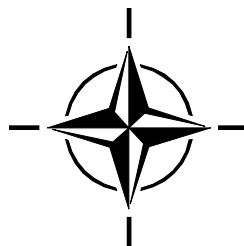AC/323(MSG-054)TP/418

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RTO TECHNICAL REPORT

TR-MSG-054

Risk-Based Tailoring of the Verification, Validation, and Accreditation/ Acceptance Processes

(Adaptation fondée sur le risque, des
processus de vérification, de validation,
et d'accréditation/d'acceptation)

This Report documents the findings of the Modelling and Simulation
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by

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USA

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.

Table of Contents

List of Figures/Tables

List of Acronyms

AGARD   Advisory Group for Aerospace Research and Development
AVT   Applied Vehicle Technology

CM   Composite Model

DRG   Defence Research Group

FEDEP   Federation Development and Execution Process

HFM   Human Factors and Medicine

IEEE-SA   Institute of Electrical and Electronics Engineers Standards Association
IST   Information Systems Technology
IT IS   Institut für Technik Intelligenter Systeme

M&S   Modeling & Simulation, model(s) and simulation(s)
MSG-019   Modelling & Simulation Group 019
MSG-054   Modelling & Simulation Group 054

NATO   North Atlantic Treaty Organisation
NMSG   NATO Modelling and Simulation Group

OWL   Web Ontology Language

PAR   Project Authorization Request
PDG   Product Development Group
PfP   Partners for Peace

R&T   Research and Technology
RBA   Risk-Based VV&A
RTA   Research and Technology Agency
RTB   Research Technology Board
RTO   Research and Technology Organisation

SAS   System Analysis and Studies
SCI   Systems Concepts and Integration
SET   Sensors and Electronics Technology
SISO   Simulation Interoperability Standards Organization
SIW   Simulation Interoperability Workshop
STANAG   Standardization Agreement

TG   Task Group
TG-016   Task Group 016
TG-037   Task Group 037

USA   United States of America

V&V   Verification and Validation
VV&A   Verification, Validation, and Accreditation

Definitions

Acceptability Criteria: A set of standards that a particular model or simulation and its associated data must meet to be acceptable for its intended use.

Acceptance: The decision to use the results produced by a model or simulation and its associated data for an intended use.

Activity: A set of tasks that consumes time and resources and whose performance is necessary for the execution of the VV&A processes.

Accreditation: The official certification that a model or simulation and its associated data are acceptable for use for a specific purpose.

Development Product: Any artifact of the M&S development or modification processes.

M&S Use Risk: The risk incurred by the application of M&S results and that is calculated as a function of M&S uncertainty, VV&A assessment uncertainty, and the importance of the M&S results based on the intended use.

Risk: A measure of the probability and severity of undesired effects often taken as the simple product of probability and consequence.

Validation: The process of determining the degree to which a model or simulation and its associated data are an accurate representation of the real world from the perspective of the intended uses of the model.

Verification: The process of determining that a model or simulation and its associated data accurately represent the developer's conceptual description and specifications.

History of Meetings and Significant Events

Year	Month	Meeting Location	Event
MSG-019/TG-016			
2000	September		MSG-019/TG-016 Opened
2006	September		MSG-019/TG-016 Closed
MSG-054/TG-037			
2006	March-May		First round of comment by SISO VV&A PDG
2006	August-September		Second round of comments by SISO VV&A PDG
2006	September	Orlando, FL, US	First Technical Activity Meeting held in conjunction with 2006 Fall SIW
2006	September		SISO Standards Activity Committee approved beginning IEEE balloting
2006	October		IEEE Project Authorization Request (PAR) submitted
2006	December		IEEE PAR approved by IEEE Standards Board
2007	April-May		IEEE Sponsor Ballot achieved consensus and was approved by the majority of balloters
2007	June-July		IEEE Recirculation Ballot completed
2007	September	Ottawa, Canada	Work on Composite Model
2007	September		IEEE 1516.4-2007^{TM} approved by IEEE Standards Board
2008	February	Washington, DC, US	Work on Composite Model
2008	April		TR-MSG-019 published
2008	June	Edinborough, UK	Held in conjunction with 2008 Euro-SIW
2008	September	Laurel, MD, US	Work on Composite Model
2008	December	Orlando, FL, US	Work on Composite Model
2009	March	San Diego, CA	Held in conjunction with 2009 Spring SIW, work on Composite Model
2009	September	Orlando, FL, US	Held in conjunction with 2009 Fall SIW, work on Composite Model
2009	December		Draft RTO-TR-MSG-054

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Risk-Based Tailoring of the Verification, Validation, and Accreditation/Acceptance Processes
(RTO-TR-MSG-054)

Executive Summary

In September 2006, the RTO approved the formation of MSG-054/TG-037, "An Overlay Standard for Verification, Validation, and Accreditation (VV&A) of Federations". This M&S Group was established to formalize the draft recommended practice previously produced by MSG-019 as an international industry standard by participating in vetting the document through the Simulation Interoperability Standards Organization's (SISO) and the Institute of Electrical and Electronics Engineers Standards Association's (IEEE-SA) standards processes. Additionally, the group was tasked to address the concept of VV&A tailoring and to provide sufficient guidance on the tailoring and practical implementation of the VV&A overlay.

MSG-054 worked in conjunction with the SISO VV&A Product Development Group (PDG) to adjudicate the comments from two rounds of review of the MSG-019 product and to revise the product to reflect the comments. On the recommendation of the SISO VV&A PDG, the IEEE-SA Standards Board approved the project "P1516.4 – Verification, Validation, and Accreditation of a Federation, an Overlay to the High Level Architecture Federation Development and Execution Process" on December 6, 2006. A balloting group was formed and formal balloting was conducted. As in the previous phase of the process, MSG-054 supported the adjudication of reviewer comments. As a result of MSG-054/TG-037 efforts, IEEE Std 1516.4™-2007 was approved by the IEEE-SA Standards Board in September 2007 and was published as an international industry standard in December 2007.

In addition to the establishment of the IEEE standard, MSG-054/TG-037 worked to develop the components of tailoring guidance. The resulting product, the Verification and Validation (V&V) Composite Model [see Appendix 1 which describes the components of the V&V processes (i.e., phases, activities, and tasks)] from which to select in order to match the risk and resource constraints of the V&V efforts while still adhering to relevant policies, standards, and guidance. The V&V Composite Model is a superset of the possible activities and the context in which those activities can be tailored into working V&V processes.

This report describes the accomplishments of MSG-054/TG-037.

Adaptation fondée sur le risque, des processus de vérification, de validation, et d'accréditation/d'acceptation
(RTO-TR-MSG-054)

Synthèse

En septembre 2006, la RTO a approuvé la création du MSG-054/TG-037, « Une norme Overlay pour la Vérification, la Validation, et l'Accréditation (VV&A) des Fédérations ». Ce groupe M&S a été mis en place pour formaliser le projet de technique recommandée fourni antérieurement par le MSG-019 comme norme industrielle internationale, en révisant ce document au travers du processus de normalisation de l'Organisation des Normes de Simulation pour l'Interopérabilité (SISO) et de l'Association des Normes de l'institut des Ingénieurs Electriciens et Electroniciens (IEEE-SA). Le groupe a également eu pour tâche de traiter le concept d'adaptation du VV&A et de fournir des directives suffisantes pour l'adaptation et la mise en œuvre pratique de l'overlay VV&A.

Le MSG-054 a travaillé en relation avec le Groupe de Développement de Produits (PDG) SISO VV&A pour se prononcer sur les observations issues des deux phases d'examen du produit MSG-019 et pour remanier le produit afin de prendre en compte ces observations. Sur recommandation du PDG SISO VV&A, la commission des normes de l'IEEE-SA a approuvé le projet « P1516.4 – Vérification, Validation, et Accréditation d'une Fédération, et d'un Overlay pour le processus de développement et d'exécution de la fédération d'architecture de haut niveau » le 6 décembre 2006. Un groupe de scrutateurs a été formé et un scrutin formel a été organisé. Comme pour la phase antérieure du processus, le MSG-054 a soutenu l'agrément des résultats des rapporteurs. A la suite des travaux du MSG-054/TG-037, la Norme IEEE 1516.4 ™-2007 a été approuvée par la commission des normes de l'IEEE-SA en septembre 2007 et a été publiée en tant que norme industrielle international en décembre 2007.

En complément à la mise en place d'une norme IEEE, le MSG-054/TG-037 a travaillé à développer les composantes des directives d'adaptation. Le produit résultant est le Modèle Composite de Vérification et de Validation (V&V) [voir l'Appendice 1 qui décrit les composants des processus V&V (par exemple, les phases, les activités, et les tâches)] à partir duquel sont opérés des choix pour faire face aux risques et aux contraintes de ressources des activités V&V tout en continuant à se conformer aux politiques, normes, et directives pertinentes. Le Modèle Composite V&V est un sur-ensemble d'activités possibles et aussi le contexte dans lequel ces activités peuvent être adaptées dans les processus de travail de V&V.

Ce rapport décrit les réalisations du MSG-054/TG-037.

