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.

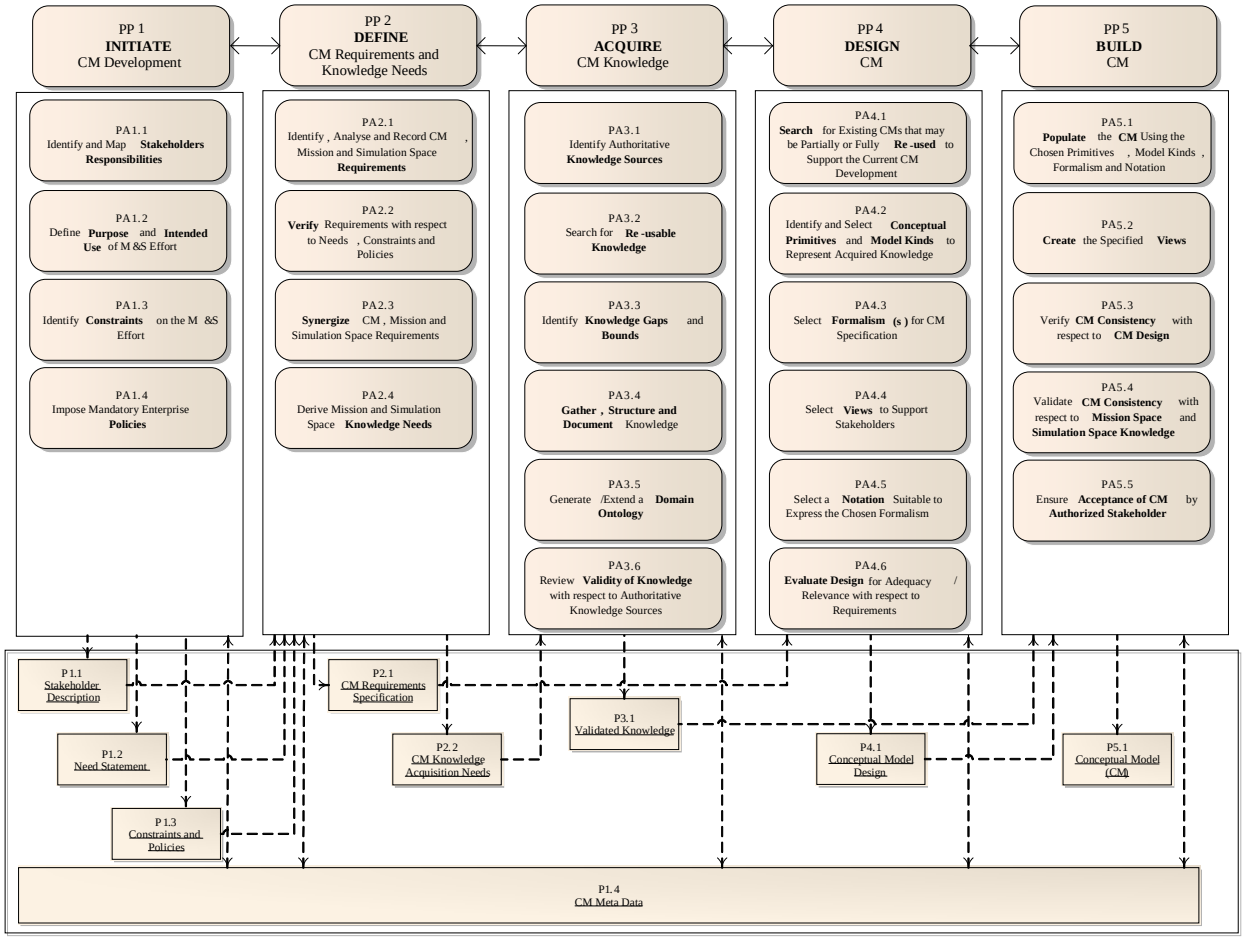

Figure 6-1: Conceptual Model Process and Product Relationships.

