/wainer/standard/.

Table F-7: Department of Defense Architecture Framework (DoDAF).

ATTRIBUTE	COMMENTS
Organization:	DoD U.S.
Definition:	Department of Defense Architecture Framework.
Intended Use:	The DoDAF defines a standard way to organize an Enterprise Architecture (EA) or systems architecture into complementary and consistent views. All major U.S. Government Department of Defense (DoD) weapons and information technology system procurements are required to develop and document an EA using the views prescribed in the DoDAF. While it is clearly aimed at military systems, DoDAF has broad applicability across the private, public and voluntary sectors around the world, and represents only one of a large number of systems architecture frameworks. It is especially suited to large systems with complex integration and interoperability challenges, and is apparently unique in its use of “operational views” detailing the external customer’s operating domain in which the developing system will operate.
Community of Usage:	All major U.S. Government Department of Defense (DoD) procurements.

ATTRIBUTE	COMMENTS
Significant Attributes:	DoDAF views are organized into four basic view sets: • Overarching All View (AV); • Operational View (OV); • Systems View (SV); and • Technical Standards View (TV). It does not prescribe a modeling language (e.g., UML). April 23, 2007: Version 1.5 was released, 'Volume I: Definitions and Guidelines' (46 pages), 'Volume II: Product Descriptions' (284 pages), and 'Volume III: Architecture Data Description' (223 pages).
Relevance to Our Work:	Framework provides a potential definition for a conceptual model. It contains: • An overall, high-level scenario (OV-1) – includes scope, purpose; • Connectivity between and within systems (OV-2); • Information exchanged during system connectivity (OV-3); • Systems used by the organizations to perform the activities (OV-3); • Organizations performing the activities (OV-4); • Activities performed in the scenario (V-6); and • Data elements contained in information exchanges (OV-7).
Relevance of Form for Our Product Specification	The Task Group did not employ DoDAF schemas explicitly in its product specification on the grounds that while the DoDAF views, usage, and associated tools may well support practitioner's needs, the approach is inherently specific with respect to representational schemas required, and peculiar in its endorsement by one Member Nation represented on the Task Group. The degree to which practitioners following the best-practice guidance herein use DoDAF conventions is considered elective particularly with respect to the consequences of their efforts and the nature of military (or other) simulations' conceptual models.
References:	DoDAF Promulgation Memo Feb 9, 2004 – DODAF Policy Directive mandates use, all Architectures approved after 12/01/03 must be DODAF compliant. http://www.defenselink.mil/cio-nii/docs/DoDAF_Volume_I.pdf, DoDAF 1.5 Volume 1] – Provides definitions, guidelines, background material. http://www.defenselink.mil/cio-nii/docs/DoDAF_Volume_II.pdf, DoDAF 1.5 Volume 2] – Describes each architecture product. http://www.defenselink.mil/cio-nii/docs/DoDAF_Volume_III.pdf, DoDAF 1.5 Volume 3] – Provides the architecture data description. DoDAF 1.0 Deskbook – Provides supplementary "how to" information relating to architectures. The DODAF architecture documents were updated on April 23, 2007 to version 1.5. Currently the Deskbook, which is from February 9, 2004, has not been updated.

Table F-8: Generic Methodology for Verification and Validation (GM-V&V).

ATTRIBUTE	COMMENTS
Organization:	NMSG-073
Definition:	Standards: GM-VV to support acceptance of Models, Simulations, and Data.
Intended Use:	The GM-V&V aims to provide a common generic framework for making formal and well-balanced acceptance decisions on a specific usage of models, simulations (both legacy and new development) and data. Moreover, the GM-V&V comprises of methods, practices and techniques that capture the interplay between the allocation of V&V resources (costs, etc.), stakeholders' needs, and M&S usage risks in decision-making. The GM-V&V is based on a three pillar-view; product, process and organization. The objective of a GM-V&V based project is to make well-informed acceptance decisions on a specific usage of a model, simulations or data based upon a precise and formal argumentation. GM-V&V adopts a goal-driven approach to derive acceptance criteria from the stakeholders' purpose, and subsequently derives evidence criteria and associated tests from those acceptance criteria. This goal-driven approach is considered in a context of the M&S system intended use, development, use-risk, V&V cost-benefits and project constraints. The goal-based hierarchical derivation of criteria is on the one hand well suited for use in compliance with (an adapted) ISO/IEC 9126, and on the other hand clearly focuses on the special elements needed for measuring the quality of the Modeling part. The hierarchical derivation starts with the goal to show that the Conceptual Model provides utility for its use in the development of an end-product. From that goal other utility type of goals can be derived, which can also be further broken down into validity goals, related to the Modeling abstractions, and correctness goals, related to the implementation of needed Conceptual Model views. Some of the utility and correctness criteria are covered by ISO/IEC 9126, others must be found elsewhere such as in [Lindland], [Pace] or [Teeuw] The validity criteria will be highly domain and application dependent and must thus be derived for each Conceptual Model anew until domain/application specific referents are constructed. After the criteria have been defined test must be defined and comparison material made available in order to produce evidence. The tests are for conceptual models often executed in the form of literature comparisons, comparisons with existing data on the same domain or problem and often it will be the collection of expert opinion. After collection of evidence it is "summed up" as a V&V Claim Network to the level of the top goal. If the top claim is equal to the top goal, fitness for purpose of the Conceptual Model is shown. If this is not the case the culprit(s) can be found by tracing back from the top claim via the claim hierarchy to evidence that indicate failed criteria and up the goal hierarchy to find for which purposes the Conceptual Model can not be proven to be good.
Community of Usage:	Modeling & Simulation.
Significant Attributes:	Systematic guidance for V&V.

<table>
<tr><th>ATTRIBUTE</th><th>COMMENTS</th></tr>
<tr><td></td><td></td></tr>
<tr><td>Relevance to Our Work:</td><td>
Below mappings are provide between the GM-V&V and the guidance in this report.
Mapping of Conceptual Model processes/products/roles to GM-V&V is shown in the tables below.
Mapping of Roles Defined in this Report to the Roles Defined in GM-V&V.
<table>
<tr><td>NMSG-058</td><td>GM-V&V</td></tr>
<tr><td>Initiator/Sponsor/Client</td><td>VV&A Sponsor</td></tr>
<tr><td>M&S Project Manager</td><td></td></tr>
<tr><td>Custodian/Administrator</td><td></td></tr>
<tr><td>Controller/VV&A Agent</td><td>VV&A Project Manager, Acceptance Leader, V&V Leader, V&V Implementers</td></tr>
<tr><td>Consumers / Conceptual Model Users</td><td>VV&A Problem Owner</td></tr>
</table>
Mapping between GM-V&V Processes Steps and the Process Activities Described in this Report.
<table>
<tr><td>NMSG-058</td><td>GM-V&V</td></tr>
<tr><td>PP1 – Initiate Conceptual Model Development</td><td>VV&A Requirements Definition Process
VV&A Requirements Analysis Process</td></tr>
<tr><td>PP2 – Define Requirements and Analyze Knowledge Needs for the Conceptual Model</td><td>Partial:
V&V Design Process
V&V Implementation Process
V&V Integration Process</td></tr>
<tr><td>PP3 – Acquire Mission Space and Simulation Space Knowledge</td><td>Partial:
V&V Design Process
V&V Implementation Process
V&V Integration Process</td></tr>
<tr><td>PP4 – Design the Conceptual Model</td><td>Partial:
V&V Design Process
V&V Implementation Process
V&V Integration Process</td></tr>
<tr><td>PP5 – Build the Conceptual Model</td><td>Final:
V&V Design Process
V&V Implementation Process
V&V Integration Process
Acceptance Assessment Process
VV&A Transition Process</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><th>ATTRIBUTE</th><th>COMMENTS</th></tr>
<tr><td></td><td></td></tr>
<tr><td>Relevance to Our Work (cont’d):</td><td>Mapping of GM-V&V “Worlds” to NMSG-058 “Spaces”.
<table>
<tr><td>NMSG-058</td><td>GM-V&V</td></tr>
<tr><td>Mission space</td><td>Real world</td></tr>
<tr><td>Mission space</td><td>Problem world</td></tr>
<tr><td>Simulation space</td><td>M&S world</td></tr>
<tr><td>User space</td><td>Product world</td></tr>
</table></td></tr>
<tr><td>Relevance of Form for Our Product Specification</td><td>N/A pending completion of SISO product standard.</td></tr>
<tr><td>References:</td><td>http://www.sisostds.org/StandardsActivities/DevelopmentGroups/GMVVPDGGenericMethodologyforVVAintheM.aspx.</td></tr>
</table>

Table F-9: Integration Definition for Function Modeling (IDEFØ).

ATTRIBUTE	COMMENTS
Organization:	NIST – National Institute of Standards and Technology. In December 1993, the Computer Systems Laboratory of the National Institute of Standards and Technology (NIST) released IDEFØ as a standard for Function Modeling in FIPS Publication 183.
Definition:	Process oriented function in cell (node), controls/inputs/outputs and mechanisms-on-arrow notation.
Intended Use:	IDEFØ models are often created as one of the first tasks of a system development effort. IDEFØ is useful in establishing the scope of an analysis, especially for a functional analysis. As a communication tool, IDEFØ enhances domain expert involvement and consensus decision-making through simplified graphical devices. As an analysis tool, IDEFØ assists the modeler in identifying what functions are performed, what is needed to perform those functions, what the current system does right, and what the current system does wrong.
Community of Usage:	Systems engineers needing function or process-oriented representational notation.
Significant Attributes:	IDEFØ is a method designed to model the decisions, actions, and activities of an organization or system. Effective IDEFØ models help to organize the analysis of a system and to promote good communication between the analyst and the customer. Thus, The “box and arrow” graphics of an IDEFØ diagram show the function as a box and the interfaces to or from the function as arrows entering or leaving the box.

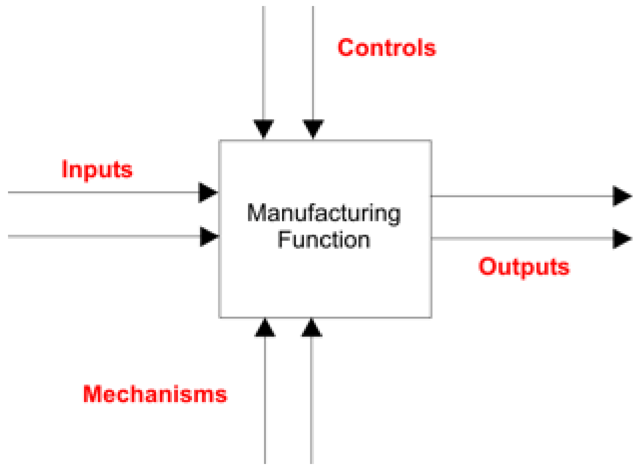
ATTRIBUTE	COMMENTS
Significant Attributes (cont'd):	To express functions, boxes operate simultaneously with other boxes, with the interface arrows "constraining" when and how operations are triggered and controlled. The basic syntax for an IDEFØ model is shown in the figure below.  **Figure F-1: IDEFØ Box and Arrow Graphics.**
Relevance to Our Work:	The fundamentals of function-on-node and control-on-arrow notation were widely and conveniently used by the Group in establishing and explaining the conceptual modeling process.
Relevance of Form for Our Product Specification:	While the semantics conveniently captured in the IDEFØ notation schema were carefully considered in establishing the resulting formal specification of best-practice process contained in Annex G; nevertheless, neither IDEFØ notation nor tools were used to produce that guidance in order not to intimate to practitioners that the notation per se was either required or preferentially recommended.
References:	http://www.idef.com/IDEF0.htm; http://www.idef.com/pdf/idef0.pdf.

Table F-10: Integration Definition for Function Modeling (IDEF5).

ATTRIBUTE	COMMENTS
Organization:	Armstrong Laboratory, AL/HRGA, Wright-Patterson Air Force Base, Ohio 45433
Definition:	Ontology Description Capture Method.
Intended Use:	The IDEF5 method provides a theoretically and empirically well-grounded method specifically designed to assist in creating, modifying, and maintaining ontologies. Standardized procedures, the ability to represent ontology information in an intuitive and natural form, and higher quality results enabled through IDEF5 application also serve to reduce the cost of these activities.

ATTRIBUTE	COMMENTS
Community of Usage:	Systems engineers / Ontology analysts.
Significant Attributes:	Supporting the ontology development process are IDEF5's ontology languages. There are two such languages: the IDEF5 schematic language and the IDEF5 elaboration language. The schematic language is a graphical language, specifically tailored to enable domain experts to express the most common forms of ontological information. The other language is the IDEF5 elaboration language, a structured textual language that allows detailed characterization of the elements in the ontology.
Relevance to Our Work:	IDEF5 focuses particularly on Ontology languages. On that account it is neither as intuitive nor as powerful as UML or other such notations in addressing the generation of ontological descriptions *per se*, nor in documenting them for persistent reference as is necessary in simulation conceptual modeling. This bias and relative dislocation from the purpose of the Task Group's scope of interest is reflected in both the IDEF concepts and in its diagrammatic –notational vocabulary. The standard was not strongly or formally employed in the Task Group's effort, though it might have served well enough for the subject deliberations if its familiarity were more prevalent among team members.
Relevance of Form for Our Product Specification:	The standard was not invoked explicitly in formulation of an expression of the best-practice guidance despite its ontological intentions. Whether its use in execution of the best-practice proffered, is left as with all other standards to the discretion of the practitioner in context of the prevailing conceptual modeling enterprise environment.
References:	http://www.idef.com/IDEF5.htm; http://www.idef.com/pdf/Idef5.pdf.

Table F-11: Joint Command Control Communication Information Exchange Data Model (JC3IDEM).

ATTRIBUTE	COMMENTS
Organization:	The NATO Data Administration Group (NDAG) cooperates with the (Multi-national Interoperability Programme) MIP's Data Modeling Working Group (DMWG) in building of JC3IEDM.
Definition:	JC3IEDM, or Joint Command, Control and Consultation Information Exchange Data Model is an evolution of the Command and Control Information Exchange Data Model (C2IEDM) standard that includes joint operational concepts, just as the Land Command and Control Information Exchange Data Model (LC2IEDM) was extended to become C2IEDM.
Intended Use:	The overall goal is to specify the minimum set of data that needs to be exchanged in coalition or multi-national operations.

ATTRIBUTE	COMMENTS
Intended Use (cont'd):	Each NATO Nation, agency or community of interest is free to expand its own data dictionary to accommodate its additional information exchange requirements with the understanding that the added specifications will be valid only for the participating NATO Nation, agency or community of interest. Any addition that is deemed to be of general interest may be submitted as a change proposal within the configuration control process to be considered for inclusion in the next version of the specification. The main source of information and the basis for the ontology design and development is the MIP (Multi-lateral Interoperability Programme) proposed standard JC3IEDM. The MIP aims to provide an assured capability for interoperability of information to support joint military operations. Interoperability is not envisioned merely at a data level but also at strategic, operational and tactical level to allow proper planning and functioning of joint operations.
Community of Usage:	NATO North Atlantic Treaty Organisation.
Significant Attributes:	JC3IEDM is intended to represent the core of the data identified for exchange across multiple functional areas and multiple views of the requirements. Toward that end, it lays down a common approach to describing the information to be exchanged in a Command and Control (C2) environment. • The structure should be sufficiently generic to accommodate joint, land, sea, and air environmental concerns. • The data model describes all objects of interest in the sphere of operations, e.g., organizations, persons, equipment, facilities, geographic features, weather phenomena, and military control measures such as boundaries. • Objects of interest may be generic in terms of a class or a type and specific in terms of an individually identified item. All object items must be classified as being of some type (e.g., a specific tank that is identified by serial number WS62105B is an item of type "Challenger" that is a heavy UK main battle tank). • An object must have the capability to perform a function or to achieve an end. Thus, a description of capability is needed to give meaning to the value of objects in the sphere of operations. • It should be possible to assign a location to any item in the sphere of operations. In addition, various geometric shapes need to be represented in order to allow commanders to plan, direct, and monitor operations. Examples include boundaries, corridors, restricted areas, minefields, and any other control measures needed by commanders and their staffs. • Several aspects of status of items need to be maintained. • The model must permit a description of the composition of a type object in terms of other type objects. Such concepts include tables of organizations, equipment, or personnel. • The model must reflect information about what is held, owned or possessed in terms of types by a specific object item.

ATTRIBUTE	COMMENTS
Significant Attributes (cont'd):	• There is a need to record relationships between pairs of items. Key among these is the specification of unit task organizations and orders of battle. • The model must support the specification of current, past, and future role of objects as part of plans, orders, and events. • The same data structure should be used to record information for all objects, regardless of their hostility status. • Provision must be made for the identification of sources of information, the effective and reporting times, and an indication of the validity of the data. The JC3IEDM is described from three different perspectives: • Conceptual Data Model: A top, high level, Conceptual Data Model of generalized concepts such as Actions, Organizations, Materiel, Personnel, Features, Facilities, Locations, intended for top officers, senior commanders, etc., who do not need to know the specific technical details of the model, but is sufficient to be aware of the different concepts and their relationships. • Logical Data Model: Middle, Logical Data Model which is more detailed, is based upon breaking down the high level concepts into specific information that is regularly used. For example, a tank is an armored fighting vehicle that is a piece of equipment that is a piece of materiel. It also makes implicit knowledge explicit, like following the human reasoning patterns that a tank is a piece of armored fighting equipment and allows command and control systems to generalize by recognizing, for instance, that tanks are equipment. A logical data model specifies the way data is structured with an entity-attribute-relationship diagram and supporting documentation. At this level, technical implementation specific details are still obscured from view. This level is useful for middle level system analysts and domain experts. • Physical Data Model: The third and lower most, Physical Data Model provides the detailed specifications that are necessary to generate a physical schema that defines the structure of a database. Mainly intended for the information system developer. The physical data model can be seen as a traditional database schema model, which illustrates the different logical concepts (tables), their attributes (fields) and the relationships.
Relevance to Our Work:	• To describe a Conceptual Model, one needs the same concepts of Objects or Entities of interests around which the operation is focused. • Each entity has both static characteristics as well as dynamic properties, as is represented by the situation concepts in the JC3IEDM. • Relevant if the main focus in our conceptual models is that of activities, or Actions as proposed in the JC3IEDM as well. • And to co relate pieces of information, to provide the context and other vital information, a group of information packages is required as well.
Relevance of Form for Our Product Specification:	It depends on our chosen Conceptual models structure, content or process will make use of.

ATTRIBUTE	COMMENTS
References:	http://www.mip-site.org. http://encyclopedia.thefreedictionary.com/JC3IEDM. http://en.wikipedia.org/wiki/JC3IEDM. FOI-R—175--SE.

Table F-12: Kernel Meta Meta Model (KM3).

ATTRIBUTE	COMMENTS
Organization:	FOI – Swedish Defence Research Agency
Definition:	The Knowledge Meta Model (KM3), developed by the Swedish Defence Research Institute (FOI), has its place as a tool and a language to construct well-formed conceptual models that are to be used successfully in simulation model and Development.
Intended Use:	The intention when producing the KM3 was not to construct a grand "unified model description language". It rather represents one possibility to capture system structures and behavior in an object-oriented and rule-based way. The KM3 is all of the following (in no particular order): • The KM3 is a specification. It is a specification consisting of object-oriented concepts, primarily aimed at capturing different dependencies in and between activities. In this setting this means that the KM3 is a specification for the creation of generic and reusable conceptual models of objects and processes of (military) interest. • The KM3 is a tool. It is a tool for structuring knowledge about objects and processes as conceptual models. The main objective of KM3 is to produce generic templates of knowledge (MSMs, in the above list). • The KM3 is a language. It is a common language to for different stakeholders involved in the modeling process, to enable them to construct conceptual models. The KM3 is mainly used as a specification for construction of generic models, which in turn are used to model knowledge at an instance level. KM3 is, in this respect, a model for how to make models. A model produced using the KM3 is a well-formed, well-understood conceptual model which in turn can be instantiated to be used as a simulation model.
Community of Usage:	FOI and Swedish Armed Forces.
Significant Attributes:	• Is an *activity centric* structure. • Covers *static* and *dynamic* aspects of objects in the same model. • Covers *relations* between objects. • Captures *rules* of behaviour.

ATTRIBUTE	COMMENTS
Relevance to Our Work:	• A general and flexible structure and a potential candidate for Conceptual Model Template. • The interpreted information is subsequently transformed into a common format, generalized and stored as a reusable model. This common format is described by a Knowledge Meta Model (KM3). • The reusable conceptual model, now called a Mission Space Model (MSM), can be instantiated with real-world data and serve as a basic structure when performing simulations.
Relevance of Form for Our Product Specification:	A source of inspiration and example of the way we can specify our Conceptual Models.
References:	FOI-R—1754--SE. 05F-SIW-040.

Table F-13: Model Driven Architecture (MDA).

ATTRIBUTE	COMMENTS
Organization:	Object Management Group (OMG)
Definition:	Model Driven Architecture (MDA) is a software development process (M1 level, because it specifies the Modeling languages). It is the base architecture for OMG's software development standards, including MOF, UML, OWM and XMI.
Intended Usage:	MDA separates software business and application logic from underlying platform technology. By leveraging OMG's universally accepted MOF and UML standards, the MDA allows creation of software applications that are portable across, and interoperate naturally across, a broad spectrum of systems from embedded, to desktop, to server, to mainframe, and across the Internet. In MDA, attention focuses first on the application's business functionality and behavior, allowing stakeholders' investment to concentrate on the aspects that critically affect core business processes. Technical aspects, also critical but secondary to business functions, are well handled by automated or semi-automated development tools. MDA is always ready to deal with yesterday's, today's and tomorrow's challenges and makes it easier to integrate applications and facilities across middleware boundaries. Domain facilities defined in the MDA by OMG's Domain Task Forces provide much wider interoperability by always being available on a domain's preferred platform, and on multiple platforms whenever there is a need.
Community of Usage:	OMG Task Forces organized around industries including Finance, Manufacturing, Biotechnology, Space technology, and others use the MDA to standardize facilities in their domains.

ATTRIBUTE	COMMENTS
Significant Attributes:	The MDA is structured around Computation Independent Model (CIM), Platform Independent Model (PIM), Platform Specific Model (PSM) and implementations: • The CIM represents the requirements of the system in the form of a domain model. It is also a source of vocabulary for the other models. The transformations from and to this model are mainly for requirements traceability. • The PIM describes a system without anchoring it to technology-specific functional interfaces. • The PSM implements in an abstract fashion the specification of the PIM using technology-specific functionalities. • The Implementation is the operational system. The different models are linked through automatic conversions. This improves traceability, consistency, uniformity and productivity. The MDA is implemented using OMG's software development standards. The MOF is OMG's foundation specification for modeling languages; MOF compliance allows UML structural and behavioral models, and CWM data models, to be transmitted via XMI, stored in MOF-compliant repositories, and transformed and manipulated by MOF-compliant tools and code generators. Patterns play a critical role in most MDA-based development projects. Successful transformation from PIM to PSM, and from PSM to code, requires that the PIM contain enough detail to completely guide the software tools through the process. By incorporating this detail through the use of patterns, instead of inserting it by hand, we gain multiple benefits: architects do less work, the resulting PIM reflects the collective wisdom of many contributors, and the tools can work the pattern (parameterized as necessary in our UML models) through the transformations, ultimately pulling implementation code from a library written by experts and inserting it into the application.
Relevance to Our Work:	The MDA process could be applied directly to M&S conceptual modeling, i.e., that a new MOF-based conceptual model language adapted to military M&S could be developed or an existing one could be reused (e.g., UML). However, since the MSG-058 mandate is to provide a guidance (M2 level), proposing the MDA as-is would be too prescriptive. MDA could be stated as an example of a development process implementation leading to a high level of maturity: focus on functionality and behavior while technical aspects are automated or semi-automated, high maintainability and interoperability through shared domain facilities. The notion of patterns is also desirable to apply in the MSG-058 work-product.
Relevance of Form for Our Product Specification:	The MDA philosophy (different abstraction levels linked with automatic transformations) is applicable to the MSG-058 product specification. It has influenced our strategic goal because it greatly improves the level of maturity of a process.
References:	MDA – http://www.omg.org/mda/. MDA Guide Version 1.0.1, OMG, omg/2003-06-01, June 2003, 62 pp.

ATTRIBUTE	COMMENTS
References (cont'd):	MOF – http://www.omg.org/mof/. Meta Object Facility (MOF) Specification Version 1.4, OMG, April 2002, 358 pp. UML – http://www.uml.org/. Unified Modeling Language Specification Version 1.4.2, OMG formal/05-04-01, ISO/IEC 19501:2005(E), January 2005, 454 pp. OMG Unified Modeling Language (UML), Infrastructure, V2.1.2, formal/2007-11-04, November 2007, 224 pp. OMG Unified Modeling Language (OMG UML), Superstructure, V2.1.2, formal/2007-11-02, November 2007, 738 pp.

Table F-14: NATO Architecture Framework (NAF).

ATTRIBUTE	COMMENTS
Organization:	NATO, NC3A
Definition:	NATO Architecture Framework is a derivative framework based on DoDAF.
Intended Use:	• It provides guidance on describing communication and information systems (or C3 systems) through architectures and provides the rules, guidance, and templates for developing and presenting architecture descriptions to ensure a common denominator for understanding, comparing, and integrating architectures in NATO. The application of the NAF is designed to enable architectures to contribute most effectively to acquiring and fielding cost-effective and interoperable military capabilities. • The ability to define views of architectural information in a more flexible way and support Stakeholders so that extensive analysis can be made to provide rationale for prioritization decision-making. • A standardized way of documenting NATO-wide business processes and to provide support to Capability-based planning. • Critical support for the achievement of NNEC and NATO transformation by facilitating the move from a system-oriented paradigm to a service-oriented paradigm, and by identifying mechanisms to handle the complexity of the relationships within the NATO federation of systems in a holistic manner. • A NAF Meta-Model (NMM) and repository to enable stakeholders and users to extract bespoke architecture information and make necessary analyses to support development, interoperability, acquisition or technical considerations. • A complementary tool to NATO and National programme management, contributing to reduction in cost overruns, risk reduction, and more efficient use of common funded budgets.

ATTRIBUTE	COMMENTS
Intended Use (cont'd):	• A coherent mechanism to identify capability gaps and promote interoperability across NATO, including for the critical deployed force and NRF scenarios.
Community of Usage:	NATO, PfP.
Significant Attributes:	The NAF is still in development. NAF introduces a number of new "Service Views" to support Service Orientated Architecture. It is likely that DoDAF and NAF may converge into a single or very closely related architecture sometime in the near future.
Relevance to Our Work:	See DoDAF.
Relevance of Form for Our Product Specification	See DoDAF.
References:	http://194.7.80.153/website/book.asp?menuid=15&vs=0&page=volume1%2Fch03s02.html.

Table F-15: Open Knowledge Base Connectivity (OKBC).

ATTRIBUTE	COMMENTS
Organization:	The development of OKBC is being overseen by a working group. Richard Fikes is the working group chair and the following six institutions are the voting members: • Cycorp; • Information Sciences Institute; • Knowledge Systems Laboratory, Stanford; • Science Applications International Corporation (SAIC); • SRI International; and • Teknowledge.
Definition:	OKBC is an application programming interface for accessing knowledge bases stored in Knowledge Representation Systems (KRSs). OKBC is being developed under the sponsorship of DARPA's High Performance Knowledge Base program (HPKB), where it is being used as an initial protocol for the integration of various technology components.

ATTRIBUTE	COMMENTS
Intended Use:	[OKBC] … provides a set of operations for a generic interface to underlying KRSs ... OKBC is complementary to language specifications developed to support knowledge sharing. KIF, the Knowledge Interchange Format, provides a declarative language for describing knowledge. As a pure specification language, KIF does not include commands for knowledge base query or manipulation. Furthermore, KIF is far more expressive than most KRSs. OKBC focuses on operations that are efficiently supported by most KRSs (e.g., operations on frames, slots, facets — inheritance and slot constraint checking). OKBC is intended to be well impedance-matched to the sorts of operations typically performed by applications that view or manipulate object-oriented KRSs.
Community of Usage:	Knowledge management specialists.
Significant Attributes:	OKBC specifies a knowledge model of KRSs (with KBs, classes, individuals, slots, and facets). It also specifies a set of operations based on this model (e.g., find a frame matching a name, enumerate the slots of a frame, delete a frame). An application uses these operations to access and modify knowledge stored in an OKBC-compliant KRS.
Significant Attributes:	The current implementation of OKBC is object-oriented: methods in the appropriate object-oriented programming language for an application are used to implement OKBC operations. We refer to the set of methods that implement the protocol for a particular KRS as a back end. Many OKBC operations have default implementations written in terms of other OKBC operations; therefore, the programmer need define only a core sub-set of all OKBC operations in order to implement a compliant back end. These OKBC operations are called mandatory, and they comprise the OKBC kernel. The default implementations can be overridden within a given back end to improve efficiency. The design objectives for OKBC are as follows. Simplicity: It is important to have a relatively simple specification that can be implemented quickly, even if that means sacrificing theoretical considerations or support for idiosyncrasies of a particular KRS. Generality: The protocol should apply to many KRSs, and support all the most common KRS features. For example, it should support all the knowledge access and modification functionality that will be required by a graphical KB editor. The protocol should not require numerous changes to a KRS for which the protocol is implemented. That is, the protocol should not legislate the behavior of an underlying KRS, but should serve as an interface between an existing KRS and an application. Performance: Inserting the protocol between an application and a KRS should not introduce a significant performance cost. Consistency: The protocol should exhibit consistent behavior across different KRSs. That is, a given sequence of operations within the protocol should yield semantically equivalent results over a range of KRSs.
Relevance to Our Work:	OKBC is of potential use in executing any of the various knowledge collection and management activities cited within the best-practice process.

ATTRIBUTE	COMMENTS
Relevance of Form for Our Product Specification:	While OKBC was not used explicitly in the best-practice process specification, it is understood that utility may be found by the practitioner in executing the best-practice process and in documenting the conceptual model product itself.
References:	http://www.ai.sri.com/~okbc/. http://www.ai.sri.com/~okbc/spec.html.

Table F-16: Web Ontology Language (OWL).

ATTRIBUTE	COMMENTS
Organization:	W3C – Worldwide Web Consortium
Definition:	"OWL is the W3C's recommended ontology Language for representing information on the Semantic Web. It is typically used to define an ontology for a particular domain. An OWL ontology is a set of axioms describing classes, properties, and the relationships between them." – Lacey 2005.
Intended Use:	"The purpose of OWL is to provide a standard language for Semantic Web information representation." – Lacey. The W3C OWL 2 Web Ontology Language (OWL) is a Semantic Web language designed to represent rich and complex knowledge about things, groups of things, and relations between things." OWL is a computational logic-based language such that knowledge expressed in OWL can be reasoned with by computer programs either to verify the consistency of that knowledge or to make implicit knowledge explicit. OWL documents, known as ontologies, can be published in the World Wide Web and may refer to or be referred from other OWL ontologies" – http://www.w3.org/TR/2009/REC-owl2-primer-20091027/.
Community of Usage:	Data managers, web application developers, and database engineers who what to leverage the power of the Semantic Web by representing their information using the Web Ontology Language – OWL in order to enable Semantic Web applications and services to process and interpret content.
Significant Attributes:	"OWL 2 is a language for expressing ontologies." "OWL 2 is not a programming language: OWL 2 is declarative, i.e., it describes a state of affairs in a logical way" "OWL 2 is not a schema language for syntax conformance." "OWL 2 is not a database framework." "OWL 2 is a knowledge representation language, designed to formulate, exchange and reason with knowledge about a domain of interest". OWL assumes basic knowledge modeling practice and includes provision for representation of information related to classes, properties, and individuals. For survey of features see: http://www.w3.org/TR/2009/REC-owl2-primer-20091027/#ref-owl-2-quick-reference. The currently most widely used OWL editor is Protégé, a free open-source editing framework developed at Stanford University.

ATTRIBUTE	COMMENTS
Significant Attributes (cont'd):	By virtue of its open plug-in structure, it allows for the easy integration of special-purpose ontology editing components. Other editors include TopQuadrant's commercial TopBraid Composer and the open-source systems SWOOP and NeOn-Toolkit. There are several reasons for OWL DL which differs somewhat in terms of coverage of the supported reasoning features. For some of these, OWL 2 conformance is currently planned and the corresponding implementations are in progress. The Test Suite Status document lists to which extent some of the reasons mentioned below comply with the test cases. For reasoning within OWL DL, the most prominent systems are Fact++ by the University of Manchester, Hermit by Oxford University Computing Laboratory, Pellet by Clark & Parsia, LLC, and RacerPro by Racer Systems. In addition to those general-purpose reasons aiming at supporting all of OWL DL, there are reasoning systems tailored to the tractable profiles of OWL. CEL by Dresden University of Technology supports OWL EL. QuOnto by Sapienza University di Roma supports OWL QL. ORACLE 11 g supports OWL RL. The open-source OWL API plays a rather prominent role as the currently most important development tool around OWL.
Relevance to Our Work:	The OWL standard and knowledge/concept specification schema is designed to address the description of ontological domains. In the present work, such relevant domains are the military mission space and simulation executive domains. Therefore OWL is a language whose relevance to expressing the semantic content of military model and simulation conceptual models is direct and obvious. Further, toe prospect of using Semantic Web interface and communications infrastructure in association with cloud computing techniques is highly suggestive for the present effort. Relationship of OWL to XML is also prospectively significant for consideration of machine readable military model and simulation conceptual models.
Relevance of Form for Our Product Specification:	The notational schema manifest in OWL for ontology specification and semantic elaboration is effectively similar to that of UML and is manifestly suitable to the needs for notational specification of military simulation conceptual models.
References:	OWL: Representing Information Using the Web Ontology Language, Lee W. Lacey, Trafford, Victoria, BC, Canada, 2005; and http://www.w3.org/TR/#tr_OWL_Web_Ontology_Language.

Table F-17: Resource Description Framework (RDF).

ATTRIBUTE	COMMENTS
Organization:	World-Wide-Web Consortium (W3C)
Definition:	"RDF is a standard model for data interchange on the Web. RDF has features that facilitate data merging even if the underlying schemas differ, and it specifically supports the evolution of schemas over time without requiring all the data consumers to be changed."

ATTRIBUTE	COMMENTS
Intended Use:	Semantic description of data exchanged between independent users. It is not human readable.
Community of Usage:	Anyone who need to describe web content such that independent applications can discover and retrieve it.
Significant Attributes:	"RDF extends the linking structure of the Web to use URIs to name the relationship between things as well as the two ends of the link (this is usually referred to as a "triple"). Using this simple model, it allows structured and semi-structured data to be mixed, exposed, and shared across different applications. This linking structure forms a directed, labeled graph, where the edges represent the named link between two resources, represented by the graph nodes. This *graph view* is the easiest possible mental model for RDF and is often used in easy-to-understand visual explanations." RDF is written in XML. It is designed to be read by computers. Its basic building block is an object-attribute-value triple, called a statement.
Relevance to Our Work:	May be used for representing Meta data about conceptual models.
Relevance of Form for Our Product Specification:	The Task Group did not use RDF standard specifications or standards in framing the best-practice guidance for military model conceptual modeling on the assumption that our work-product would be a text document and that a practitioner would leverage such relatively fundamental standards in accordance with their own enterprise practices in due course of developing and managing simulation conceptual models.
References:	http://www.w3.org/RDF/. http://www.w3.org/standards/techs/rdf. http://www.w3.org/2001/sw/.