RISK-BASED TAILORING OF THE VERIFICATION, VALIDATION, AND ACCREDITATION/ACCEPTANCE PROCESSES

1.0 INTRODUCTION

1.1 Background

The idea for an exploratory team on Verification, Validation, and Accreditation (VV&A) of federations was first proposed during the 5th North Atlantic Treaty Organisation (NATO) Modelling and Simulation Group meeting in July 2000. Initial discussions over the Internet and during a meeting in September 2000 by interested parties at the Defense Modeling and Simulation Office in the United States made clear that sufficient interest and substance existed for the formation of a NATO Task Group (TG) on the subject of federation VV&A.

MSG-019/TG-016 was established in 2001 and met several times through 2005 in both the United States and Europe. MSG-019 carefully analyzed IEEE Std 1516.3™-2003 [1][1] to identify where VV&A contributions were needed, but were undefined. The Task Group also developed an initial model of the VV&A process to ensure the development of consistent VV&A guidance for federations.

In January 2005, the Simulation Interoperability Standards Organization (SISO) established the Verification, Validation, and Accreditation Overlay to the Federation Development and Execution Process (FEDEP) Product Development Group (PDG) to produce a VV&A Overlay to IEEE 1516.3™. At the same time, MSG-019 also had determined the need for such a standard and began contributing to the development as part of the SISO VV&A Overlay PDG. MSG-019 ensured the standard under development would meet NATO/Partners for Peace (PfP) specific needs.

MSG-019 completed its objectives by producing a draft recommended practice for the VV&A of federations [2]. MSG-019 reported its activities in the Research and Technology Organisation (RTO) Technical Report, Verification, Validation, and Accreditation (VV&A) of Federations (TR-MSG-019) [3] and closed in September 2006. MSG-019 made these recommendations:

- NATO should adopt the draft recommended practice as an interim Standardization Agreement (STANAG) until the IEEE standard is issued and then revise the STANAG to adopt the IEEE standard.

- MSG-054 (the follow-on study group) should:
  - Participate in the IEEE Std 1516.4™-2007 [4] balloting process;
  - Monitor on-going VV&A case study initiative and incorporate suggested improvements to the Overlay during the balloting process; and
  - Study the relationship between user risk, acceptance criteria, and tailoring of the VV&A process.

- NATO should consider adopting similar collaborative relationships with international standards bodies as appropriate.

In September 2006, the RTO approved the formation of MSG-054/TG-037, "An Overlay Standard for Verification, Validation, and Accreditation (VV&A) of Federations", to formalize the draft recommended practice previously produced by MSG-019 as an international industry standard by participating in vetting the

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[1] A list of References may be found in Section 5.

document through SISO's and the Institute of Electrical and Electronics Engineers Standards Association's (IEEE-SA) standards processes. The specific tasking assigned to MSG-054/TG-037 is discussed next in Section 1.2.

1.2   Tasking

The Terms of Reference [5] for MSG-054/TG-037 identified these specific activities to be performed:

- Complete development of a canonical VV&A process started by MSG-019;

- Identify a set of terms needed to adequately describe the elements of that process and choose consistent definitions for those terms;

- Apply the canonical VV&A process to define the activities, tasks, activity inputs and activity products of the FEDEP VV&A Overlay;

- Participate in the review, comment and balloting efforts of the SISO VV&A Overlay PDG that will make the VV&A Overlay an IEEE standard;

- Address such special topics as basic concepts and VV&A tailoring and provide sufficient guidance in these areas to practically implement the VV&A overlay;

- Develop qualifications that guide application of the VV&A Overlay standard to NATO/PfP-specific initiatives;

- Develop the standard adoption and qualification guidance recommendations for a final Technical Report; and

- Finalize the Technical Report.

1.3   Task Group Membership

Nations participating in the MSG-054/TG-037 were Canada, France, Germany, the United Kingdom, and the United States. The United States representative served as the chairperson.

1.4   Scope of Effort

The MSG-019 product defined a comprehensive set of VV&A activities, tasks, and products that overlay the phases of the FEDEP. As expected in an overlay, the product adopted the fundamental principles associated with the parent document including the concept of tailoring. The FEDEP specifically stated that the development and execution process was meant to be tailored for a specific application. The concept of tailoring was extended to VV&A by including a high level discussion regarding tailoring and its impact on planning for and implementing VV&A.

During the balloting rounds, there were a significant number of comments that related to the defined tailoring section. Although there was general recognition of the critical nature of the tailoring function, several of the balloting comments identified the need for additional, detailed guidance on how and when to tailor the verification and validation processes. The SISO VV&A PDG Drafting Group intended that additional, more detailed guidance products would be developed to address key concepts such as tailoring. Tailoring VV&A to address a specific intended use is driven by the risk associated with the use of the federation results and resource constraints such as available information, budget, skills, and time. Quantifying risk and the tolerance for those risks are factors that drive tailoring decisions. Developing a tailoring approach is predicated on an understanding of the relationship and impacts of tailoring and risk.

Section 2 describes the results of the IEEE-SA standards process that resulted in an approved international industry standard. Section 3 describes the V&V Composite Model which was developed as guidance for tailoring VV&A processes.

2.0 IEEE STD 1516.4™-2007

The SISO VV&A PDG conducted the first round of review and comment of the MSG-019 product from March 31 to May 15, 2006, and a total of 214 comments were received. The SISO VV&A PDG Drafting Group and MSG-054/TG-037 met June 5-9, 2006 in Ottawa, Ontario, Canada, to review and finalize resolutions for non-editorial type comments. A SISO VV&A PDG teleconference was conducted on June 28, 2006 to vote on the resolutions of the comments. The vote was conducted in accordance with the PDG's voting rules. One comment that was unresolved during the teleconference was resolved via an electronic vote for which the polling feature of the SISO VV&A PDG discussion forum was used.

A second round of comments by the SISO VV&A PDG was conducted from August 4 to September 4, 2006. An additional non-editorial type 22 comments were addressed by the SISO VV&A PDG at its meeting on September 14, 2006 held in conjunction with the 2006 Fall Simulation Interoperability Workshop. As a result of voting conducted in accordance with the PDG's voting rules, two comments were withdrawn by the submitter and 20 resolutions were approved. The PDG also voted to recommend the SISO Standards Activity Committee approve the proposed standard for entry into the IEEE-SA standards process.

A Project Authorization Request was submitted to the IEEE-SA Standards Board to begin that organization's standards process. On December 6, 2006 the IEEE-SA Standards Board approved the project "P1516.4 – Verification, Validation, and Accreditation of a Federation, an Overlay to the High Level Architecture Federation Development and Execution Process." Both SISO and IEEE distributed messages announcing the project and inviting members to join the ballot pool in January 2007.

There were 55 individuals who joined the Sponsor Ballot that was conducted from April 17 through May 17, 2006. The Sponsor Ballot achieved a 93.6% (44/47 responders) approval rate. Table 1 summarizes how the votes were distributed according to the IEEE-SA classification codes.

Table 1: Sponsor Ballot Voter Summary.

Classification	Affirmative	Negative	Abstain	Unreturned	Total
Academic	5	0	0	0	5
General Interest	11	0	3	2	16
Government/Military	12	0	1	0	13
Producer	5	1	1	0	7
User	11	2	0	1	14
Totals	**44**	**3**	**5**	**3**	**55**

A total of 80 comments were received. All comments were addressed and negative comments were adjudicated directly with the submitter. A revised version of draft P1516.4 was produced and a message announcing the

recirculation ballot was distributed on June 26, 2007. The recirculation ballot ended on July 6, 2007 with no new comments received.

As a result of the recirculation ballot, one negative vote was changed to affirmative. The document achieved a 96% (45/47 respondents) affirmative vote. Table 2 summarizes the results of the recirculation ballot.

Table 2: Recirculation Ballot Voter Summary.

Classification	Affirmative	Negative	Abstain	Unreturned	Total
Academic	5	0	0	0	5
General Interest	11	0	3	2	16
Government/Military	12	0	1	0	13
Producer	5	1	1	0	7
User	12	1	0	1	14
Totals	**45**	**2**	**5**	**3**	**55**

As a result of MSG-054/TG-037 efforts, IEEE Std 1516.4™-2007 [4] was approved by the IEEE-SA Standards Board in September 2007 and was published as an international industry standard in December 2007.

3.0   DESCRIPTION OF V&V COMPOSITE MODEL

3.1   Approach to VV&A Tailoring

Enabling the tailoring of VV&A processes begins with describing the range of phases, activities, and tasks that possibly could be performed when implementing VV&A processes. The efforts of MSG-054/TG-037 resulted in the description of the phases, activities, and tasks for the Verification and Validation (V&V) processes only. The phases, activities, and tasks for the accreditation process were not completed as a result of these efforts.

The V&V Composite Model (see Appendix 1) describes the components of the processes (i.e., phases, activities, and tasks) from which to select to match the risk and resource constraints of the V&V efforts while still adhering to relevant policies, standards, and guidance. The V&V Composite Model is a superset of the possible activities and the context in which those activities can be tailored into working V&V processes.