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.

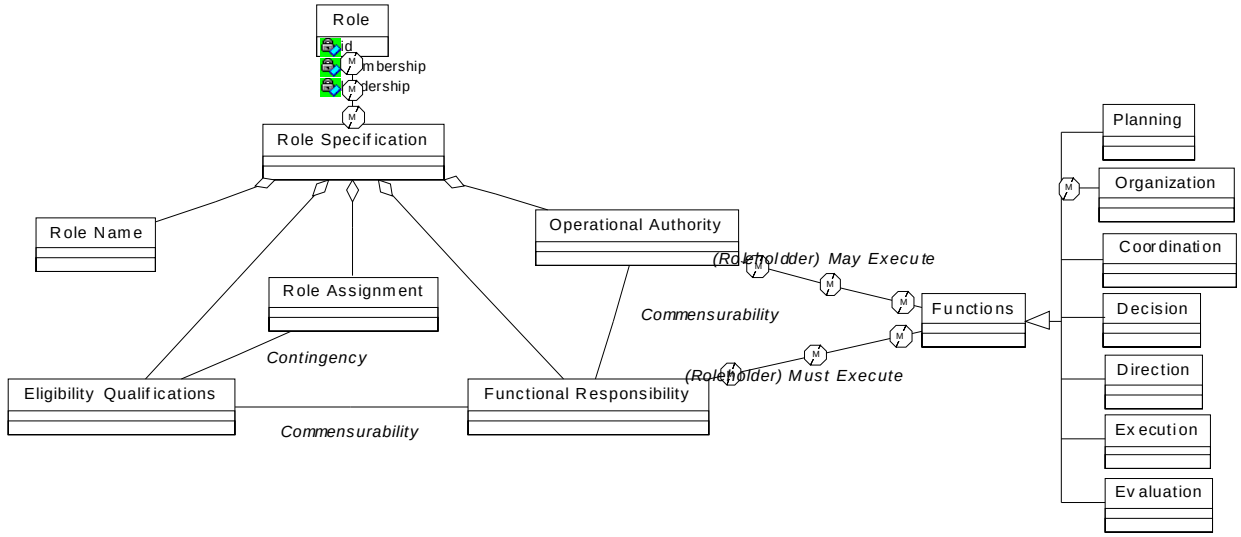

Figure 6-2: Components of a Role Specification and Relationships to Role Functions.

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.