Table F-18: Rational Unified Process (RUP).

ATTRIBUTE	COMMENTS
Organization:	IBM
Definition:	"IBM Rational Unified Process® (RUP®) is a comprehensive process framework that provides industry-tested practices for software and systems delivery and implementation and for effective project management."
Intended Use:	**"**RUP promotes iterative development and organizes the development of software and systems into four phases, each consisting of one or more executable iterations of the software at that stage of development."
Community of Usage:	Software developers in enterprise environments and project teams.
Significant Attributes:	Systematic, tailorable process for software development. Extensive support tools and training/coaching available.

ATTRIBUTE	COMMENTS
Relevance to Our Work:	Significant software development bias but includes software system conceptual modeling within scope.
Relevance of Form for Our Product Specification	N/A.
References:	http://www-01.ibm.com/software/awdtools/rup/. http://www.ibm.com/developerworks/rational/library/content/03July/1000/1251/1251 bestpractices_TP026B.pdf. "Rational Unified Process, Best-Practices for Software Development Teams, Rational Software – White Paper", TP026B, Rev 11/01.

Table F-19: Systems Modeling Language (SysML).

ATTRIBUTE	COMMENTS
Organization:	The UML for Systems Engineering RFP was developed jointly by the OMG and the International Council On Systems Engineering (INCOSE) and issued by the OMG in March 2003
Definition:	Systems Modeling Language.
Intended Use:	The SysML is a Domain-Specific Modeling language for systems engineering. It supports the specification, analysis, design, verification and validation of a broad range of systems and systems-of-systems. SysML was originally developed by an open source specification project, and includes an open source license for distribution and use. SysML is defined as an extension of a sub-set of the Unified Modeling Language (UML) using UML's profile mechanism. SysML offers system engineers several noteworthy improvements over UML, which tends to be software-centric. These improvements include the following: SysML's semantics are more flexible and expressive. SysML reduces UML's software-centric restrictions and adds two new diagram types, requirement and parametric diagrams. The former can be used for requirements management; the latter can be used for performance analysis and quantitative analysis. As a result of these enhancements, SysML is able to model a wide range of systems, which may include hardware, software, information, processes, personnel, and facilities. SysML is a smaller language that is easier to learn and apply. Since SysML removes many of UML's software-centric constructs, the overall language is smaller as measured both in diagram types and total constructs. SysML allocation tables support common kinds of allocations. Whereas UML provides only limited support for tabular notations, SysML furnishes flexible allocation tables that will support requirements allocation, functional allocation, and structural allocation. This capability facilitates automated Verification and Validation (V&V) and gap analysis.

ATTRIBUTE	COMMENTS
Intended Use (cont'd):	SysML model management constructs support models, views, and viewpoints. These constructs extend UML's capabilities and are architecturally aligned with IEEE-Std-1471-2000 (IEEE Recommended Practice for Architectural Description of Software Intensive Systems). SysML uses seven of UML 2.0's thirteen diagrams, and adds two diagrams (requirements and parametric diagrams) for a total of nine diagram types. SysML also supports allocation tables, a tabular format that can be dynamically derived from SysML allocation relationships.
Community of Usage:	Systems Engineering.
Significant Attributes:	The Object Management Group announced the adoption of the OMG SysML™ on July 6, 2006 and the availability of OMG SysML™ v1.0 in September 2007. With SysML you can use Requirement diagrams to efficiently capture functional, performance and interface requirements, whereas with UML you are subject to the limitations of Use Case diagrams to define high-level functional requirements. Likewise, with SysML you can use Parametric diagrams to precisely define performance and mechanical constraints such as maximum acceleration, curb weight, air conditioning capacity, and interior cabin noise management. UML provides no straightforward mechanism to capture this essential performance and mechanical information.
Relevance to Our Work:	SysML can be used as a conceptual model language format.
Relevance of Form for Our Product Specification	Relatively little – See UML.
References:	http://www.omgsysml.org/.

Table F-20: Unified Modeling Language (UML).

ATTRIBUTE	COMMENTS
Organization:	OMG – Object Modeling Group
Definition:	Modeling notation and syntactic denotation specification created for software development, but evolved into practical systematic, comprehensive and formal notational method for specification of any system.
Intended Use:	"... enabling object visual modeling tool interoperability."
Community of Usage:	"The objective of UML is to provide system architects, software engineers, and software systems as well as for modeling business and similar processes with tools for analysis, design, and implementation of software-based systems as well as for modeling business and similar processes."

ATTRIBUTE	COMMENTS
Significant Attributes:	"The modeling concepts of UML are grouped into language units. A language unit consists of a collection of tightly coupled modeling concepts that provide users with the power to represent aspects of the system under study according to a particular paradigm or formalism. For example, the State Machines language unit enables modelers to specify discrete event-driven behavior using a variant of the well-known state charts formalism, while the Activities language unit provides for modeling behavior based on a workflow-like paradigm. A model contains three major categories of elements: Classifiers, events, and behaviors. Each major category models individuals in an incarnation of the system being modeled. A classifier describes a set of objects; an object is an individual thing with a state and relationships to other objects. An event describes a set of possible occurrences; an occurrence is something that happens that has some consequence within the system. A behavior describes a set of possible executions; an execution is the performance of an algorithm according to a set of rules. Models do not contain objects, occurrences, and executions, because those things are the subject of models, not their content. Classes, events, and behaviors model sets of objects, occurrences, and executions with similar properties. Value specifications, occurrence specifications, and execution specifications model individual objects, occurrences, and executions within a particular context. The distinction between objects and models of objects, for example, may appear subtle, but it is important. Objects (and occurrences and executions) are the domain of a model and, as such, are always complete, precise, and concrete. Models of objects (such as value specifications) can be incomplete, imprecise, and abstract according to their purpose in the model."
Relevance to Our Work:	Highly relevant to the present work in multiple ways. First, UML is a suitable notational schema in which to manifest, represent, and document a simulation conceptual model itself. The notation is powerful and versatile, and it has extensive mechanisms for specialization to alternative representation domains. As far as is known, UML is sufficient (though not necessary) to specify any simulation conceptual model envisioned by the present study. In addition, UML might be used to document the best-practice process and intended conceptual model work-product specification conceived by the MSG-058 Task Group.
Relevance of Form for Our Product Specification:	While not used extensively within the formal simulation conceptual model process and product specifications of Annexes G and H below or in the accompanying text of Chapters 4, 5 and 6 of the document, UML could have been used as the primary meta-language to provide such specifications. As a practical matter, the Task Group felt is desirable not to adopt pre-emptively any single notational schema lest the practitioner find himself constrained artificially to that choice. Nevertheless, UML is a candidate for future (alternative) best-practice standards specifications.
References:	OMG Unified Modeling Language TM (OMG UML), UML Superstructure Specification, v2.3, May 2010. OMG Unified Modeling Language TM (OMG UML), UML Infrastructure Specification, v2.3, May 2010. http://www.uml.org/. http://www.omg.org/technology/documents/modeling_spec_catalog.htm#UML.

Annex G – CONCEPTUAL MODELING PROCESS ACTIVITY DESCRIPTION

Table G-1: Generic Template for Specification of Process Activity.

PROCESS ACTIVITY CHARACTERISTIC	
Process Activity Identity	
• Process Step Name and Aliases	*<Denotative name of process step appears here.>*
Process Activity Description	
• Process Step Rationale / Need / Motivation	*<Here an account of the motivation of the subject Process Step is provided, in order that the investment agent executing the Process Step can have explicit record of his expected intention in executing the subject Process Step.>*
Process Activity Initiation	
• Entrance Criteria	*<This field specifies component values of the state of the decision problem in its entirety that are necessary and sufficient for the subject Process Step to be begun with high probability of successful completion.>*
Process Activity Method	
• Process Activity Procedure	*<In this field, the investment evaluation agent is provided procedural guidance for the execution of the subject Process Step. Note that relationships to other activities, needs for tools or information, and expected work-products are specified in other form records. Process Step procedure should be as nearly as possible algorithmically prescriptive. Note however that any procedure may entail almost arbitrary complexity and that the procedure step in question may be replaced with defining notation other than text.>*
Inter Process Activity Relationships	
• Process Activity Sequence and Control-Flow	*<Instruction cites relationships among activities. These may be composition (is a part of) relationship in which one Process Step is executed as one of several components of a composite Process Step. Otherwise, Process Step precedence (comes-before-relationship) and Process Step successor (comes-after-relationship) may be designated. This latter relationship specification may be contingent allowing programmatic branching, loop recursion, or self repetition.>*
• Process Activity Information Flow	*<Typically information from: a) inside the process (endogenous) – perhaps having been developed by means of the execution of one or another of the activities; or b) information from outside the decision process (exogenous) may be identified as necessary input to a Process Step.>*

• Process Activity Information Flow (cont'd)	*<Alternatively information may flow out of the Process Step having been generated by execution of the Process Step. In either case it is prudent to indicate the information pool involved as container, and the information type specification needed or generated.>*
Associated Entities	
• Tools	*<Identify tools such as hardware or software necessary and sufficient to complete the Process Step. In the case of M&S investment Process Step, algorithms are likely tool-types.>*
• Actor-Agents	*<Indicate the actor agent (individual member of one or another stakeholder class) responsible for completion of the Process Step. Clearly Groups or anonymous agents may be designated. If the responsibility of members of the Group need to be differentiated, it may be prudent to decompose the Process Step into its component parts in order to reduce the cardinality of agents to activities from N-to-1 to 1-to-1.>*
• Information Pools	*<Data stores of any type containing information used as input or generated as output from a particular Process Step. May contain intermediate information re-used by successor activities, or components of the process result compiled as residual product documentation.>*
• Product / Object / Artefacts	*<The principle intended output in any form consequent execution of the subject Process Step. Ultimately an investment decision, but meanwhile, information artefacts, qualifications to be associated with the decision, or guidance as to how the resulting decision should be pursued.>*
Process Activity Completion	
• Exit Criteria	*<This field specifies component values of the state of the decision problem in its entirety that are necessary and sufficient for the subject Process Step to be considered finished with high probability of successful completion.>*

Table G-2: Conceptual Model Process Activity 1.1 Description.

PROCESS ACTIVITY CHARACTERISTIC	
Process Activity Identity	
• Process Activity Name and Aliases	PA1.1 – Identify and Map Stakeholder Responsibilities.
Process Activity Description	
• Process Activity Rationale / Need / Motivation	This activity is necessary to produce PA1.1 – Stakeholder Descriptions which are used to derive conceptual model requirements and conceptual model Knowledge Needs.
Process Activity Initiation	
• Entrance Criteria	Entrance criteria consists of the completion of the following activities, availability of information and establishment of operational capability: • May begin once PA1.2 – Define Purpose and Intended Use of M&S Effort initiates.
Process Activity Method	
• Process Activity Procedure	The following PRELIMINARY or PREFATORY ACTIVITIES establish the context within which the bulk of direct conceptual model population will occur: • Identify relevant M&S responsibilities based upon purpose and intended use, constraints, and policies. • Map responsibilities into stakeholder roles by category. • Identify stakeholders by organization or name based upon M&S purpose and intended use, constraints, and policies. • Map roles onto individual stakeholders. • Document results in P1.1 – Stakeholder Description.
Inter Process Activity Relationships	
• Process Activity Sequence and Control-Flow	Once initiated, may be executed concurrently with other Phase 1 activities, or recursively in an iterative process with activities in other phases.
• Process Activity Information Flow	Information from external pools such as listed below flow into this process step. Information from the other three activities in the first phase flow into this activity. All information flow out of this activity is to the P1.1 – Stakeholder Description.
Associated Entities	
• Tools	No custom tools.
• Actor-Agents	Producer.
• Information Pools	• Points of contact lists. • Employee roles. • Organizational charts.

• Information Pools (cont'd)	• Personnel databases. • Referrals. • Resumes. • Biographies, etc.
• Product / Object / Artefacts	This Process Activity produces the P1.1 – Stakeholder Description.
Process Activity Completion	
• Exit Criteria	Criteria-types for demonstration of satisfactory completion of the subject activity include the following: • All stakeholders are identified and mapped to roles and responsibilities.

Table G-3: Conceptual Model Process Activity 1.2 Description.

PROCESS ACTIVITY CHARACTERISTIC	
Process Activity Identity	
• Process Activity Name and Aliases	PA1.2 – Define Purpose and Intended Use of M&S Effort.
Process Activity Description	
• Process Activity Rationale / Need / Motivation	This activity is necessary to produce P1.2 – Need Statement which is used to derive conceptual model requirements and conceptual model Knowledge Needs.
Process Activity Initiation	
• Entrance Criteria	Entrance criteria consists of the completion of the following activities, availability of information and establishment of operational capability: • May begin upon stated or implied intent to develop a model, simulation, or conceptual model.
Process Activity Method	
• Process Activity Procedure	The following PRELIMINARY or PREFATORY ACTIVITIES establish the context within which the bulk of direct conceptual model population will occur: • Collect information from Information Pools below, relating to purpose and intended use of M&S effort. • Integrate and deconflict collected information into a self-consistent set of descriptions of M&S purpose and use. • Provide information to other activities in this phase. • Translate M&S purpose and intended use into descriptions of needs for the conceptual model. • Document descriptions of needs for the conceptual model in P1.2 – Need Statement.

Inter Process Activity Relationships	
• Process Activity Sequence and Control-Flow	Once initiated, may be executed concurrently with other Phase 1 activities, or recursively in an iterative process with activities in other phases.
• Process Activity Information Flow	Information from external pools such as listed below flow into this process step. No information from the other three activities in this phase flows into this activity. Information from this activity may flow into the other three activities in the first phase. Information flows out of this activity to the P1.2 – Need Statement.
Associated Entities	
• Tools	No custom tools.
• Actor-Agents	Producer.
• Information Pools	Information pools relevant to this activity include: • Task orders. • Mission needs statements. • User requirement documents. • Requests for proposal. • Statements of work. • Formal or informal directives. • Test agreements, etc.
• Product / Object / Artefacts	This Process Activity produces the P1.2 – Need Statement.
Process Activity Completion	
• Exit Criteria	Criteria-types for demonstration of satisfactory completion of the subject activity include the following: • Purpose and intended use of M&S effort is defined.

Table G-4: Conceptual Model Process Activity 1.3 Description.

PROCESS ACTIVITY CHARACTERISTIC	
Process Activity Identity	
• Process Activity Name and Aliases	PA1.3 – Identify Constraints on the M&S Effort.
Process Activity Description	
• Process Activity Rationale / Need / Motivation	This activity is necessary to produce P1.3 – Constraints and Policies which is used to derive conceptual model requirements and conceptual modeling knowledge needs.

Process Activity Initiation	
• Entrance Criteria	Entrance criteria consists of the completion of the following activity, availability of information and establishment of operational capability: • May begin once PA1.2 – Define Purpose and Intended Use of M&S Effort initiates.
Process Activity Method	
• Process Activity Procedure	The following PRELIMINARY or PREFATORY ACTIVITIES establish the context within which the bulk of direct conceptual model population will occur: • Collect information from Information Pools below, relating to constraints on the M&S effort. • Integrate and deconflict collected information into a self-consistent set of descriptions of M&S constraints. • Provide information to the PA1.1 activity for constraints that impact selection of stakeholders and respective responsibilities. • Document Constraints for the conceptual model in P1.3 – Constraints and Policies.
Inter Process Activity Relationships	
• Process Activity Sequence and Control-Flow	Once initiated, may be executed concurrently with other Phase 1 activities, or recursively in an iterative process with activities in other phases.
• Process Activity Information Flow	Information from external pools such as listed below flow into this process step. Information from PA1.2 may flow into this activity. Information from this activity may flow into PA1.1. Information flows out of this activity to P1.3 – Constraints and Policies.
Associated Entities	
• Tools	No custom tools.
• Actor-Agents	Producer.
• Information Pools	Information pools relevant to this activity include: • Documented resource constraints. • Senior stakeholder preferences and requirements. • Planning/budgeting/management limitations. • Legacy M&S preferences and availability. • Data availability. • Enterprise preferences, etc.
• Product / Object / Artefacts	This Process Activity contributes to P1.3 – Constraints and Policies.

Process Activity Completion	
• Exit Criteria	Criteria-types for demonstration of satisfactory completion of the subject activity, include the following: • Constraints of M&S effort are defined sufficiently to constrain the scope and content of the conceptual model. • Sufficient contributions are made for the development of P1.3 – Constraints and Policies.

Table G-5: Conceptual Model Process Activity 1.4 Description.

PROCESS ACTIVITY CHARACTERISTIC	
Process Activity Identity	
• Process Activity Name and Aliases	PA1.4 – Identify Mandatory Enterprise Policies.
Process Activity Description	
• Process Activity Rationale / Need / Motivation	This activity is necessary to produce P1.3 – Constraints and Policies which is used to derive conceptual model requirements and conceptual model Knowledge Needs.
Process Activity Initiation	
• Entrance Criteria	Entrance criteria consists of the completion of the following activity, availability of information and establishment of operational capability: • May begin once PA1.2 – Define Purpose and Intended Use of M&S Effort initiates.
Process Activity Method	
• Process Activity Procedure	The following PRELIMINARY or PREFATORY ACTIVITIES establish the context within which the bulk of direct conceptual model population will occur: • Collect information from Information Pools below, relating to Enterprise Policy Mandates. • Integrate and deconflict collected information into a self-consistent set of mandates. • Provide information to the PA1.1 activity for mandates that impact selection of stakeholders and respective responsibilities. • Document Mandates for the conceptual model in P1.3 – Constraints and Policies.
Inter Process Activity Relationships	
• Process Activity Sequence and Control-Flow	Once initiated, may be executed concurrently with other Phase 1 activities, or recursively in an iterative process with activities in other phases.

• Process Activity Information Flow	Information from external pools such as listed below flow into this process step. Information from PA1.2 may flow into this activity. Information from this activity may flow into PA1.1. Information flows out of this activity to P1.3 – Constraints and Policies.
Associated Entities	
• Tools	No custom tools.
• Actor-Agents	Producer.
• Information Pools	Information pools relevant to this activity include: • Enterprise standard operating procedures. • Industry and government standards. • Enterprise executive mandates law. • Agency regulations. • Agency directives. • Written policy. • Implied enterprise mandates, etc.
• Product / Object / Artefacts	This Process Activity contributes to P1.3 – Constraints and Policies.
Process Activity Completion	
• Exit Criteria	Criteria-types for demonstration of satisfactory completion of the subject activity, include the following: • Enterprise Mandates are defined sufficiently to align the scope and content of the conceptual model to mandates. • Sufficient contributions are made for the development of P1.3 – Constraints and Policies.

Table G-6: Conceptual Model Process Activity 2.1 Description.

PROCESS ACTIVITY CHARACTERISTIC	
Process Activity Identity	
• Process Activity Name and Aliases	PA2.1 – Identify, Analyze and Record conceptual Model Mission and Simulation Space Requirements.
Process Activity Description	
• Process Activity Rationale / Need / Motivation	This activity produces the requirements that will guide the design of the conceptual model and indirectly also the conceptual model itself.
• Process Activity Classification	May be classified depending on sensitivity of the content.

Process Activity Initiation	
• Entrance Criteria	May begin as soon as some of the needs for the simulation are clarified or some constraints or policies applicable to the development project are defined.
Process Activity Method	
• Process Activity Procedure	This Process Activity will typically consist of the following sub-activities: • Discussions with the initiator/client in order to ensure a mutual understanding of the client's needs. • Conferring with domain and M&S experts in order to refine the needs statement into more detailed requirements. This activity may profitably be based on descriptions of scenarios and/or use cases. • Consulting documents describing the mission domain. • Review of earlier requirement documents and legacy models in order to leverage earlier development efforts. • Documenting the elicited requirements using simple and unambiguous language.
Inter Process Activity Relationships	
• Process Activity Sequence and Control-Flow	This Process Activity initiates the definition phase of the conceptual model development process. It may be carried out in several passes after PA2.2 – Requirement Verification has revealed incompleteness, incorrectness or ambiguities.
• Process Activity Information Flow	The activity takes as inputs P1.2 – Need Statement and P1.3 – Constraints and Policies and produces a preliminary requirement specification.
Associated Entities	
• Tools	Requirements management tool.
• Actor-Agents	Conceptual model producer, domain SMEs, M&S SMEs.
• Information Pools	Legacy requirements and conceptual models, descriptions of military equipment and documentation of military tactics, techniques, and procedures.
• Product / Object / Artefacts	This Process Activity produces a preliminary requirement specification to be verified in PA2.2.
Process Activity Completion	
• Exit Criteria	All relevant requirements for the conceptual model have been identified and documented.

Table G-7: Conceptual Model Process Activity 2.2 Description.

PROCESS ACTIVITY CHARACTERISTIC	
Process Activity Identity	
• Process Activity Name and Aliases	PA2.2 – Verify Requirements with Respect to Needs, Constraints and Policies.
Process Activity Description	
• Process Activity Rationale / Need / Motivation	This activity will ensure that all needs are accounted for and constraints and policies are adequately described in the requirement specification.
Process Activity Initiation	
• Entrance Criteria	Entrance criteria consists of the completion of the following activity, availability of information and establishment of operational capability: • At least some requirements must have been documented prior to starting this activity.
Process Activity Method	
• Process Activity Procedure	The following PRELIMINARY or PREFATORY ACTIVITIES establish the context within which the bulk of direct conceptual model population will occur: • Specify the quality attributes that the requirement specification shall satisfy. • Review and modify the conceptual model requirement specification to ensure that the chosen quality attributes are satisfied.
Inter Process Activity Relationships	
• Process Activity Sequence and Control-Flow	This activity follows the PA2.1 – Requirements Definition and is followed PA2.3 – Synergize Requirements.
• Process Activity Information Flow	The activity takes as inputs P1.2 – Need Statement and P1.3 – Constraints and Policies and updates the preliminary requirement specification. In addition, V&V evidence must be added to Meta data of the conceptual model.
Associated Entities	
• Tools	Requirement management tool.
• Actor-Agents	Producer (requirement engineer).
• Information Pools	Information pools relevant to this activity include: • Preliminary requirement specification. • Meta data.
• Product / Object / Artefacts	This Process Activity updates the preliminary requirement specification.

Process Activity Completion	
• Exit Criteria	Criteria-types for demonstration of satisfactory completion of the subject activity, include the following: • All requirements have been evaluated with respect to chosen quality attributes. • Any identified discrepancies have been rectified.

Table G-8: Conceptual Model Process Activity 2.3 Description.

PROCESS ACTIVITY CHARACTERISTIC	
Process Activity Identity	
• Process Activity Name and Aliases	PA2.3 – Synergize Conceptual Model, Mission and Simulation Space Requirements.
Process Activity Description	
• Process Activity Rationale / Need / Motivation	Reconciling any incompatibilities between conceptual model, mission and simulation space requirements.
Process Activity Initiation	
• Entrance Criteria	Entrance criteria consists of the completion of the following activity, availability of information and establishment of operational capability: • At least some requirements of different categories must have been defined.
Process Activity Method	
• Process Activity Procedure	The following PRELIMINARY or PREFATORY ACTIVITY establish the context within which the bulk of direct conceptual model population will occur: • Review and modify the conceptual model requirement specification to ensure compatibility between conceptual model, mission, and simulation space requirements.
Inter Process Activity Relationships	
• Process Activity Sequence and Control-Flow	This activity follows PA2.2 and is followed by PA2.4.
• Process Activity Information Flow	This Process Activity takes the preliminary requirement specification produced by PA2.2 as input and produces P2.1 – Conceptual Model Requirement Specification.
Associated Entities	
• Tools	Requirement management tool.
• Actor-Agents	Producer (requirement engineer).

• Information Pools	Information pools relevant to this activity include: • Preliminary requirement specification.
• Product / Object / Artefacts	P2.1 – Conceptual Model Requirement Specification.
Process Activity Completion	
• Exit Criteria	Criteria-types for demonstration of satisfactory completion of the subject activity, include the following: • All requirements have been evaluated for compatibility with respect to requirements of the other categories. • P2.1 has been completed.

Table G-9: Conceptual Model Process Activity 2.4 Description.

PROCESS ACTIVITY CHARACTERISTIC	
Process Activity Identity	
• Process Activity Name and Aliases	PA2.4 – Derive Mission and Simulation Space Knowledge Needs.
Process Activity Description	
• Process Activity Rationale / Need / Motivation	The purpose of this Process Activity is to communicate to the conceptual model producer what knowledge must be acquired in order to design and build a conceptual model that will serve its intended purpose.
Process Activity Initiation	
• Entrance Criteria	Entrance criteria consists of the completion of the following activity, availability of information and establishment of operational capability: • At least some conceptual model requirement must have been identified and documented.
Process Activity Method	
• Process Activity Procedure	The following PRELIMINARY or PREFATORY ACTIVITY establish the context within which the bulk of direct conceptual model population will occur: • Analyze the requirement specification in order to derive knowledge needs. • Document knowledge needs.
Inter Process Activity Relationships	
• Process Activity Sequence and Control-Flow	This Process Activity follows the PA2.3 and is the final activity in Process Phase 2.
• Process Activity Information Flow	This Process Activity uses P2.1 – Conceptual Model Requirement Specification as input and produces P2.2 – Conceptual Model Knowledge Acquisition Needs as output.

Associated Entities	
• Tools	None.
• Actor-Agents	Producer (knowledge engineer).
• Information Pools	Information pools relevant to this activity include: • Legacy knowledge. • Need descriptions.
• Product / Object / Artefacts	This Process Activity produces P2.2 – Conceptual Model Knowledge Acquisition Needs.
Process Activity Completion	
• Exit Criteria	Criteria-types for demonstration of satisfactory completion of the subject activity, include the following: • An exhaustive list of knowledge elements needed to design and build the desired conceptual model has been documented in P2.2.

Table G-10: Conceptual Model Process Activity 3.1 Description.

PROCESS ACTIVITY CHARACTERISTIC	
Process Activity Identity	
• Process Activity Name and Aliases	PA3.1 – Identify Authoritative Knowledge Sources.
Process Activity Description	
• Process Activity Rationale / Need / Motivation	This activity is about identifying authoritative knowledge sources to fetch correct and authoritative information that describes a certain domain, for example through books, papers, tutorials, interviewing the SMEs, etc.
Process Activity Initiation	
• Entrance Criteria	Entrance criteria consists of the completion of the following activity, availability of information and establishment of operational capability: • May begin once P2.1 – Conceptual Model Requirement Specification and P2.2 – Conceptual Model Knowledge Acquisition Needs exist.
Process Activity Method	
• Process Activity Procedure	There is no specific methodology for identifying appropriate sources for KA, but here is a couple of recommendations: • Having a deeper understanding of the problem domain and (preferably) having experience of the particular area are necessary qualities for success.

• Process Activity Procedure (cont'd)	• Rely only on authoritative knowledge sources, those authorised by some organisation/authority beforehand (who this person or agency should be is beyond the scope of this report). • These sources can be anything from books, web information, papers, regulations documents, pictures, maps, and case studies, but perhaps most important of all interviews with Subject-Matter Experts (SMEs).
Inter Process Activity Relationships	
• Process Activity Sequence and Control-Flow	This activity may be initiated as soon as the inputs P2.1 – Requirement Specification and P2.2 – Conceptual Model Knowledge Acquisition Needs are available. But it must be done before activity PA3.4 – Gather, Structure and Document Knowledge begins.
• Process Activity Information Flow	This activity takes as inputs P2.1 – Conceptual Model Requirement Specification and P2.2 – Conceptual Model Knowledge Acquisition Needs and produces a list of authoritative knowledge sources which corresponds to requirements and needs identified in Phase 2.
Associated Entities	
• Tools	No custom tools.
• Actor-Agents	No specific actors or agents has been identified, however existence of some organisation or authority who can point out authoritative knowledge sources is of great benefit.
• Information Pools	Information pools relevant to this activity include: • List of authoritative knowledge sources for different military activities. • Simulation expertise, etc. • Points of contact lists. • List of SMEs. • Employee roles. • Organizational charts. • Biographies, etc.
• Product / Object / Artefacts	The final product of this activity will be a list of authoritative knowledge sources for a certain kind of knowledge.
Process Activity Completion	
• Exit Criteria	Criteria-types for demonstration of satisfactory completion of the subject activity, include the following: • When at least one authoritative knowledge sources adequate for the certain kind of knowledge has been identified.

Table G-11: Conceptual Model Process Activity 3.2 Description.

<table>
<tr><th colspan="2">PROCESS ACTIVITY CHARACTERISTIC</th></tr>
<tr><td colspan="2">Process Activity Identity</td></tr>
<tr><td>• Process Activity Name and Aliases</td><td>PA3.2 – Search for the Reusable Knowledge in the Conceptual Model Repository.</td></tr>
<tr><td colspan="2">Process Activity Description</td></tr>
<tr><td>• Process Activity Rationale / Need / Motivation</td><td>Given that a conceptual model repository already exists, no acquisition of new knowledge is justified before checking if the required conceptual model already is either partly or completely modelled and stored in the conceptual model repository.</td></tr>
<tr><td colspan="2">Process Activity Initiation</td></tr>
<tr><td>• Entrance Criteria</td><td>Entrance criteria consists of the completion of the following activity, availability of information and establishment of operational capability:
May begin once P2.1 – Conceptual Model Requirement Specification and P2.2 – Conceptual Model Knowledge Acquisition Needs exist.</td></tr>
<tr><td colspan="2">Process Activity Method</td></tr>
<tr><td>• Process Activity Procedure</td><td>There is no specific methodology for identifying appropriate sources for KA, but here are a couple of recommendations.
The list of needs and requirements will be the foundation for building the necessary queries to the repository:
Analyze P2.1 – Conceptual Model Requirement Specification and P2.2 – Conceptual Model Knowledge Acquisition Needs to find syntactic and/or semantic key words for the search.
Do search in an already existing conceptual model repository for the reusable knowledge.
Keep in mind that several qualitative properties are critically important to search and find either the reusable knowledge component (part of a conceptual model) or a complete conceptual model fulfilling a specific need:
One is to try to model knowledge in smaller components that makes reusability easier.
The other property is to have a degree of formalisation and semantic description that makes it possible to compose smaller components for building the needed conceptual model.
The third is to have good Meta data addressing artefacts in the conceptual model Repository; this makes it possible to easily find the knowledge which corresponds to the need.</td></tr>
</table>

Inter Process Activity Relationships	
• Process Activity Sequence and Control-Flow	This activity may be initiated as soon as the inputs P2.1 – Conceptual Model Requirement Specification and P2.2 – Conceptual Model Knowledge Acquisition Needs are available. But it must be done before activity PA3.4 – Gather, Structure and Document Knowledge begins.
• Process Activity Information Flow	This activity takes as inputs P2.1 – Conceptual Model Requirement Specification and P2.2 – Conceptual Model Knowledge Acquisition Needs and produces a list of authoritative knowledge sources which corresponds to requirements and needs identified in Phase 2.
Associated Entities	
• Tools	Query making and repository searching tools.
• Actor-Agents	No specific actors or agents have been identified.
• Information Pools	Information pools relevant to this activity include: • Reusable knowledge components which partly or completely fulfill the need may be found as an intermediate product.
• Product / Object / Artefacts	The final product of this activity will be either: • A positive answer that the required conceptual model is found in the conceptual model repository; • Reusable knowledge components which only partly fulfill the need has been found; or • A negative answer about nothing of value for the specific need was found.
Process Activity Completion	
• Exit Criteria	Criteria-types for demonstration of satisfactory completion of the subject activity, include the following: • When the search is done and adequate result has been retrieved.

Table G-12: Conceptual Model Process Activity 3.3 Description.

PROCESS ACTIVITY CHARACTERISTIC	
Process Activity Identity	
• Process Activity Name and Aliases	PA3.3 – Identify Knowledge Gaps and Bounds.
Process Activity Description	
• Process Activity Rationale / Need / Motivation	This activity concerns whether the knowledge retrieved from an existing conceptual model repository is in accordance with the requirements and needs or not.

• Process Activity Rationale / Need / Motivation (cont'd)	The reusability of already gathered knowledge will be examined to see if they can be used for the new purpose. This outcome aids in identifying what is missing.
Process Activity Initiation	
• Entrance Criteria	Entrance criteria consists of the completion of the following activity, availability of information and establishment of operational capability: • This activity will happen (will be considered) only if the result of the previous activity PA3.2 – Search for the Reusable Knowledge is case b), which is the knowledge components found in the conceptual model repository partly fulfill the need.
Process Activity Method	
• Process Activity Procedure	The following PRELIMINARY or PREFATORY ACTIVITY establish the context within which the bulk of direct conceptual model population will occur: • If the result of PA3.2 is case a) "the required knowledge is found in the conceptual model repository" end this activity immediately and initiate PA3.5. • If the result of PA3.2 is case c) "nothing of value for the specific need was found" end this activity immediately and initiate PA3.4. • If the result of PA3.2 is case b) "reusable knowledge components which only partly fulfil the need has been found"; then the result has to be analyzed and compared with the need to identify knowledge gaps, i.e., what part/parts are missing.
Inter Process Activity Relationships	
• Process Activity Sequence and Control-Flow	This activity will be initiated after PA3.2 is done. Depending to the result it will either be followed by PA3.4 or PA3.5.
• Process Activity Information Flow	This activity takes as inputs P2.2 – Conceptual Model Knowledge Acquisition Needs and the result of PA3.2 – Search for the Reusable Knowledge, and if no knowledge gap is identified it will initiate PA3.5, but if significant knowledge is still missing will produce an intermediate document addressing that gap which will be used of PA3.4 – Gather, Structure and Document Knowledge.
Associated Entities	
• Tools	Knowledge comparison tools.
• Actor-Agents	Knowledge engineer, SME.

• Information Pools	Information pools relevant to this activity include: • Intermediate result from PA3.2, P2.1 and P2.2.
• Product / Object / Artefacts	The final product of this activity will either be: • No knowledge gaps identified; or • A notion of what kind of information is missing and a list of authorized knowledge sources for KA.
Process Activity Completion	
• Exit Criteria	Criteria-types for demonstration of satisfactory completion of the subject activity, include the following: • When knowledge comparison is done and the gaps are addressed.

Table G-13: Conceptual Model Process Activity 3.4 Description.

PROCESS ACTIVITY CHARACTERISTIC	
Process Activity Identity	
• Process Activity Name and Aliases	PA3.4 – Gather, Structure and Document Knowledge.
Process Activity Description	
• Process Activity Rationale / Need / Motivation	This activity is about acquiring certain knowledge which often is not documented anywhere but only available through Subject-Matter Experts (SME). This acquired knowledge will then be structured and documented for further use.
Process Activity Initiation	
• Entrance Criteria	Entrance criteria consists of the completion of the following activity, availability of information and establishment of operational capability: • When the result of PA3.2 – Search for the Reusable Knowledge has been case c) “nothing of value for the specific need was found”; or • When PA3.3 – Identify Knowledge Gaps and Bounds has ended.
Process Activity Method	
• Process Activity Procedure	The following PRELIMINARY or PREFATORY ACTIVITY establish the context within which the bulk of direct conceptual model population will occur: • The first step in this activity is about gathering knowledge. Information sources for military activities can be anything from instructions, books, military doctrines, military scenarios, case studies to military experts.