Several assumptions underlie the construction of the V&V Composite Model:

- The V&V Composite Model is a general model representing V&V processes.
- The audience for the V&V Composite Model are stakeholders in the V&V processes.
- Accreditation refers to the process used to arrive at an acceptability decision based on an assessment of evidence collected by implementing V&V processes.
- Acceptability refers to the decision to apply an M&S for an intended use.
- Acceptability criteria adequately describe the M&S capabilities needed to support an intended use.

- The primary purpose for implementing V&V processes is to collect evidence to support applying M&S results for an intended use.

- Risk refers to the risk of using an M&S (i.e., use risk).

The paper included as Appendix 2, *"Decomposing the VV&A Processes to Support Their Tailoring"* (08S-SIW-066) was presented at the 2008 Spring Simulation Interoperability Workshop sponsored by the Simulation Interoperability Standards Organization in Providence, Rhode Island, USA, on April 14-18, 2008 [6]. Authored by the United States, the paper describes the components of the V&V Composite Model phases, activities, and tasks. Since 2008, the V&V Composite Model has been updated and revised, but the paper still serves as a good source of background information. Additionally, information from the paper was adapted for inclusion in Sections 3.2 and 3.3.

3.2   Components of Tailoring Guidance

Using risk as an effective tailoring mechanism for VV&A processes depends on understanding the factors that drive the risk as well as the VV&A activities and tasks that can and should be implemented to address the use risks. The V&V Composite Model (see Appendix 1) describes one perspective of the activities and tasks that constitute the V&V processes for M&S upon which to found risk-based VV&A tailoring.

The V&V Composite Model generalizes the guidance provided in IEEE Std 1516.4^{TM}-2007 [4] to apply to M&S beyond just federations, and extends that guidance to consider the broad range of possible sources of validation evidence. This model of the V&V processes defines the tasks that may be tailored to best suit the limits of acceptable use risk and optimize the resources available for VV&A.

As the complexity of the M&S and the associated V&V processes increase while budgets and schedules decrease, it is likely that not all V&V activities and tasks will be able to be performed. Additionally, when V&V is performed on legacy M&S, legacy developmental products may not be available to review, analyze, and test. To avoid becoming overwhelmed by the tasks described, to utilize resources efficiently, and to mitigate risk effectively, tailoring of the V&V processes is needed. Tailoring guidance helps determine the activities required for different V&V implementations.

Tailoring guidance is embedded within the descriptions of the activities in the V&V Composite Model. This guidance helps the V&V practitioner determine what tasks to omit and to understand the corresponding risk.

3.3   Overview of the V&V Composite Model

The V&V Composite Model comprises phases, activities, and tasks that decompose the general V&V processes. The highest levels are phases and there are eight phases in the V&V Composite Model:

- **PHASE 1: Plan the V&V Effort.** The V&V processes are planned to address the acceptability criteria (developed during planning for accreditation) and the requirements for using the M&S. The V&V practitioner executes and evolves the V&V Plan throughout the V&V effort. This includes monitoring the V&V effort and adjusting the V&V Plan to better reflect any new information gained while executing the V&V processes. The V&V Plan should be approved by the individual responsible for ensuring the V&V processes are implemented.

- **PHASE 2: Apply Relevant Historical Information.** When a legacy M&S is to be applied for the same or a similar intended use for which it has been previously accredited, considerable historical information

may exist upon which to base the new accreditation decision. In those instances, it is possible the entire V&V effort could focus upon the collection and analysis of historical information. When a legacy M&S is changed, when the simuland changes, or when the intended use changes, historical information may contribute to identifying the gaps in the additional V&V evidence that will be needed. Applying historical information begins by determining how closely the prior intended uses match the current intended use to determine what part of the history is relevant to the current problem. Historical information can come from prior V&V and testing activities, the records of prior uses, and the developer's accounts of the M&S capabilities and limitations. The V&V practitioner should analyze the relevant historical record to identify the factors that may constrain use. Then a coherent picture of the M&S capabilities and limitations based upon the historical evidence can be assembled. If results validation will be performed, the V&V practitioner can use the historical evidence to identify possible output sampling areas to improve its efficiency.

- **PHASE 3: Verify and Validate the Conceptual Model.** The conceptual model serves as a bridge between the requirements for developing an M&S and the M&S design, providing the developer's interpretation of the requirements. The conceptual model is the documented theoretical approach to the design of the M&S. The conceptual model describes what the M&S is expected to do, to be, and what data and other elements are needed for a successful outcome. The V&V practitioner begins by characterizing its coverage of the intended use and inferring the M&S capabilities from the information that the conceptual model contains. Conceptual model verification involves checking it for internal consistency problems. After that, the V&V practitioner can evaluate the conceptual model against the acceptability criteria to determine its validity. The objective of performing conceptual model validation is to demonstrate that the M&S functional elements accurately and completely represent the M&S requirements and to identify where assumptions, limitations, or architectural structure impact the intended M&S use. If available, the V&V practitioner should also verify and, if needed, validate the use scenarios.

- **PHASE 4: Perform Supplemental Verification.** How much the V&V practitioner contributes to development product verification depends largely upon the verification activities performed and documented by the developer of the M&S. The V&V practitioner begins the supplemental verification by collecting the developer's development products and determining how much additional verification is needed to achieve the desired confidence. The types of verification tasks that can be performed depend largely upon the development products available. The verification and validation activities performed and documented by the developer against the requirements for building the M&S can be used to support the M&S validation activities performed by the V&V practitioner. The V&V practitioner should leverage as much of the developer's verification and validation evidence as possible and only perform what supplemental verification is needed to increase the confidence in and bolster the validation evidence.

- **PHASE 5: Apply The Verification Products to Validation.** During this phase, the V&V practitioner applies the collected verification information to develop evidence on the M&S validity, adds to the information to support the accreditation recommendations, estimates the coverage and uncertainties in the development product verification evidence, and employs the verification evidence to identify factors that may constrain use and candidate output sampling areas.

- **PHASE 6: Verify and Validate the Data and Knowledge Sets.** V&V is performed on both the M&S and data used by the M&S. This phase focuses upon the data used to build the M&S, the data used as input into the M&S, and the data output by the M&S. Data and knowledge sets are distinguished by definition. Knowledge is a class of data that incorporates a knowledge representation scheme

(e.g., production rules, semantic network), while data are representations of facts, concepts, or instructions in a formalized manner suitable for communication, interpretation, or processing by humans or by automatic means. Data and knowledge set V&V should be performed because of their independence from the M&S and because the M&S relies upon those sets to produce its output. The phase begins by identifying their sources and the pedigrees of those sources because in many cases the organizations responsible for producing the data differ from the organizations that either develop or use the M&S. The credibility of those data-producing organizations often weighs heavily in determining the credibility of the data itself. After establishing the pedigrees of the data and knowledge, the V&V practitioner should verify the internal consistency of the data sets; verify any transformations used to make the data accessible and meaningful to the M&S (e.g., units transformations, coordinate transformations) then validate the completeness and correctness of the data sets against the acceptability criteria. The data validation information can then be used to identify output sampling guidance and factors that may constrain M&S use.

- **PHASE 7: Validate the M&S Results.** During this phase, the V&V practitioner reviews, analyzes, and tests the M&S. Tests are run to produce output; the output is analyzed to determine capabilities; and the capabilities are reviewed against the acceptability criteria to infer validity. The V&V practitioner uses the developer's test results to tailor the results validation effort, if those results are available. Design of experiments techniques are applied to build the test cases used to sample the M&S output. The V&V practitioner executes the test cases, collects the output, analyzes the output, and documents an integrated description of the M&S capabilities and limitations from the collected V&V evidence.

- **PHASE 8: Integrate the V&V Evidence.** The preceding phases produce the evidence that this phase integrates into a description of the M&S validity to support the accreditation recommendations. The V&V practitioner examines the evidence produced by the preceding activities, forms a consistent picture of the M&S validity and estimates the confidence in that determination. The V&V practitioner identifies the factors that may constrain use and combines those constraints with the assessments of the M&S completeness and correctness for the intended use. Then, the V&V practitioner assembles the results of this integration with the evidence produced by the prior V&V activities into the V&V Report. The information in the V&V Report should present the evidence upon which an accreditation assessment can be made to base the accreditation recommendations. This phase may include any post-execution follow-up and archival activities.