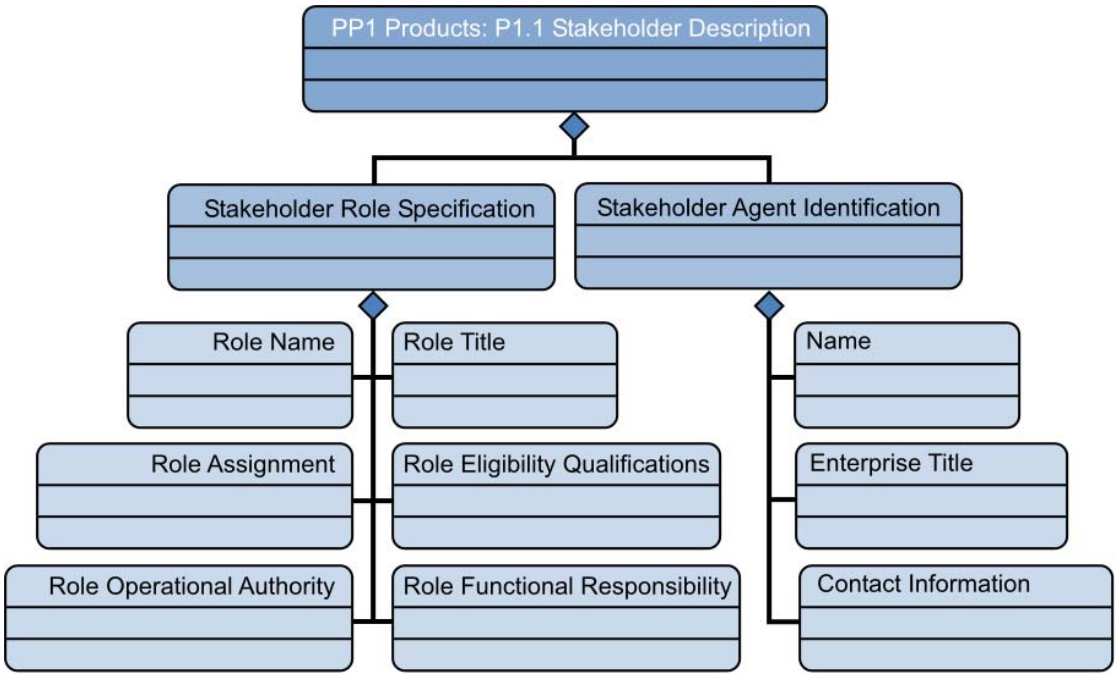

Figure 6-3: Suggested Role Specification and Stakeholder Role Assignment Information Taxonomy.

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.

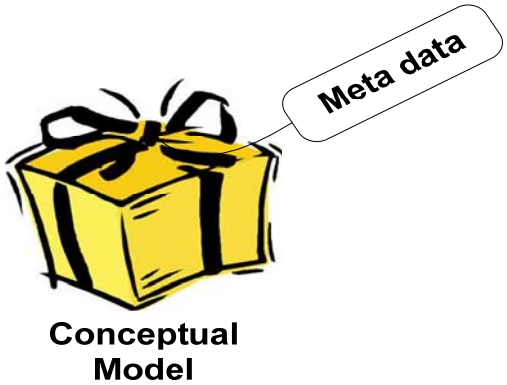

Figure 6-4: Conceptual Model Meta Data Must Always be Attached to the Conceptual Model.

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.

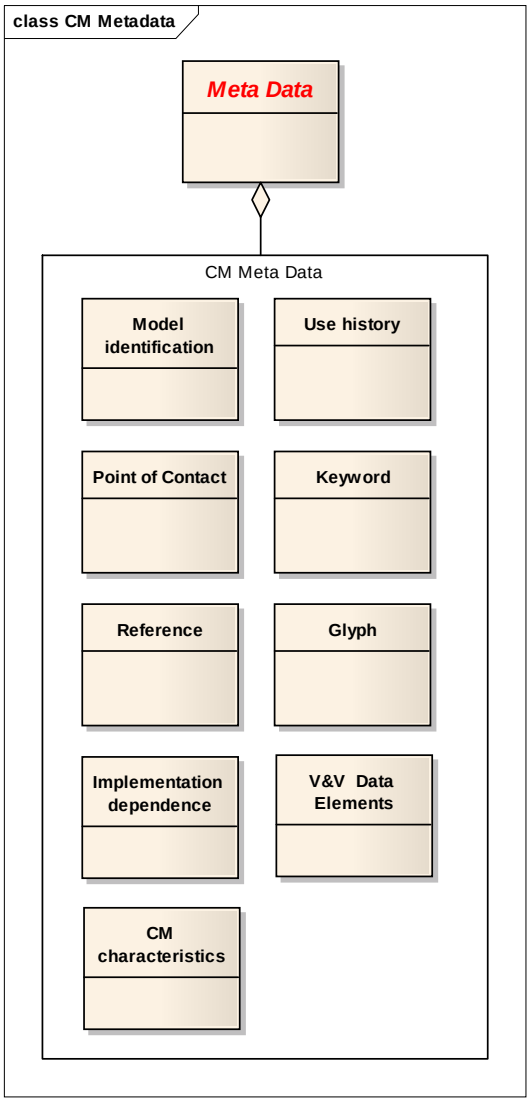

Figure 6-5: Conceptual Model Meta Data.

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.