• Process Activity Procedure (cont'd)	However, the information that is needed for a certain purpose is often not documented anywhere and is only available through SMEs. Below we provide examples of techniques that can be used for this kind of knowledge elicitation (mainly through interviews): • Unstructured: The SME has a general discussion of the domain, designed to provide a list of topics and concepts. • Structured: The interviewer asks the SME or end user questions relating to a specific topic. • Problem-solving: The SME is provided with a real-life problem, something that they deal with during their working life and are then asked to solve it. As the expert does so, they are required to describe each step, and the reasons for doing it. • Prototyping: The SME is asked to evaluate a prototype of a system. • Simulation: The SME is asked to use a simulator so that the SME's behaviors can be observed. • Dialogue: The SME interacts with a client, in the way that they would normally do during their normal work routine. • Sample lecture preparation: The SME prepares a lecture, and the knowledge engineer analyses its content. • Questionnaires: These are useful when the knowledge is to be gathered from several different subject-matter experts. • When the knowledge is acquired a methodology must be chosen to structure the knowledge. • Finally the gathered and structured knowledge must be documented for further use and reuse. • Last but not least must conceptual model Meta data product be update with new information.
Inter Process Activity Relationships	
• Process Activity Sequence and Control-Flow	This activity will be initiated either by PA3.2 – Search for the Reusable Knowledge or after PA3.3 – Identify Knowledge Gaps and Bounds is done. This activity must be done before PA3.5 – Generate/Extend a Domain Ontology begins.
• Process Activity Information Flow	This activity takes the intermediate product generated in PA3.3 – Identify Knowledge Gaps and Bounds as input and produces another intermediate product called structured knowledge corpus.

Associated Entities	
• Tools	• Knowledge Acquisition (KA) tools. • Structuring tools.
• Actor-Agents	• Knowledge Acquisition expert. • Knowledge engineer.
• Information Pools	Intermediate result from PA3.3, P2.1 and P2.2. Information sources for military activities can be anything from instructions, books, military doctrines, military scenarios, case studies to military experts. However, the information that is needed for a certain purpose is often not documented anywhere and is only available through SMEs.
• Product / Object / Artefacts	The final product of this step is some structured and documented information gathered to fulfil a certain need of knowledge.
Process Activity Completion	
• Exit Criteria	Criteria-types for demonstration of satisfactory completion of the subject activity, include the following: • When the needed knowledge is gathered, structured and documented.

Table G-14: Conceptual Model Process Activity 3.5 Description.

PROCESS ACTIVITY CHARACTERISTIC	
Process Activity Identity	
• Process Activity Name and Aliases	PA3.5 – Generate/Extend a Domain Ontology.
Process Activity Description	
• Process Activity Rationale / Need / Motivation	This activity covers structuring, tagging, and storing the gathered information either as new domain ontology or as an extension to an existing one.
Process Activity Initiation	
• Entrance Criteria	Entrance criteria consists of the completion of the following activity, availability of information and establishment of operational capability: • May be initiated by PA3.3 – Identify Knowledge Gaps and Bounds. • When PA3.4 – Gather, Structure and Document Knowledge has ended and the intermediate product Structured Knowledge corpus is available.
Process Activity Method	
• Process Activity Procedure	The following PRELIMINARY or PREFATORY ACTIVITY establish the context within which the bulk of direct conceptual model population will occur:

• Process Activity Procedure (cont'd)	• New knowledge most likely will introduce new military concepts, properties, relations, and constraints which should be stored in some kind of knowledge base for future use and reuse.
	• Check if ontology/ontologies for the current subject already exist, and in that case update the/those ontology/ontologies with the most recent acquired knowledge.
	• If no ontology exists for the current subject/domain one may be created.
	• There are different methodologies for integrating these new concepts into existing ontologies as well as for creating new ones. The appropriate creation methodology will depend upon, and be influenced by, the requirements and design criteria that exist. Examples of these for such an ontological knowledge base may be:
	  • Flexibility;
	  • Adaptability;
	  • Traceability;
	  • Machine readability;
	  • Interoperability; and
	  • Reusability for multiple applications; or might simply be rapid and easy development.

Inter Process Activity Relationships	
• Process Activity Sequence and Control-Flow	• The previous activities captured and documented new knowledge about a certain military activity that did not already exist in the conceptual model repository. As soon as this intermediate product (new documented knowledge) is available this activity can begin. • This activity may indicate that the acquiring and documentation of knowledge is done and ready for review, and thereby PA3.6 may be initiated.
• Process Activity Information Flow	This activity takes the intermediate product generated in PA3.4 called structured knowledge corpus and either produces a new ontology or update/extend an existing one.
Associated Entities	
• Tools	• Ontology engineering tools. • Ontology creation tools. • Ontology integration tool.
• Actor-Agents	• Ontology experts. • Conceptual modeler.

• Information Pools	Information pools relevant to this activity include: • Intermediate result from PA3.3. • Structured knowledge corpus created in PA3.4. • Existing ontology repository. • Knowledge base.
• Product / Object / Artefacts	The final product of this activity will either be: • A new domain ontology; or • An updated/extended version of an existing ontology, covering the latest acquired knowledge.
Process Activity Completion	
• Exit Criteria	Criteria-types for demonstration of satisfactory completion of the subject activity, include the following: • When domain ontology is build; or • An existing one is updated/extended.

Table G-15: Conceptual Model Process Activity 3.6 Description.

PROCESS ACTIVITY CHARACTERISTIC	
Process Activity Identity	
• Process Activity Name and Aliases	PA3.6 – Review Validity of Knowledge with Respect to the Authoritative Knowledge Sources.
Process Activity Description	
• Process Activity Rationale / Need / Motivation	This activity discusses and examines the validity of acquired knowledge with respect to authoritative knowledge sources.
Process Activity Initiation	
• Entrance Criteria	Entrance criteria consists of the completion of the following activity, availability of information and establishment of operational capability: • Will be initiated when PA3.5 – Generate/Extend a Domain Ontology is done and the acquired knowledge is ready for review.
Process Activity Method	
• Process Activity Procedure	The validity of acquired knowledge with respect to authoritative knowledge sources can be done using different V&V methodologies, e.g., GM-V&V. The following PRELIMINARY or PREFATORY ACTIVITY establish the context within which the bulk of direct conceptual model population will occur:

• Process Activity Procedure (cont'd)	• It is about checking – preferably performed by a VV&A agent – with the experts, whose realities have been captured and documented, to see if the documented knowledge is correct and completely represents the activity. • Examine whether the result of the knowledge acquisition phase is acceptable to the owner of the mission space (the SME). • An ontology expert may also examine if the generation or integration of the ontology is done correctly.
Inter Process Activity Relationships	
• Process Activity Sequence and Control-Flow	This activity may be initiated as soon as the activity PA3.5 – Generate/Extend a Domain Ontology is done and the acquired knowledge or the ontology is ready for review. And when the acquired knowledge or the ontology is validated this phase is completed.
• Process Activity Information Flow	This activity takes P2.2 – Conceptual Model Knowledge Acquisition Needs and the intermediate product from PA3.5 the ontology, and produce the P3.1 – Validated Knowledge.
Associated Entities	
• Tools	• V&V tools. • Ontology reviewing tools.
• Actor-Agents	• V&V agents. • SMEs. • Ontology experts.
• Information Pools	Information pools relevant to this activity include: • The ontology created, updated or extended as a result of PA3.5. • Existing ontology repository or knowledge base. • P2.2 – Conceptual Model Knowledge Acquisition Needs. • List of authoritative knowledge sources produced as an intermediate product in PA3.1.
• Product / Object / Artefacts	This is the last activity and the last check within Phase 3, and artefacts which pass this check are qualified to go to the next phase of the conceptual modeling process.
Process Activity Completion	
• Exit Criteria	Criteria-types for demonstration of satisfactory completion of the subject activity, include the following: • When the acquired knowledge is validated.

Table G-16: Conceptual Model Process Activity 4.1 Description.

PROCESS ACTIVITY CHARACTERISTIC	
Process Activity Identity	
• Process Activity Name and Aliases	PA4.1 – Search for Existing Conceptual Models that May be Partially of Fully Re-Used to Support the Current Conceptual Model Development.
Process Activity Description	
• Process Activity Rationale / Need / Motivation	This activity identifies the need to partially or fully reuse existing conceptual models.
Process Activity Initiation	
• Entrance Criteria	Entrance criteria consists of the completion of the following activities, availability of information and establishment of operational capability: • May begin when PA2.3 has substantial progress and when PA2.1 – Conceptual Model Requirement Specification has substantial input to start identifying search criteria for reuse. • A repository with conceptual models that have Meta data descriptions that is relevant to designing conceptual models.
Process Activity Method	
• Process Activity Procedure	The following PRELIMINARY or PREFATORY ACTIVITY establish the context within which the bulk of direct conceptual model population will occur: • Parse P2.1 – Conceptual Model Requirement Specification to become acquainted with what design characteristics are required. • Identify search criteria based upon these required design characteristics and search for candidate conceptual model. • If conceptual model compositions have already been identified in the preliminary conceptual model design, search for conceptual models with similar design characteristics. • Identify suitability for reuse based on criteria listed in the conceptual model Requirements Specification. • Record or update the found conceptual models to the preliminary conceptual model design artefact.
Inter Process Activity Relationships	
• Process Activity Sequence and Control-Flow	This activity is executed at least once and may be executed iteratively after new inputs to the preliminary conceptual model design during PA4.2, PA4.3, PA4.4 or PA4.5 or after the failure to meet the conceptual model requirements during PA4.6

• Process Activity Sequence and Control-Flow (cont'd)	evaluation or after the addition of requirements in P2.1 from either some build experience in PA5.1, the arrival of new stakeholders, the evolution to different conceptual model characteristics (quality, utility, formality, abstractness), etc.
• Process Activity Information Flow	Information from P2.1 – Conceptual Model Requirement Specification and from external information pools flows into this activity. Information from this activity flows into the preliminary conceptual model design and eventually into P4.1 – Conceptual Model Design if selected.
Associated Entities	
• Tools	No custom tools.
• Actor-Agents	• Producer. • Conceptual model developer.
• Information Pools	Information pools relevant to this activity include: • P2.1 – Conceptual Model Requirement Specification, preliminary conceptual model design, preliminary conceptual model, existing conceptual models. • Conceptual models that have relevance in the mission space. • Expected views driven by Stakeholder roles.
• Product / Object / Artefacts	This Process Activity contributes to a preliminary conceptual model design.
Process Activity Completion	
• Exit Criteria	Criteria-types for demonstration of satisfactory completion of the subject activity, include the following: • Some (not necessarily all or definitely) conceptual models have been found and recorded to the preliminary conceptual model design.

Table G-17: Conceptual Model Process Activity 4.2 Description.

PROCESS ACTIVITY CHARACTERISTIC	
Process Activity Identity	
• Process Activity Name and Aliases	PA4.2 – Identify and Select Conceptual Primitives and Model Kinds to Represent Acquired Knowledge.
Process Activity Description	
• Process Activity Rationale / Need / Motivation	This activity is necessary to select suitable conceptual primitives that will capture the knowledge elements and model kinds that will organize the conceptual primitives. This activity is necessary to be intentionally selective on the conceptual primitive and model kind options. This activity is an investment against the risk of uninformed use of conceptual primitives and model kinds.

Process Activity Initiation	
• Entrance Criteria	Entrance criteria consists of the completion of the following activities, availability of information and establishment of operational capability: • May begin when PA2.3 has substantial progress and P2.1 – Conceptual Model Requirement Specification has valuable input.
Process Activity Method	
• Process Activity Procedure	The following PRELIMINARY or PREFATORY ACTIVITY establish the context within which the bulk of direct conceptual model population will occur: • Parse P2.1 – Conceptual Model Requirement Specification to become acquainted with the type of knowledge to be captured and organized. • Analyze conceptual model characteristics requirements from P2.1 – Conceptual Model Requirement Specification to derive the implications on conceptual primitives and model kinds. • Survey conceptual primitive and model kind options either from the literature or from experience. • Make an elective choice of conceptual primitives and model kinds that suit the requirements and that make a coherent conceptual model composite combination. • If views have been selected in the preliminary conceptual model design, select model kinds that represent these views. • If model kinds have been selected in the preliminary conceptual model design, select conceptual primitives that compose these model kinds. • If conceptual primitives have been selected in the preliminary conceptual model design, select model kinds that will use these conceptual primitives. • Record or update the selected conceptual primitives and model kinds in a preliminary conceptual model design artefact.
Inter Process Activity Relationships	
• Process Activity Sequence and Control-Flow	Executed at least once and may be executed iteratively after new inputs to the preliminary conceptual model design during PA4.1, PA4.3, PA4.4 or PA4.5 or after the failure to meet the conceptual model requirements during PA4.6 evaluation or after the addition of requirements in P2.1 from either some build experience in PA5.1, the arrival of new stakeholders, the evolution to different conceptual model characteristics (quality, utility, formality, abstractness), etc.

• Process Activity Information Flow	Information from P2.1 – Conceptual Model Requirement Specification and from external information pools flows into this activity. Information from this activity flows into the preliminary conceptual model design and eventually into P4.1 – Conceptual Model Design.
Associated Entities	
• Tools	Specific modeling tools can help to select coherent conceptual model composite combinations. Tool availability is likely to influence the design choices.
• Actor-Agents	Producer.
• Information Pools	Information pools relevant to this activity include: • P2.1 – Conceptual Model Requirement Specification. • Preliminary conceptual model design. • Preliminary conceptual model. • Existing conceptual models. • Literature on conceptual primitives and model kinds.
• Product / Object / Artefacts	This Process Activity contributes to a preliminary conceptual model design.
Process Activity Completion	
• Exit Criteria	Criteria-types for demonstration of satisfactory completion of the subject activity, include the following: • Some (not necessarily all or definitely) conceptual primitives and model kinds have been selected and recorded to the preliminary conceptual model design.

Table G-18: Conceptual Model Process Activity 4.3 Description.

PROCESS ACTIVITY CHARACTERISTIC	
Process Activity Identity	
• Process Activity Name and Aliases	PA4.3 – Select Formalism(s) for Conceptual Model Specification.
Process Activity Description	
• Process Activity Rationale / Need / Motivation	This activity is necessary to select the formalism(s) that will be followed in the build process. This activity is necessary to be intentionally selective on the formalism options. This activity is an investment against the risk of uninformed use of formalisms.
Process Activity Initiation	
• Entrance Criteria	Entrance criteria consists of the completion of the following activities, availability of information and establishment of operational capability:

• Entrance Criteria (cont'd)	• May begin when PA2.3 has substantial progress. • P2.1 – Conceptual Model Requirement Specification has valuable input.
Process Activity Method	
• Process Activity Procedure	The following PRELIMINARY or PREFATORY ACTIVITY establish the context within which the bulk of direct conceptual model population will occur: • Parse P2.1 – Conceptual Model Requirement Specification to become acquainted with the type of knowledge to be modeled. • Analyze conceptual model characteristics requirements from P2.1 – Conceptual Model Requirement Specification to derive the implications on formalisms. • If a formalism has been mandated by policies, record it to the preliminary conceptual model design. • Survey formalism options either from the literature or from experience. • Analyze the preliminary conceptual model design to derive appropriate formalisms to fit the conceptual primitives, model kinds and views. • Make an elective choice of formalism(s) that suit the requirements and that make a coherent conceptual model composite combination. • Record or update the selected formalism(s) in the preliminary conceptual model design artefact.
Inter Process Activity Relationships	
• Process Activity Sequence and Control-Flow	Executed at least once and may be executed iteratively after new inputs to the preliminary conceptual model design during PA4.1, PA4.2, PA4.3 or PA4.5 or after the failure to meet the conceptual model requirements during PA4.6 evaluation or after the addition of requirements in P2.1 from either some build experience in PA5.1, the arrival of new stakeholders, the evolution to different conceptual model characteristics (quality, utility, formality, abstractness), etc.
• Process Activity Information Flow	Information from P2.1 – Conceptual Model Requirement Specification and from external information pools flows into this activity. Information from this activity flows into the preliminary conceptual model design and eventually into P4.1 – Conceptual Model Design.
Associated Entities	
• Tools	Specific modeling tools can help to select coherent conceptual model composite combinations. Tool availability is likely to influence the design choices.

• Actor-Agents	Producer.
• Information Pools	Information pools relevant to this activity include: • P2.1 – Conceptual Model Requirement Specification. • Preliminary conceptual model design. • Preliminary conceptual model. • Existing conceptual models, literature on formalisms.
• Product / Object / Artefacts	This Process Activity contributes to a preliminary conceptual model design.
Process Activity Completion	
• Exit Criteria	Criteria-types for demonstration of satisfactory completion of the subject activity, include the following: • At least one formalism has been selected and recorded to the preliminary conceptual model design.

Table G-19: Conceptual Model Process Activity 4.4 Description.

PROCESS ACTIVITY CHARACTERISTIC	
Process Activity Identity	
• Process Activity Name and Aliases	PA4.4 – Select Views to Support Stakeholders.
Process Activity Description	
• Process Activity Rationale / Need / Motivation	This activity is necessary to select the views that will fit the purpose of the different stakeholders.
Process Activity Initiation	
• Entrance Criteria	Entrance criteria consists of the completion of the following activities, availability of information and establishment of operational capability: • May begin when PA2.3 has substantial progress and P2.1 – Conceptual Model Requirement Specification has valuable input.
Process Activity Method	
• Process Activity Procedure	The following PRELIMINARY or PREFATORY ACTIVITY establish the context within which the bulk of direct conceptual model population will occur: • Parse P2.1 – Conceptual Model Requirement Specification to become acquainted with the type of knowledge to be communicated. • Analyze the stakeholders' view requirements from P2.1 – Conceptual Model Requirement Specification to derive the implications on view selection.

• Process Activity Procedure (cont'd)	• Survey view options either from the literature or from experience. • If formalisms have been selected in the preliminary conceptual model design, analyze the impact of the formalisms on the discretionary specification of views. • Make an elective choice of views that support the stakeholders' requirements. • Record or update the selected views in the preliminary conceptual model design artefact.
Inter Process Activity Relationships	
• Process Activity Sequence and Control-Flow	Executed at least once and may be executed iteratively after new inputs to the preliminary conceptual model design during PA4.1, PA4.3 or PA4.5 or after the failure to meet the conceptual model requirements during PA4.6 evaluation or after the addition of requirements in P2.1 from either some build experience in PA5.1, the arrival of new stakeholders, the evolution to different conceptual model characteristics (quality, utility, formality, abstractness), etc.
• Process Activity Information Flow	Information from P2.1 – Conceptual Model Requirement Specification and from external information pools flows into this activity. Information from this activity flows into the preliminary conceptual model design and eventually into P4.1 – Conceptual Model Design.
Associated Entities	
• Tools	Specific modeling tools can help to select coherent conceptual model composite combinations. Tool availability is likely to influence the design choices.
• Actor-Agents	Producer.
• Information Pools	Information pools relevant to this activity include: • P2.1 – Conceptual Model Requirement Specification. • Preliminary conceptual model design. • Preliminary conceptual model. • Existing conceptual models. • Literature on views.
• Product / Object / Artefacts	This Process Activity contributes to the preliminary conceptual model design.
Process Activity Completion	
• Exit Criteria	Criteria-types for demonstration of satisfactory completion of the subject activity, include the following: • At least one view has been selected and recorded to the preliminary conceptual model design.

Table G-20: Conceptual Model Process Activity 4.5 Description.

PROCESS ACTIVITY CHARACTERISTIC	
Process Activity Identity	
• Process Activity Name and Aliases	PA4.5 – Select a Notation Suitable to Express the Chosen Formalism.
Process Activity Description	
• Process Activity Rationale / Need / Motivation	This activity is necessary to select a notation to express the conceptual primitives, model kinds, views and formalisms. This activity is necessary to be intentionally selective on the notation options. This activity is an investment against the risk of uninformed use of notations.
Process Activity Initiation	
• Entrance Criteria	Entrance criteria consist of the completion of the following activities, availability of information and establishment of operational capability: May begin when PA2.3 has substantial progress; P2.1 – Conceptual Model Requirement Specification has valuable input.
Process Activity Method	
• Process Activity Procedure	The following PRELIMINARY or PREFATORY ACTIVITY establish the context within which the bulk of direct conceptual model population will occur: • Analyze the preliminary conceptual model design to identify which conceptual primitives, model kinds and formalisms must be supported by the notation. • Survey notations options either from the literature or from experience. • Make an elective choice of notations(s) in accordance with the conceptual model characteristics from P2.1 – Conceptual Model Requirement Specification. • Record or update the selected notation(s) in the preliminary conceptual model design artefact.
Inter Process Activity Relationships	
• Process Activity Sequence and Control-Flow	Executed at least once and may be executed iteratively after new inputs to the preliminary conceptual model design during PA4.1, PA4.2 or PA4.3 or after the failure to meet the conceptual model requirements during PA4.6 evaluation or after the addition of requirements in P2.1 from either some build experience in PA5.1, the arrival of new stakeholders, the evolution to different conceptual model characteristics (quality, utility, formality, abstractness), etc.

• Process Activity Information Flow	Information from P2.1 – Conceptual Model Requirement Specification and from external information pools flows into this activity. Information from this activity flows into the preliminary conceptual model design and eventually into P4.1 – Conceptual Model Design.
Associated Entities	
• Tools	Specific modeling tools can help to select coherent conceptual model composite combinations. Tool availability is likely to influence the design choices.
• Actor-Agents	Producer.
• Information Pools	Information pools relevant to this activity include: • P2.1 – Conceptual Model Requirement Specification. • Preliminary conceptual model design. • Preliminary conceptual model. • Existing conceptual models. • Literature on views.
• Product / Object / Artefacts	This Process Activity contributes to a preliminary conceptual model design.
Process Activity Completion	
• Exit Criteria	Criteria-types for demonstration of satisfactory completion of the subject activity, include the following: • At least one notation has been selected and recorded to the preliminary conceptual model design.

Table G-21: Conceptual Model Process Activity 4.6 Description.

PROCESS ACTIVITY CHARACTERISTIC	
Process Activity Identity	
• Process Activity Name and Aliases	PA4.6 – Evaluate Design for Adequacy/Relevance with Respect to Requirements.
Process Activity Description	
• Process Activity Rationale / Need / Motivation	This activity is necessary for verifying whether conceptual model requirements have been met by the conceptual model design.
Process Activity Initiation	
• Entrance Criteria	Entrance criteria consists of the completion of the following activities, availability of information and establishment of operational capability: • P2.1 – Conceptual Model Requirement Specification.

• Entrance Criteria (cont'd)	• The preliminary conceptual model design. • The V&V argumentation framework.
Process Activity Method	
• Process Activity Procedure	The following PRELIMINARY or PREFATORY ACTIVITY establish the context within which the bulk of direct conceptual model population will occur: • Parse P2.1 – Conceptual Model Requirement Specification to become acquainted with what design characteristics are required. • Parse the Preliminary conceptual model Design and check whether all conceptual model compositions have been identified. • Part of the V&V argumentation framework is concerned with the quality of the design of the conceptual model. These topics must be specified and transformed into design quality criteria, such as whether all views needed by the stakeholders are available or whether the chosen formalism is capable of expressing the conceptual model. • For each design quality criterion, evidence must be obtained. • Finally, update the design characteristics in the conceptual model data and publish the conceptual model design.
Inter Process Activity Relationships	
• Process Activity Sequence and Control-Flow	Perform after the PA4.1 – PA4.5 activities have finished.
• Process Activity Information Flow	Preliminary design whether the conceptual model Design meets the conceptual model requirements and accepts the conceptual model design.
Associated Entities	
• Tools	Book keeping aids like requirements tools.
• Actor-Agents	Producer.
• Information Pools	Information pools relevant to this activity include: • P2.1 – Conceptual Model Requirement Specification. • Preliminary conceptual model design. • The preliminary conceptual model.
• Product / Object / Artefacts	Verified conceptual model design and conceptual model Meta data.
Process Activity Completion	
• Exit Criteria	Criteria-types for demonstration of satisfactory completion of the subject activity, include the following: • When conceptual model design meets the conceptual model requirements and when P4.1 is complete.

Table G-22: Conceptual Model Process Activity 5.1 Description.

PROCESS ACTIVITY CHARACTERISTIC	
Process Activity Identity	
• Process Activity Name and Aliases	PA5.1 – Populate the Conceptual Model Using the Chosen Primitives, Model Kinds, Formalism, and Notation.
Process Activity Description	
• Process Activity Rationale / Need / Motivation	Given information contained in P3.1 – Validated Knowledge and P4.1 – Model Design; it is necessary to compile a (DRAFT or FINAL) version of the preliminary conceptual model. This process step is critical to the generation of the Process Phase 5 final work-product P5.1 – Conceptual Model insofar as it constitutes the accumulation, binding, and permanent authoritative documentation of the desired complete and consistent conceptual model itself, relevant to the military mission space intending to be represented in the pursuant model or simulation, in a preliminary form, pending articulation and confirmation to yield the final conceptual model artefact. The fundamental motivation of this process step is to capture in concrete, persistent form the entire STRUCTURE and PROCESS entailed in the mission space in detail, scope, and fidelity appropriate to the intended use of the conceptual model.
Process Activity Initiation	
• Entrance Criteria	Entrance criteria consists of the completion of the following activities, availability of information and establishment of operational capability: • Completion of previous activities (namely Process Phase 3 and Process Phase 4), and availability in DRAFT or FINAL form of their work-products (i.e., P3.1 – Validated Knowledge and P4.1 – Conceptual Model Design). • Establishment of conceptual model drafting Group. • Planning of effort entailed in PP5 Activity.
Process Activity Method	
• Process Activity Procedure	The following PRELIMINARY or PREFATORY ACTIVITIES establish the context within which the bulk of direct conceptual model population will occur: • Build strategy – Establish the style of operation by the Group, election of alternative design options not otherwise bound by requirements, and establishing such stylistic conventions as may facilitate cooperation and efficiency of the Group. Build versions may be spiral so that a succession of products is generated progressively converging on the desired result. Alternatively,

• Process Activity Procedure (cont'd)	parallelization techniques such as partitioning the mission space, allocating model constructs (i.e., primitives or model kinds) to Group members of the group may be convenient. • Notation – Establish election of alternative options for Primitives, Model kinds, Formalisms and Notation which may persist, consistent with P4.1 – Conceptual Model Design specified constraints may be necessary. These determinations and such style conventions to be shared across the Group should be established by consensus before significant build composition effort is begun. Checking the implications of such determinations during first spiral reviews will reassure the Group of the wisdom of its choices. • Sufficiency Criteria – Establish agreement upon prefatory interpretation of sufficiency criteria for the expected product, cast in terms of easily observable and confirmable product characteristics and evidently correlated to requirements specification elements will provide insurance against shortfalls in product quality in areas such as detail and completeness (scope, entities, entity-attribute and entity-relationships) as specified. • Tools – Select and provide prompt access to sufficient Tools to the conceptual model population Group. Selection of such tools should be made carefully with consideration for: a) familiarity and competence of Group, b) power to meet conceptual design capture and specification, and c) facility to generate views and published data products acceptable to customer user stakeholders. • Documentation – Establish Product Document management process and information storage and retrieval sufficient to contain the evolving conceptual model work-product, control of its authoritative configuration and containing commentary on tactical decisions – just as is prudent for requirements or code management under other circumstances. The following EXECUTION ACTIVITIES constitute the bulk of the conceptual model composition effort – to be executed with information contained in P3.1 – Validated Knowledge, in accordance with the constraints manifest in P4.1 – Conceptual Model Design, commensurate with the build strategy and manifesting the notational conventions previously agreed-upon: • Designate object entities.

• Process Activity Procedure (cont'd)	• Designate entity class abstractions. • Designate entity class or entity object attributes or predicates. • Designate entity class and entity object methods or operational processes. • Designate static relationships among object entities and object classes including typically inheritance (e.g., specialization-abstraction), logical (e.g., causal), process subordination or composition and structural composition relationships. • Designate dynamic relationships associated with object entities and classes, including typically state transition, event trace, information flow and interface, and activity control relationships. Please NOTE that the enumeration of activity elements cited above is not guaranteed to be complete or fully systematic, notwithstanding its being characteristic of guidance provided in respected literature and commonly observed in practice. It should, in its entirety, however, provide procedurally concrete guidance to the conceptual model population practitioner In addition, the vernacular used in the operational guidance, while somewhat particular, should not be interpreted as limiting or constraining in any way the determinations made *a priori* regarding "Primitives, Model kinds, Formalisms and Notation " Instead, they should be considered a good faith attempt to indicate in unbiased form the effort-elements recommended to capture a reasonable preliminary conceptual model population.
Inter Process Activity Relationships	
• Process Activity Sequence and Control-Flow	Process Build Strategy – <see above>. Process Step Iteration – <see above>. Process Step Parallelization – <see above>.
• Process Activity Information Flow	Contingent guidance on Process Activity sequence and control flow above, the following guidance is provided: • Collaboration – During execution, conduct of Group reviews of work progress, product convergence according to build strategies, and product quality should compliment normal program reviews and control mechanisms. Cultivation of consistency of vision across the conceptual model build Group is a powerful mechanism to maintain consistency of product, and collaboration among Group members. • Upstream – Knowledge/Design providers, Stakeholders – essential to compliance.

• Process Activity Information Flow (cont’d)	• Within activities – Population Group cohort … essential to convergence and consistency of product. • To product – Preliminary conceptual model as official record of original entry… essential to closure.
Associated Entities	

• Tools	Notational Standards – Information and notational standards assets likely to support the subject activity include, for:
	• Process-Perspective:
	  • IDEF 0.
	  • Petri Net.
	  • …
	• Object-Perspective:
	  • UML.
	  • SYSML.
	  • IDEF-4.
	  • Resource Description Frameworks (XML/RDF/RDFS).
	  • Meta Object Facility (MOF) Core Specification – OMG adopted specification.
	  • …
	• Data/Knowledge/Information-Perspective:
	  • IDEF- 1, 1xKnowledge Interchange Format (KIF).
	  • Open knowledge Base Connectivity Protocol.
	  • Knowledge Representation System (KRS).
	  • SQL.
	  • Entity Relationship Model (ERM)…
	  • …
	• Ontology Perspective:
	  • ISO/IEC 1350 Topic Maps.
	  • OWL.
	  • IDEF 5.
	  • Ontology Interface Layer (OIL).
	  • Ontology Exchange Language (OXL).
	  • Ontolingua.
	  • …
	COTS CASE Tools – Software assets likely to support the subject activity are available from within the assets of four coexisting communities of practice as follows:

• Tools (cont'd)	• Systems Engineering/Architecture – Typical, but not necessarily recommended tools in this category are:
	  • Systems Architect.
	  • Microsoft Visio.
	  • Cradle.
	  • CORE.
	  • …
	• Software development – Typical, but not necessarily recommended tools in this category are:
	  • IBM Rational Software Modeler (formerly Rational Rose).
	  • Microsoft Visio.
	  • …
	• Data Engineering – Typical, but not necessarily recommended tools in this category are:
	  • Myriad DBMS assets.
	  • …
	• Ontology and Knowledge Analysis – Typical, but not necessarily recommended tools in this category are:
	  • Apollo.
	  • LinkFactory.
	  • OILdOntoEdit.
	  • Ontolingua Server.
	  • OpenKnoME.
	  • Protégé – 2000.
	  • SymOntoXWebODE.
	  • WebOntoChimera.
	  • FCA-Merge.
	  • PROMPT.
	  • ODEMerge.
	  • …
	NOTE that suitability of tools is strongly contingent upon the *a priori* selection of Primitives, Model kinds, Formalisms and Notation cited above. In particular, tools are invariably notation specific; but their having implicit capability or bias toward one or another set of object- versus process- versus data-orientation and choice of primitives is significant and should not be overlooked.

• Actor-Agents	Agents populating the preliminary conceptual model are typically individuals or a designated Group specifically familiar with the required activities and expected consequential products. Execution – implementation agents must be familiar with a range of optional approaches, competent to execute the designated procedures, and competent to collaborate with other stakeholder role holders to ensure that the process executed and product generated are acceptable for intended use of the prospective conceptual model.
• Information Pools	Information pools relevant to this activity include input data artefacts and preliminary conceptual model product in whole or in part pursuant to the completion of the subject activity. In addition, it is likely that a variety of intermediate information pools will be generated as Group member contributions are generated or partial activity results components are generated in anticipation of compilation of these elements in the DRAFT preliminary conceptual model work-product.
• Product / Object / Artefacts	The principle desired output of the subject activity is the preliminary conceptual model. This product is described in Annex F.
Process Activity Completion	

• Exit Criteria	Criteria-types for demonstration of satisfactory completion of the subject activity, include the following:
	• Execution all process steps indicated above.
	• Generation of a preliminary conceptual model, including intentional bindings of Primitives, Model kinds, Formalisms and Notation; according to an unambiguously specified notational formalism; with the following attributes:
	  • Completeness:
	    • Preliminary conceptual model shall exhaust in scope of its contents the description of mission-space and simulation-space domains.
	    • The model shall contain all the expository features entailed in the notational schema (as tailored) that is used in the capture of the model documentation.
	  • Consistency:
	    • Preliminary conceptual model shall exhibit commensurate detail among its respective conceptual model components.
	    • Expression of the preliminary conceptual model shall be expressed systematically in accord with the notational schema of chosen tools and representational notations.

• Exit Criteria (cont'd)	• Correctness: • Preliminary conceptual model contents shall be plausibly correct in providing representations of mission-space and simulation space domains, contingent execution of VV&A and further credibility determinations and findings to be achieved in following activities. • Sufficiency: • Preliminary conceptual model shall be plausibly sufficient for its intended use by each of several stakeholders committed to the subject enterprise. Criteria reference "values" for demonstration of satisfactory completion of the subject activity – insofar as they shall be needed in addition to the specific guidance above – shall be established by the conceptual model development Group and made a matter of explicit record in anticipation of the subject completion evaluation.

Table G-23: Conceptual Model Process Activity 5.2 Description.