Figure 1 identifies the activities that compose each of the eight phases. Each activity includes a description, as well as possible tailoring guidance, notes, and assumptions. Each activity is decomposed into tasks. Each task includes a description, information required to perform the task, the source of that information, and the information produced by the task. The V&V Composite Model assumes that once a product is created, it is available for all subsequent activities; even though the product might not be identified as information that is required to perform the task.
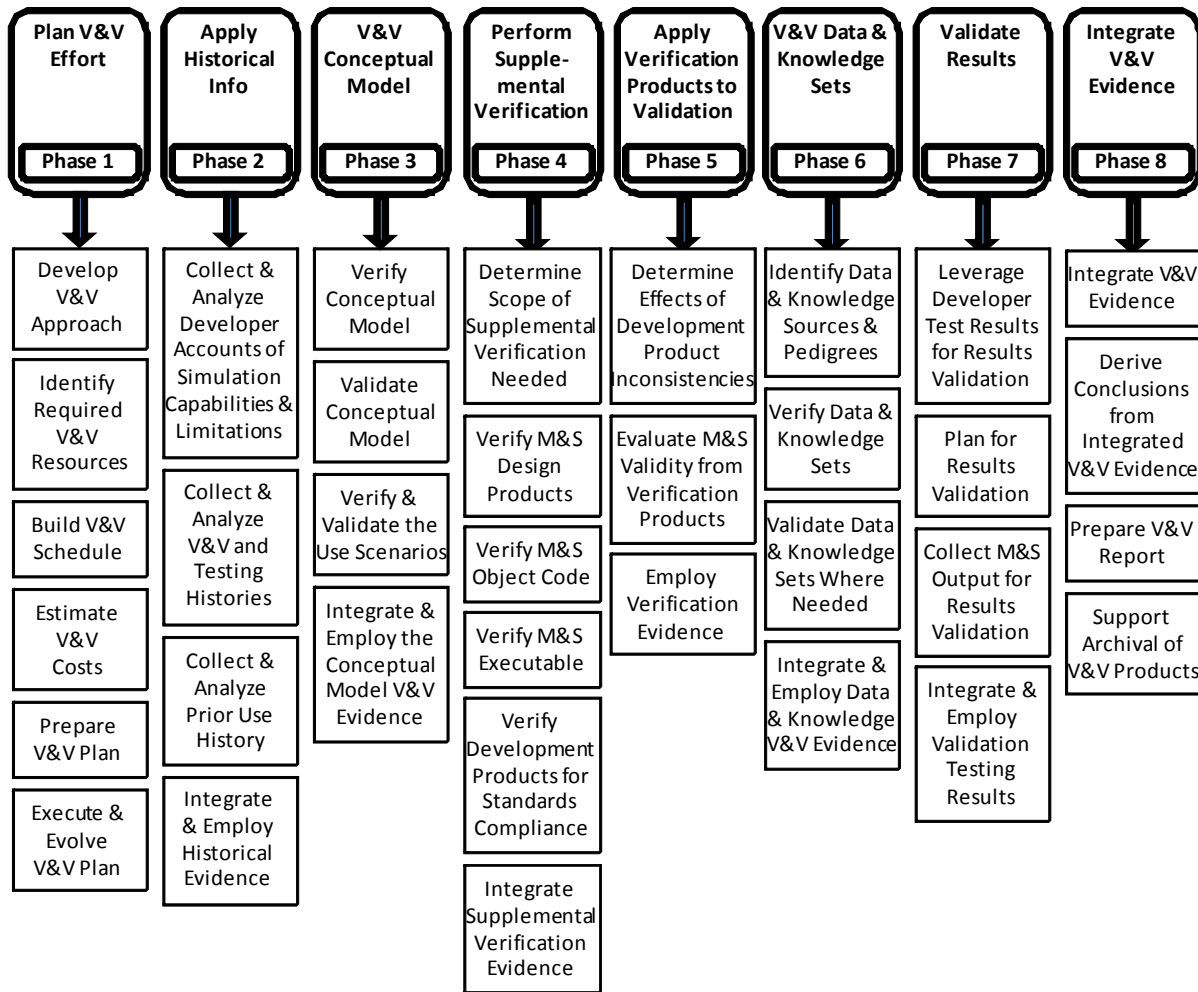
Plan V&V Effort	Apply Historical Info	V&V Conceptual Model	Perform Supplemental Verification	Apply Verification Products to Validation	V&V Data & Knowledge Sets	Validate Results	Integrate V&V Evidence
Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	Phase 7	Phase 8

Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	Phase 7	Phase 8
Develop V&V Approach	Collect & Analyze Developer Accounts of Simulation Capabilities & Limitations	Verify Conceptual Model	Determine Scope of Supplemental Verification Needed	Determine Effects of Development Product Inconsistencies	Identify Data & Knowledge Sources & Pedigrees	Leverage Developer Test Results for Results Validation	Integrate V&V Evidence
Identify Required V&V Resources		Validate Conceptual Model	Verify M&S Design Products	Evaluate M&S Validity from Verification Products	Verify Data & Knowledge Sets	Plan for Results Validation	Derive Conclusions from Integrated V&V Evidence
Build V&V Schedule	Collect & Analyze V&V and Testing Histories	Verify & Validate the Use Scenarios	Verify M&S Object Code	Employ Verification Evidence	Validate Data & Knowledge Sets Where Needed	Collect M&S Output for Results Validation	Prepare V&V Report
Estimate V&V Costs	Collect & Analyze Prior Use History	Integrate & Employ the Conceptual Model V&V Evidence	Verify M&S Executable		Integrate & Employ Data & Knowledge V&V Evidence	Integrate & Employ Validation Testing Results	Support Archival of V&V Products
Prepare V&V Plan	Integrate & Employ Historical Evidence		Verify Development Products for Standards Compliance				
Execute & Evolve V&V Plan			Integrate Supplemental Verification Evidence				

Figure 1: Activities Associated with Each V&V Composite Model Phase.

Although many of the activities and tasks in Figure 1 might appear sequential, the intention is not to restrict the implementation to any specific approach (e.g., waterfall, spiral, evolutionary). Rather, the diagram is meant to highlight the general activities from which V&V processes can be tailored to meet the needs of the M&S application based upon the intended use.

3.4   Verification of the V&V Composite Model

The Web Ontology Language (OWL) [7] was used to create a partial ontological implementation of the Risk-based VV&A methodology structure to verify its composition and relationships. In the future, a complete ontological implementation could serve as a tool to promote coherent tailoring, to generate reliable documentation, and to facilitate future methodology upgrades. A few detailed examples were implemented using OWL to demonstrate the basic implementation principles; however the RBA methodology is not yet finalized, and neither are the details of the relationships of the individual activities and tasks. The MSG-054 German representative developed a paper that describes the results of this effort (Appendix 3).

Three conclusions were reached based on the work thus far to verify the V&V Composite Model:

1) The implementation of the RBA methodology as an OWL ontology is feasible without making any compromise and appears to promise a greater flexibility and upgradeability than more conventional approaches while preserving the fundamental advantages of the RBA methodology.

2) It will allow, with some additional work, a seamless integration in comprehensive ontology-based modeling and simulation tool platforms.

3) Ontological tools implementing reasoning mechanisms potentially can track tailoring effects throughout the RBA sequence of activities and tasks; additional work might reveal whether sufficient quality assurance guarantees can be provided in this manner for deeper, more customized tailoring approaches. Further work might also consider using such tools to visualize tailoring effects in a user friendly manner in order to facilitate tailoring decisions and to explore the relationships between risk constellations and the tailoring strategies most appropriate for them.

4.0 CONCLUSIONS AND RECOMMENDATIONS

MSG-054/TG-037 succeeded in its task to institutionalize VV&A processes overlaid upon the federation development and execution process with the publication of IEEE Std 1516.4[TM]-2007 [4] in December 2007. As an international commercial standard, IEEE Std 1516.4[TM]-2007 is available for application by government, industry, and academia worldwide.

IEEE Std 1516.4[TM]-2007 focused on VV&A processes for federations and purposely did not address the VV&A processes associated with the individual federates (e.g., federation managers, data collectors, live systems, M&S, viewers, etc.). Because information from the VV&A processes conducted on federates is used by the federation, it is important that the federate level information be complete, credible, and accessible. Therefore, MSG-054/TG-037 leveraged the IEEE Std 1516.4[TM]-2007 concepts to develop a composite model of the V&V processes that could be applied to federation and federate level M&S, as well as to M&S that were not distributed. MSG-054/TG-037 accomplishments further extended to the development of guidance for tailoring the VV&A processes.

MSG-054/TG-037 was successful in producing a draft composite model of the V&V processes but was unable to complete work on the accreditation/acceptance processes due to the availability of resources to the various members. Additionally, while the members of MSG-054/TG-037 were able conduct some level of vetting of the V&V Composite Model within their national M&S communities, the model would benefit from more extensive vetting.

MSG-054/TG-037 leveraged NATO STANAG 4603 [8] and IEEE Std 1516.3™-2003 [1] in the development of IEEE Std 1516.4™-2007 [4] and the V&V Composite Model. The group found that leveraging established standards ensured consistency and understanding of basic VV&A concepts across products.

MSG-054/TG-037 feels it made progress in providing detailed descriptions of how to conduct V&V processes, but the work is not complete.

Based on these conclusions, MSG-054/TG-037 makes the following recommendations:

• NATO should process and ratify IEEE Std 1516.4[TM]-2007, *IEEE Recommended Practice for Verification, Validation, and Accreditation of a Federation – An Overlay to the High Level Architecture Federation Development and Execution Process,* as a NATO Standardization Agreement.

- NATO should continue the decompose the accreditation/acceptance aspects of the V&V Composite Model necessary to evolve it into a complete VV&A Composite model. Enhancements include:

  - Update the V&V activities and tasks by including more information in Activity Tailoring Guidance, Activity Notes, and Activity Assumptions.
  - Incorporate accreditation/acceptance activities and tasks.
  - Revise based on comments received from reviews.
  - Add phase descriptions.
  - Map the completed VV&A Composite Model to IEEE Std 1516.4^{TM}-2007.

- Member Nations should each to continue vetting the composite model within their M&S communities.

- NATO should complete the effort to create an ontological implementation of the completed VV&A Composite Model to verify its consistency, completeness, and correctness.

- NATO should continue participation in the Simulation Interoperability Standards Organization and lead the effort to process the VV&A Composite Model as a standard once it is completed and fully vetted.

5.0   REFERENCES

[1]   IEEE Std 1516.3™-2003, IEEE Recommended Practice for High Level Architecture (HLA) Federation Development and Execution Process (FEDEP), 2003.

[2]   Simulation Interoperability Standards Organization and MSG-019/TG-016. Recommended Practice for Verification, Validation, and Accreditation of a Federation, an Overlay to the High Level Architecture Federation Development and Execution Process, Draft, October 2006.

[3]   North Atlantic Treaty Organisation for Defence Research and Technology Organization, RTO Technical Report TR-MSG-019, Verification, Validation, and Accreditation (VV&A) of Federations, Copyright © RTO/NATO 2008, April 2008.

[4]   IEEE Std 1516.4™-2007, IEEE Recommended Practice for Verification, Validation, and Accreditation of a Federation – An Overlay to the High Level Architecture Federation Development and Execution Process, December 2007.

[5]   Terms of Reference RTG On An Overlay Standard for Verification, Validation, and Accreditation (VV&A) of Federations, MSG-054, TG-037, March 2006.

[6]   Harmon, S.Y. and Youngblood, S., "Decomposing the VV&A Processes to Support their Tailoring", Paper 08S-SIW-066 in the Proceedings of the 2008 Spring Simulation Interoperability Workshop, Simulation Interoperability Standards Organization, Providence, Rhode Island, April 14-18, 2008.

[7]   W3C: OWL Web Ontology Language, http://www.w3.org/TR/owl-ref/ – 10.02.2004.

[8]   North Atlantic Treaty Organisation Standardization Agreement 4603 (Edition 1), Modeling and Simulation Architecture Standards for Technical Interoperability: High Level Architecture (HLA), 2 July 2008.

Appendix 1 – VERIFICATION AND VALIDATION (V&V) COMPOSITE MODEL

TABLE OF CONTENTS

#	Title
PHASE 7	**VALIDATE THE M&S RESULTS**
Activity 7.1	Leverage the Developer Test Results for Results Validation
Activity 7.2	Plan for Results Validation
Activity 7.3	Collect M&S Output for Results Validation
Activity 7.4	Integrate and Employ the Validation Testing Results
PHASE 8	**INTEGRATE THE V&V EVIDENCE**
Activity 8.1	Integrate the V&V Evidence
Activity 8.2	Derive the Conclusions from the Integrated V&V Evidence
Activity 8.3	Prepare the V&V Report
Activity 8.4	Support Any Archival of the V&V Products

A1.1   COMPOSITE MODEL OVERVIEW

The Composite Model defines the superset of V&V activities from which a V&V Plan would be tailored. Each activity in the Composite Model is described in a consistent format. This format includes:

- The activity description;

- Tailoring guidance associated with the activity;

- Notes related that add clarification to the purpose or implementation of the activity;

- Assumptions that underlie the implementation of the activity; and

- Descriptions of the tasks to be performed:

    - Descriptions of the information required to perform each task; and

    - Descriptions of the information produced by each task.

Instances where tailoring guidance, notes or assumptions are not defined for a specific activity are denoted by (Blank).

A1.2   PHASE 1 – PLAN THE V&V EFFORT

Activity 1.1 – Develop the V&V Approach

Activity Description: This activity selects the specific activities and tasks that will be performed as part of the V&V approach. It also identifies the techniques and tools needed to accomplish the selected V&V tasks. Together, these elements define the V&V approach form which the rest of the V&V Plan is constructed.

Activity Tailoring Guidance: (Blank)

Activity Notes: The term "complexity" is used here, in the most general sense, as a measure of the difficulty of a task. These tasks do not include any iteration either within this activity or between the other V&V Planning activities.

Activity Assumptions: Guidance exists to aid the selection of V&V tasks and techniques and needs prioritization.

Task Descriptions:

1.1.1   Obtain the Acceptability Criteria Report and Accreditation Plan, if available.

Information Required:
- Accreditation Plan; Acceptability Criteria Report (Source: Preceding accreditation activity)

Information Produced:
- Accreditation Plan; Acceptability Criteria Report are forwarded to follow-on activities

1.1.2   Obtain the M&S requirements.

Information Required:
- M&S requirements (Source: User)

Information Produced:
- M&S requirements are forwarded to follow-on activities

1.1.3   Obtain a description of the M&S.

Information Required:
- M&S description (Source: Developer)

Information Produced:
- M&S description are forwarded to follow-on activities

1.1.4   Analyze the M&S requirements, accreditation information requirements and M&S description to develop the scope statement for the V&V effort.

Information Required:
- M&S requirements (Source: Task 1.1.2)
- M&S description (Source: Task 1.1.3)
- Accreditation information requirements (Source: preceding accreditation activity)

Information Produced:
- V&V effort scope statement

1.1.5   Analyze the Acceptability Criteria Report or the M&S Requirements and M&S description to determine the acceptability criteria that define the required functionality.

Information Required:
- Acceptability Criteria Report or M&S requirements (Source: Task 1.1.1 or 1.1.2)
- M&S description (Source: Task 1.1.3)

Information Produced:
- Acceptability criteria defining needed functionality

1.1.6   Analyze the Acceptability Criteria Report or the M&S Requirements and M&S description to determine the acceptability criteria that define the required quality.

Information Required:
- Acceptability Criteria Report or M&S Requirements (Source: Task 1.1.1 or 1.1.2)
- M&S description (Source: Task 1.1.3)

Information Produced:
- Acceptability criteria defining needed quality

1.1.7   Analyze the Accreditation Plan, the acceptability criteria and any VV&A task selection guidance to determine the V&V activities and tasks that could be performed.

Information Required:
- Accreditation Plan (Source: Preceding accreditation activity)
- Acceptability criteria defining needed functionality (Source: Task 1.1.5)
- Acceptability criteria defining needed quality (Source: Task 1.1.6)
- VV&A task selection guidance (Source: Open literature)

Information Produced:
- Candidate V&V activities and tasks

1.1.8   Analyze the acceptability criteria, the Accreditation Plan and the needs prioritization guidance to assign the needs priorities to the acceptability criteria.

Information Required:
- Accreditation Plan (Source: Preceding accreditation activity)
- Acceptability criteria defining needed functionality (Source: Task 1.1.5)
- Acceptability criteria defining needed quality (Source: Task 1.1.6)
- Needs prioritization guidance (Source: Open literature)

Information Produced:
- Assigned acceptability criteria priorities

1.1.9   Analyze the candidate V&V activities and tasks, the level of technique rigor required, the acceptability criteria and any VV&A technique selection guidance to select the V&V techniques that could be applied.

Information Required
- Candidate V&V activities and tasks (Source: Task 1.1.7)
- Assigned acceptability criteria priorities (Source: Task 1.1.8)
- Acceptability criteria defining needed functionality (Source: Task 1.1.5)
- Acceptability criteria defining needed quality (Source: Task 1.1.6)
- VV&A technique selection guidance (Source: Open literature)

Information Produced:
- Candidate V&V techniques

1.1.10   Analyze the candidate V&V techniques to identify the tools needed to support the application of those techniques.

Information Required:
- Candidate V&V techniques (Source: Task 1.1.9)

Information Produced:
- Candidate tools needed to support V&V

1.1.11   Analyze the Accreditation Plan, the acceptability criteria and aspects of the V&V approach to estimate the complexity of each of the V&V tasks to be performed.

Information Required:
- Accreditation Plan (Source: Preceding accreditation activity)
- Acceptability criteria defining needed functionality (Source: Task 1.1.5)
- Acceptability criteria defining needed quality (Source: Task 1.1.6)
- Candidate V&V activities and tasks (Source: Task 1.1.7)
- Candidate V&V techniques (Source: Task 1.1.9)
- Candidate tools needed to support V&V (Source: Task 1.1.10)

Information Produced:
- Estimated complexity of each of the V&V tasks to be performed

1.1.12   Assemble the candidate V&V tasks, techniques, tools and estimated complexity into a description of the V&V approach.

Information Required:
- Candidate V&V activities and tasks (Source: Task 1.1.7)
- Candidate V&V techniques (Source: Task 1.1.9)
- Candidate tools needed to support V&V (Source: Task 1.1.10)
- Estimated complexity of each of the V&V tasks to be performed (Source: 1.1.11)

Information Produced
- Description of the V&V approach

Activity 1.2 – Identify the Required V&V Resources

Activity Description: This activity identifies the candidate personnel resources needed to perform the V&V activities. These candidates are selected from the skills required to perform the V&V tasks and the personnel that are available to the V&V effort.