PROCESS ACTIVITY CHARACTERISTIC	
Process Activity Identity	
• Process Activity Name and Aliases	PA5.2 – Create the Specified Views.
Process Activity Description	
• Process Activity Rationale / Need / Motivation	Given information contained in the result of activity PA5.1, e.g., the preliminary conceptual model; it is necessary to elaborate that model by establishing the set of canonical 'views' or perspective of that preliminary conceptual model so that that model's contents may be precisely and thoroughly appreciated by the stakeholder community and in particular so the it may be systematically appreciated and understood consistently by the members of the P5.1 – Conceptual Model product development Group for purposes of execution of activities PA5.2 – PA5.4. Consistent appreciation of the content and significances of the syntax and semantics of the Preliminary conceptual model by all members of the conceptual model development Group is essential to the convergence of the preliminary model to the final conceptual model artefact.
Process Activity Initiation	
• Entrance Criteria	Entrance criteria consists of the following activities, availability of information and establishment of operational capability:

• Entrance Criteria (cont'd)	• Completion of the Preliminary conceptual model to the degree that its stability, scope and relevance are evident, *prime facie*, to the conceptual model development Group. • Documentation of the notational schema whereby the Preliminary Conceptual model has been compiled, and publication of tools and associated data interchange schemas known readily to be available for operating upon the contents of the preliminary conceptual model. • Designation of the conceptual model views generation and publication work cadre.
Process Activity Method	
• Process Activity Procedure	The following activities constitute the process whereby the establishment of views reflecting the contents of the Preliminary conceptual model shall be made manifest: • Strategy – Establish systematic strategy and procedures for educing and publishing views from the Preliminary Conceptual Mode. • View Inventory – Select views to be employed in depicting the preliminary Conceptual model. Such views should be assured to support the interests of enterprise stakeholders, but particularly the following: a) VV&A agents, b) Customers and users of the information contained in the conceptual model, and particularly, c) developers of the intended objective simulation system These determinations and such style conventions to be shared across the Group should be established by consensus before significant build composition effort is begun. Checking the implications of such determinations during first spiral reviews will reassure the Group of the wisdom of its choices. • Sufficiency Criteria – Establish agreement upon prefatory interpretation of sufficiency criteria for the expected product, cast in terms of easily observable and confirmable product characteristics and evidently correlated to requirements specification elements will provide insurance against shortfalls in product quality in areas such as detail and completeness (scope, entities, entity-attribute and entity-relationships) as specified. • Tools – Select and provide prompt access to sufficient Tools to the conceptual model view generation Group. Selection of such tools should be made carefully with consideration for: a) familiarity and competence of Group, b) power to meet conceptual design capture and specification, and c) facility to generate views and

• Process Activity Procedure (cont'd)	published data products acceptable to customer user stakeholders. Documentation – establish Product Document management process and information storage and retrieval sufficient to contain the evolving conceptual model view-set work-product, control of its authoritative configuration and containing commentary on tactical decisions – just as is prudent for requirements or code management under other circumstance. The following EXECUTION ACTIVITIES constitute the bulk of the conceptual model view generation effort – to be executed consonant with information contained in the preliminary conceptual model, commensurate with the build strategy, and manifesting the notational conventions previously agreed-upon: • Elect one of the (possibly) several view types identified for this activity. • Using the preliminary conceptual model as a basis for interpretation and representation, generate view components consistent with the view type being addressed, covering the entire scope of the Preliminary Conceptual model and preserving detail contained in the preliminary conceptual model in so far as the subject view allows. Integrate view elements by means of composition, or generalization relationships insofar as the subject view schema allows. • Select another of the intended representation views and repeat as above. When one pass implementing all desired views are completed proceed to next step following. • Conduct systematic cross-reference of view consistency by means suitable to ensure that all vies represent/reflect/ reveal the Preliminary conceptual model consistently and comprehensively. Such cross-reference techniques as are deemed suitable by the conceptual model views generation Group are acceptable, but the following are particularly endorsed: a) thorough reconciliation of representative use case in mission space and simulation space domains, b) reconciliation of views for any such components of the Preliminary conceptual model as may be perceived to have unusually close coupling in object or process terms, c) reconciliation of views for parts of preliminary conceptual model as may be considered particularly significant; that is: those which were unusually difficult to generate originally, those which are perceived to be particularly difficult to understand, and those that are perceived to be particularly relevant to one or another stakeholder.

• Process Activity Procedure (cont'd)	• Document all views generated with qualifying commentary regarding their significance, their relationships, and the use of notational conventions with which they have been conceived and published. Please NOTE that the enumeration of activity elements cited above is not guaranteed to be complete or fully systematic, notwithstanding its being characteristic of guidance provided in respected literature and commonly observed in practice. It should, in its entirety, however, provide procedurally concrete guidance to the conceptual model population practitioner. In addition, the vernacular used in the operational guidance, while somewhat particular, should not be interpreted as limiting or constraining in any way the determinations made *a priori* regarding Conceptual model views. Instead, they should be considered a good faith attempt to indicate in unbiased form the effort-elements recommended to disclose a reasonable preliminary conceptual model population.
Inter Process Activity Relationships	
• Process Activity Sequence and Control-Flow	Process Build Strategy – <see above>. Process Step Iteration – <see above>. Process Step Parallelization – <see above>.
• Process Activity Information Flow	Contingent guidance on Process Activity sequence and control flow above, the following guidance is provided: • Collaboration – During execution, conduct of Group reviews of work progress, product convergence according to build strategies, and product quality should compliment normal program reviews and control mechanisms. Cultivation of consistency of vision across the conceptual model build Group is a powerful mechanism to maintain consistency of product, and collaboration among Group members. • Upstream – Knowledge/Design providers, Stakeholders – essential to compliance. • Within activities – Population Group cohort … essential to convergence and consistency of product. • To product – Preliminary conceptual model as official record of original entry … essential to closure.
Associated Entities	
• Tools	See discussion of standards and COTS/CASE tools provided in exposition of process step 5.1 above.
• Actor-Agents	Agents producing views of the preliminary conceptual model are typically individuals or a designated Group specifically familiar with the required activities and expected

• Actor-Agents (cont'd)	consequential products. Execution – implementation agents must be familiar with a range of optional approaches, competent to execute the designated procedures, and competent to collaborate with other stakeholder role holders to ensure that the process executed and product generated are acceptable for intended use of the prospective conceptual model. Merit exists in choosing views generation agents from the preliminary development Group and from among stakeholders associated with prospective conceptual model verification, validation and use, in order to assure that the most consistent, intelligible and potentially useful suite of conceptual model views is generated by consensus among disparate stakeholder communities.
• Information Pools	Information pools relevant to this activity include input data artefacts and preliminary conceptual model product in whole or in part pursuant to the completion of the subject activity. In addition, it is likely that a variety of intermediate information pools will be generated as Group member contributions are generated or partial activity results components are generated in anticipation of compilation of these elements in the DRAFT preliminary conceptual model work-product.
• Product / Object / Artefacts	The principle desired output of the subject activity is the suite of expository views of the preliminary conceptual model. This product is described in Annex F.
Process Activity Completion	

• Exit Criteria	Criteria-types for demonstration of satisfactory completion of the subject activity, include the following:
	• Execution all process steps indicated above.
	• Generation of an ensemble of views for the subject preliminary conceptual model, according to an unambiguously specified notational formalism; with the following attributes:
	  • Completeness:
	    • Preliminary conceptual model views shall exhaust in scope of its contents the description of mission-space and simulation-space domains.
	    • The model views shall contain all the expository features entailed in the notational schema (as tailored) that is used in the capture of the model documentation.

• Exit Criteria (cont'd)	• Consistency: • Preliminary conceptual model views shall exhibit commensurate detail among its respective conceptual model components. • Expression of the preliminary conceptual model views shall be expressed systematically in accord with the notational schema of chosen tools and representational notations. • Correctness: • Preliminary conceptual model view contents shall be plausibly correct in providing representations of mission-space and simulation space domains, contingent execution of VV&A and further credibility determinations and findings to be achieved in following activities. • Sufficiency: • Preliminary conceptual model views shall be plausibly sufficient for its intended use by each of several stakeholders committed to the subject enterprise. Criteria reference "values" for demonstration of satisfactory completion of the subject activity – insofar as they shall be needed in addition to the specific guidance above – shall be established by the Conceptual Model development Group and made a matter of explicit record in anticipation of the subject completion evaluation.

Table G-24: Conceptual Model Process Activity 5.3 Description.

PROCESS ACTIVITY CHARACTERISTIC	
Process Activity Identity	
• Process Activity Name and Aliases	PA5.3 – Verify Conceptual Model Consistency with Respect to Conceptual Model Design.
Process Activity Description	
• Process Activity Rationale / Need / Motivation	Given information contained in the result of activity PA5.1, e.g., the preliminary conceptual model; it is necessary to establish the credibility and user confidence appropriate to be held in the preliminary conceptual model. On this account, two steps are warranted: verification of the preliminary model in comparison to the conceptual model Design (Product P4.1) and, subsequently, the validation of the preliminary model in comparison to the validated knowledge manifest of the simulation representation and simulation execution domains as Product P3.1. This section addresses the former effort.

<table>
<tr><th colspan="2">Process Activity Initiation</th></tr>
<tr><td>• Entrance Criteria</td><td>Entrance criteria consists of the following activities, availability of information and establishment of operational capability:
• Completion of the Preliminary conceptual model and its associated views heretofore incorporated, to the degree that its credibility and commensurability to the Conceptual Model Design are evident, prime facie, to the conceptual model development group.
• Documentation of the verification plan whereby the preliminary conceptual model is to be evaluated, this plan should contain strategies, and procedures whereby the congruity of the preliminary conceptual model and the antecedent Conceptual Model Design is to be demonstrated.
• Designation of the Conceptual Model verification evaluation and publication work cadre.</td></tr>
<tr><th colspan="2">Process Activity Method</th></tr>
<tr><td>• Process Activity Procedure</td><td>The fundamental nature of verification of a subject artefact (here, the preliminary Conceptual Model) to a referent information source (here, the content of the P4.1 – Conceptual Model Design), entails corroboration of conformance of the former in its structure, attributes and (functionality) to the informational content of the latter.
Procedural guidance for verification execution is highly contingent upon the nature of the subject, the referent, and the intended use of the subject for which verification confirmation is desired. On that count, no more than provisional guidance can be provided here to guide verification execution toward successful conclusion. In fact, however, there exists a copious literature whereby such verification may be conducted.
In view of the specialization of VV&A necessary for any particular conceptual model evaluation, and the myriad of techniques for that purpose available in National, and international ‘best-practice’ guidance (e.g., HLA, NATO); Only precepts, strategic guidance and cautionary instructions are provided in the procedural entries that follow:
• Publish and execute a conceptual model verification plan, including specification of: a) verification needs, b) requirements, c) activities, d) data products, e) necessary and sufficient resources, f) management, and g) work-product.
• Show rationale whereby planned verification effort devolves and satisfies to a sufficient degree the intention of verification, itself predicated upon appreciation of the intended use of the conceptual model.</td></tr>
</table>

• Process Activity Procedure (cont'd)	• Particularly link verification effort to the demonstration of suitable compliance of the preliminary conceptual model to the Conceptual Model Design manifest in the work-product P4.1. • Establish clearly defined verification evaluation components and criteria for satisfaction of verification evaluation component activities. • Report results of verification effort in accordance with description of the Accreditation Report element of conceptual model work produce specified in Annex F. • Coordinate verification plan and results with significant stakeholders.
Inter Process Activity Relationships	
• Process Activity Sequence and Control-Flow	Process Build Strategy – <see above>. Process Step Iteration – <see above>. Process Step Parallelization – <see above>.
• Process Activity Information Flow	Contingent guidance on Process Activity sequence and control flow above, the following guidance is provided: • Collaboration – During execution, conduct of Group reviews of work progress, product convergence according to build strategies, and product quality should compliment normal program reviews and control mechanisms. Cultivation of consistency of vision across the Conceptual Model Build Group is a powerful mechanism to maintain consistency of product, and collaboration among Group members. • Upstream – Input from Conceptual Model Design product and product-providers, Stakeholders – essential to compliance. • Within activities – Population Group cohort … essential to convergence and consistency of product. • To product – Preliminary conceptual model or to Conceptual Model Verification Report as official record of original entry is essential to closure.
Associated Entities	
• Tools	See discussion of standards and COTS/CASE tools provided in exposition of process step 5.1 above.
• Actor-Agents	V&V Agents.
• Information Pools	P4.1 – Conceptual Model Design documentation, together with Preliminary conceptual model artefact are information necessary and sufficient to support the completion of this activity.

• Product / Object / Artefacts	While no formal work-product is indicated in the process model as consequent the execution of this activity, it is recommended that a certificate of verification be produced and made a part of the formal documentary conceptual model data package for reference in subsequent VV&A efforts and for reference within the enterprise environment.
Process Activity Completion	
• Exit Criteria	Determination of the adequacy of verification of the conceptual model with regard to consistency with conceptual model design and generation of an authoritative, permanent, accessible record of such verification.

Table G-25: Conceptual Model Process Activity 5.4 Description.

PROCESS ACTIVITY CHARACTERISTIC	
Process Activity Identity	
• Process Activity Name and Aliases	PA5.4 – Validate Conceptual Model with Respect to Mission Space and Simulation Space Knowledge.
Process Activity Description	
• Process Activity Rationale / Need / Motivation	Given information contained in the result of activity PA5.1, e.g., the preliminary conceptual model; it is necessary to establish the credibility and user confidence appropriate to be held in the preliminary conceptual model. On this account, two steps are warranted: verification of the preliminary model in comparison to the conceptual model Design (Product P4.1), and, subsequently, the validation of the preliminary model in comparison to the validated knowledge manifest of the simulation representation and simulation execution domains as Product P3.1. This section addresses the latter effort.
Process Activity Initiation	
• Entrance Criteria	Entrance criteria consists of achievement of the following state: • Tasks PA5.1 – 5.3 are complete. • Product P3.1 is available. • Preliminary conceptual model DRAFT is available for evaluation.
Process Activity Method	
• Process Activity Procedure	Execution agent conducts following activity: • Establish rational for validation criteria. • Specify validation criterion sufficiency levels based on state of mission and simulation space knowledge.

• Process Activity Procedure (cont'd)	• Evaluate preliminary conceptual model attributes. • Compare attributes as evaluated to the criterion values previously established. • Document compliance or minimal sufficiency of attributes of the preliminary conceptual model in relation to reference values. • Revise conceptual model (or reconsider mission space and simulation space knowledge formulation and/or contents). • Repeat evaluation step until sufficiency achieved.
Inter Process Activity Relationships	
• Process Activity Sequence and Control-Flow	This activity follows Activity PA5.3 and subsequent determination of adequacy of the results of that activity. It precedes Activity PA5.6.
• Process Activity Information Flow	Activity uses information from Product P3.1 – Validated Knowledge and provides information to the preliminary conceptual model.
Associated Entities	
• Tools	VV&A tools chosen for use within the enterprise.
• Actor-Agents	V&V agent.
• Information Pools	Information pools relevant to this activity include the preliminary conceptual model and P3.1 – Validated Knowledge.
• Product / Object / Artefacts	None.
Process Activity Completion	
• Exit Criteria	Complete demonstration of satisfaction of attributes of the preliminary conceptual model to criteria derived from.

Table G-26: Conceptual Model Process Activity 5.5 Description.

PROCESS ACTIVITY CHARACTERISTIC	
Process Activity Identity	
• Process Activity Name and Aliases	PA5.5 – Ensure Acceptance of Conceptual Model by Authorized Stakeholders.
Process Activity Description	
• Process Activity Rationale / Need / Motivation	Satisfaction of stakeholders' needs in creation and subsequent utility of conceptual models is the fundamental objective of conceptual model development activity. Confirmation of suitability of the conceptual model work-product with stakeholder(s) authorized to render that judgement is the proximate objective of the effort.

Process Activity Initiation	
• Entrance Criteria	Completion of development Process Activities through PA5.4 and a FINAL DRAFT of the conceptual model, together with associated work-products are necessary pre-conditions for completing this activity.
Process Activity Method	
• Process Activity Procedure	Particular activities considered necessary and sufficient to complete this process step include: • Check for completion of preceding efforts and entrance criteria. • Compile full documentation suite including FINAL DRAFT preliminary conceptual model. • Identify authoritative stakeholder(s) whose approval is considered necessary. • Prepare decision briefing. • Prepare authorization documentation. • Execute decision briefing. • Obtain authorization documentation signature.
Inter Process Activity Relationships	
• Process Activity Sequence and Control-Flow	This Process Activity follows Activity PA5.4 and the adequacy decision following. It is the last step in PP5.
• Process Activity Information Flow	Information flow into this activity includes the FINAL DRAFT preliminary conceptual model as well as any necessary information from preceding information data products generated during the conceptual modeling process Output information includes a formally approved conceptual model designated Product 5.1.
Associated Entities	
• Tools	No special tools required.
• Actor-Agents	Principal actor agents contributing in this activity are the conceptual model development effort program manager (and associated administrative staff) and the designated authoritative Stakeholder(s) whose approval is solicited.
• Information Pools	Preliminary conceptual model and associated collateral documentation.
• Product / Object / Artefacts	P5.1 – Approved Conceptual Model.
Process Activity Completion	
• Exit Criteria	Approval of FINAL DRAFT conceptual model by authoritative stakeholder(s).

Annex H – CONCEPTUAL MODEL PRODUCT DESCRIPTION

Table H-1: Generic Template for Specification of Product.

PRODUCT CHARACTERISTIC	
Product Identity	
• Product Name and Aliases	*<Denotative names and identifiers of Product.>*
Product Description	
• Product Definition	*<A definition of the subject Product.>*
• Product Purpose	*<Describes the purpose of the Product, both in the development process and as an artefact for later reference.>*
• Product Content	*<Describe the content of the product.>*
• Product Structure/Format	*<Describe the structure of the product.>*
Product Initiation	
• Entrance Criteria	*<This field specifies component values that are necessary and sufficient for the development of subject Product to be effectively initiated.>*
Product Development Guidance	
• Product Development	*<In this field, the agent is provided procedural guidance for the development of the subject Product. Note that relationships to Process Activities and needs for tools or information are specified in other form records.>*
Product Relationships	
• Product – Process Relationships	*<Instruction regarding the Process steps and sub-steps that produce this Product, and the Process steps and sub-steps that use this Product.>*
• Inter-Product Relationships	*<Instruction regarding the relationships between this Product and all other relevant Products. These instructions should indicate which Products are predecessors to this Product, which are successors, and which may be done in concurrence.>*
Associated Entities	
• Tools	*<Identify tools such as hardware or software necessary and sufficient, or useful, to complete the Product.>*
• Actor-Agents	*<Indicate the actor agents responsible for development of the Product, and their respective roles.>*

• Information Pools	*<Data stores of any type containing information used as input or generated as key content of the Product. May contain intermediate information re-used by this or successor Products, or components of the Product compiled as residual documentation.>*
Product Completion	
• Exit Criteria	*<This field specifies component values that are necessary and sufficient for the subject Product to be considered finished.>*

Table H-2: Conceptual Model Product 1.1 Description.

PRODUCT CHARACTERISTIC	
Product Identity	
• Product Name and Aliases	P1.1 – Stakeholder Description.
Product Description	
• Product Definition	Document mapping stakeholders to roles and responsibilities in the Conceptual Model effort.
• Product Purpose	The purpose of this product is to identify the stakeholders of this Conceptual Model development process and their respective roles and responsibilities to enable staffing/tasking of the Conceptual Model development effort, derivation of stakeholder-related requirements and stakeholder-related knowledge needs, and identification of subject-matter expertise for knowledge acquisition.
• Product Content	Conceptual model knowledge acquisition needs shall describe at a minimum: • Relevant Conceptual Model development responsibilities identified and grouped into roles; and • Stakeholders identified organizationally, mapped to responsibilities and roles. Desired: • Stakeholder identities by name, along with contact information.
• Product Structure/Format	No mandated format.
Product Initiation	
• Entrance Criteria	Entrance criteria consists of the following activities, availability of information and establishment of operational capability: • Product development may begin once PA1.1 begins.
Product Development Guidance	
• Product Development	See PA1.1.
Product Relationships	
• Product – Process Relationships	PA1.1 produces this product, which is used by PA2.1 and PA2.4.
• Inter-Product Relationships	This product may be developed concurrently with P1.2, P1.3, and P1.4, but must be completed prior to the completion of products from any later phases.
Associated Entities	
• Tools	None required.

• Actor-Agents	• Producer. • Conceptual Model Developer.
• Information Pools	Information pools relevant to this activity include: • Points of contact lists. • Employee roles. • Organizational charts. • Personnel databases, referrals, resumes, biographies. • Any intermediate information generated during execution of PA1.1.
Product Completion	
• Exit Criteria	Criteria-types for demonstration of satisfactory completion of the subject activity, include the following: • Product must contain comprehensive list of stakeholders by organization as a minimum, mapped to all related requirements and roles.

Table H-3: Conceptual Model Product 1.2 Description.

PRODUCT CHARACTERISTIC	
Product Identity	
• Product Name and Aliases	P1.2 – Need Statement.
Product Description	
• Product Definition	Document that defines the intended use of the Conceptual Model derived from the purpose and intended use of the M&S effort.
• Product Purpose	This product serves as the source from which to derive the set of Conceptual Model requirements and knowledge needs which are driven by M&S purpose and intended use.
• Product Content	Description of Conceptual Model intended use driven by M&S purpose and intended use.
• Product Structure/Format	No mandated format.
Product Initiation	
• Entrance Criteria	Entrance criteria consists of the following activities, availability of information and establishment of operational capability: • Product development may begin once PA1.2 begins.
Product Development Guidance	
• Product Development	See PA1.2.

Product Relationships	
• Product – Process Relationships	PA1.2 produces this product, which is used by PA2.1, PA2.2, and PA2.4.
• Inter-Product Relationships	This product may be developed concurrently with P1.1, P1.3, and P1.4, but must be completed prior to the completion of products from any later phases.
Associated Entities	
• Tools	Requirements Management tools optional.
• Actor-Agents	• Producer. • Conceptual Model Developer.
• Information Pools	Information pools relevant to this activity include: • Task orders. • Mission needs statements. • M&S needs statements. • User requirement documents. • Requests for proposal. • Statements of work. • Formal or informal directives. • Test agreements. • Any intermediate information generated during execution of PA1.2.
Product Completion	
• Exit Criteria	Criteria-types for demonstration of satisfactory completion of the subject activity, include the following: • Product must contain comprehensive description of Conceptual Model intended use sufficient to drive all Conceptual Model requirements and knowledge needs related to purpose and intended use of M&S.

Table H-4: Conceptual Model Product 1.3 Description.

PRODUCT CHARACTERISTIC	
Product Identity	
• Product Name and Aliases	P1.3 – Constraints and Policies.
Product Description	
• Product Definition	Document that defines the constraints and policies to be applied to the Conceptual Model effort based upon initial direction and enterprise scope.

• Product Purpose	This product serves as a set of constraints upon the Conceptual Model requirements and knowledge needs and impacts the content of Conceptual Model requirements and knowledge needs which are driven by constraints and policies.
• Product Content	List of constraints and mandates affecting the Conceptual Model development and design.
• Product Structure/Format	No mandated format.
Product Initiation	
• Entrance Criteria	Entrance criteria consists of the following activities, availability of information and establishment of operational capability: • Product development may begin once PA1.3 or PA1.4 begins.
Product Development Guidance	
• Product Development	Execute PA1.3 and PA1.4 concurrently or in any order.
Product Relationships	
• Product – Process Relationships	PA1.3 and PA1.4 produce this product, which is used by PA2.1, PA2.2, and PA2.4.
• Inter-Product Relationships	This product may be developed concurrently with P1.1, P1.2, and P1.4, but must be completed prior to the completion of products from any later phases.
Associated Entities	
• Tools	None.
• Actor-Agents	• Producer. • Conceptual Model Developer.
• Information Pools	Information pools relevant to this activity include: • Enterprise standard operating procedures. • Industry and government standards. • Enterprise executive mandates, law. • Agency regulations. • Agency directives. • Written policy. • Implied enterprise mandates. • Documented resource constraints. • Senior stakeholder preferences and requirements. • Planning/budgeting/management limitations. • Legacy M&S preferences and availability. • Data availability.

• Information Pools (cont'd)	• Enterprise preferences. • Any intermediate information generated during execution of PA1.3 and PA1.4.
Product Completion	
• Exit Criteria	Criteria-types for demonstration of satisfactory completion of the subject activity, include the following: • Product must contain comprehensive list of Conceptual Model constraints and policies sufficient to constrain Conceptual Model requirements and knowledge needs in keeping with direction and enterprise mandates.

Table H-5: Conceptual Model Product 1.4 Description.

PRODUCT CHARACTERISTIC	
Product Identity	
• Product Name and Aliases	P1.4 – Conceptual Model Meta Data.
Product Description	
• Product Definition	The conceptual model Meta data will address the conceptual model, acting as its identifier. Conceptual models are stored together with their Meta data specifying how they have been produced, i.e., when, where, by whom, from what, using what tool, and so on.
• Product Purpose	This Meta data is necessary to ensure traceability and reusability of the conceptual model.
• Product Content	The Meta data template can accommodate a number of meta features of the conceptual model, for example: Name, Type, Version, Modification Date, Security Classification, Release Restriction, Purpose, Application Domain, Description, Use Limitation, Use History, V&V Data Elements, Keyword, Implementation Dependencies, Point Of Contact (POC), Reference and Glyph.
• Product Structure/Format	A table with an entry for each data element in the Meta data.
Product Initiation	
• Entrance Criteria	Entrance criteria consists of the following activities, availability of information and establishment of operational capability: • Product development may begin once PA1.1 begins.
Product Development Guidance	
• Product Development	The entire list of activities given in text of "Product 1.4 Guidance" should be completed.

Product Relationships	
• Product – Process Relationships	Almost all the Process Activities in all the five Process Phases will continuously fill the conceptual model Meta data table to finally produce this product.
• Inter-Product Relationships	This product will be developed concurrently with all other products, and will be updated and completed till final conceptual model is built.
Associated Entities	
• Tools	No specific tools or software to complete this product has been identified.
• Actor-Agents	No specific actor or agent has been identified to be alone responsible for the development of this product, however all actors and agents involved in the development of the conceptual model are responsible for filling the conceptual model Meta data with the relevant data from their activities.
• Information Pools	Information pools relevant to this activity include: • **POC:** Holds information about an organization or a person having a particular role with respect to the conceptual model. • **Model Identification:** Can accommodate information related to the identification of a conceptual model such as: Name, Type, Version, Modification Date, Security Classification, Release Restriction, Purpose, Application Domain, Description, and Use Limitation. • **Use History:** Provides a description of where this conceptual model has been used. • **Reference:** Specifies a pointer to additional sources of information such as locations in XML documents and references to ontologies (both domain and middle level) which are used by the conceptual model. • **Implementation Dependencies:** Maintains a log of all dependencies determined during the development of this conceptual model, such as domain ontologies or any other new concept introduced by the process during the implementation of this conceptual model. • **Key Word:** Holds information about the key words of this conceptual model for future use. It helps users in searching for this conceptual model. • **Glyph:** Is responsible for holding the image of conceptual model, which can be used to visually represent a conceptual model in a tool palette or a web repository.

• Information Pools (cont'd)	• **V&V Data Elements:** The V&V process can produce an enormous amount of data. These data are collected under a label called V&V Data Elements and placed in the product "conceptual model Meta data". In the table below a list of data items is presented together with the Process Activities where that data is produced.
Product Completion	
• Exit Criteria	Criteria-types for demonstration of satisfactory completion of the subject activity, include the following: • Product development may end once the Meta data table is completed.

Table H-6: Conceptual Model Product 2.1 Description.

PRODUCT CHARACTERISTIC	
Product Identity	
• Product Name and Aliases	P2.1 – Conceptual Model Requirement Specification.
Product Description	
• Product Definition	The conceptual model requirement specification documents a collection of verifiable properties, attributes and characteristics of the Conceptual Model necessary for it to satisfy its intended purpose.
• Product Purpose	The conceptual model requirement specification shall communicate to Conceptual Model designers and builders all intended uses of the conceptual model, the aspects of the mission space to be represented by it and the simulator features to be supported.
• Product Content	Requirement statements documenting the content of the Conceptual Model and what criteria the Conceptual Model must satisfy.
• Product Structure/Format	Each requirement must be given a unique identifier. It may be useful to categorizing the requirements as belonging to one of the three "spaces" (Conceptual Model, mission, simulation).
Product Initiation	
• Entrance Criteria	Entrance criteria consists of the following activities, availability of information and establishment of operational capability: • At least some of the content or the intended uses of the simulation must have been documented.

Product Development Guidance	
• Product Development	• Use the need statement and constraints and policies inputs to identify requirements for the Conceptual Model. • Analyze the requirements with respect to completeness, consistency and correctness. • Document the requirements in an appropriate format. • Subject the requirement specification to review by competent subject-matter experts and approval by the client.
Product Relationships	
• Product – Process Relationships	The conceptual model requirement specification is produced by the process step P2.1 Identify, analyse and record User, Mission and Simulation Space Requirements. It serves as an input to the derivation of knowledge needs and guides the development of the Conceptual Model design.
• Inter-Product Relationships	The conceptual model requirement specification translates P1.2 – Need Statement and P1.3 – Constraints and Policies into verifiable requirements. It spells out in greater detail and more precisely what is implied by these inputs. It influences the P4.1 – Conceptual Model Design and indirectly the P5.1 – Conceptual Model itself.
Associated Entities	
• Tools	A requirement management tool may prove useful to maintain traceability from needs to requirements and Conceptual Model content.
• Actor-Agents	The conceptual model requirement specification is produced in collaboration between mission space and Modeling SMEs and subject to comment and approval by the client.
• Information Pools	Information pools relevant to this activity include: • Scenarios. • Use cases. • Repository of previously developed requirement specifications.
Product Completion	
• Exit Criteria	Criteria-types for demonstration of satisfactory completion of the subject activity, include the following: • The requirements for the Conceptual Model are sufficiently detailed to allow unambiguous derivation of knowledge needs and Conceptual Model design.

Table H-7: Conceptual Model Product 2.2 Description.

PRODUCT CHARACTERISTIC	
Product Identity	
• Product Name and Aliases	P2.2 – Conceptual Model Knowledge Acquisition Needs.
Product Description	
• Product Definition	Conceptual model knowledge acquisition needs describe the scope and level of detail of knowledge needed by the Conceptual Model developer to produce a Conceptual Model satisfying the client's need statement.
• Product Purpose	Conceptual model knowledge acquisition needs shall guide the Conceptual Model developer in collecting the necessary knowledge and limit knowledge acquisition to the minimum sufficient knowledge set.
• Product Content	Conceptual model knowledge acquisition needs shall describe: • The entities and activities in the mission space the modeler must understand in order to represent them correctly and with appropriate detail. • The simulation technique, tools and legacy assets the modeler must understand in order to represent implementation requirements and constraints correctly.
• Product Structure/Format	Textual description.
Product Initiation	
• Entrance Criteria	Entrance criteria consists of the following activities, availability of information and establishment of operational capability: • At least some of the requirements for the Conceptual Model must have been documented.
Product Development Guidance	
• Product Development	The developer must review the Conceptual Model requirement specification in order to identify knowledge needed for developing a Conceptual Model with sufficient fidelity to satisfy its purpose. Such knowledge will typically include: • Technologies applied in mission space entities and their capabilities and limitations. • Physical theories underpinning these technologies. • Military tactics, techniques and procedures. • Candidate simulation technologies. • Legacy simulation models and their capabilities and limitations.

PRODUCT CHARACTERISTIC	
Product Relationships	
• Product – Process Relationships	Conceptual model knowledge acquisition needs are developed in Process Activity PA2.4 – Derive Mission Space and Simulation Space Knowledge Needs. Knowledge acquisition needs form the input to Process Phase 3 – Acquire Conceptual Model Knowledge.
• Inter-Product Relationships	P2.2 – Conceptual Model Knowledge Acquisition Needs are developed based on P2.1 – Conceptual Model Requirement Specification. It is used in order to develop P3.1 – Validated Knowledge.
Associated Entities	
• Tools	Not applicable.
• Actor-Agents	The main agents participating in the development of Conceptual Model knowledge needs are subject-matter experts from the military mission domain, the military technology domain and modeling and simulation domain.
• Information Pools	Information pools relevant to this activity include: • Previously developed knowledge needs descriptions.
Product Completion	
• Exit Criteria	Criteria-types for demonstration of satisfactory completion of the subject activity, include the following: • A description of the knowledge needed for Conceptual Model development has been developed that is sufficiently comprehensive and specific to serve as guidance for the knowledge acquisition phase.

Table H-8: Conceptual Model Product 3.1 Description.

PRODUCT CHARACTERISTIC	
Product Identity	
• Product Name and Aliases	P3.1 – Validated Knowledge.
Product Description	
• Product Definition	The product Validated Knowledge is produced in the NATO conceptual modeling Process Phase 3, called Acquire Conceptual Model Knowledge. It is a validated piece of knowledge, developed in response to an identified need and/or requirement in the previous phase (2). It will be acquired from authoritative knowledge sources, and then will be structured, documented, and validated with respect to that authoritative knowledge source.

PRODUCT CHARACTERISTIC	
• Product Purpose	This will be the sole and very important product produced during Phase 3. The next phase Design the Conceptual Model will use this product to design a conceptual model. It is to say that this product will serve as the foundation for designing and building the final conceptual model.
• Product Content	A structured and documented piece of knowledge which has been validated with respect to the authoritative knowledge sources.
• Product Structure/Format	No mandated format.
Product Initiation	
• Entrance Criteria	Entrance criteria consists of the following activities, availability of information and establishment of operational capability: • The knowledge needs and the requirements list from the previous phase (2) are required. • Access to an existing conceptual model repository with reusable knowledge is beneficial and preferred. • A list of the authoritative knowledge sources for the required knowledge is also advantageous.
Product Development Guidance	
• Product Development	After identifying the needs and the requirements for the knowledge which were done in the previous phase (2), the authoritative knowledge sources for the particular knowledge which is requested are identified. Next activity in the process will start looking for the corresponding reusable knowledge which may already exist in an existing conceptual model repository, knowledge that can totally or partly be usable for this new need. If not, the lack of knowledge and the gaps which must be filled is identified. After that the knowledge will be gathered, structured and documented. Next, there should be enough information to either generate domain ontology for this particular mission space or extend existing domain ontology. Finally the validity of the acquired knowledge, with respect to the authoritative knowledge sources, will be reviewed and this product will be produced.
Product Relationships	
• Product – Process Relationships	This is the final product of Phase 3 in the NATO conceptual model Process, and to produce it one should go through the Process Activities PA3.1 to PA3.6.
• Inter-Product Relationships	Products P2.1 – Conceptual Model Requirement Specification and P2.2 – Conceptual Model Knowledge Acquisition Needs are the predecessors and P4.1 – Conceptual Model Design is the successor to this product.

PRODUCT CHARACTERISTIC	
Associated Entities	
• Tools	This product is a result of a knowledge development process and thus support of appropriate tools, methods, and techniques from the knowledge development area is very much appreciated, such as: • Methodologies for acquisition of data, information, and knowledge. • Methodologies for documentation, representation, and formatting the acquired knowledge. • Tools for knowledge acquisition, representation, formalization, etc. • Tools for managing and maintaining ontologies.
• Actor-Agents	• Knowledge engineer; to provide experience in acquiring, gathering and compiling information. • SME; to provide the domain and task knowledge. • Analysis and formatting expert; experienced in the appropriate formatting analysis method and technique. • Ontology expert; experienced in mapping and interpreting information held in the ontology, as well as being skilled in how to further develop and extend ontologies. • VV&A-agent; for validating the result.
• Information Pools	Information pools relevant to this activity include: • An existing conceptual model repository with reusable knowledge. • Domain ontologies in a knowledge base are very much appreciated but not mandatory.
Product Completion	
• Exit Criteria	Criteria-types for demonstration of satisfactory completion of the subject activity, include the following: • The Process Activity 3.6 – Review Validity of Acquired Knowledge with Respect to the Authoritative Knowledge Sources will guarantee that the product lives up to the expectations.

Table H-9: Conceptual Model Product 4.1 Description.

PRODUCT CHARACTERISTIC	
Product Identity	
• Product Name and Aliases	P4.1 – Conceptual Model Design.