Activity Tailoring Guidance: (Blank)

Activity Notes:
- These tasks do not include any iteration either within this activity or between the other V&V Planning activities; and
- The term "labor estimate" refers to the number of hours required.

Activity Assumptions: The Sponsor can provide a list of the available candidate V&V personnel. If the Sponsor does not provide that information then the V&V practitioner may need to identify those personnel.

Task Descriptions:

1.2.1   Analyze the V&V approach to determine the skills required to perform each of the tasks.

        Information Required:
- V&V approach (Source: Activity 1.1)

        Information Produced:
- Skills required for each V&V task to be performed

1.2.2   Obtain a list of the available candidate V&V personnel using the skills required for each V&V task to be performed.

        Information Required:
- List of the available candidate V&V personnel (Source: Sponsor)
- Skills required for each V&V task to be performed (Source: Task 1.2.1)

        Information Produced:
- List of the available candidate V&V personnel are forwarded to follow-on activities

1.2.3   Analyze the V&V approach and the skills required for each V&V task to be performed to estimate the amount of labor required to perform each task for each skill.

        Information Required:
- V&V approach (Source: Activity 1.1)
- Skills required for each V&V task to be performed (Source: Task 1.2.1)

        Information Produced:
- Labor estimate for each task and skill

1.2.4   Analyze the V&V approach, the list of available candidate V&V personnel and the labor estimate for each task and skill to identify candidate personnel to perform each of the V&V tasks.

Information Required:
- V&V approach (Source: Activity 1.1)
- List of the available candidate V&V personnel (Source: Task 1.2.2)
- Labor estimate for each task and skill (Source: Task 1.2.3)

Information Produced:
- Candidate personnel to perform each of the V&V tasks

1.2.5   Analyze the labor estimate for each task and skill and the candidate personnel to perform each of the V&V tasks to map the labor required onto each candidate.

Information Required:
- Labor estimate for each task and skill (Source: Task 1.2.3)
- Candidate personnel to perform each of the V&V tasks (Source: Task 1.2.4)

Information Produced:
- Labor required from each candidate person

1.2.6   Assemble the skills required, available candidate personnel, labor estimates, candidate personnel task assignments and labor from each candidate into the required V&V resources.

Information Required:
- Skills required for each V&V task to be performed (Source: Task 1.2.1)
- List of the available candidate V&V personnel (Source: Task 1.2.2)
- Labor estimate for each task and skill (Source: Task 1.2.3)
- Candidate personnel to perform each of the V&V tasks (Source: Task 1.2.4)
- Labor required from each candidate person (Source: Task 1.2.5)

Information Produced:
- Required V&V resources

Activity 1.3 – Build the V&V Schedule

Activity Description: This activity produces a schedule for the V&V effort that aligns with the accreditation schedule and, ultimately, the project schedule.

Activity Tailoring Guidance: (Blank)

Activity Notes:
- This set of tasks implicitly assumes that the schedule can determine the costs rather than vice versa.
- These tasks do not include any iteration either within this activity or between the other V&V Planning activities.
- The Sponsor can provide a schedule of the availability of the candidate V&V personnel. If the Sponsor cannot provide that information then the V&V practitioner may need to obtain it.

Activity Assumptions: The accreditation plan describes the programmatic scheduling constraints (in the accreditation activities).

Task Descriptions:

1.3.1   Obtain the availability schedule of the candidate V&V personnel using the required V&V resources.

Information Required:
- Candidate V&V personnel availability schedule (Source: Sponsor)
- Required V&V resources (Source: Activity 1.2)

Information Produced:
- Candidate V&V personnel availability schedule is forwarded to follow-on activities

1.3.2   Analyze the V&V approach to determine the task dependencies.

Information Required:
- V&V approach (Source: Activity 1.1)

Information Produced:
- V&V task dependencies

1.3.3   Analyze the V&V approach and the V&V task dependencies to determine the V&V task sequencing.

Information Required:
- V&V approach (Source: Activity 1.1)
- V&V task dependencies (Source: Task 1.3.2)

Information Produced:
- V&V task sequencing

1.3.4   Analyze the Accreditation Plan, the candidate V&V personnel availability schedule and the V&V task sequencing to determine the V&V schedule.

Information Required:
- Accreditation Plan (Source: Preceding accreditation activity)
- Candidate V&V personnel availability schedule (Source: Task 1.3.1)
- V&V task sequencing (Source: Task 1.3.3)

Information Produced:
- V&V effort schedule

Activity 1.4 – Estimate the V&V Costs

Activity Description: This activity produces estimates of the costs of performing V&V. These costs include components for labor, travel and costs other than labor and travel (e.g., to purchase tools or hardware).

Activity Tailoring Guidance: (Blank)

Activity Notes: These tasks do not include any iteration either within this activity or between the other V&V Planning activities.

Activity Assumptions: (Blank)

Task Descriptions:

1.4.1   Analyze the V&V approach and the required V&V resources to estimate the labor costs for each V&V task.

Information Required:
*   V&V approach (Source: Activity 1.1)
*   Required V&V resources (Source: Activity 1.2)

Information Produced:
*   Estimated labor costs for each V&V task

1.4.2   Analyze the V&V approach and the required V&V resources to estimate the possible travel required to perform V&V and their costs.

Information Required:
*   V&V approach (Source: Activity 1.1)
*   Required V&V resources (Source: Activity 1.2)

Information Produced:
*   Estimated V&V travel requirements and costs

1.4.3   Analyze the estimated labor costs for each V&V task and the estimated V&V travel requirements and costs to estimate the costs other than labor and travel required to perform V&V.

Information Required:
*   Estimated labor costs for each V&V task (Source: Task 1.4.1)
*   Estimated V&V travel requirements and costs (Source: Task 1.4.2)

Information Produced:
*   Estimated V&V costs other than labor and travel

1.4.4   Analyze the V&V approach, the estimated labor costs for each V&V task, the estimated V&V travel requirements and costs and the estimated V&V costs other than labor and travel to estimate a total cost of the V&V effort.

Information Required:
*   V&V approach (Source: Activity 1.1)
*   Estimated labor costs for each V&V task (Source: Task 1.4.1)
*   Estimated V&V travel requirements and costs (Source: Task 31.4.2)
*   Estimated V&V costs other than labor and travel (Source: Task 1.4.3)

Information Produced:
*   Estimated V&V effort cost

Activity 1.5 – Prepare the V&V Plan

Activity Description: This activity assembles the components produced by the previous activities into the V&V Plan, circulates that plan to interested parties, and responds to the comments from those parties with modifications to the plan.

Activity Tailoring Guidance: (Blank)

Activity Notes:
- Iteration between the various parts of plan preparation can be coordinated within this activity; and
- Modifying the plan may require revisiting any of the preceding V&V Planning activities.

Activity Assumptions: (Blank)

Task Descriptions:

1.5.1 Construct the initial requirements traceability matrix.

 Information Required
- M&S requirements (Source: Activity 1.1)
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)

 Information Produced:
- Initial requirements traceability matrix

1.5.2 Prepare citations of the information used for V&V Planning.

 Information Required:
- Accreditation Plan (Source: Activity 1.1)
- Acceptability Criteria Report (Source: Activity 1.1)
- M&S requirements (Source: Activity 1.1)
- M&S description (Source: Activity 1.1)
- List of the available candidate V&V personnel (Source: Activity 1.2)
- Candidate V&V personnel availability schedule (Source: Activity 1.3)

 Information Produced:
- Citations of information used for V&V Planning

1.5.3 Assemble the V&V approach, V&V resource needs, V&V schedule, V&V cost estimate and citations of the information used for V&V Planning into an integrated draft V&V Plan.

 Information Required:
- V&V approach (Source: Activity 1.1)
- Required V&V resources (Source: Activity 1.2)
- V&V schedule (Source: Activity 1.3)
- Estimated V&V effort cost (Source: Activity 1.4)
- Initial requirements traceability matrix (Source: Task 1.5.1)
- Citations of information used for V&V Planning (Source: Task 1.5.2)

 Information Produced:
- Draft V&V Plan

1.5.4 Analyze the draft V&V Plan for internal consistency and correct any inconsistencies.

Information Required:
- Draft V&V Plan (Source: Task 1.5.3)

Information Produced:
- Correct draft V&V Plan

1.5.5   Circulate the corrected draft V&V Plan for review and collect comments and recommendations for change.

Information Required:
- Corrected draft V&V Plan (Source: Task 1.5.4)

Information Produced:
- Comments and recommendations for change received on draft V&V Plan

1.5.6   Modify the corrected draft V&V Plan from the comments and recommendations for change received.

Information Required:
- Corrected draft V&V Plan (Source: Task 1.5.4)
- Comments and recommendations for change received on draft V&V Plan (Source: Task 1.5.5)

Information Produced:
- Modified V&V Plan

1.5.7   Analyze the modified V&V Plan for internal consistency, correct any inconsistencies and prepare the final V&V Plan.

Information Required:
- Modified V&V Plan (Source: Task 1.5.6)

Information Produced:
- Final V&V Plan

1.5.8   Prepare the V&V Plan versioning history with the final V&V Plan.

Information Required:
- Final V&V Plan (Source: Task 1.5.7)

Information Produced:
- V&V Plan versioning history

Activity 1.6 – Execute and Evolve the V&V Plan

Activity Description: This activity executes the V&V Plan, monitors the results of the execution process and evolves the V&V Plan in response to those results.

Activity Tailoring Guidance: (Blank)

Activity Notes: Developing the V&V Plan may require several iterations and necessitate revisiting the preceding planning activities. Determining what parts of the plan need to be evolved will be done within this activity.

Activity Assumptions: A V&V Plan versioning history is kept, possibly as part of a program-level configuration management process.

Task Descriptions:

1.6.1   Execute the V&V Plan.

Information Required:
- V&V Plan (Source: Activity 1.5)

Information Produced:
- Updated V&V Plan

1.6.2   Monitor the V&V Plan execution and collect data on the results of that execution.

Information Required:
- V&V Plan (Source: Activity 1.5)

Information Produced:
- V&V Plan execution results

1.6.3   Analyze the V&V Plan and the results from its execution to determine the deviation from the expected results.

Information Required:
- V&V Plan execution results (Source: Task 1.6.2)
- V&V Plan (Source: Activity 1.5)

Information Produced:
- Deviations from the expected V&V Plan results

1.6.4   Analyze the revised Accreditation Plan to determine the modifications needed to accommodate those revisions in the V&V Plan.

Information Required:
- Revised Accreditation Plan (Source: Preceding accreditation activity)

Information Produced:
- Modifications to the existing V&V Plan from Accreditation Plan revisions

1.6.5   Obtain changes to the M&S requirements.

Information Required:
- M&S requirements changes (Source: User)

Information Produced:
- M&S requirements changes forwarded to follow-on activities

1.6.6   Analyze changes to the M&S requirements to determine modifications needed to the requirements traceability matrix.

Information Required:
- M&S requirements (Source: Task 1.6.5)

Information Produced:
- Requirements traceability matrix modifications

1.6.7   Analyze the revisions to the Accreditation Plan and deviations from the expected V&V Plan results to determine the modifications needed to accommodate the observed deviations from the existing V&V Plan.

Information Required:
- Deviations from the expected V&V Plan results (Source: Task 1.6.3)
- V&V Plan (Source: Activity 1.5)

Information Produced:
- Modifications to the existing V&V Plan from deviations from that plan

1.6.8   Analyze the revisions to the Accreditation Plan and deviations from the expected V&V Plan results to determine the modifications needed to accommodate the observed deviations from the existing V&V Plan.

Information Required:
- Modifications to the existing V&V Plan from Accreditation Plan revisions (Source: Task 1.6.4)
- Modifications to the existing V&V Plan from deviations from that plan (Source: Task 1.6.7)
- Requirements traceability matrix modifications (Source: Task 1.6.6)
- V&V Plan (Source: Activity 1.5)

Information Produced:
- Draft revised V&V Plan

1.6.9   Circulate the draft revised V&V Plan for review and collect comments and recommendations for change.

Information Required:
- Draft revised V&V Plan (Source: Task 1.6.8)

Information Produced:
- Comments and recommendations for change received on draft revised V&V Plan

1.6.10   Modify the draft revised V&V Plan from the comments and recommendations for change received.

Information Required:
- Draft revised V&V Plan (Source: Task 1.6.8)

- Comments and recommendations for change received on draft revised V&V Plan
  (Source: Task 1.6.9)

  Information Produced:
  - Modified V&V Plan

1.6.11 Analyze the modified V&V Plan for internal consistency, correct any inconsistencies and prepare the final V&V Plan.

  Information Required:
  - Modified V&V Plan (Source: Task 1.6.10)

  Information Produced:
  - Final revised V&V Plan

1.6.12 Update the V&V Plan versioning history associated with the V&V Plan.

  Information Required:
  - V&V Plan versioning history (Source: Activity 1.5)

  Information Produced:
  - V&V Plan versioning updates

1.6.13 Analyze the V&V Plan execution results, deviations from the expected plan results and modifications to the plan to develop the lessons learned from exercising the V&V process.

  Information Required:
  - V&V Plan execution results (Source: Task 1.6.2)
  - Deviations from the expected V&V Plan results (Source: Task 1.6.3)
  - Existing V&V Plan modifications from Accreditation Plan revisions (Source: Task 1.6.4)
  - V&V Plan (Source: Activity 1.5)

  Information Produced:
  - Collected lessons learned from exercising the V&V process

A1.3   PHASE 2 – APPLY RELEVANT HISTORICAL INFORMATION

Activity 2.1 – Collect and Analyze Developer Accounts of M&S Capabilities and Limitations

Activity Description: The M&S Developer possesses unique insight into its capabilities and limitations, and this insight can contribute greatly to the knowledge of the M&S's capabilities. In this activity, the V&V practitioner locates, obtains, and analyzes developer accounts of a M&S's capabilities and limitations. These Developer's accounts can come from any documentation produced by the Developer's activities and interviews concerning the development, testing, and maintenance of the M&S.

Activity Tailoring Guidance:
- This activity may not be performed if the Developer has produced no documentation from which knowledge of the M&S's capabilities can be abstracted.

- This activity should not be performed if the Developer cannot produce any documentation of the M&S's configuration management history.

Activity Notes:
- This activity may still apply to new M&S situations for which no history exists, since Developers often produce useful documentation during the development process (e.g., user's manuals, training materials).

- Tasks identify the V&V Plan as input because they apply the techniques and tools identified in the V&V Plan to perform the analyses.

Activity Assumptions: This activity assumes that the M&S configuration management history has not been obtained through prior activities. (See the guidance note above)

Task Descriptions:

2.1.1   Obtain the M&S configuration management history from the Developer.

Information Required:
- M&S configuration management history (Source: Developer)

Information Produced:
- M&S configuration management history

2.1.2   Obtain any available documentation produced by the Developer's activities.

Information Required:
- Developer's documentation about the M&S (Source: Developer)

Information Produced:
- Developer's documentation about the M&S

2.1.3   Analyze the Developer's documentation with the M&S configuration management history to identify that documentation that is relevant to the current M&S configuration.

Information Required.
- Developer's documentation about the M&S (Source: Task 2.1.2)
- M&S configuration management history (Source: Task 2.1.1)

Information Produced:
- Relevant Developer's documentation

2.1.4   Analyze the relevant Developer's documentation with the acceptability criteria to identify that documentation that applies to the intended use.

Information Required:
- Developer's documentation relevant to the current M&S configuration (Source: Task 2.1.3)
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)

Information Produced:
- Relevant and applicable Developer's documentation

2.1.5   Analyze the Relevant and applicable Developer's documentation to determine the capabilities and limitations of the current M&S configuration.

Information Required:
- Relevant and applicable Developer's documentation (Source: Task 2.1.4)
- V&V Plan (Source: Activity 1.5)

Information Produced:
- Description of the M&S capabilities and limitations from the Developer's documentation

2.1.6   Analyze the M&S capabilities and limitations, the Relevant and applicable Developer's documentation and the acceptability criteria to identify any gaps and inconsistencies that exist in the evidence from the Developer's documentation.

Information Required:
- Description of the M&S capabilities and limitations from the Developer's documentation (Source: Task 2.1.5)
- Relevant and applicable Developer's documentation (Source: Task 2.1.4)
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)
- V&V Plan (Source: Activity 1.5)

Information Produced:
- Description of the gaps and inconsistencies in the evidence from the Developer's documentation

2.1.7   Interview the Developer, where needed and practical, to fill any gaps, resolve any inconsistencies, describe any gaps or inconsistencies that cannot be resolved and document the results from these interviews.

Information Required:
- Description of the M&S capabilities and limitations from the Developer's documentation (Source: Task 2.1.5)
- Description of the gaps and inconsistencies in the evidence from the Developer's documentation (Source: Task 2.1.6)
- Information from interviews with the Developer (Source: Developer)

Information Produced:
- Description of the M&S capabilities and limitations from the Developer's accounts
- Description of the unresolved gaps and inconsistencies in Developer's accounts

2.1.8   Prepare citations of the Relevant and applicable Developer's accounts and resolve any citation problems.

Information Required:
- M&S configuration management history (Source: Task 2.1.1)
- Relevant and applicable Developer's documentation (Source: Task 2.1.4)
- Information from interviews with the Developer (Source: Developer)

Information Produced:
- Citations of information from Developer's accounts

Activity 2.2 – Collect and Analyze the V&V and Testing Histories

Activity Description: Any available documentation of prior V&V or testing activities can contribute tremendously to an ongoing V&V effort. In this activity, the V&V practitioner locates, obtains and analyzes any available prior V&V and testing reports. Often testing activities perform many of the same functions that V&V does and can be leveraged directly.

Activity Tailoring Guidance:
- This activity should not be performed if no documentation of prior VV&A or testing activities exists.