PRODUCT CHARACTERISTIC	
Product Description	
• Product Definition	Document recording the conceptual model design decisions with a justification of the elective choice.
• Product Purpose	This product serves as a blue print to build the conceptual model.
• Product Content	Conceptual model design shall describe: • A record of conceptual model composites: conceptual primitives, model kinds, views, formalisms and notations. • A justification of each design decision with traceability to the driving requirement.
• Product Structure/Format	No mandated format.
Product Initiation	
• Entrance Criteria	Product development may begin as soon as PP4 begins.
Product Development Guidance	
• Product Development	Iteratively: • Make elective choices of conceptual model composites. • Reconcile choices into a coherent conceptual model composite combination. • Evaluate the conceptual model design for adequacy/ relevance with the conceptual model requirements.
Product Relationships	
• Product – Process Relationships	The product exists in a preliminary form over PA4.1 to PA4.5 iterations. PA4.6 produces the final P4.1 product, which is used by PA5.1. P4.6 also uses this product to evaluate the design and update P1.4 – Conceptual Model Meta Data accordingly.
• Inter-Product Relationships	This product completely relies on P2.1 – Conceptual Model Requirement Specification and may be used to produce P5.1 – Conceptual Model as soon as it has valuable input. It may evolve iteratively with P5.1.
Associated Entities	
• Tools	No specific tool is required to document the selection of conceptual model composites. A requirement management tool could be useful to document traceability.
• Actor-Agents	Producers.
• Information Pools	Information pools relevant to this activity include: • P2.1 – Conceptual Model Requirement Specification, preliminary conceptual model design and literature surveys.

PRODUCT CHARACTERISTIC	
Product Completion	
• Exit Criteria	Criteria-types for demonstration of satisfactory completion of the subject activity, include the following: • Product must pass PA4.6 evaluation against P2.1 – Conceptual Model Requirement Specification.

Table H-10: Conceptual Model Product 5.1 Description.

PRODUCT CHARACTERISTIC	
Product Identity	
• Product Name and Aliases	P5.1 – Conceptual Model.
Product Description	
• Product Definition	The authorized conceptual model work-product resulting from the conceptual modeling activity and including collateral materiel generated during the conceptual modeling effort as are necessary and sufficient to qualify the conceptual model product artefact per se and to support its evolution an use in context of the simulation enterprise environment for which it was produced.
• Product Purpose	The purpose of this work-product is to document in systematic, persistent, authoritative and detailed form information constituting the subject conceptual model in order to support simulation development operations and maintenance as well as model and simulation re-use throughout the duration of the M&S enterprise.
• Product Content	Product contains full and detailed articulation of the mission space and simulation space ontology (entities, attributes, behaviours, and relationships) that is necessary and sufficient to support simulation development and life-cycle evolution.
• Product Structure/Format	Product structure is elective in accordance with decisions made during the conceptual modeling process; including particularly election of conceptual model primitives, model kinds, formalism, views, design features, mission- and simulation-space information to be made manifest in the preliminary (and final) conceptual model. Documentary conventions and media are likewise left to the developer insofar as they are decided explicitly, consistently, and in conformance with protocols and strategic guidance associated with the M&S enterprise.
Product Initiation	
• Entrance Criteria	Product development proper (i.e., in addition to the compilation of ancillary information products generated during the conceptual modeling process), begins at completion of Activity PP4.

PRODUCT CHARACTERISTIC	
Product Development Guidance	
• Product Development	Activity PP5 and its sub-sections PA5.1 through PA5.5 specify in detail product development activity.
Product Relationships	
• Product – Process Relationships	See PA5.1 – PA5.5.
• Inter-Product Relationships	Products directly input to the generation of Product P5.1 are P3.1 – Validated Knowledge and P4.1 – Conceptual Model Design.
Associated Entities	
• Tools	CASE tools implied by the conceptual model design and implementation process elements are relevant to the generation of the subject product.
• Actor-Agents	Conceptual product development team.
• Information Pools	Information contained in P3.1 and P4.1 are required as input to the subject work-product.
Product Completion	
• Exit Criteria	Approval of FINAL DRAFT conceptual model by authoritative stakeholder(s).

Annex I – CONCEPTUAL MODEL EXAMPLES

This document deliberately presented guidance, as opposed to specification, to conceptual modeling to capture the essential best-practices while remaining tailorable to a broad range of enterprise contexts. In this line, this annex presents examples to illustrate the various Process Activities and Products.

The objective of this annex is to guide the reader in the implementation of a conceptual modeling process and conceptual model products in its own enterprise context while avoiding restricting it to standard templates. The examples are intended to clarify the most abstract parts of the guidance, to bring out the range of applicability and to expose important issues.

For conciseness and time constraints, no thorough end-to-end example is included and trivial parts have been omitted. The examples have been selected amongst a number of current enterprise practices. The domain covered by the examples must not be taken as a limitation to the scope of applicability of the guidance.

Example I-1 differentiates between conceptual model space, mission space and simulation space requirements and demonstrates how to derive knowledge needs from requirements. Example I-2 presents a method to: gather, structure and document knowledge; generate domain ontology; and, use this knowledge to design and build conceptual model artefacts. Example I-3 differentiates the representation of mission-space knowledge, simulation-space knowledge and the conceptual model of a simulation. Example I-4 presents sample conceptual model artefacts based on a community-specific conceptual model design. Finally, Example I-5 illustrates the iterative evolution of a conceptual model requirements, design and artefacts.

I.1 DEFINING CONCEPTUAL MODEL REQUIREMENTS AND DERIVING KNOWLEDGE NEEDS

I.1.1 Process Activity 2.1 – Identify, Analyze and Record Conceptual Model, Mission and Simulation Space Requirements

In Process Activity 2.1, the conceptual model requirements are identified, analyzed and recorded. It is suggested to address the conceptual model requirement definition in terms of conceptual model space, mission space and simulation space requirements. The objective of this example is to differentiate between conceptual model space, mission space and simulation space requirements and to demonstrate what is inclusive in the conceptual modeling process. This example was developed by the MSG-058 Task Group in testing several requirements against the three-space classification. Although very partial, the artefact in Table I-1 is an example of Product 2.1 – Conceptual Model Requirement Specification. The conceptual model requirement classification may be arbitrary and is not error proof. The key point is to be all inclusive when capturing conceptual model requirements.

Table I-1: Examples of Conceptual Model Requirements Categorized in Terms of Conceptual Model Space, Mission Space and Simulation Space.

Conceptual Model Space **Conceptual Model** requires…	**Mission Space** **Conceptual Model** requires…	**Simulation Space** **Conceptual Model** requires…
To have views adapted to each stakeholder	*To represent a battalion*	*To represent a decision-maker training simulation*
To be useful for interoperability within NATO	*To represent the command and control system*	*To represent the live usage of a decision support tool*
To be readable by a computer	*To represent a peace keeping mission*	*To represent fair fight*
To be readable in French	*To represent insurgents*	*To represent an HLA simulation*

I.1.2 Process Activity 2.4 – Derive Mission Space and Simulation Space Knowledge Needs

In Process Activity 2.4, the mission space and simulation space knowledge needs are derived. The objective of this example is to demonstrate how to derive knowledge needs from requirements. Table I-2 presents knowledge needs derived from a few requirements of Table I-1. Although very partial, the artefact in Table I-2 is an example of Product 2.2 – Conceptual Model Knowledge Acquisition Needs. Deriving knowledge needs requires experience and it is more easily done iteratively. The outcome can turn out to be arbitrary, thus a special effort must be made to avoid preconceived ideas to produce an objective knowledge need statement.

Table I-2: Examples of Conceptual Model Knowledge Needs Derived from Some of the Sample Conceptual Model Requirements of Table I-1.

Space	**Conceptual Model Requirements**	**Conceptual Model Knowledge Needs**
Simulation Space + *Mission Space*	• *To represent a battalion* • *To represent the live usage of a decision support tool*	• *Need knowledge on battalion composition, humans, equipments, etc., at the level of detail supported by the decision tool and at the level of fidelity detectable by the tool* • *Need knowledge from a tank driver, from a physicist, etc.*
Simulation	• *To represent the live usage of a decision support tool*	• *Need knowledge in the decision support tool inputs* • *Need the minimum detectable thresholds for each input*
Simulation	• *To represent an HLA simulation*	• *Need knowledge on the HLA concepts: classes, interactions, time management, data management, etc.*
Simulation	• *To represent a decision-maker training simulation*	• *Need knowledge on the human interface* • *Need knowledge on the evaluation metrics*

I.2 FROM KNOWLEDGE ACQUISITION TO KNOWLEDGE USE IN A CONCEPTUAL MODEL

This example is taken from the Swedish Defence Conceptual Modeling Framework (DCMF) Project [1]. The DCMF process could be an implementation of the proposed conceptual modeling guidance. It is divided in four main phases: knowledge acquisition, knowledge representation, knowledge modeling and knowledge use.

The example is written as straight forward steps to introduce sample product artefacts although, in reality, the knowledge acquisition and the conceptual model construction have been done iteratively. The proposed conceptual modelling guidance does not prevent to produce conceptual model artefacts to represent the knowledge as it is acquired to help acquiring more knowledge. In fact, it is rather advised to do so. This is part of the modeling art.

This example presents the conceptual model of a scenario, as opposed to the conceptual model of a system. The sample scenario is taking place in Kosovo and its surroundings, in May 2002. NATO forces are conducting a Peace Support Operation in order to regain stability and security in Kosovo. A Swedish patrol (KS05) from the Swedish peace keeping force discovers a looted weapons depot and report this into the information system of the Swedish Intelligence. An intelligence officer in Sweden receives the report and starts a further investigation. Information from different sources leads to the estimate that the missing weapons might be smuggled to Sweden by organized criminals. Cooperation between different military and civil organizations to acquire information leads to the confiscation of the weapons in the harbor of Gothenburg in Sweden.

I.2.1 Process Activity 3.4 – Gather, Structure and Document Knowledge

Process Activity 3.4 consists in gathering, structuring and documenting knowledge to ultimately produce a conceptual model. The objective of this example is to illustrate a method for performing Process Activity 3.4.

In this example, knowledge acquisition was performed using video clippings and in-depth interviews carried out with subject-matter experts for further clarification and enrichment of the scenario description. It resulted in a description of the scenario in natural language, for which an excerpt corresponding to paragraph 1 is presented in Table I-3.

Table I-3: Sample Scenario Description in Natural Language (Paragraph 1).

A Swedish patrol from a battalion in Kosovo finds weapons in the forest near a village called Janjevo. The finding is reported in the battalion's intelligence report and this is transferred in code to Stockholm. The information about the finding is received by the Intelligence Division at MUST and the report is registered in the System. The information about the found weapons is made available for the department of international intelligence (MUST IntUnd).

Then, implicit and explicit knowledge was represented from the natural language description. Table I-4 presents some implicit knowledge inferred from paragraph 1 of the scenario description in natural language.

Table I-4: Sample Implicit Knowledge Inferred from the Scenario Description.

- *There is a Peace Support Operation in Kosovo sometime in MAY 2002, of which the Swedish contingent is a part of. (Inferred from background context material).*
- *Janjevo is a geographical location in Kosovo.*
- *There is a forest near Janjevo.*
- *Swedish troops go on regular patrol missions.*
- *There is a procedure (military) to be followed by any military PATROL if they are on a patrolling mission. It also implies that there would be standard operating procedures and regulations governing this process of patrolling.*
- *'Swedish' implies that Sweden is a sovereign nation, and that it has military capability, and is part of the UN Peace Support Operations.*
- *Weapons are hidden, that is, they are obscured from normal sight and they are not left for public viewing.*

Explicit knowledge can be extracted using different methods. Table I-5 presents the results of the Five Ws method applied on paragraph 1 of the scenario description in natural language.

Table I-5: Sample Explicit Knowledge Extracted from the Scenario Description Using the Five Ws Method.

Who	Patrol from Swedish contingent KS05	Patrol: Military type Organization (under govt. type object-type: Unit-Type: has Affiliation object type relation to Swedish Contingent: Object-Item-Group Swedish: Affiliation
What	Patrolling	Patrolling: Action-task purpose: WHY AOI: Location
When	From 1st May to 31st May 2002	
Why	To secure AOI	
Where	AOI somewhere in Kosovo	AOI: Specification detail AOI is both a Location as well as a CONTROL FEATURE: may even be a sub-type of control – feature like ROUTE, etc.

Table I-6 presents the results of the Knowledge Meta Meta Model (KM3) methodology [1] applied on paragraph 1 of the scenario description in natural language.

Table I-6: Sample Explicit Knowledge Extracted from the Scenario Description Using the KM3 Method.

Entity Type :: Swedish patrol
Entity Type :: Contingent in Kosovo
ElementComposition : <Swedish patrol , Contingent in Kosovo>
Entity Type :: Weapons
Entity Type :: Forest
Attribute : Close to ET:Janjevo, in kilometers
    CompositionType : RangedAttribute
    Domain : Distance
    StartValue : 0
    StopValue : 10
Entity Type :: Janjevo
Attribute : Village in Kosovo
    CompositionType : RangedAttribute
    Domain : Inhabitants
    StartValue : 100
    StopValue : 1000
Action Type :: Finds
Time : May 2002
RoleInAction : <finder, patrol>
RoleInOrganisationType : <patrol, ET: Swedish patrol>
Criterion :: SF: (prob 1, isStartCriterion t,
[Swedish patrol : onPatrol AND Forest AND Weapons])
State: found weapons
ActivityState : Finding weapons (has occurred) /* activity Finds has occurred */

Entity Type : Swedish patrol
    State: alerted AND onPatrol
Entity Type :: Weapons
    State: found

I.2.2 Process Activity 3.5 – Generate/Extend a Domain Ontology

In Process Activity 3.5, the knowledge captured in previous activities is formalized semantically as domain ontology. The objective of this example is to illustrate how to generate domain ontology. This example uses the knowledge of example I-2.1 to translate it in domain ontology.

The knowledge was modeled through a semantic mapping of the semi-structured information. The implicit knowledge was merged with the explicit knowledge in a machine readable format, namely in the DCMF ontology developed using the Web Ontology Language (OWL) [2]. Table I-7 lists some of the concept (class) types that were instantiated to model the sample scenario paragraph.

Table I-7: Sample Ontology Classes Instantiated to Document the Scenario.

- *Action-Task*
- *Action-Task-Status*
- *Action-Objective-Type (securing area of interest)*
- *Action-Required-Capability (for patrol mission) related to*
- *Action-Event-Status: (through this it is associated to action-event. Finding weapons in a particular action-task: patrolling.)*
- *Reporting-data*
- *Action-Event*
- *Object-Item-Group-Account: (the composition or relation of object types involved in the patrolling action.)*
- *Capability: sub type: Mission-Capability: (specifies required parameters for carrying out a patrol.)*
- *Affiliation*
- *Context*
- *Location*
- *Control Feature*
- *Action-Temporal-Association: time events, sequences and info for placing the action tasks and events in temporal sequence*
- *Object-Type:Equipment-Type:Non-Consummable-Equipment-Type:Weapons*

Table I-8 presents an excerpt of the OWL code format for the Patrol Mission instance of the Action-Required-Capability concept from the sample scenario paragraph. The artefact in Table I-8 is an example of Product 3.1 – Validated Knowledge.

Table I-8: Sample OWL Code for the Patrol Mission Instance of the Action-Required-Capability Class Capturing the Scenario Knowledge.

```
<Action-Required-Capability rdf:ID="patrolreqdqty">
 <quantifies>
 <Mission-capability rdf:ID="patrolmission">
 <capability-id rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
 >CMmscapability2</capability-id>
 <capability-unit-of-measure-code rdf:datatype= "http://www.w3.org/2001/XMLSchema#string"
 >square-metres-per-hour</capability-unit-of-measure-code>
 <is-quantified-in rdf:resource="#patrolreqdqty"/>
 <capability-subcategory-code rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
 >maximum-Range</capability-subcategory-code>
 <capability-category-code rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
 >military-load-capability</capability-category-code>
 <capability-day-night-code rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
 >day-and-night</capability-day-night-code>
 </Mission-capability>
 </quantifies>
 <capability-id rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
 >CMmscapabilityid1</capability-id>
 <is-minimum-required-for rdf:resource="#actioneventstatus1"/>
 <action-required-capability-quantity rdf:datatype=

 "http://www.w3.org/2001/XMLSchema#int">15</action-required-capability-quantity>
 <action-id rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
 >patrol_reqd_qty</action-id>

</Action-Required-Capability>
```

Figure I-1 illustrates how the Patrol Mission instance is represented in the Protégé ontology editor [3]. In this example, the capability categories have been imported from the Joint C3 Information Exchange Data Model (JC3IEDM) [4], which is an illustration of knowledge reused following Process Activity 3.2.

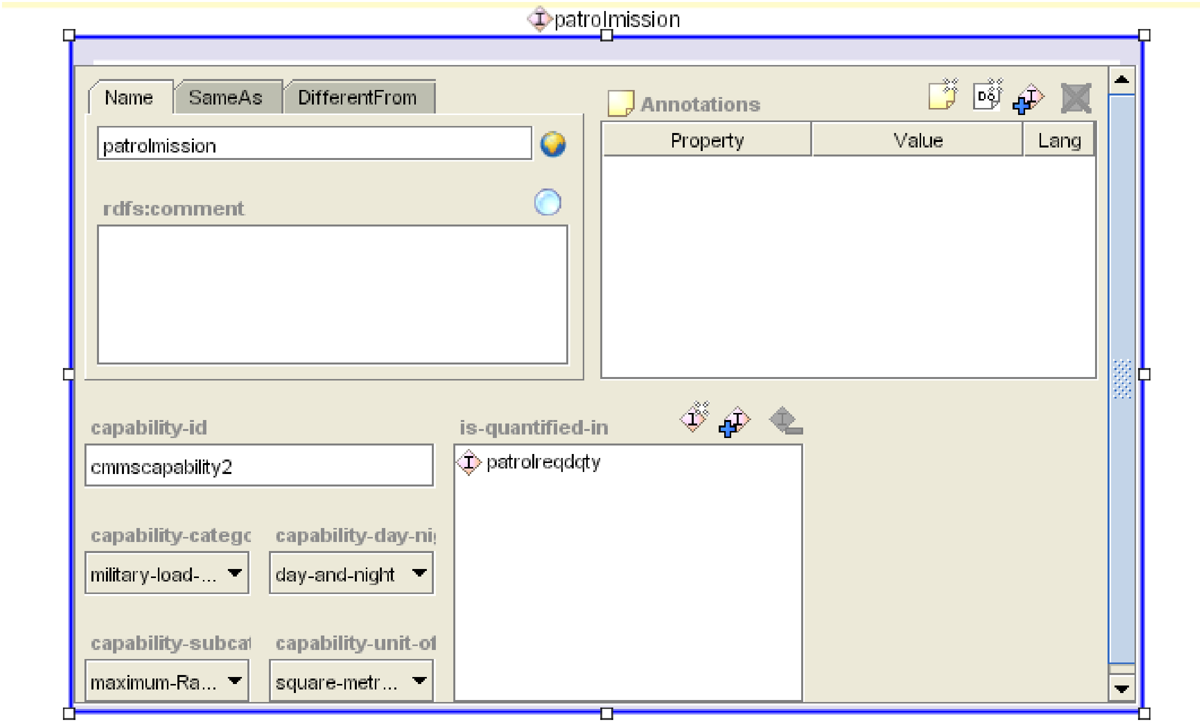


Figure I-1: Sample Scenario Knowledge (Patrol Mission Object) in the Protégé Ontology Editor.

I.2.3 Process Phase 4 – Design Conceptual Model

A conceptual model is used to contain and represent the knowledge in a construct that will fit the type of knowledge acquired during Process Phase 3 and that will allow to make use of that knowledge. In Process Phase 4, the conceptual model design is driven by the intended purpose captured in Product 2.1 – Conceptual Model Requirement Specification. The objective of this example is to illustrate a few design options to fit different usages of the conceptual model. The artefact in Table I-9 is an example of Product 4.1 – Conceptual Model Design.

Table I-9: Conceptual Model Design for the Scenario Description Example.

Component	Design	Build
Conceptual Primitives	*Pool*	*Swedish Contingent, MUST*
	Activity	*Patrol Mission, File Area Clear Report, etc.*
	Event	*Send Search, Interrogate Order/Request*
	Gateway	*Area Secure, Analyze Results*
	Actor	*Intel Officer, Depot Personnel*
	Use Case	*Report File to MUST, Check Information System*
Model Kinds	*Collaboration process diagram, composed of 2 Abstract process diagrams*	
	Use Case	
Views	*Simplest human understandable high-level description of the scenario*	*See Figure I-1*
	Collaboration between organizations	*See Figure I-3*
	Comparison of a scenario procedure to a recommended procedure	*See Figure I-4*
Formalisms	*BPMN*	
	Use Case	
Notations	*BPMN*	
	Custom Pictogram	

Process Activity 4.1 suggests that the conceptual model design may be influenced by the design of another conceptual model being reused. In this example, no existing conceptual model was reused and no constraint of that sort was imposed on the design.

In Process Activity 4.2, conceptual primitives fit for the type of knowledge are selected. The current example involves the conceptual model of a military scenario. Therefore, appropriate conceptual primitives are actors, activities, events, etc. Eligible model kinds that represent interactions between scenario elements include collaboration, activity, sequence, and use case diagrams.

Different formalisms allow representing these combinations of conceptual primitives and model kinds: Petri Nets, ontology, use case, BPMN, etc. In Process Activity 4.3, the formalism choice is influenced by the conceptual model requirement specification. In this example, the conceptual model was intended for visualisation purpose for communication with the subject-matter experts and for process optimization or conformance checking by analysts. Graphical expressiveness was a key driver to present information to participants while robust inference for system interoperability was not an intended use of the conceptual model. The use case formalism was selected for its simplicity (only actors and use cases). BPMN [5] was privileged over Petri Nets and ontology.

The targeted stakeholders and intended purpose drive the selection of views during Process Activity 4.4. Custom views can be created from the generic conceptual model content. For example, a simple high-level description of the scenario is created for communication with the subject-matter experts. An organisational collaboration view and a procedure comparison view are appropriate to the work of the process analysts. In addition to these process views, others views could have useful to other usages, for example component or deployment views to model the communications between information systems.

In Process Activity 4.5, a notation is selected to implement the chosen formalism. BPMN is a formalism that comes with its own notation, a frequent practice in the modeling domain. The BPMN notation was chosen over the UML notation because of its graphical expressiveness, a driving requirement in this example. BPMN supports a few model kinds and their conceptual primitives (Pool, Activity, Event, Gateway). The same Collaboration Process Diagram model kind is used to produce two different views. For the same reason, a custom pictogram notation was selected over the UML notation to express the use case formalism.

Finally, as advised in Process Activity 4.6, the conceptual model conformance to the requirements should be verified. Formal metrics could be derived to measure how fit is the conceptual model for the specific purposes. In this example illustrated in Table I-9, only the overall stakeholders' work efficiency proved the conceptual model usefulness.

I.2.4 Process Phase 5 – Build Conceptual Model

In Process Phase 5, the validated knowledge produced (Product 3.1) is used to populate the content (conceptual primitives) of the conceptual model. The objective of this example is to illustrate the different views generated from the conceptual model based on the knowledge of example I-2.2 and the design choices (formalism, notation, model kinds) summarized in Table I-9.

Figure I-2 presents the simplest human understandable high-level description of the scenario using a custom pictogram notation to express the use case formalism. Figure I-3 shows the collaboration between organizations and Figure I-4 compares the organizational procedures, both using collaboration process diagrams from BPMN.

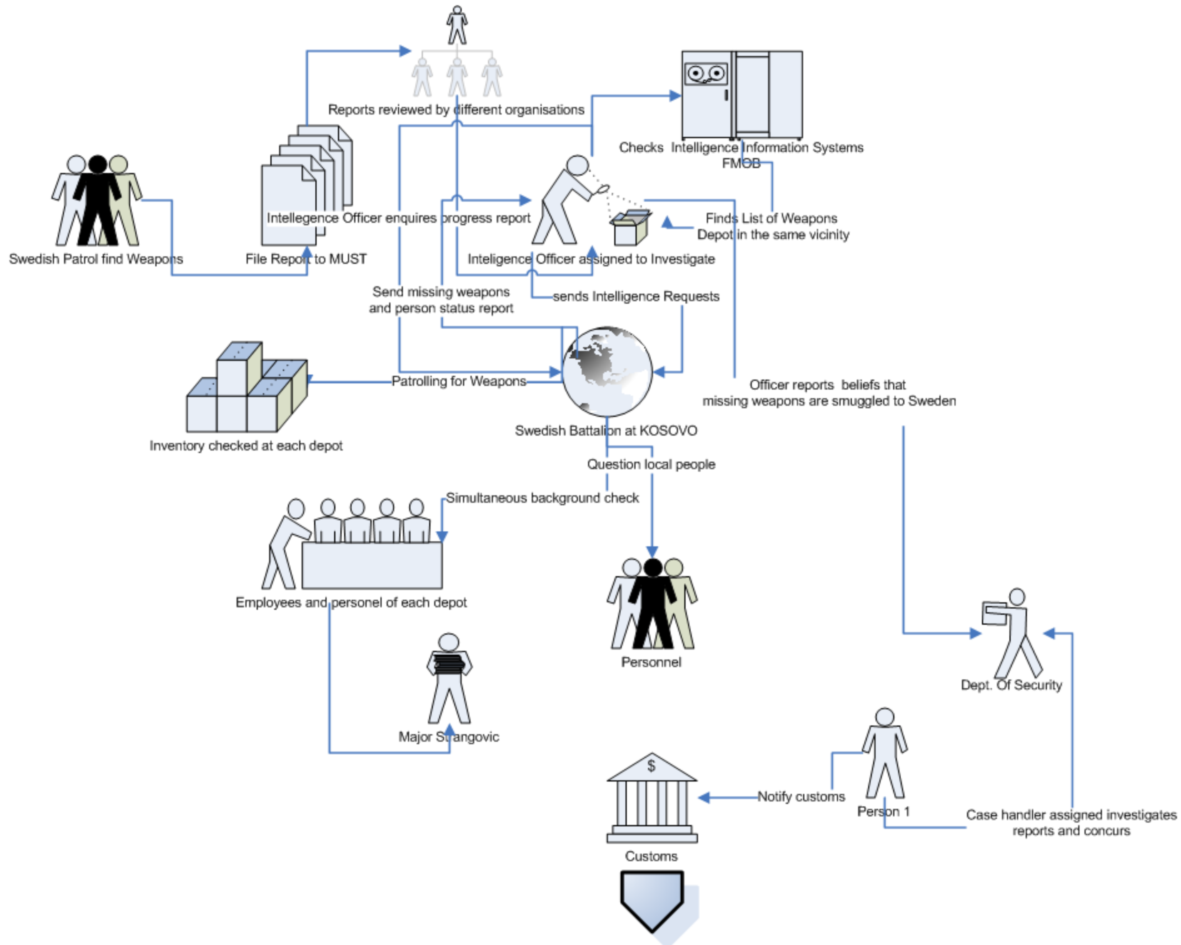


Figure I-2: Sample View of the Conceptual Model of the Scenario Allowing to Visualize the Simplest Human Understandable High-Level Description of the Scenario.

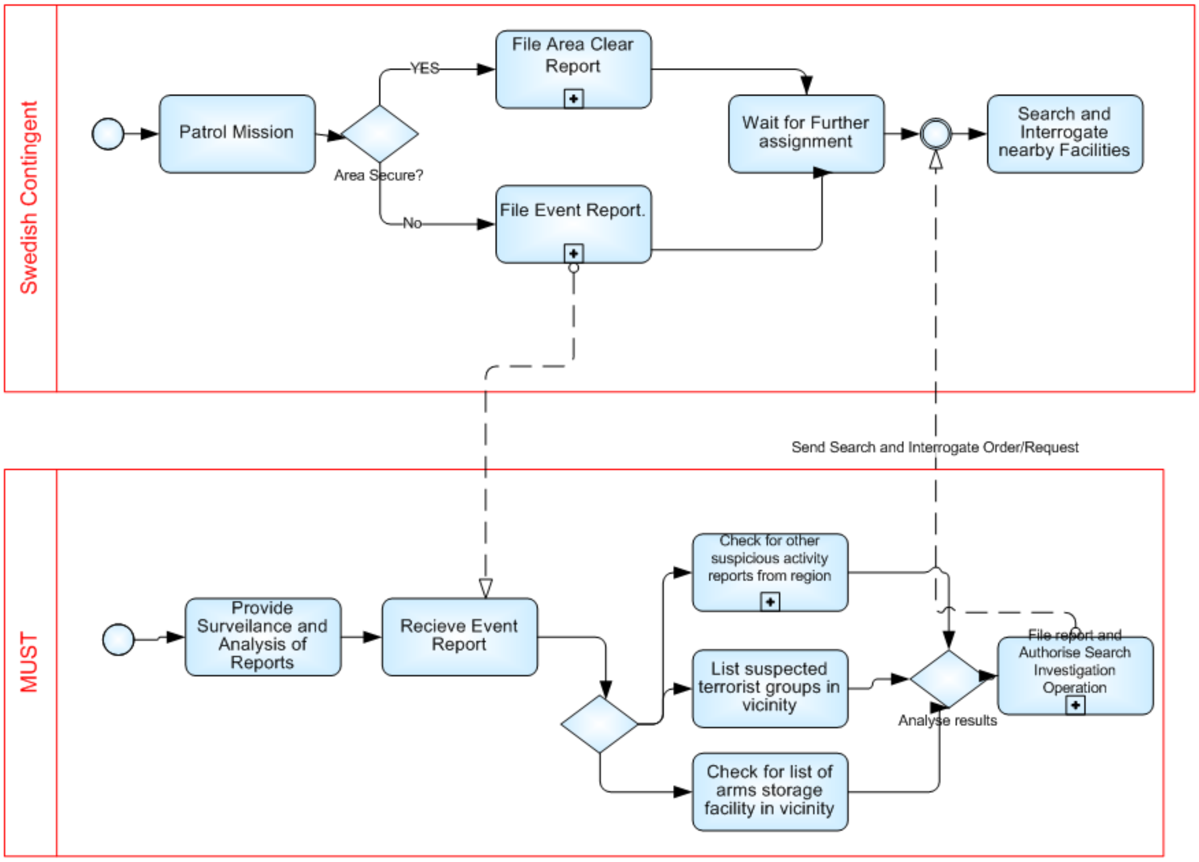


Figure I-3: Sample View of the Conceptual Model of the Scenario Allowing Visualizing the Collaboration Between Organizations.

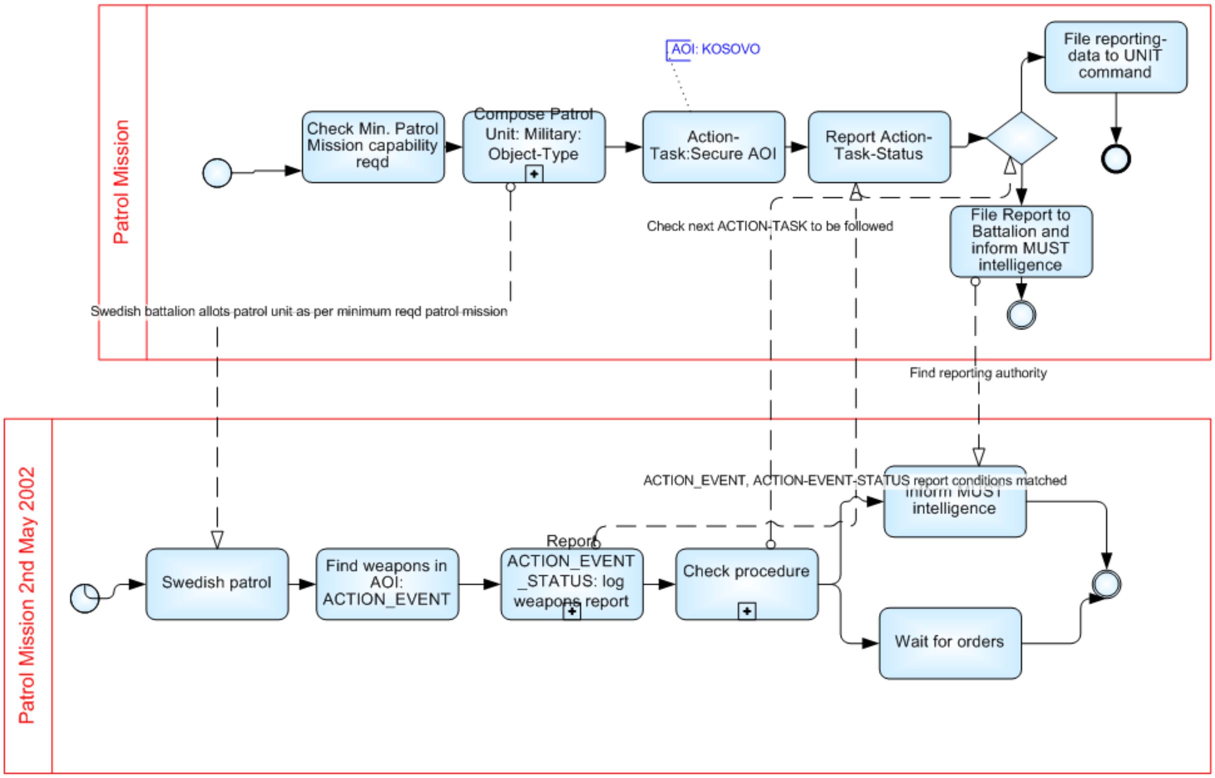


Figure I-4: Sample View of the Conceptual Model of the Scenario Allowing to Compare Procedures.

The artefacts in Figure I-2 to Figure I-4, all together, are an example of Product 5.1 – Conceptual Model.

I.3 RELATION BETWEEN KNOWLEDGE REPRESENTATION AND A CONCEPTUAL MODEL

The proposed conceptual modeling guidance does separate the knowledge documentation in Process Phase 3 from the conceptual model of a simulation in Process Phases 4 and 5. In reality, similar documentation techniques may be used for both. The objective of this example is to differentiate the representation of mission-space knowledge, simulation-space knowledge and the conceptual model of a simulation.

This example is taken from the Canadian IMAGE Project [6]. It presents the conceptual model of a military mission to be simulated. The mission is a humanitarian operation to reconstruct a school in a rugged region akin to Afghanistan. It involves convoys subjected to IEDs and evolving within a dynamical social terrain. Blue friendly forces and red insurgents compete for recruiting the allegiance of the general population. The convoys utilize different roads or tracks over time, some with limiting conditions related to the 3D ruggedness of the terrain. Mine attacks occur with a probability that depends of the type of physical and social grounds being travelled and type of carriers used.

I.3.1 Process Activity 3.4 – Gather, Structure and Document Knowledge

In Figure I-5, the mission-space knowledge is structured and document using conceptual graphs [7] in the CoGUI tool [8]. In Figure I-6, the simulation-space knowledge is represented using a hierarchy of the simulation framework concepts, in this case, a custom Canadian simulation framework.

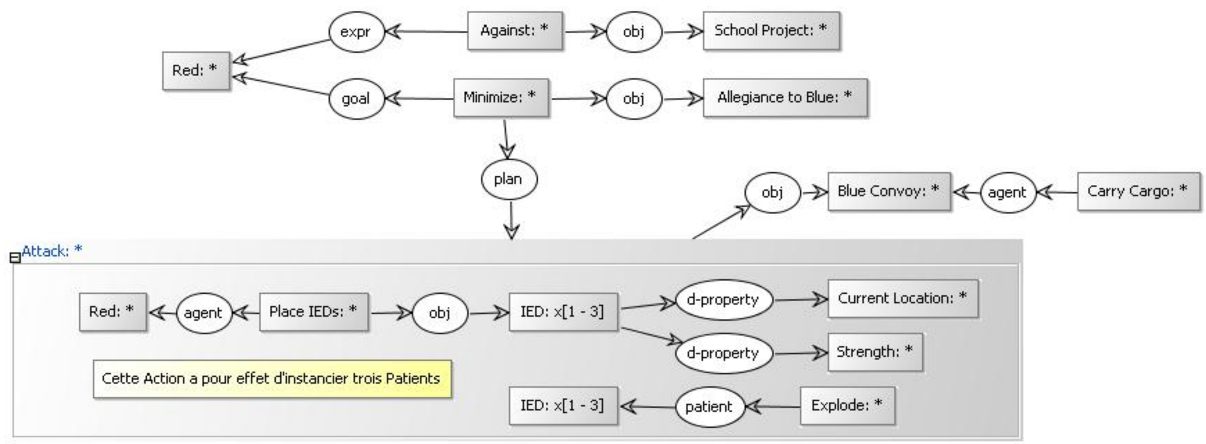


Figure I-5: Sample Mission-Space Knowledge Documentation.

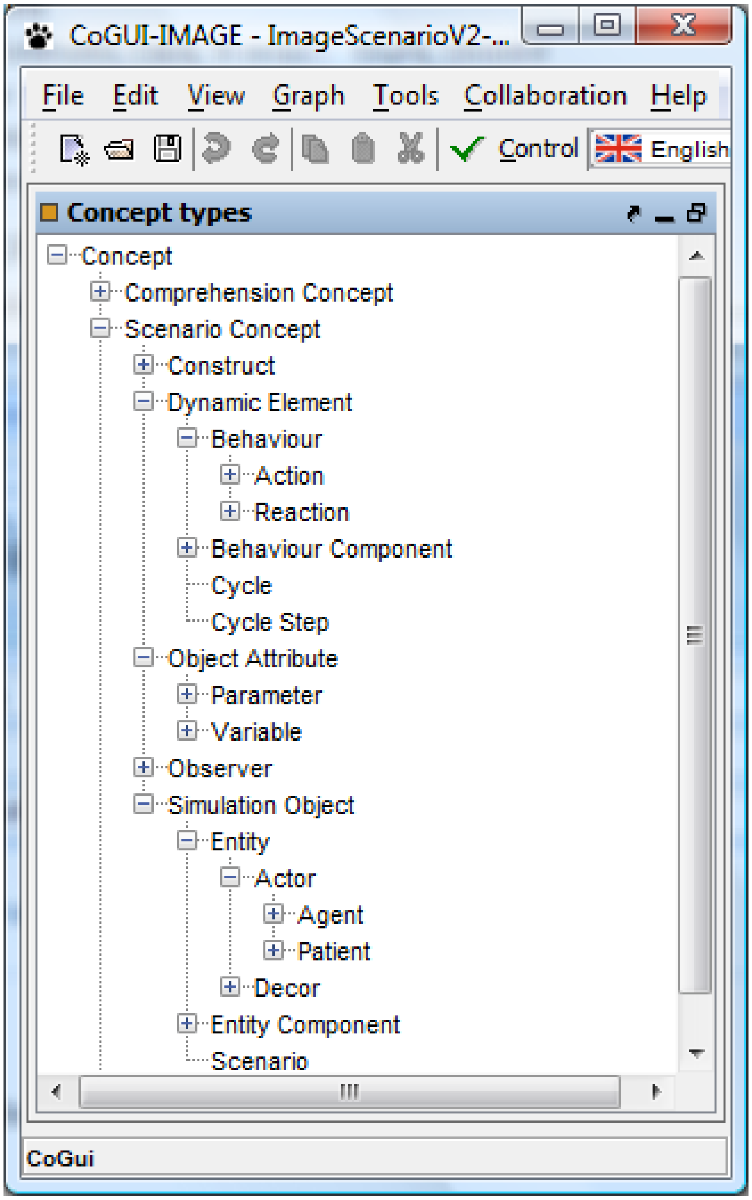


Figure I-6: Sample Simulation-Space Knowledge Documentation.

I.3.2 Process Phase 4 – Design Conceptual Model

In this example, the conceptual graph formalism was pre-selected as an arbitrary choice of the project Group. The conceptual model design components were derived from the formalism. Table I-10 summarizes the conceptual model design components for the conceptual model views of Figure I-5, Figure I-6 and Figure I-7. The artefact in Table I-10 is an example of Product 4.1 – Conceptual Model Design.

Table I-10: Sample Conceptual Model Design for IMAGE.

Component	Design	Build
Conceptual Primitives	*Concept*	*Blue Convoy, Red, IED, etc.*
	Relation	*Agent, Object, Plan, etc.*
	Context	*Attack, Concept Group*
Model Kinds	*Conceptual Graphs*	
Views	*Mission Concepts Inter-Relation*	*See Figure I-5*
	Simulation Concepts Hierarchy	*See Figure I-6*
	Simulation Specification for the Mission	*See Figure I-7*
Formalisms	*Conceptual Graphs*	
Notations	*Conceptual Graphs*	

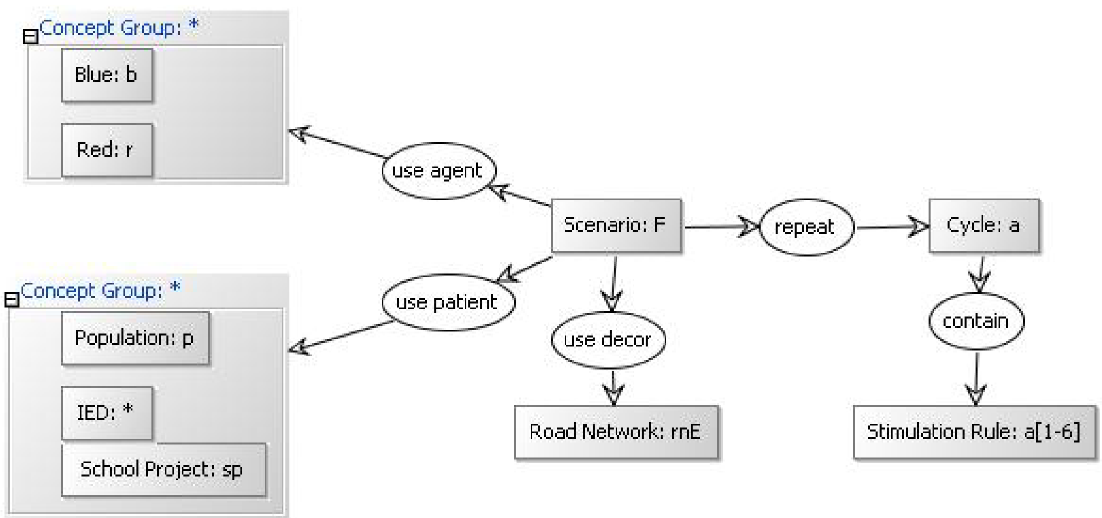


Figure I-7: Sample View from the Conceptual Model of a Simulation.

I.3.3 Process Phase 5 – Build Conceptual Model

Figure I-7 is a conceptual model view illustrating how the scenario concepts are mapped to simulation concepts to describe the specification for the simulation. For example, the Blue and Red concepts become simulation Agents; the Population, IED and School Project become simulation Patients; the Road Network becomes a Decor; and, a simulation Scenario uses the defined Agents, Patients and Decor. Table I-10 includes a mapping of the conceptual primitives and model kinds populated in the conceptual model.

The knowledge representations in Figure I-5 and Figure I-6 can be seen as other views of the conceptual model. This example is representative of the reality where the conceptual model of a simulation often relies on conceptual models of the mission space and the simulation space.

I.4 COMMUNITY-SPECIFIC CONCEPTUAL MODEL DESIGN AND ARTEFACTS

The conceptual modelers have access to a variety of design options. The conceptual model design components being strongly interrelated, one design choice usually imposes constraints on the remaining component options. This explains why different communities have created conceptual model design combinations tailored to their specific domains. The objective of this example is to present sample conceptual model artefacts based on a community-specific conceptual model design.

This example is taken from the United States OneSAF Project [10]. OneSAF Objective System (OOS) is a composable Computer Generated Forces (CGF) simulation framework.

I.4.1 Process Phase 4 – Design Conceptual Model

The OneSAF Group has developed its own conceptual modeling formalism, called CML [11], adapted to model simulations of the tactical military mission space. The CML formalism, notation and conceptual primitives are illustrated in Figure I-8. CML uses a color-coded notation. Table I-11 presents the CML design components.

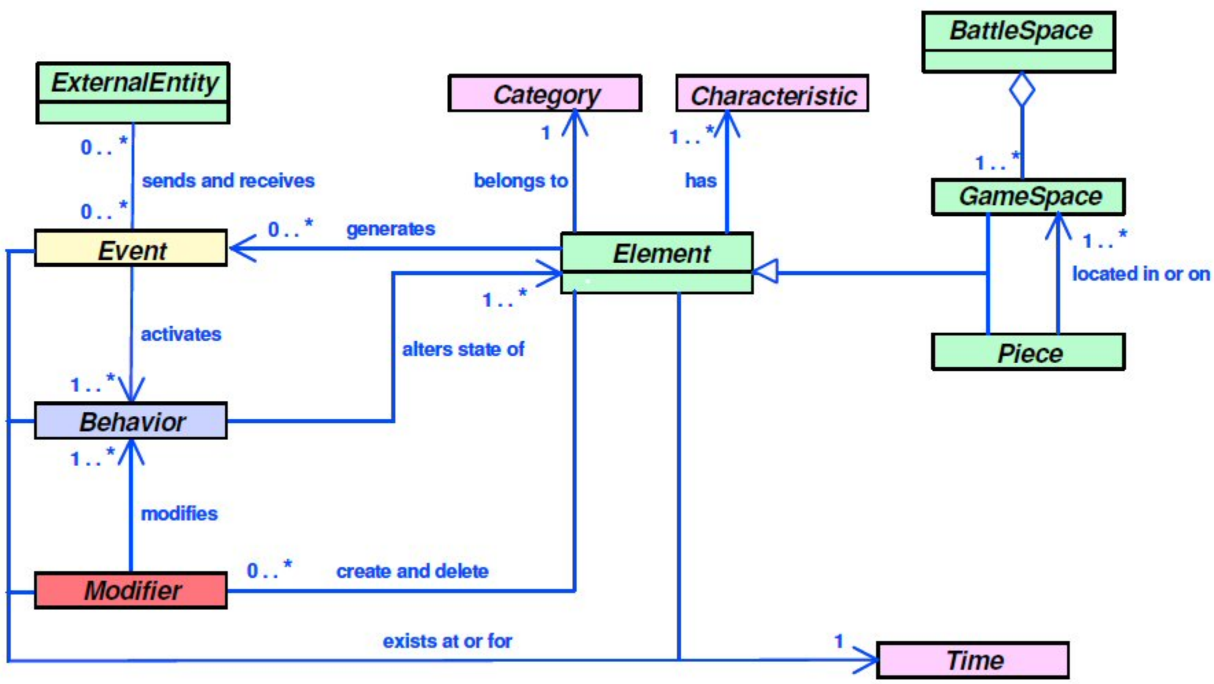


Figure I-8: The CML Formalism, Notation and Conceptual Primitives.

Table I-11: Conceptual Model Design for OneSAF.

Component	Design	Build
Conceptual Primitives	*Element*	*Chassis, Articulation, Weapon, Sensor, Movement Adjudicator*
	Event	*Activate Steering, Fire Command*
	Behavior	*Steering Behavior, Maintain SA, FDC Execute Fire Missions*
	Characteristic	*Movement Freedom, Rotational Freedom*
Model Kinds	*Conceptual Model Language*	
Views	*Entity*	*Entity Composition (see Figure I-9)*
	Common	*Unit Movement Control (see Figure I-10)*
	Battlefield Operating System	*Tactical Fire Direction Center (see Figure I-11)*
Formalisms	*CML*	
Notations	*CML*	

I.4.2 Process Phase 5 – Build Conceptual Model

The OneSAF conceptual model was built according to the CML design. The column “Build” of Table I-11 above includes a few examples of how the components have been populated. Figure I-9 presents a sample Entity view for the Entity Composition. Figure I-10 shows a sample Common view representing the Unit Movement Control. Figure I-11 is an example of a Battlefield Operating System view for the Tactical Fire Direction Center. These artefacts, all together, are part of Product 5.1 – Conceptual Model.

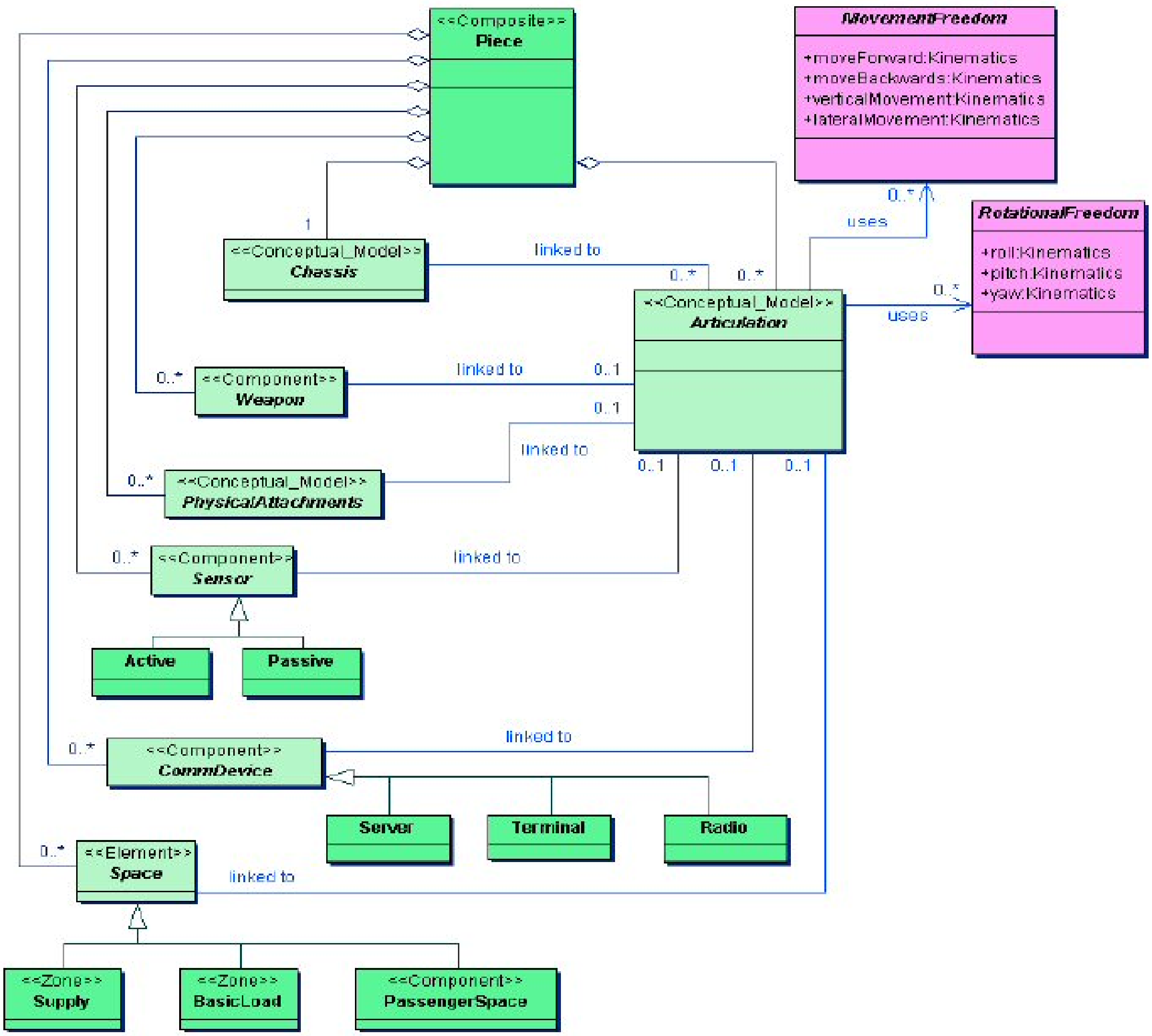


Figure I-9: Sample View from the OneSAF Conceptual Model Representing Entity Composition.

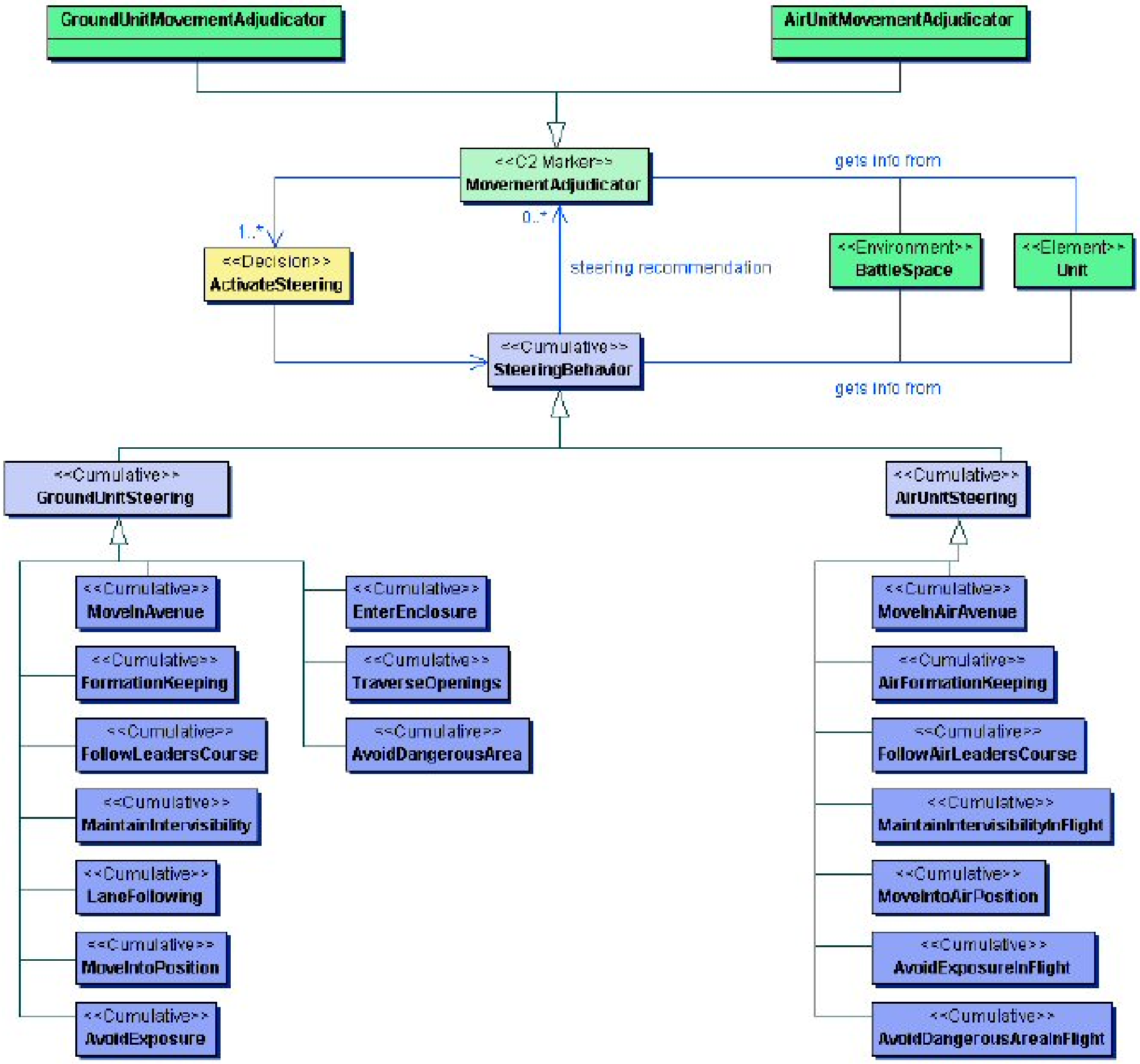


Figure I-10: Sample View from the OneSAF Conceptual Model Representing Unit Movement Control.

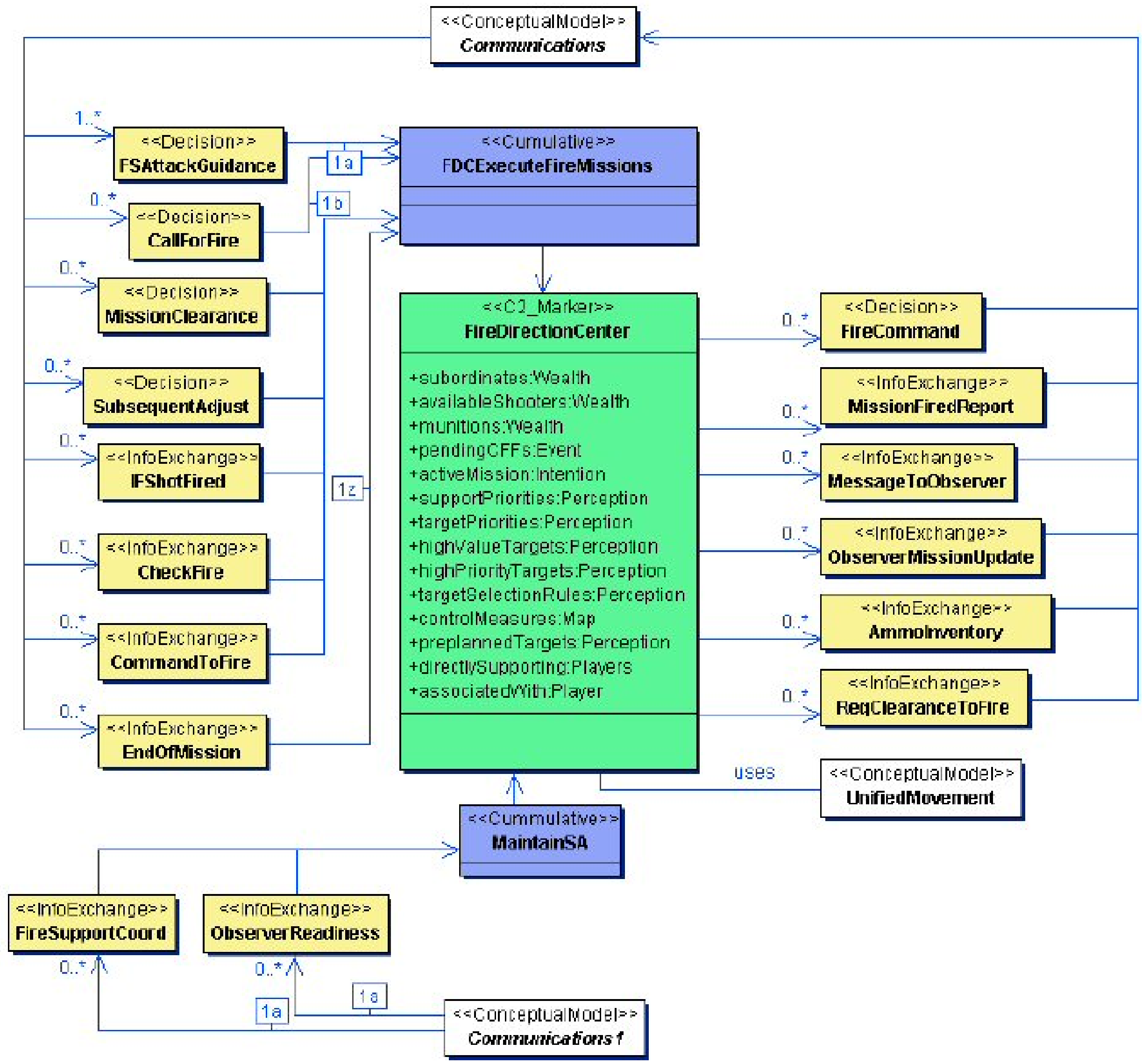


Figure I-11: Sample View from the OneSAF Conceptual Model Representing Tactical Fire Direction Center.

I.5 ITERATIVE EVOLUTION OF CONCEPTUAL MODEL REQUIREMENTS, DESIGN AND ARTEFACTS

Producing preliminary conceptual model artefacts contributes to the learning process and helps refining the conceptual model requirements. The conceptual model design evolves accordingly over several iterations. The objective of this example is to presents the iterative evolution of conceptual model requirements (Process Activity 2.1), design (Process Phase 4) and artefacts (Process Phase 5). New requirements are challenging the conceptual model design and new representation capabilities are incorporated to support the logical thinking process.

This example is taken from the Canadian KARMA Project [11]. KARMA is a simulation framework for guided-weapon engagement simulation intended to be used to develop countermeasures and to assess missile performance. The project started from a blank page, without any legacy simulation system to integrate.

The first conceptual model requirement was to allow the project manager to represent the mission space requirements. The informal view of Figure I-12 was developed using a MindMap design summarized in Table I-12.

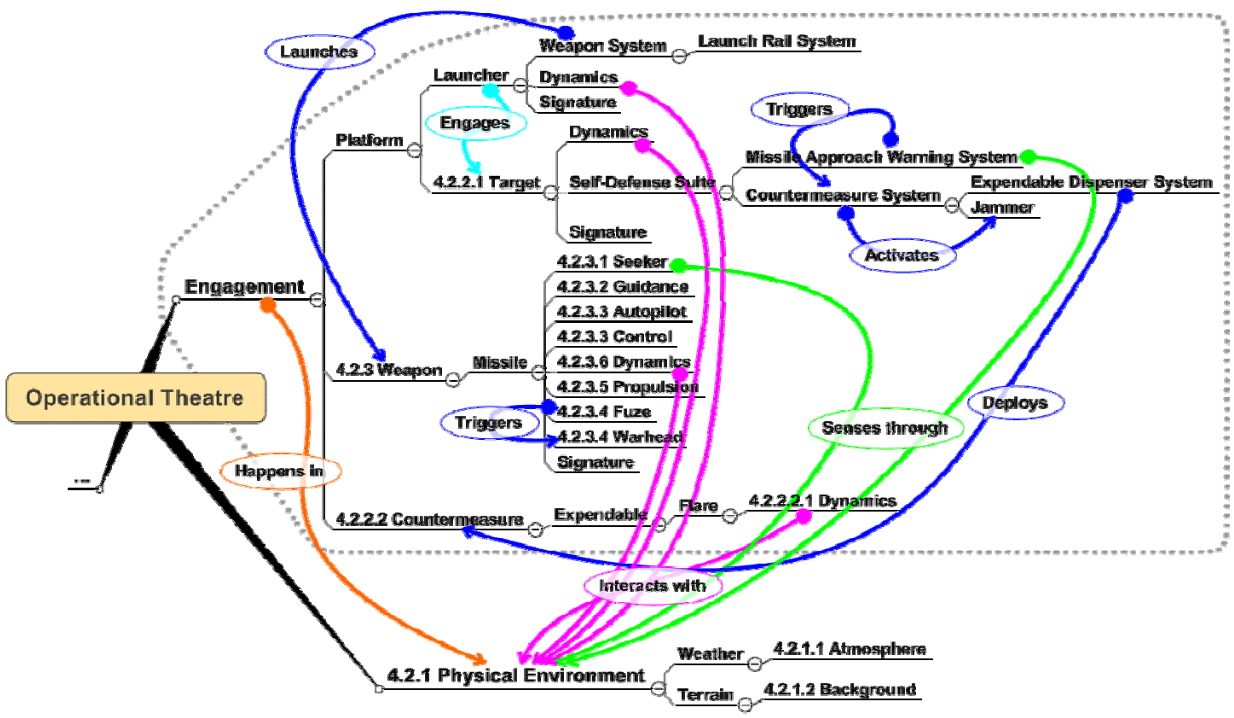


Figure I-12: Sample View of the KARMA Conceptual Model Representing the Engagement Mission Space.

Table I-12: Conceptual Model Design for KARMA Engagement Mission Space.

Component	Design	Build
Conceptual Primitives	*Entity*	*Engagement, Platform, Missile, Autopilot*
	Relationship	*Has a*
	Interaction	*Engages, Triggers, Senses*
Model Kinds	*MindMap*	
Views	*Component*	*Engagement Mission Space (see Figure I-12)*
Formalisms	*MindMap*	
Notations	*Mind Manager® MindMap*	

The second step involved the software architect and the subject-matter experts who needed a conceptual model to support the simulation architecture design. The conceptual model was used to capture the subject-matter experts' knowledge, to engineer the knowledge in order to derive key concepts and to agree on a common understanding to be used as the design reference. Figure I-13 shows the final key concepts diagram. Several iterations of that diagram were produced during working sessions before to adopt a version satisfying the reusability, interoperability and composability requirements. For example, an early version of that diagram included threat/target and red/blue concepts, which was representative of the subject-matter experts' bias. The conceptual model proved to be useful to get rid of that bias. Other views, such as the sequence view in Figure I-14 and the states view in Figure I-15, were used to complete the representation and proof the design. Table I-13 summarizes the conceptual model design components based on the UML notation.

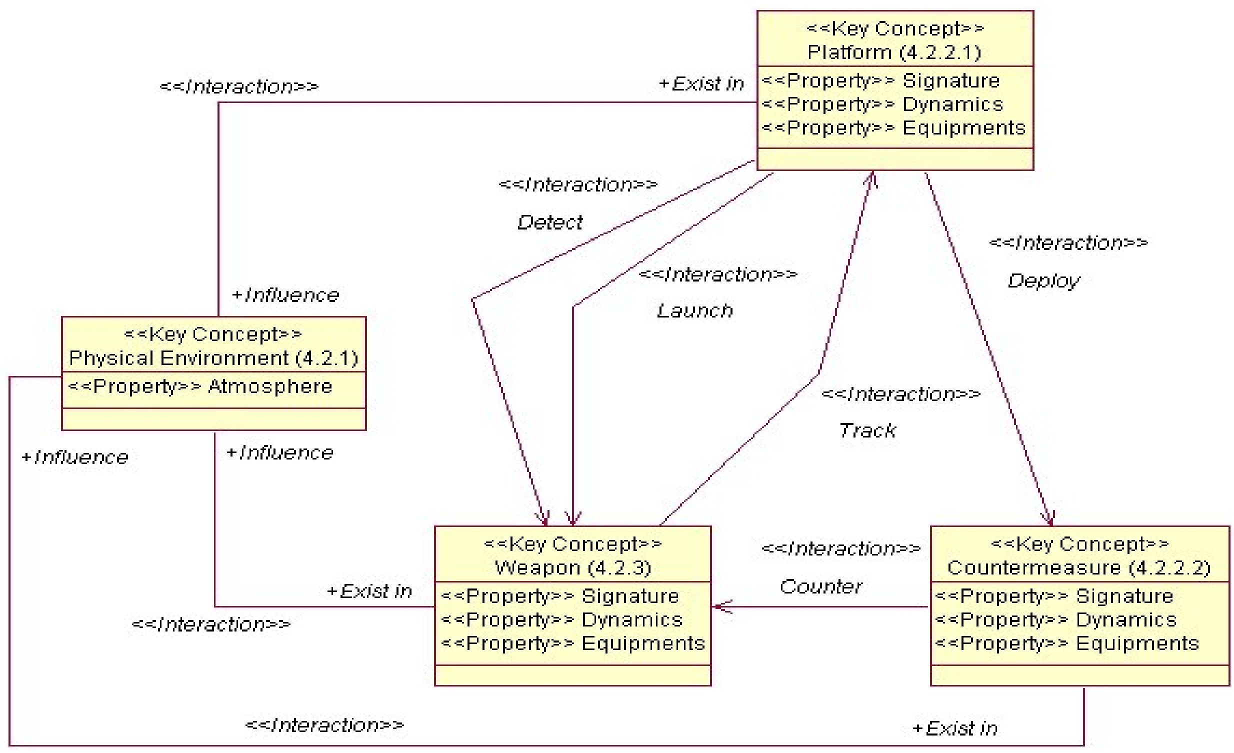


Figure I-13: Sample View of the KARMA Conceptual Model Representing the Engagement Key Concepts.

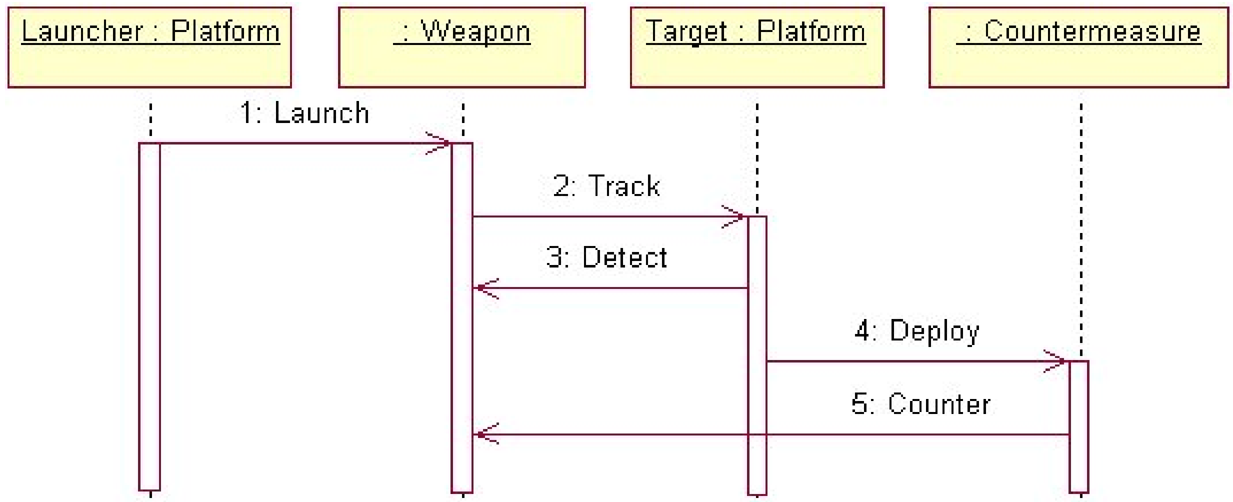


Figure I-14: Sample View of the KARMA Conceptual Model Representing an Engagement Sequence.

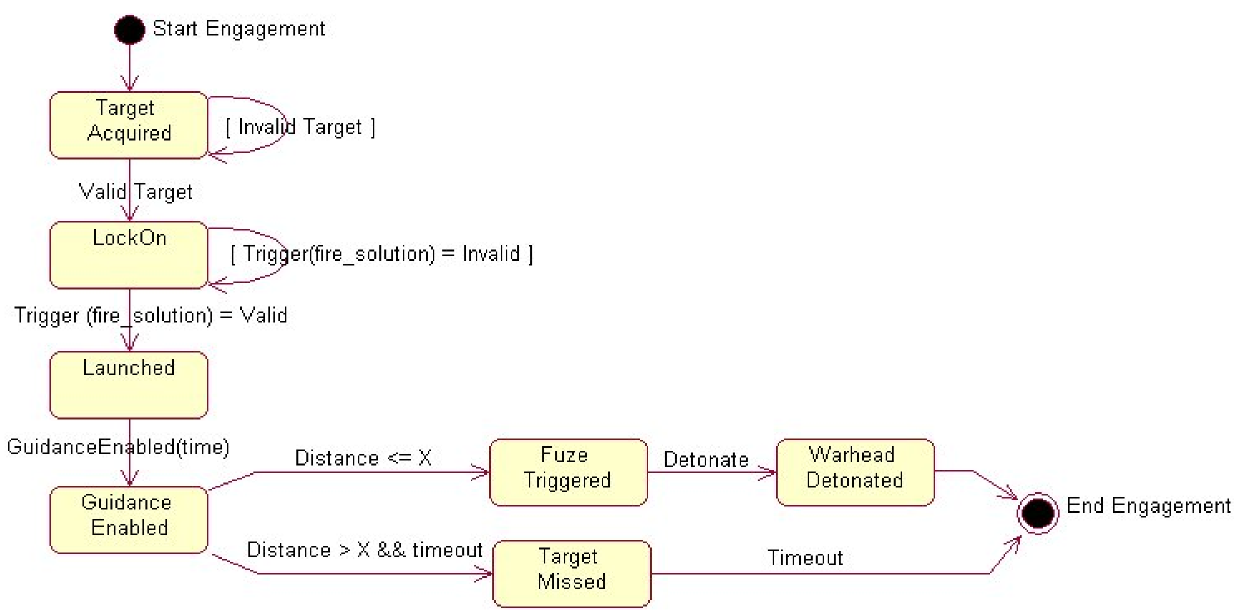


Figure I-15: Sample View of the KARMA Conceptual Model Representing an Engagement States.

Table I-13: Conceptual Model Design for KARMA Engagement Key Concepts.

Component	Design	Build
Conceptual Primitives	*Key Concept (Class)*	*Physical Environment, Platform, Weapon, Countermeasure*
	Property (Attribute)	*Signature, Dynamics, Equipments, Atmosphere*
	Interaction	*Detect, Launch, Track, Deploy, Counter, Exist In, Influence*
	Instance	*Launcher, Target*
	States	*Target Acquired, LockOn, Launched*
Model Kinds	*Class Diagram*	
	Sequence Diagram	
	State Diagram	
Views	*Logicals*	*Engagement Key Concepts (see Figure I-13)*
		Engagement Sequence (see Figure I-14)
		Engagement States (see Figure I-15)
Formalisms	*UML*	
Notations	*UML*	

The conceptual model further evolved to allow the software developers to implement the simulation architecture. The engagement concepts were expressed in the object-oriented formalism as shown in Figure I-16. Simulation space concepts, such as the scheduler and logger mechanisms, were introduced as represented in Figure I-17. Additional primitives (classes, attributes, methods, etc.) completed the model to allow the automatic generation of a C++ implementation from the model.

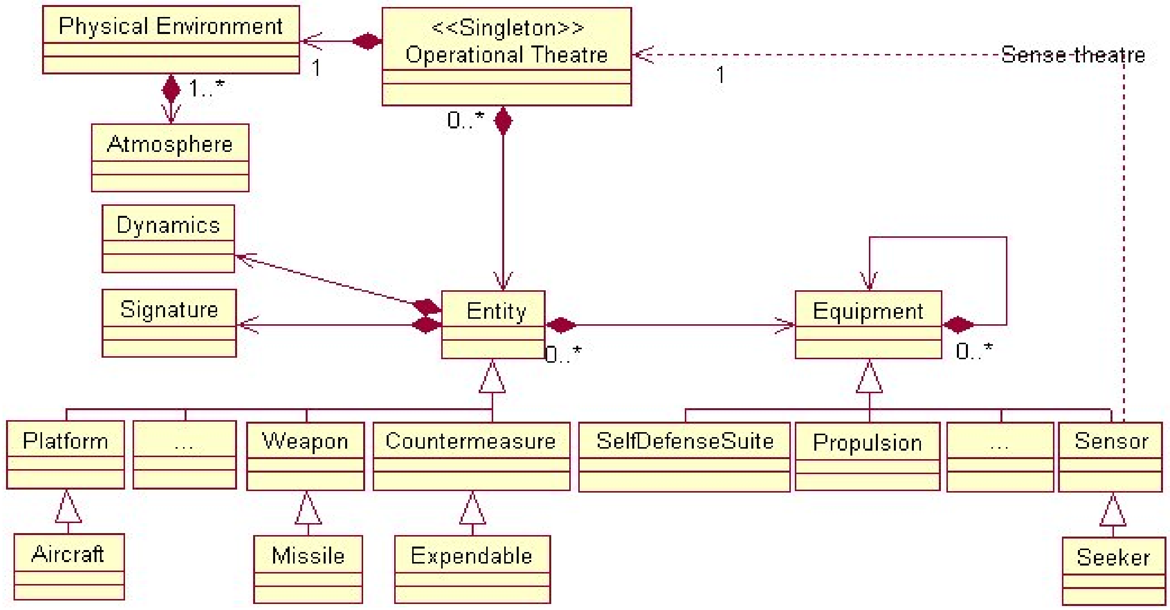


Figure I-16: Sample View of the KARMA Conceptual Model Representing an Engagement in the Object-Oriented Formalism.

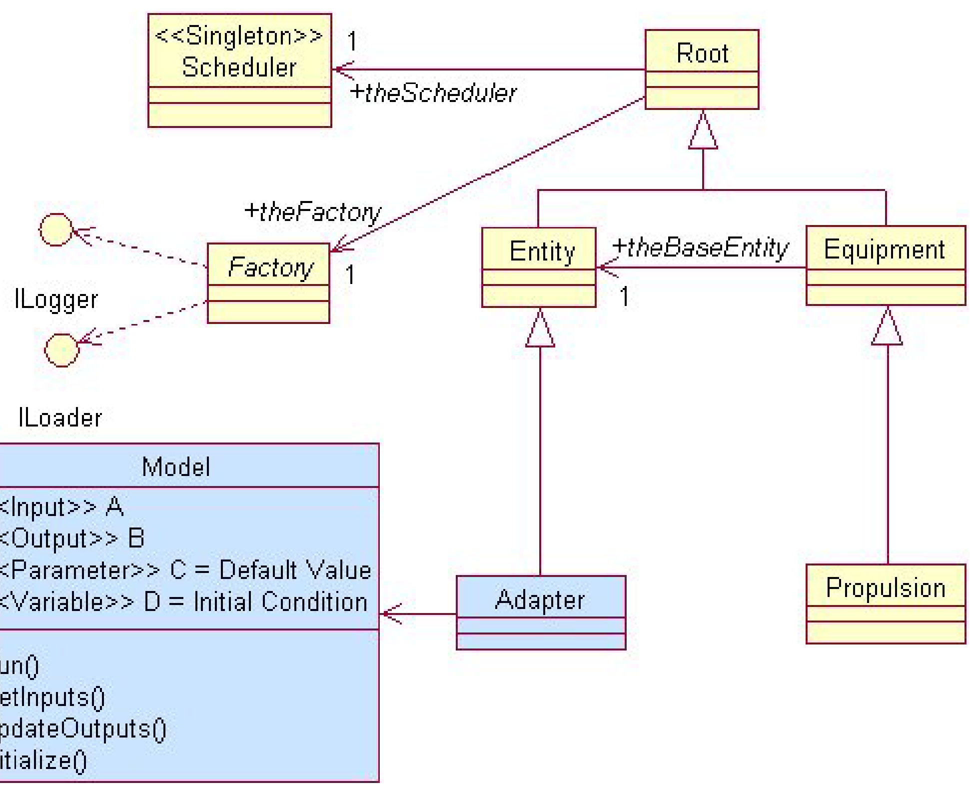


Figure I-17: Sample View of the KARMA Conceptual Model Including Simulation Space Concepts and Implementation-Related Conceptual Primitives.

The complete conceptual allows for the complete traceability from needs to requirements to specification to implementation. Each stakeholder is leveraging the conceptual model for his purpose.

I.6 CONCLUSION

This annex presented a limited number of examples complementing the best-practice guidance. In the interim of a standard conceptual model specification, each enterprise has to specify its own conceptual modeling process and conceptual model products, to a level down to actual templates if required. The proposed guidance should serve as reference and the examples, as inspiration. Every customization of the guidance will contribute to the science of conceptual modeling and will bring valuable experience to the standardization table.

I.7 REFERENCES

[1] Mojtahed, V., Garcia Lozano, M., Svan, P., Andersson, B. and Kabilan, V., DCMF-Defence CM Framework, Systems Technology Methodology Report Number FOI-R–1754–SE, ISSN 1650-1942, FOI-Swedish Defence Research Agency, November 2005, UML: http://www2.foi.se/rapp/foir1754.pdf.

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Annex J – LEXICON/GLOSSARY

Term	DEFINITION or COMMENT	REFERENCE
Abstract (Adjective)	4.a) Withdrawn or separated from matter, from material embodiment, from practice, or from particular examples. Opposed to concrete.	OED
Abstraction (Noun)	Denotes the essential characteristics of an object that distinguish it from all other kinds of objects and thus provide crisply defined conceptual boundaries, relative to the perspective of the user.	M&S Glossary, DMSO Survey of Semi-Automated Forces
Abstraction (Noun/Verb)	1) The process of selecting the essential aspects of simuland to be represented in a model or simulation while ignoring those aspects that are not relevant to the purpose of the model or simulation. 2) The set of elements produced by this process. 3) The act or process of separating the inherent qualities or properties of something from the actual physical object or concept to which they belong. 4) A product of this process, as a general idea or word representing a physical concept.	Houghton Mifflin Co., Webster's II, New College Dictionary
Abstraction (Noun)	An intuitive technique transforming the essential features of a real system into a different form.	Jake Borah Tutorial
Abstraction (Noun)	Denotes the essential characteristics of an object that distinguish it from all other kinds of objects and thus provide crisply defined conceptual boundaries, relative to the perspective of the user.	OED
Abstraction (Verb)	Generalization of a concept, idea, or symbol versus specialization.	
Abstraction (Verb)	Process of generalization by reducing the information content of a concept 3264 or an observable phenomenon typically in order to retain only information 3265 which is relevant for a particular purpose.	M&S Glossary
Abstraction (Verb)	The act of process of separating in thought, of considering a thing independently of its associations; or a substance independently of its attributes; or an attribute or quality independently of the substance to which it belongs.	OED
Abstractness	Degree of abstraction.	
Abstractness	Relates to the degree to which the conceptual model abstracts or symbolizes the referent.	Text
Accessibility	The ease of approaching, entering, obtaining, or using.	DoD "Data Quality Assurance Procedures", DoD 8320. 1-M-3

Term	DEFINITION or COMMENT	REFERENCE
Accreditation	Official acceptance or certification that a model, the data for a simulation or a simulation is suitable for a specific purpose or application.	Report from the Fidelity Implementation Study Group
Accuracy	Correctly know in quantity.	
Accuracy	The degree to which a parameter or variable or set of parameters or variables within a model or simulation conform exactly to reality or to some chosen standard or referent. See resolution, fidelity, and precision.	Report from the Fidelity Implementation Study Group
Actions	1) The process or conditions of acting or doing (in the widest sense), the exertion of energy or influence; working, agency, operation. a. Of persons. (Distinguished from *passion,* from *thought* or *contemplation*, from *speaking* or *writing*.) b. Of things. (Distinguished from *inaction, repose.*) *quantity of action*, in *Physics:* The momentum of a body multiplied into the time. 3) a. A thing done, a deed, not always distinguished from **ACT**, but usually viewed as occupying some time in doing, and in *pl.* referred to habitual or ordinary deeds, the sum of which constitutes *conduct.*	Houghton Mifflin Co., Webster's II, New College Dictionary
Actions	Elementary components of behaviour of an entity, object or system.	
Activity	A task that consumes time and resources and whose performance is necessary for a system to move from event to the next.	"IEEE Standard Glossary of Modeling and Simulation Technology", IEEE Std 610. 3-1989, nd
Activity Model	A model of the processes that make up a functional activity showing inputs, outputs, controls, and mechanisms through which the processes of the functional activity are or will be conducted.	DoD, "Data Administration Procedures", DoD 8320.1-M
Actor	The subject (perpetrator, agent) of action.	Text
Adaptability	The quality of being adaptable; capacity of being adapted or of adapting oneself; potential fitness for one or another intended purpose. (See Tailorability)	
Aggregation	The ability to group items, whether entities or processes, while preserving the effects of item behavior and interaction while grouped. A relationship between objects in the data model where one object contains other objects. (See Disaggregation).	DoD M&S Master Plan, DoD 5000-59-P, SEDRIS Glossary
Aggregation (Noun) Also Aggregate	A whole composed of many particulars; a mass formed by the union of distinct particles; a gathering, assemblage, collection.	OED

Term	DEFINITION or COMMENT	REFERENCE
Aggregation (Verb)	The action or process of collecting particles into a mass, or particulars into a whole; or of adding one particle to an amount; collection, assemblage, union.	OED
Analytical Frame	In this context – one or another way of looking at the world. Alternatives of such frames include for instance: ontology, systems engineering, software engineering, and knowledge management; together with a wide variety of tools and techniques for pursuing explication of each frame, such as model driven architecture, Knowledge Acquisition / Knowledge Engineering (KA/KE) assets, systems engineering tools, etc.	Text
Architecture	The structure of components in a program or system, their interrelationships, and the principles and guidelines governing their design and evolution over time.	DoD, M&S Master Plan, DoD 5000-59-P
Artefact	All or part of a work-product generated by the Task Group or by M&S conceptual model practitioners in generating, and documenting a simulation conceptual model.	
Artefact	. A) *n*. Anything made by human art and workmanship; an artificial product. In Archaol applied to the rude products or original work mans hip as distinguished from natural remains. B) In technical and medical use, a product or effect that is not present in the natural state (of an organisms, etc.) but occurs during or as a result of investigation or is brought about by some extraneous agency.	OED
Attribute	In object oriented analysis, (and simulation representation) the set of characteristics of some class inherited by its specializations and instances – which together with its behaviours and relationships, completely describes the state of an object of system of object entities.	
Attribute	. 1) A quality or character ascribed to any person or thing, one which is in common estimation or usage assigned to him; hence, *sometimes*, an epithet or appellation in which the quality is ascribed. 4) A quality or character considered to belong to or be inherent in a person or thing; a characteristic quality. c. in Logic, that which may be predicated of any thing; a quality, mode of existence, affection; strictly an essential and permanent quality.	OED
Attribute	1) A property or characteristic of one or more entities or objects (e.g., COLOR, WEIGHT, SEX). 2) A property inherent to an entity or associated with that entity for database purposes. 3) A quantifiable property of an object (e.g., the color of a building or the width of a road).	DoD, “Data Administration Procedures”, DoD 8320.1-M, SEDRIS Glossary
Authoritative Data Source	A data source whose products have undergone producer data verification, validation, and certification activities.	The Fidelity ISG Glossary
Authoritative Representation	Models, algorithms, and data that have been developed or approved by a source which has accurate technical knowledge of the entity or phenomenon to be modeled and its effects.	The Fidelity ISG Glossary

Term	DEFINITION or COMMENT	REFERENCE
Behavior	The means an actor performs or uses to actuate events.	Text
Behavior	1) For a given object, how attribute value changes affect or are affected by the attribute value changes of the same or other objects. 2) The way in which a system responds to stimuli over time.	Report from the Fidelity Implementation Study Group
Best-Practice Standard	Guidance containing prescriptive instructions of such quality that is not exceeded elsewhere.	
Business Ecosystem	The environment including entities, processes, and active agents constituting a universe of operations for one or another set of business transactions or operations. (See Economic Ecosystem)	
CASE	Computer Aided Systems Engineering.	
Class	A description of a group of objects with similar properties, common behavior, common relationships, or common semantics.	The Fidelity ISG Glossary
Class Hierarchy	A specification of a class, sub-class, or “is-a-kind-of” relationship between object classes in a given domain.	The Fidelity ISG Glossary
COTS	A good that is available in the private sector market, normally at a price established by supply and demand and distributed under proprietary licensing.	
Commonality	Consistency between or among entities of processes facilitating the capability to communicate, influence one another, and generally cooperate to some intended constructive purpose.	
Completeness	Degree to which a work-product exhausts its requirements. All needs, constraints and policies are covered by one or more requirements, or all requirements are covered by the content of the consequent conceptual model product.	
Composability	Capacity or suitability to be subject to composition.	
Composition	Act of combining elements or components into an intended aggregate entity or system.	
Computational Model	A model consisting of well-defined procedures that can be executed on a computer (e.g., a model of the stock market, in the form of a set of equations and logic rules).	“IEEE Standard Glossary of M&S Terminology”, IEEE Std 610.3-1989, nd.
Computer Science	Computer Science or Computing Science (abbreviated CS) is the study of the theoretical foundations of information and computation and of practical techniques for their implementation and application in computer systems.	http://en.wikipedia.org/wiki/Computer_science

Term	DEFINITION or COMMENT	REFERENCE
Computer Simulation	A dynamic representation of a model, often involving some combination of executing code, control/display interface hardware, and interfaces to real-world equipment.	The Fidelity ISG Glossary
Computer Software	A set of computer programs, procedures, and associated documentation concerned with the operation of a data processing system (e.g., compilers, library routines, manuals, and circuit diagrams); software.	The Fidelity ISG Glossary
Concept	Roughly equivalent to the "idea in the mind" resulting from a perception or the mental processing of perceptions and existing ideas.	David Hume
Concept	In normal language, concept may mean "something out there in the world" or alternatively and inconsistently, "an entity within one's head" Formally, a concept may be defined as: "A mental representation that can serve as the meaning of a linguistic expression."	Ray Jackendoff
Concept	Concepts are the Materials of reason and knowledge.	John Locke
Concept	"… concepts are [the] constituents of thought." "Conceptions explain epistemological facts (e.g., how we judge that something is a dog), while concepts explain meta-physical facts (e.g., what makes something a dog)." "… concepts *just are* perceptual detection mechanisms." "Concepts are prototypes, where prototypes are perceptually derived representations that can be recruited by working memory to represent a category." Therefore, "[i]f concepts are prototypes, thinking is a simulation process."	Jesse Prinz
Concept	An abstract idea or a mental symbol, typically associated with a corresponding representation in language or symbology that denotes all of the objects in a given category or class of entities, interactions, phenomena, or relationships between them.	Text
Conceptual (Model) Primitives	Atomic components from which conceptual model specifications are composed. (See Primitives)	Text
Conceptual Category	One of "… a small set of major ontological categories (or conceptual 'parts of speech') such as Thing, Event, State, Place, Path, Property and Amount."	Ray Jackendoff
Conceptual Constituent	The major units of conceptual structure, each of which belongs to a small set of conceptual categories.	Ray Jackendoff
Conceptual Model	Model that abstractly represents a referent.	
Conceptual Model	A simulation developer's method of translating modeling requirements into a detailed design framework-[use].	Dale Pace
Conceptual Model	1) A description of the content and internal representations that are the users' and developer's combined concept of the model including logic and algorithms and explicitly recognizing assumptions and limitations. 2) An implementation-independent description of the content and internal representations that represent the sponsor's, user's and developer's combined concept of the system or simulation under development including logic, architecture, algorithms, available data and explicitly recognising assumptions and limitations.	Report from the Fidelity Implementation Study Group

Term	DEFINITION or COMMENT	REFERENCE
Conceptual Model Characteristic	Attributes or qualia of a conceptual model, such as Quality, utility, formality, abstractness, etc.	
Conceptual Model Components	Parts comprising a conceptual model, such as conceptual primitive, model kind, view, formalism, notation, etc.	
Conceptual Model Design	See 'Design' and Section 6.2.8.	Text
Conceptual Model of (a) Simulation	The conceptual model of the Mission Space integrated with the conceptual model of Simulation Space.	Text
Conceptual Model of the Mission Space (CMMS)	First abstraction of the real world that serves as a frame of reference for simulation development by capturing the basic information about important entities involved in any mission and their key actions and interactions; simulation-neutral view of those entities, actions, and interactions occurring in the real world.	The Fidelity ISG Glossary
Conceptual Model Quality	The totality of features and characteristics of a conceptual model that bear on its ability to satisfy stated or implied needs.	
Conceptual Model Requirements	See 'Requirements' and Section 6.2.5.	Text
Conceptual Model Space	Domain to which conceptual model representation refers.	
Conceptual Schema	A descriptive representation of data and data requirements that supports the "logical" view or data administrator's view of the data requirement. This view is represented as a semantic model of the information that is stored about objects of interest to the functional area. This view is an integrated definition of the data that is unbiased toward any single application of data and is independent of how the data is physically stored or accessed.	DoD, "Data Administration Procedures", DoD 8320.1-M
Conceptual Scheme/Schema	A self-consistent style of abstraction and associated conceptual categories and primitives or constituents employed in personal or enterprise perception and descriptive communication.	W.V. Quine
Conceptualization	"… an abstract simplified view of the world." (See Concept)	Dragan Gasevic
Consistency	Degree to which components of a whole are congruent or are similarly conceived, configured, and expressed. Lack of incongruity or logical incompatibility among such components.	
Consumer	Role position designating person or organization that will put the conceptual model to use in order to implement an executable model to satisfy the sponsor's needs.	
Consumer (Analyst)	1) Understanding operational issues and mission context. 2) Producing relevant analysis products.	Text
Consumer (Model Implementer)	1) Understanding operational issues and mission context. 2) Implementation of simulation model.	

Term	DEFINITION or COMMENT	REFERENCE
Consumer (Model Implementer) (cont'd)	3) Verification of simulation model compliance with conceptual model.	
Consumer (Training System Developer)	1) Understanding operational issues and mission context. 2) Producing adequate training environment.	Text
Consumption	Process of using products in order to satisfy needs and desires (self-generated or imposed; real or imagined) so that the products are used up, transformed, or deteriorated in such a manner as not to be either reusable or recognizable in their original form. In economics, the final using up of goods and services. The term excludes the use of intermediate products in the production of other goods (e.g., the purchase of buildings, machinery, or software by an enterprise). Also, Consumption can be viewed as a basically subjective phenomenon, with individual or organizational utility, or satisfaction, having primary importance in the valuation of the product(s) consumed.	Metrics for M&S Investments
Consumption	The process of expending money by a/an organization/individual/ department/entity/project that does not result in an increase of assets.	Metrics for M&S Investments
Control	Defines what can occur within an activity. Constraint upon behaviour of relevant entity.	Text
Correctness	The property of an artefact (e.g., a conceptual model) to comply with formal rules and bodies of reference information for its representation and for the transformation of its representation into another one.	
Correctness	All needs, constraints and policies have been interpreted as the sponsor intended.	
Correctness	Degree to which the Conceptual Model implementation is free of error and of sufficient precision.	
Cost	"The amount or equivalent paid or charged for something" or the "loss or penalty incurred especially in gaining something" (http://www.merriam-webster.com/dictionary/cost). Normally, the value of a liquid asset or cash that must be paid for a good or service. (See Value)	
Cost Benefit	A method of reaching economic decisions by comparing the costs of doing something with its benefits. Especially useful when contributing factors are inherently monetary – can be complex when the decision being contemplated involves some cost or benefit for which there is no market price or which, because of an externality, is not fully reflected in the market price.	
Credibility	Quality of being credible, i.e., capable of being believed; believable.	OED
Criteria	The value of a variable or parameter against which some commensurable measured or observed value relevant to an object or process of interest can be compared for purposes of evaluation (singular, criterion).	

Term	DEFINITION or COMMENT	REFERENCE
Custodian	The person or organization that ensures that the repository is maintained and policies adhered to.	
Custodian	Provide services for effective reuse of available knowledge and Conceptual Model components.	
Customer	The buyer of a good or service, sometimes, but not necessarily the also the consumer – user.	
Customer	Buyer of some good or service. Sometimes, in prospectus, having bought in the past or considered likely to buy in the future. Customers normally have discretionary choice whether to buy a good or service, but normally do not effect price in public sector markets. Customers in government economic transactions normally negotiate with seller to control price, rate, quality, and risk. Influence of customers in private sector markets seldom persists beyond the sales event except insofar as warranty or goodwill considerations pertain.	Metrics for M&S Investments
Data	1) A representation of facts, concepts, or instructions in a formalized manner suitable for communication, interpretation, or processing by humans or by automatic means. 2) Assumed, given, measured, or otherwise determined facts or propositions used to draw a conclusion or make a decision.	DoD, "Data Administration Procedures", DoD 8320.1-M, Houghton Mifflin Co., Webster's II, New College Dictionary, 1995
Data Architecture	The framework for organizing and defining the interrelationships of data in support of an organization's missions, functions, goals, objectives, and strategies. Data architectures provide the basis for the incremental, ordered design and development of databases based on successively more detailed levels of data modeling.	DoD, "Data Administration Procedures", DoD 8320.1-M
Data Dictionary	A specialized type of database containing Meta data that is managed by a data dictionary system; a repository of information describing the characteristics of data used to design, monitor, document, protect, and control data in information systems and databases.	The Fidelity ISG Glossary
Data Model	1) The user's logical view of the data in contrast to the physically stored data, or storage structure. 2) A description of the organization of data in a manner that reflects the information structure of an enterprise. 3) A description of the logical relationships between data elements where each major data element with important or explicit relationships is captured to show its logical relationship to other data elements.	DoD, "Data Administration Procedures", DoD 8320.1-M, SEDRIS Glossary
Data Repository	A specialized database containing information about data such as meaning, relationships to other data, origin, usage, and format, including the information resources needed by an organization.	

Term	DEFINITION or COMMENT	REFERENCE
Data Representation	1) A format used to describe some type of data. 2) A variety of forms used to describe a terrain surface, the features placed on the terrain, the dynamic objects with special 3-D model attributes and characteristics, the atmospheric and oceanographic features, and many other forms of data.	Report from the Fidelity Implementation Study Group, SEDRIS Glossary, 29 June 1998
Data Source	1) An organization or subject-matter expert who, because of either mission or expertise, serves as a data producer. 2) A publication that serves as an authoritative source of data used in a model or simulation.	Report from the Fidelity Implementation Study Group
Data Validation	The documented assessment of data by subject area experts and its comparison to known values.	DoD, "M&S Master Plan", DoD 5000-59-P
Data Verification	Data producer verification is the use of techniques and procedures to ensure that data meets constraints defined by data standards and business rules derived from process and data modeling. Data user verification is the use of techniques and procedures to ensure that data meets user specified constraints defined by data standards and business rules derived from process and data modeling, and that data are transformed and formatted properly.	DoD, "M&S Master Plan", DoD 5000-59-P
Deaggregation (Disaggregation)	The ability to separate grouped items, whether entities or processes, while preserving the effects of item behavior and interaction whether grouped or separated.	The Fidelity ISG Glossary
Design (noun)	1. a. A plan or scheme conceived in the mind and intended for subsequent execution; the preliminary conception of an idea that is to be carried into effect by action.	OED
Design (noun)	2. The purposeful or inventive arrangement of parts or details.	The free Dictionary, http://www.thefreedictionary.com/design
Design (noun)	The arrangement of elements or details in a product or work of art.	http://www.merriam-webster.com/dictionary/design?show=1&t=1303403590
Design (noun)	A plan or drawing produced to show the look and function or workings of a building, garment, or other object before it is built or made.	Wikipedia

Term	DEFINITION or COMMENT	REFERENCE
Design (n.)	The visual characteristics embodied in or applied to an article [in patent law].	http://www.uspto.gov/web/offices/pac/mpep/documents/1500_1502.htm
Detail	1.a. The dealing with matters item by item, detailed treatment; attention to particulars … i.e., to deal or treat with a thing in its individual particulars.	OED
Detail	Having to do with precision of identification or description.	
Developers	Agents responsible for development of conceptual models.	Text
Disaggregate	Activity that decomposes an aggregated entity into multiple entities representing its components.	Report from the Fidelity Implementation Study Group
Domain	3.a. *fig*. A sphere of thought or action; field province, scope of a department of knowledge, etc.	OED
Domain	The physical or abstract space in which the [relevant] entities and processes operate.	The Fidelity ISG Glossary
Domain Analysis	The process of identifying, acquiring and evaluating the information related to a problem domain to be used in specifying and constructing a model or simulation.	Report from the Fidelity Implementation Study Group
Domain of Knowledge	Knowledge related to a given domain.	
Domain Ontology	The ontology of a given domain.	
Economic Ecosystems	An economic community supported by a foundation of interacting organizations and individuals--the organisms of the business world. This economic community produces goods and services of value to customers, who are themselves members of the ecosystem. The member organizations also include suppliers, lead producers, competitors, and other stakeholders. Over time, they co-evolve their capabilities and roles, and tend to align themselves with the directions set by one or more central companies. Those companies holding leadership roles may change over time, but the function of ecosystem leader is valued by the community because it enables members to move toward shared visions to align their investments and to find mutually supportive roles. (Source: Predators and Prey: A New Ecology of Competition, by James F. Moore, Harvard Business Review, May/June 1993).	

Term	DEFINITION or COMMENT	REFERENCE
Emulate	To represent a system by a model that accepts the same inputs and produces the same outputs as the system represented (e.g., to emulate an 8-bit computer with a 32-bit computer).	"IEEE Standard Glossary of M&S Terminology", IEEE Std 610-3-1989, nd
Encapsulation	The process of hiding the details of an object that do not contribute to its essential characteristics.	The Fidelity ISG Glossary
Enterprise	One or more organizations under common control. Generally refers to the broadest scope of organizations and operational process relevant to the subject discussion rather than to individual components thereof.	Text
Enterprise Concepts-of-Operations	The single, unified Concept of Operations (CONOPS) whereby the multiple organizations comprising an enterprise ensemble cooperate. Enterprise CONOPS often entail more formality, and systematic consensus-based collaboration, as well as more explicitly coordinated and documented modeling and simulation development and employment than is common in more parochial contextual environments.	
Enterprise Context	The operational or environmental context at which enterprise considerations agents, relationships, and transactions are relevant.	
Enterprise Model	An information model(s) that presents an integrated top-level representation of processes, information flows, and data.	DoD, "Data Administration Procedures", DoD 8320.1-M
Enterprise-Based	Operations, process, or work-products typically tailored-to or used-in or generated-from enterprise-style circumstances.	
Entity	A distinguishable person, place, thing, event or concept about which information is kept. Something that exists as a particular and discrete unit.	The Fidelity ISG Glossary
Entity/Entities	A thing. Usually an element or component part of the mission space or simulation space representation domain of a conceptual model of a simulation. Note that entity is distinguished throughout the document from 'object', whose specific connotations in object-oriented analysis, and object-based software development have been intentionally avoided.	
Entity Relationship Diagram (ERD)	A graphic representation of a data model.	The Fidelity ISG Glossary
Epistemology	The theory or science of the method or grounds of knowledge.	OED
Evaluator	Person or organization that validates the conceptual models, ensuring validity of Conceptual Model and compliance with requirements.	
Event	Occurrence of the change of value of one or another of the 'state variables' of the simulation representation information set.	

Term	DEFINITION or COMMENT	REFERENCE
Event (cont'd)	In 'discrete-event simulation' techniques, events occupy no duration but have as attributes the value of the simulation time at which the related represented state-change occurred.	
Event	An action composed of activities.	Text
Event	A change in an object attribute value, an interaction between objects, an instantiation of a new object, or a deletion of an existing object that is associated with a particular point on the federation time axis. An individual stimulus from one object to another at a particular point of time.	The Fidelity ISG Glossary
Executability	Ability of prescriptive guidance to be executed or accomplished. Alternatively, the ability of a computer program, algorithm or simulation to be made to operate according to program guidance and consistent with expectation.	
Expressiveness	Efficiency of communication of information in an expression. Information density combined with readability or correct interpretation.	
Extensibility	The ability of a data structure to accommodate additional values or iterations of data over time without impacting its initial design.	DoD, "Data Quality Assurance Procedures", DoD 8320.1-M-3, DoD, "Data Administration Procedures", DoD 8320.1-M
External Schema	A logical description of an enterprise that may differ from the conceptual schema upon which it is based in that some entities, attributes, or relationship may be omitted, renamed, or otherwise transformed.	DoD, "Data Administration Procedures", DoD 8320.1-M
Federation Object Model (FOM)	An identification of the essential classes of objects, object attributes, and object interactions that are supported by a High Level Architecture federation. In addition, optional classes of additional information may also be specified to achieve a more complete description of the federation structure and/or behavior.	The Fidelity ISG Glossary
Fidelity	Accuracy or correctness of representation – the degree to which the representation conforms in resemblance to the referent.	
Fidelity	1) The degree to which a model or simulation reproduces the state and behavior of a real-world object or the perception of a real-world object, feature, condition, or chosen standard in a measurable or perceivable manner; a measure of the realism of a model or simulation; faithfulness. Fidelity should generally be described with respect to the measures, standards or perceptions used in assessing or stating it. See accuracy, sensitivity, precision, resolution, repeatability, model/simulation validation.	Report from the Fidelity Implementation Study Group

Term	DEFINITION or COMMENT	REFERENCE
Fidelity (cont'd)	2) The methods, metrics, and descriptions of models or simulations used to compare those models or simulations to their real-world referents or to other simulations in such terms as accuracy, scope, resolution, level of detail, level of abstraction and repeatability. Fidelity can characterize the representations of a model, a simulation, the data used by a simulation (e.g., input, characteristic or parametric), or an exercise. Each of these fidelity types has different implications for the applications that employ these representations.	Report from the Fidelity Implementation Study Group
Formal Conceptual Model	A conceptual model with the following attributers or consequences of formality: - Unambiguous description of model structure separated from software implementation. - Useful once users and colleagues understand informal model and want more detail. - Used as an aid to detect omissions and inconsistencies and resolve ambiguities inherent in informal models.	Jake Borah Tutorial
Formal Language	In logic, a set of symbols together with a set of formation rules that designate certain sequences of symbols as well-formed formulas, and a set of rules of inference (transformation rules) that, given a certain sequence of well-formed formulas, permits the construction of another well-formed formula. The symbols chosen vary from language to language, but typically they contain both logical constants and non-logical vocabulary, e.g., in the language of the propositional calculus the logical constants are truth-functional connectives and the non-logical vocabulary consists solely of sentence letters, in the predicate calculus, variable, predicates and quantifiers are needed. The formation rules will naturally reflect the chosen vocabulary. The rules of inference are to be thought of as governing only the manipulation of symbols, independently of any interpretation they may have. Although formal languages do not require at any state the notion of an interpretation, they are nevertheless constructed with interpretations in mind, and rules of inference that do not preserve truth, although not formally unsatisfactory, are of no interest.	The Fidelity ISG Glossary
Formalism	The practice or the doctrine of strict adherence to prescribed or external forms.	
Formalism	Constraint of form over content.	
Formalisms	Examples are UML, CML, SysML, IDEF0, BOM, BOM++, Conceptual Graphs, Mind Maps, and BPMN.	Text
Formality	Amount of constraints imposed on the form.	
Formality	Compliance with formal or conventional rules.	Text
Formality	Formality is compliance with formal or conventional rules.	Text

Term	DEFINITION or COMMENT	REFERENCE
Generality	Applicability to a wide class of instances.	
Glyph	Responsible for holding the image of conceptual model, which can be used to visually represent a conceptual model in a tool palette or a web repository. From: 1. A structured mark or symbol. *rare*.	Text, OED
Implementation Dependencies	Constraints occurring at time of creation determined during the development of the conceptual model and manifest at the time of implementation or execution of the conceptual model, such as may result from peculiarities of domain ontologies, representational schema or any other new concept introduced by the process during the implementation of the conceptual model.	
Incentive	Incentive system: "A method of organizing production that uses a market-like mechanism inside the firm."	CFA Institute
Incentive	Any factor (financial or non-financial) that provides a motive for a particular course of action, or counts as a reason for preferring one choice to the alternatives.	Wikipedia
Informal Conceptual Model	A conceptual model with the following attributers or consequences of informality: - Written using natural language and contains assumptions made during its construction. - Plays fundamental role during the period of activity when the modeler conceives, programs, debugs, and test models. - Helps users and colleagues comprehend basic outline of the model from their perspective on how the real world operates.	Jake Borah Tutorial
Information	Details the capabilities of a Behaviour, Actor, Event, or Control.	Text
Inheritance	The object-oriented concept where a child class also has the features (attributes and methods) of its parent class; one of the types of relationships between objects in the data model.	SEDRIS Glossary
Instantiation	To represent an abstraction by a concrete instance.	The Fidelity ISG Glossary
Interactions	Transactions among entities wherein information exchange occurs or causal influence is manifest.	
Interoperability	The capability of two or more simulation components to operate together concurrently or in sequence guaranteed by the synchronized exchange of syntactic and semantically consistent data signals/ messages.	
Investment	The process of adding to stocks of real productive assets. This may mean acquiring fixed assets, such as buildings, plan, or equipment, or adding to stocks and work in progress.	
Investment	Incurring costs in the present – for the right to receive future benefits / with the expectation of achieving an increased benefit in the future.	

Term	DEFINITION or COMMENT	REFERENCE
Investment	The process of expending money by a/an organization/individual/ department/entity/project that result in an increase of assets.	
Investment	Costs that result in the acquisition of, or addition to, end items. Such costs benefit future periods and generally are of a long-term character. Costs budgeted in the procurement and Military Construction appropriations are considered investment costs. Costs budgeted in the Research, Development, Test and Evaluation appropriation can be considered investment costs or expenses, depending on the circumstances.	Glossary of Defense Acquisition Acronyms & Terms, Defense Acquisition University Press
Knowledge	1) The rules, environment, etc., that form the structure humans use to process and relate to information, or the information a computer system must have to behave in an apparently intelligent manner. 2) The sum or range of what has been perceived discovered or learned.	Houghton Mifflin Co., Webster's II, New College Dictionary, 1995
Legacy Simulation/ Simulator	Existing simulation asset whose initial costs are already incurred and which may be in use and therefore may have stakeholder commitments for continued investment and use.	
M&S Asset	An asset or assets used in the science, practice, development, or use of M&S.	
M&S Community (M&S Community-of-Practice)	The ensemble of practitioners comprising the population of individuals and organizations with significant interests and commitments to modeling and simulation disciplines, practices, assets and uses.	
M&S Conceptual Model	Conceptual Model intended for realizing a simulation capability.	Text
M&S Investment	The process of investing (as defined) in or for M&S (as defined) assets (as defined) by a/an organization/individual/department/entity/project.	
M&S Resources	A source of relevant supply – in the case of M&S, resources normally include: models, simulations, databases, scenarios, threat libraries, V&V histories, accreditation pedigrees, environmental representations, architectures, and interfaces; but they may also include: interfaces, simulation federations, games, plans and policies, personnel, facilities and equipment, information sources, behaviors, system information and documentation, organizational knowledge, procedural knowledge, operational knowledge, mappings and translations, conceptual models, transaction protocols, software components, execution outputs, and analysis results and reports.	
Machine Readability	Ability of information to be perceived by a machine or automaton and subsequently be operated upon by that device.	
Market	"The means through which buyers and sellers are brought together to aid in the transfer of goods and/or services."	CFA Institute

Term	DEFINITION or COMMENT	REFERENCE
Market	"Any place where the sellers of a particular good or service can meet with the buyers of that goods and service where there is a potential for a transaction to take place."	http://economics.about.com/cs/economicsglossary/g/market.htm
Market	"A market exists whenever potential sellers of a good or service are brought into contact with potential sellers and a means of exchange is available."	Graham Bannock
Market	In general, a market is defined as the group of individuals/organizations/ entities that has the need for, and can afford a product/service.	Marketing definition
Mathematical Model	1) Any system of assumptions, definitions and equations that represents particular physical phenomena. See model, simulation, conceptual model, software model. 2) A document describing the assumptions, definitions and equations that represent particular physical phenomena to be simulated for a specific application.	Report from the Fidelity Implementation Study Group
Measurement	The dimensional or quantitative assignment of that which is being assessed (e.g., five inches long). A set of operations having the object of determining a value of a measure.	Practical Software Measurement, McGarry et all, 2002
Meta Data	Data on a process, event, or system that is fundamentally abstract in nature. A set of "data about data" that characterizes the referent in a more theoretical manner than first order descriptors.	
Meta Data	Information describing the characteristics of data; data or information about meaning of the data; descriptive information about an organization's data, data activities, systems, and holdings.	DoD, "Data Administration Procedures", DoD 8320.1-M, SEDRIS Glossary 29 Jun 1998
Meta-Knowledge	Knowledge about knowledge; knowledge about the use and control of domain knowledge in an expert or knowledge-based system or knowledge about how the system operates or reasons; wisdom.	The Fidelity ISG Glossary
Meta-Model	"… a specification model for a class of systems under study, where each system under study in the class is itself a valid model expressed in a certain modeling language." "… a meta-model is a model of a modeling language."	Dragan Gasevic
Meta-Model	A model of a model. Meta-models are abstractions of the M&S being developed which use functional decomposition to show relationships, paths of data and algorithms, ordering, and interactions between model components and sub-components. Meta-models allow the software engineers who are developing the model to abstract details to a level that subject-matter experts can validate.	The Fidelity ISG Glossary

Term	DEFINITION or COMMENT	REFERENCE
Metric(s)	Describe a system of measurement that includes: the item or object being measured; units to be measured, also referred to as “standard units”; and the value of a unit as compared to other units of reference. (The Metrics of Science and Technology, Geisler, 2000).	The Metrics of Science and Technology, Geisler, 2000
Military Domain	Domain or range of interest of entities and phenomenology of interest to military organizations or personnel.	
Military Domain Experts	Individuals having expert or specialized knowledge of one or another military domain.	
Military M&S Conceptual Model	An M&S Conceptual Model within the military domain.	Text
Military Mission Space	Mission space relating to military entities or functions. (See Mission Space)	
Military Modeling	Modeling conducted in support of military organizations or functions or representing military behaviours.	
Military Scenario	Scenario of interest to Military operations or agents. (See Scenario)	
Mission Space	1) The [world] in which a particular mission is performed. 2) The environment of entities, actions, and interactions comprising the set of interrelated processes used by individuals and/or organizations to accomplish assigned tasks.	Report from the Fidelity Implementation Study Group, DoD, “M&S Master Plan”, DoD 5000-59-P
Mission Space Model	A model based primarily upon knowledge of the real world. Such a model, if based entirely upon expert opinion of the real world, is a preliminary to creating a mathematical or software model. A mission space model of an object should describe what that object does, at some level of fidelity, in the environment in which the mission is executed. See model, mathematical model, software model, mission space.	Report from the Fidelity Implementation Study Group
Model	1) A physical, mathematical, or otherwise logical abstract representation of a system, entity, phenomenon, or process with its own assumptions, limitations and approximations. See simulation, conceptual model, software model, mathematical model. 2) A geometry or feature assembly built in a relative coordinate system with the intent to multiply instances of the assembly at one or more world coordinate positions. 3) A system that stands for or represents another typically more comprehensive system.	DoD, “M&S Master Plan”, DoD 5000-59-P
Model (Noun)	A pattern of something to be made.	Jake Borah Tutorial
Model (Noun)	“… a simplified view of reality.” “… A clear set of formal statements that describes something … for a specific purpose …”	Dragan Gasevic

Term	DEFINITION or COMMENT	REFERENCE
Model (Noun)	**I.** Representation of structure. b. *fig*. Something that accurately resembles something else; a person or thing that is the likeness or 'image' of another; *esp.* in ***little model***, a thing that represents on a small scale the structure or qualities of something greater. c. An archetypal image or pattern. e. A simplified or idealized description or conception of a particular system, situation, or process (often in mathematical terms: so ***mathematical model***) that is put forward as a basis for calculations, predictions, or further investigation.	OED
Model (Noun)	A simplified/abstracted representation of a part of reality or a potential reality.	Text
Model (Noun)	A physical, mathematical, or otherwise logical representation of a referent of interest	Text
Model (Verb)	1.a. *trans.* To present as in a model or outline; to portray or describe in detail. b. [after MODEL n. 2e.] To devise a (usu. mathematical) model of (a phenomenon, system, etc.).	OED
Model (Verb)	… to produce a representation of or simulation of [something].	Jake Borah Tutorial
Model Identification	Data structure that can accommodate information related to the identification of a conceptual model such as: Name, Type, Version, Modification Date, Security Classification, Release Restriction, Purpose, Application Domain, Description, and Use Limitation.	
Model Kinds	Types or alternative classes of models. Examples are dynamic, static, state machine, structural, behavioral, agent, object-based, process-based, Meta data, entity relation, activity, composition, generalization, collaboration, event trace and sequence.	Text
Modeling	… representation [*v.*] of a system for the purpose of studying the system.	Banks, Carson, and Nelson
Modeling	… cost effective use of something in place of something else for some purpose.	Ray Rothenburg
Modeling	Application of a standard, rigorous, structured methodology to create and validate a physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process.	The Fidelity ISG Glossary
Modeling and Simulation (M&S)	The use of models, including emulators, prototypes, simulators, and stimulators, either statically or over time, to develop data as a basis for making managerial or technical decisions. The terms "modeling" and "simulation" are often (though imprecisely) used interchangeably.	MSETT NAWC-TSD Glossary; DoD M&S Glossary, DoD 5000.59-M
Modeling and Simulation (M&S)	The use of models, including emulators, prototypes, simulators, and stimulators, either statically or over time, to develop data as a basis for making managerial or technical decisions. The terms "modeling" and "simulation" are often used interchangeably.	The Fidelity ISG Glossary

Term	DEFINITION or COMMENT	REFERENCE
Need	3.a. Necessity arising from the facts or circumstance of the case; 10.A A condition marked by the lack or want of some necessary thing, or requiring some extraneous aid or addition.	OED
Need	A ‘want’ or ‘need’ is related to the state of expectation or intention of one or another of the stakeholders. Individually or collectively, stakeholders may have anticipatory preferences for that which is produced as the conceptual model proper based on their intended use for it in context of their role within the enterprise. Wants and needs in this view are desiderata.	Text
Notation	A system of characters, symbols, or abbreviated expressions used in an art or science or in mathematics or logic to express technical facts or quantities.	
Notation	Set of names, symbols, or other semiotic devices together with syntactic rules for associated the elements of the notation into meaningful statements.	
Notational Schema	Schema (see below) manifest as notational symbology.	
Object	A fundamental element of a conceptual representation for a federate that reflects the “real world” at levels of abstraction and resolution appropriate for federate interoperability. For any given value of time the state of an object is defined as the enumeration of all its attribute values.	The Fidelity ISG Glossary
Object Model	A specification of the objects intrinsic to a given system, including a description of the object characteristics, or attributes, and a description of the static and dynamic relationships that exist between objects.	The Fidelity ISG Glossary
Ontology	Ontologies are formalized vocabularies of terms, often covering a specific domain and shared by a community of users. They specify the definitions of terms by describing their relationships with other terms in the ontology.	Lee Lacey
Ontology	‘An’ ontology is a specification of a conceptualization. Practically, “A representation vocabulary often specialized to some domain”. “... the body of knowledge describing the domain using the representation vocabulary” “... an explicit representation of a shared understanding of the important concepts in some domain of interest”.	OED; Dragan Gasevic
Ontology	Combination of objects and processes of interest.	Text
Ontology	An explicit formal conceptualisation of a shared understanding of the domain of interest including the vocabulary of terms, semantics as well as their pragmatics.	Text
Ontology	In short, ‘ontology’ asks the rhetorical question: What is there? In the present context, more specific formulations might be: What do we care about, or alternatively, what is it necessary to represent in a model or simulation in order for the resulting product to serve its intended use? Given this knowledge, the next question that must be addressed is: How can one select, and document the contents of such a representation?	Text

Term	DEFINITION or COMMENT	REFERENCE
Ontology (Formal)	Ontologies may be classified depending upon both their formality and complexity as a continuum as belong to the following major categories: Highly Informal, Semi Formal, and Rigorously Formal. Formal ontologies are considered to be: "… the systematic formal, axiomatic development of the logic of all forms and modes of being. It studies the formal properties and classification of the entities of the world (physical objects, events, etc.), and of the categories that model the world (concepts, property, etc.)"	Asunción Gómez Pérez
Pattern(s)	. 1) a. The original proposed imitation; the archetype; that which is to be copied; an exemplar' (J.); an example or model deserving imitation; an example or model of a particular excellence. 2) a. Anything fashioned, shaped, or designed to serve as a model from which something is to be made; a model, design, plan, or outline. [therefore a kind of a model]. 6) An example, an instance; *esp.* a typical, model, or representative instance, a signal example. c. *fig.* An arrangement or order of things or activity in abstract senses; order or form discernible in things, actions, ideas, situations, etc.	OED
Policy	A deliberate plan of action to guide decisions and achieve rational outcomes.	Wikipedia
Precision	1) The quality or state of being clearly depicted, definite, measured or calculated. 2) A quality associated with the spread of data obtained in repetitions of an experiment as measured by variance; the lower the variance, the higher the precision. 3) A measure of how meticulously or rigorously computational processes are described or performed by a model or simulation. See resolution, sensitivity.	Report from the Fidelity Implementation Study Group
Predicate	1) *Logic*. That which is predicated or said of the subject in a proposition. 2) *Gram* c. A quality, an attribute.	OED
Primitives	Elemental components from which higher-order composites may be composed. Commonly applied to conceptual model constructs. Examples are entity, object, signal, time, event, attribute, message, state.	Text
Process	1) Something that affects entities (e.g., attrition, communications, and movement). Processes have a level of detail by which they are described. 2) A system of operations in producing something. 3) A series of actions, changes, or functions that achieve an end or result.	Houghton Mifflin Co., Webster's II, New College Dictionary, 1995
Process Consistency, Commonality and Tailorability	Processes comprising the conceptual model best-practice must be appropriate for execution in a NATO-diverse constituency. Best-practice process elements must be sufficiently consistent that participation in conceptual modeling can be extended across any sub-set of the NATO M&S community.	

Term	DEFINITION or COMMENT	REFERENCE
Process Consistency, Commonality and Tailorability (cont'd)	Practice commonality must have a similar domain in order that suitable common ground exist from which NATO M&S constituents may fully appreciate both how conceptual models were achieved and what their contents are once produced. Conceptual modeling processes and products must, nevertheless, be sufficiently tailorable so that they can be socialized by any particular sub-set of the enterprise to which they will particularly pertain – and they must be sufficiently tailorable as to admit the specific referent subject matter, conceptual constructs, and representational schemas as may be elected by one or another sub-set of the stakeholder community.	
Process Guidance	Prescriptive guidance specifying the effort or activity necessary and sufficient to create a desired work-product resulting from a developmental activity.	
Process Model	A model of the processes performed by a system (e.g., a model that represents the software development process as a sequence of phases). See structural model.	The Fidelity ISG Glossary
Producer	This is a person or organization that will endeavour to satisfy the sponsor's need.	Text
Producer (Knowledge Engineer)	1) Understanding of operational issues and mission context. 2) Translation of operational issues and mission context into a conceptual model. 3) Unambiguous communication with SMEs and implementers.	Text
Producer (M&S PM)	1) Effective use of allocated resources (e.g., ensuring reuse when appropriate). 2) Unambiguous communication with customer.	Text
Producer (M&S SME) **Military SME**	1) Understanding of operational issues and mission context. 2) Translation of operational issues and mission context into a conceptual model. 3) Unambiguous communication with SMEs and implementers.	
Producer (M&S SME)	1) Understanding of operational issues and mission context. 2) Provide technical and military know-how at appropriate level of detail.	Text
Product Consistency	Conceptual model product consistency must be sufficient that the library of conceptual models deployed and used within the NATO M&S enterprise are at least evidently interpretable among stakeholders, and preferably interoperable (to within similarity of mission space referents) across the enterprise.. While complete interoperability and exhaustive re-usability are not likely to occur even under the most auspicious circumstances, and while it is certain that no degree of product 'best-practice' results could guarantee such consistency, any element of the prescribed practice that can be established with a view to improving product consistency should be adopted.	
Product Guidance	Prescriptive guidance specifying the nature of the subject work-product resulting from a developmental activity.	

Term	DEFINITION or COMMENT	REFERENCE
Product Quality	Conceptual model product quality across the enterprise is relevant from two complimentary perspectives. On the one hand consistent quality in fact resulting from the subject guidance is directly correlated to the value of the return on investment in conceptual modeling itself. On the other hand, sufficient and auditably documented product quality across conceptual models will influence greatly both the likelihood of use of the conceptual modeling best-practice guidance and the re-use sharing, and recovery of utility of the pursuant models themselves.	
Project Manager	Role title relating to responsible agent leading a project or program of activity.	
Properties	Attributes, characteristics of a thing or process.	
Purpose(s)	1) a. That which one sets before oneself as a thing to be done or attained; the object which one has in view. 2) a. Without *a* or *pl*. The action or fact of intending or meaning to do something; intention, resolution, determination. 3) The object for which anything is done or made, or for which it exists; the result or effect intended or sought; end, aim.	OED
Quality	A totality of features and characteristics of a conceptual model that bear on its ability to satisfy stated or implied needs. It measures how “good” a conceptual model might be for various purposes.	Text
Quality	Measures how “good” a conceptual model might be for various purposes.	Text
Real-Time	In modelling and simulation, simulated time advances at the same rate as actual time (e.g., running the simulation for one second results in the model advancing time by one second). See fast time, slow time.	The Fidelity ISG Glossary
Real-World	The set of real or hypothetical causes and effects that simulation technology attempts to replicate. See real battlefield. The real world defines one standard against which fidelity is measured that includes both imagined reality and material reality in order to accommodate assessment of simulation fidelity when future concepts and systems are involved. See fidelity, imagined reality, material reality, perceived truth.	Report from the Fidelity Implementation Study Group
Reference	A pointer to additional sources of information such as locations in XML documents and references to ontologies (both domain and middle level) which are used by the conceptual model.	
Referent	That part of the mission-space being represented in the simulation – also denoted the ‘simuland’.	
Referent	a. That to which something has reference; *spec.* that which is referred to by a word or expression. Also in *Comb. (appositively),* as referent-object.	OED
Referent	A set of fictive or existing systems, entities, phenomena, or processes subjected to modeling and simulation which a user may want to consider in the context of their own objects or interests.	Text

Term	DEFINITION or COMMENT	REFERENCE
Referent	1) A codified body of knowledge about a thing being simulated. 2) Something referenced or singled out for attention, a designated object, real or imaginary or any class of such objects.	Report from the Fidelity Implementation Study Group, Houghton Mifflin Co., Webster's II, New College Dictionary, 1995
Relation	3) a. That feature or attribute of things which is involved in considering them in comparison or contrast with each other; the particular way in which one thin is thought of in connection with another; any connection, correspondence, or association, which can be conceived as naturally existing between things.	OED
Relationship	The state of being related; a condition or character based upon this.	
Repository	A place where data or specimens are stored and maintained for future retrieval.	Wikipedia
Representation	2) a. *n* An image, likeness, or reproduction in some manner *of* a thing. d. The fact of expressing or denoting by means of a figure or symbol; symbolic action or exhibition. 6) a. *v* The action of presenting to the mind or imagination; an image thus presented; a clearly-conceived idea or concept.	OED
Representation	1) Something that stands in place of or is chosen to substitute for something else, e.g., representation of constituencies in government, linguistic representation of an event. 2) Something that describes as an embodiment of a specified quality. 3) The homomorphism of a group of abstract symbols into a group of more familiar objects. 4) A model or simulation.	Houghton Mifflin Co., Webster's II, New College Dictionary, 1995, Report from the Fidelity Implementation Study Group
Representational Polymorphism	Multiple representations of the same data to serve the needs of different users.	SEDRIS Glossary
Requirement	3) That which is required or needed; a want, need. b. that which is called for or demanded; a condition which must be complied with.	OED
Requirement	A 'requirement' is related to the necessary and sufficient attributes of the conceptual model as determined appropriate for the enterprise at large. Requirements both prescribe and proscribe the characteristics of the conceptual model which, if present, guarantee the model to be adequate for its several intended uses.	Text

Term	DEFINITION or COMMENT	REFERENCE
Requirement (cont'd)	As such, requirements must be monolithic within the enterprise and must manifest the potentially disparate stakeholders' wants and needs in positive-definite, observable form.	Text
Resolution	1) The degree of detail used to represent aspects of the real world or a specified standard or referent by a model or simulation. 2) Separation or reduction of something into its constituent parts; granularity.	Houghton Mifflin Co., Webster's II, New College Dictionary, 1995
Reusability	Able to be used again; suitable for second or further usage.	
Reuse	For an asset to be used again subsequent to its initial intended use.	
Risk	Possibility that actual outcomes will vary from what is expected.	
Risk	A measure of the inability to achieve program objectives within defined cost and schedule constraints. It has two components: the probability of failing to achieve a particular outcome, and the consequences of failing to achieve that outcome.	Glossary of Defense Acquisition Acronyms & Terms, Defense Acquisition University Press
Risk	"The chance of things not turning out as expected. Risk taking lies at the heart of capitalism and is responsible for a large part of the growth of an economy. In general, economists assume that people are willing to be exposed to increased risks only if, on average, they can expect to earn higher returns than if they had less exposure to risk."	http://www.economist.com/research/economics
Role	The named designation of a relationship that may be assigned-to or assumed-by an individual or organization with respect to some function or organizational entity. Role is intended to imply requisite authority and concomitant responsibility to execute the associated functions or to act successfully in relation to the designated organizational entity.	Webster..."a part or character assumed by anyone."
Role (Functional) Authority	Those functions (including decisions) that the individual person or organization assigned to a role class or instance may perform. … what the role holder may do.	
Role (Functional) Responsibility	Those functions that must be performed by the person or organization assigned to any particular role class or instance. Performance of functional responsibilities is a necessary condition of satisfactory role-position execution. … what the role holder must do.	
Scale	A specified, graduated reference used to measure the value of an item to a decision-maker or user.	
Scenario	2) A sketch, outline, or description of an imagined situation or sequence of events; esp. (a) a synopsis of the development of a hypothetical future world war, and hence an outline of any possible sequence of future events; (b) an outline of an intended course of action; (c) a scientific model or description intended to account for observable facts.	

Term	DEFINITION or COMMENT	REFERENCE
Scenario (cont'd)	Hence, in weakened series (not easily distinguishable from sense 1a *transf.* and *fig.*): a circumstance, situation, scene, sequence of events, etc.	OED
Schema	1) a. *Philos.* In Kant: Any one of certain forms or rules of the 'productive' imagination' through which the understanding is able to apply its ' categories' to the manifold of sense-perception in the process of realizing knowledge or experience... (e.g., A rule that organizes perceptions into a unitary whole.) b. *Neurol.* and *Psychol.* An automatic, unconscious coding or organization of incoming physiological or psychological stimuli, giving rise to a particular response or effect.	OED
Scope	The range, breadth, or degree of extension of the universe of discourse.	
Semantic(s)	2) a. Relating to signification or meaning.	OED
Semantics	The components of a rule or lexical entry that define the meaning of a morpheme, word, phrase, or sentence.	Steven Pinker
Semantics	1) The implied meaning of data to define what entities mean with respect to their roles in a system. 2) The study of relationships between signs and symbols and what they represent to their interpreters.	SEDRIS Glossary, 29 Jun 1998, Houghton Mifflin Co., Webster's II, New College Dictionary, 1995
Simplification	Analytical technique in which unimportant details are removed in order to define simpler relationships.	Jake Borah Tutorial
Simuland	The system being simulated by a simulation. See referent, model, and simulation.	The Fidelity ISG Glossary
Simulation	The imitative representation of the functioning of one system or process by means of the functioning of another".	
Simulation	The implementation of a model over time.	Text
Simulation	1) A method, software framework or system for implementing one or more models in the proper order to determine how key properties of the original may change over time. See model, representation. 2) An unobtrusive scientific method of inquiry involving experiments with a model rather than with the portion of reality this model represents.	Report from the Fidelity Implementation Study Group
Simulation Conceptual Model	Conceptual model of or for a simulation.	
Simulation Engineering	Sub-discipline of engineering where models and simulations are the systems of interest.	
Simulation Executable Model	The model as it is actually implemented and exercised in the simulation.	

Term	DEFINITION or COMMENT	REFERENCE
Simulation Process	The imitative representation of the actions of platform(s), munition(s), and life form(s) by computer program(s) in accordance with a mathematical model and the generation of associated battlefield entities that may be fully automated or partially automated.	The Fidelity ISG Glossary
Simulation Space	The simulation artefact wherein simulation mission space representation is manifest.	
Sponsor	Person or organization that sees a need for modeling and simulation in the solving of a problem such as specifying an operation requirement or analyzing a capability.	Text
Sponsor Responsibility	Responsibilities of a sponsor role agent include: 1) Analysis of combat outcome, system performance, system alternative trade-offs, etc. 2) Cost-effective training. 3) Credibility of analysis results. 4) Making sure the Conceptual Model represents necessary and sufficient relevant information about operational issues and mission context of interest (correct scope). 5) Decision-making based on analysis products (introducing a new tactic, procuring a new system, etc.). 6) Cost of modeling and simulation.	
Stakeholder Community	Conceptual modeling will be conducted and its value recovered in a community or practice commensurate with the scope and diversity of the enterprise participants. Concepts invoked to develop, understand, share, and reuse conceptual model artifacts with confidence, and with reasonable expectation of accruing the benefits of shared investment require that all stakeholder roles be carefully defined and be appreciated as pertaining across the enterprise scope.	
Stakeholder(s)	People or organizational persons likely to be affected by a process or product.	
Standard	1) An accepted measure of comparison for quantitative or qualitative value; a criterion. 2) Proposition of a norm or general pattern to be followed when constructing, operating or testing a (technical) device. A standard contains a set of reference criteria for functional, structural, performance or quality aspects of a device or for any combination of these.	Houghton Mifflin Co., Webster's II, New College Dictionary, 1995
Standard(s)	10) a. (Originally *fig* from 9.) An authoritative or recognized exemplar of correctness, perfection, or some definite degree of any quality. b. A rule, principle, or means of judgement or estimation; a criterion, measure. 12) a. A definite degree of any quality, viewed as a prescribed object of endeavour or as the measure of what is adequate for some purpose.	OED
Stimulation	The use of simulations to provide an external stimulus to a system or sub-system (e.g., using a simulation representing the radar return from a target to drive (stimulate) the radar of a missile system within a hardware/ software-in-the-loop simulation).	The Fidelity ISG Glossary

Term	DEFINITION or COMMENT	REFERENCE
Subject-Matter Expert	Individual particularly well-informed or adept in one or another subject matter domain.	
Syntactic Expression	Facilitates enforcement of syntactic precision upon statements whose semantic-information content is left to the modeller agent.	Text
Syntax	The component of grammar that arranges words into phrases and sentences.	Steven Pinker
System of Interest	Set of fictive or existing systems, entities, phenomena, or processes subjected to modeling and simulation representation and which a user of the system wants to consider in the context of their own needs, objectives or interests.	
Tailorable	Attribute of an entity or process whereby it admits to being changed specifically in order to make it more suitably relevant or purposefully fit for some particular intended purpose or use.	
Task	A task is a description of a military activity, including the activity performer and the activity object(s). It may be decomposed into sub-tasks (recursively decomposable) or steps (atomic).	
Traceability	Every requirement statement can be referred to a corresponding need, constraint or policy statement.	
Traceability	The quality of being traceable; to follow the course, development, or history of. Also with the course, etc., as object. fit.	
Traceability	Left to conceptual model stakeholder practitioner with respect to selection, modification and interpretation of notational schemas.	Text
Unambiguity	The requirement is given a form that avoids misinterpretation.	
Universe of Stakeholders	All of the participants with an abiding interest (types or individuals) relevant to a specific use case or instance of investment management.	
Use Cases	A description of a system's behavior as it responds to a request that originates from outside of that system. The use case technique is used in software and systems engineering to capture the functional requirements of a system. Use cases describe the interaction between a primary Actor (the initiator of the interaction) and the system itself, represented as a sequence of simple steps. Actors are something or someone which exists outside the system under study, and that take part in a sequence of activities in a dialogue with the system to achieve some goal. They may be end users, other systems, or hardware devices. Each use case is a complete series of events, described from the point of view of the Actor. In this case the system is the simulation conceptual model.	http://en.wikipedia.org/wiki/Use_case
User	Role specification denoting individual or organization who will employ the subject (conceptual model) work-product for any of a variety of purposes within scope of the M&S enterprise.	
User-Needs	See User and Needs.	
Users' View	See User and View.	

Term	DEFINITION or COMMENT	REFERENCE
Utility	The "utility" of something is one factor that is taken into consideration when determining things of "value."	
Utility	Economist-speak for a good thing; a measure of satisfaction. Underlying most economic theory is the assumption that people do things because doing so gives them utility. Individuals strive to achieve as much utility as possible. However, the more they have the less difference an additional unit of utility will make – there is diminishing marginal utility. Utility is not the same as utilitarianism, a political philosophy based on achieving the greatest happiness of the greatest number.	
Utility	The (relative) importance of items in a class to an agent.	Choices: An Introduction to Decision Theory, Resnik, 1987
Utility	The state or quality of being useful militarily or operationally. Designed for or possessing a number of useful or practical purposes rather than a single, specialized one.	Glossary of Defense Acquisition Acronyms & Terms, Defense Acquisition University Press
Utility	Utility is the property of the relative satisfaction gained by the use of a system expressed in terms of a value and cost. It measures the kinds of purposes for which the conceptual model might provide value.	Text
Utility	Assesses the effectiveness and efficiency of the conceptual model in solving the problem statement.	Text
Utility Function	A representation of a consumer's preferences that maps potential and actual items and outcomes and the value preferences of a consumer or decision-maker.	
Utility Scales	A specified, graduated reference used to measure the value of an item or process to a decision-maker or user.	
V&V Agents	Role title for those responsible for managing verification and validation within an M&S enterprise environment.	
V&V Data Elements	The V&V process can produce an enormous amount of data. These data are collected under a label called V&V Data Elements and placed in the product "conceptual model Meta data". In the table below a list of data items is presented together with the Process Activities where that data is produced.	
Validation	The process of determining the degree to which a model or simulation is an accurate representation of the real world, or some other meaningful referent, from the perspective of the intended uses of the model or simulation.	The Fidelity ISG Glossary

Term	DEFINITION or COMMENT	REFERENCE
Validation	The purpose of the Validation Process is to provide objective evidence that the services provided by a system entity when in use comply with stakeholders' requirements.	
Validation of Conceptual Model	Process of validation applied to subject conceptual model. See validation and conceptual model.	
Validity	The property of a simulation model to have, within a specific experimental frame, a behavior which is indistinguishable under a set of validation criteria from the behavior of the System of Interest.	
Validity	Assesses the level of agreement of the conceptual model behavioral representation with that of the simuland.	Text
Validity	1) The quality of being inferred, deduced or calculated correctly enough to suit a specific application. 2) The quality of maintained data that is found on an adequate system of classification (e.g., data model) and is rigorous enough to compel acceptance for a specific use. 3) The logical truth of a derivation or statement, based on a given set of propositions.	Report from the Fidelity Implementation Study Group
Value	I.1.a. That amount of some commodity, medium of exchange, etc., which is considered to be an equivalent for something else. (See Cost)	OED
Verification	The purpose of the Verification Process is to confirm that the specified design requirements are fulfilled by the system entity.	
Verification	The process of determining that a model or simulation implementation accurately represents the developer's conceptual description and specification. Verification also evaluates the extent to which the model or simulation has been developed using sound and established software engineering techniques.	DoD, "M&S Master Plan", DoD 5000-59-P
View	Instance of a model kind with selected information.	
Views	Examples are class diagram, activity diagrams, swim lanes, state diagram, operational view, etc.	
Want	2) a. Deficiency, shortage or lack (of something, desirable or necessary, esp a quality or attribute). 5) a A condition marked by the lack of some necessary thing, or requiring some extraneous aid or addition; need; also, an instance of this, and so freq. *pl* (passing into the quasi- *concr*, sense' requirement'.	OED
Want	A 'want' or 'need' is related to the state of expectation or intention of one or another of the stakeholders. Individually or collectively, stakeholders may have anticipatory preferences for that which is produced as the conceptual model proper based on their intended use for it in context of their role within the enterprise. Wants and needs in this view are desiderata.	Text

Annex K – BIBLIOGRAPHY

The literature of conceptual modeling is hopelessly large and diffuse. This follows naturally from the diversity of the significance of the key terms, 'model' and 'concept'. Topical scope of references ranges from the entire philosophical field of ontology through conceptualization used for software, and most recently simulation. References address, primitive ideas, practices, and process, tools, and concrete results over a range of referent domains that is as large as the world itself. While the Task Group did feel the need to anchor its deliberations in firmly in the academic and practical literature of conceptual modeling and to provide relevant citations allowing the reader to connect the 'web of belief' at which the Task Group finally arrived with their own appreciation of the intellectual subject; we soon realized that a comprehensive bibliographic search and analysis would itself consume the entire resources of the study effort. Caught between the Scylla of academic grounding and the Chaybdis of finite resources; we have elected to cite those references that provided us genuine insight, represented most evocatively the 'world' of modeling and simulating in which we are embedded, or occasionally, provided background so influential and broadly relevant that it could be neglected only at the risk of depriving the reader of one or another of those canonical hooks upon which he might anchor his own evolving interpretation of the subject. The bibliographic references that follow, therefore, include all citations invoked by footnotes in the text as well as those collateral citations that seemed most likely to support the reader's understanding and appreciation of the subject document. We regret egregious omissions that will be apparent to any well-informed reader and plead necessity of economy as our only defence.

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Conceptual-modeling		

14. Abstract

The objectives of the Task Group (MSG-058) include: 1) Clarify the "Conceptual Model" concepts, discuss the terminology, and emphasize the utility to better formalize conceptual models; 2) Investigate methodologies, simulation and software engineering processes, initiatives and technologies useful for the establishment of conceptual models; 3) Identify the relevant stakeholders of conceptual models; 4) Address the needs of M&S community, identifying the way conceptual models may contribute to M&S development, and provide guidance to implementation; 5) Provide guidelines for standards in conceptual modeling for M&S; thereby specifying a conceptual model to be (re)usable by users with similar knowledge; 6) Draft a guidance document on conceptual models that can be used by different stakeholders; and 7) Foster the establishment of the guidance document as a SISO standard.

This document is intended to serve as best-practice prescriptive guidance for the life cycle management of conceptual modeling in support of modeling and simulation effort within the NATO M&S enterprise. Subsequently, the contents of this document are expected to serve as a basis of evolution of conceptual modeling throughout the international M&S community of practice by virtue of its influence upon further international standards.

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