- This activity should not be performed if the Developer cannot produce any documentation of the M&S's configuration management history.

- If the M&S configuration management history has been obtained in a prior activity then that task does not need to be performed in this activity.

Activity Notes: Tasks identify the V&V Plan as input because they apply the techniques and tools identified in the V&V Plan to perform the analyses.

Activity Assumptions: This activity assumes that the M&S configuration management history has not been obtained through prior activities. (See the guidance note above)

Task Descriptions:
2.2.1   Obtain the M&S configuration management history.

Information Required:
- M&S configuration management history (Source: Developer)

Information Produced:
- M&S configuration management history

2.2.2   Obtain documentation produced by any prior VV&A efforts.

Information Required:
- Documentation from prior VV&A efforts (Source: VV&A Teams)

Information Produced:
- Documentation from prior VV&A efforts

2.2.3   Obtain documentation produced by any prior testing efforts.

Information Required:
- Documentation from prior testing efforts (Source: Testing Teams)

Information Produced:
- Documentation from prior testing efforts

2.2.4   Analyze the documentation from prior VV&A efforts and the M&S configuration management history to identify that documentation that is relevant to the current M&S configuration.

Information Required:
- Documentation from prior VV&A efforts (Source: Task 2.2.2)
- M&S configuration management history (Source: Task 2.2.1)

Information Produced:
- Relevant documentation from prior VV&A efforts

2.2.5   Analyze the documentation from prior testing efforts and the M&S configuration management history to identify that documentation that is relevant to the current M&S configuration.

Information Required
- Documentation from prior testing efforts (Source: Task 2.2.3)
- M&S configuration management history (Source: Task 2.2.1)

Information Produced:
- Relevant documentation from prior testing efforts

2.2.6   Analyze the relevant documentation from prior VV&A efforts and the acceptability criteria to identify that documentation that applies to the intended use.

Information Required:
- Relevant documentation from prior VV&A efforts (Source: Task 2.2.4)

- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)

Information Produced:
- Relevant and applicable documentation from prior VV&A efforts

2.2.7   Analyze the relevant documentation from prior testing efforts and the acceptability criteria to identify that documentation that applies to the intended use.

Information Required:
- Relevant documentation from prior testing efforts (Source: Task 2.2.5)
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)

Information Produced:
- Relevant and applicable documentation from prior testing efforts

2.2.8   Analyze the Relevant and applicable documentation from prior VV&A efforts to determine the capabilities and limitations of the current M&S configuration.

Information Required:
- Relevant and applicable documentation from prior VV&A efforts (Source: Task 2.2.6)
- V&V Plan (Source: Activity 1.5)

Information Produced:
- Description of the M&S capabilities and limitations from the relevant and applicable documentation of prior VV&A efforts

2.2.9   Analyze the Relevant and applicable documentation from prior testing efforts to determine the capabilities and limitations of the current M&S configuration.

Information Required:
- Relevant and applicable documentation from prior testing efforts (Source: Task 2.2.7)
- V&V Plan (Source: Activity 1.5)

Information Produced:
- Description of the M&S capabilities and limitations from the relevant and applicable documentation of prior testing efforts.

2.2.10 Analyze the M&S capabilities and limitations from the relevant and applicable documentation of prior VV&A efforts and the acceptability criteria to identify any gaps and inconsistencies that may exist in the evidence from that documentation.

Information Required:
- Description of the M&S capabilities and limitations from the relevant and applicable documentation of prior VV&A efforts (Source: Task 2.2.8)
- Acceptability criteria defining needed functionality (Source: Activity 1.1)

- Acceptability criteria defining needed quality (Source: Activity 1.1)
- V&V Plan (Source: Activity 1.5)

Information Produced
- Description of the gaps and inconsistencies in the evidence from the documentation of prior VV&A efforts

2.2.11   Analyze the M&S capabilities and limitations from the relevant and applicable documentation of prior testing efforts and the acceptability criteria to identify any gaps and inconsistencies that may exist in the evidence from that documentation.

Information Required:
- Description of the M&S capabilities and limitations from the relevant and applicable documentation of prior testing efforts (Source: Task 2.2.9)
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)
- V&V Plan (Source: Activity 1.5)

Information Produced:
- Description of the gaps and inconsistencies in the evidence from the documentation of prior testing efforts

2.2.12   Interview the VV&A teams, where needed and practical, to fill any gaps, resolve any inconsistencies, describe any gaps or inconsistencies that cannot be resolved and document the results from these interviews.

Information Required:
- Description of the gaps and inconsistencies in the evidence from the documentation of prior VV&A efforts (Source: Task 2.2.10)
- Information from interviews with the VV&A teams (Source: VV&A Teams)

Information Produced:
- Description of the M&S capabilities and limitations from the VV&A histories
- Description of the unresolved gaps and inconsistencies in the evidence from the VV&A histories

2.2.13   Interview the testing teams, where needed and practical, to fill any gaps, resolve any inconsistencies, describe any gaps or inconsistencies that cannot be resolved and document the results from these interviews.

Information Required:
- Description of the gaps and inconsistencies in the evidence from the documentation of prior testing efforts (Source: Task 2.2.11)
- Information from interviews with the testing teams (Source: Testing Teams)

Information Produced:
- Description of the M&S capabilities and limitations from the testing histories
- Description of the unresolved gaps and inconsistencies in the evidence from the testing histories

2.2.14 Assemble the information on the M&S capabilities and limitations from prior VV&A and testing efforts into a consistent description.

Information Required:
- Description of the M&S capabilities and limitations from the VV&A histories (Source: Task 2.2.12)
- Description of the M&S capabilities and limitations from the testing histories (Source: Task 2.2.13)

Information Produced:
- Integrated description of the M&S capabilities and limitations from prior VV&A and testing

2.2.15 Assemble the information on the unresolved gaps and inconsistencies from prior VV&A and testing efforts into a consistent description.

Information Required:
- Description of the unresolved gaps and inconsistencies in the evidence from the VV&A histories (Source: Task 2.2.12)
- Description of the unresolved gaps and inconsistencies in the evidence from the testing histories (Source: Task 2.2.13)

Information Produced:
- Integrated description of the unresolved gaps and limitations the VV&A and testing histories

2.2.16 Prepare citations of the relevant and applicable VV&A and testing histories and resolve any citation problems.

Information Required:
- M&S configuration management history (Source: Task 2.2.1)
- Relevant and applicable documentation from prior VV&A activities (Source: Task 2.2.4)
- Relevant and applicable documentation from prior testing activities (Source: Task 2.2.5)
- Information from interviews with the VV&A teams (Source: VV&A Teams)
- Information from interviews with the testing teams (Source: Testing Teams)

Information Produced:
- Citations of information from the VV&A and testing histories

Activity 2.3 – Collect and Analyze the Prior Use History

Activity Description: Like the information produced by prior V&V and testing activities, documentation of prior uses of a M&S can provide information about the M&S's validity. In this activity, the V&V practitioner locates, obtains and analyzes any documentation of prior use history. The products of prior M&S use can be reports or technical papers that document the results from studies, training exercises, experiments, and design activities.

Activity Tailoring Guidance:
- This activity should not be performed if no documentation of prior use exists.

- This activity should not be performed if the Developer cannot produce any documentation of the M&S's configuration management history.

- If the M&S configuration management history has been obtained in a prior activity then that task does not need to be performed in this activity.

Activity Notes: Tasks identify the V&V Plan as input because they apply the techniques and tools identified in the V&V Plan to perform the analyses.

Activity Assumptions: This activity assumes that the M&S configuration management history has not been obtained through prior activities. (See the guidance note above)

Task Descriptions:

2.3.1   Obtain the M&S configuration management history.

Information Required:
- M&S configuration management history (Source: Developer)

Information Produced:
- M&S configuration management history

2.3.2   Obtain any documentation produced by prior uses of the M&S.

Information Required:
- Documentation from prior uses of the M&S (Source: Users)

Information Produced:
- Documentation from prior uses of the M&S

2.3.3   Analyze the documentation from prior uses and the M&S configuration management history to identify the documentation that is relevant to the current M&S configuration.

Information Required:
- Documentation from prior uses of the M&S (Source: Task 2.3.2)
- M&S configuration management history (Source: Task 2.3.1)

Information Produced:
- Relevant documentation from prior M&S uses

2.3.4   Analyze the relevant documentation from prior uses and the acceptability criteria to identify the documentation that applies to the intended use.

Information Required:
- Relevant documentation from prior M&S uses (Source: Task 2.3.3)
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)

Information Produced:
- Relevant and applicable documentation from prior uses

2.3.5   Analyze the relevant and applicable documentation from prior uses to determine the capabilities and limitations of the current M&S configuration.

Information Required:
• Relevant and applicable documentation from prior uses (Source: Task 2.3.4)
• V&V Plan (Source: Activity 1.5)

Information Produced:
• Description of the M&S capabilities and limitations from the relevant and applicable documentation from prior uses

2.3.6   Analyze the M&S capabilities and limitations from the relevant and applicable documentation from prior uses and the acceptability criteria to identify any gaps and inconsistencies that may exist in the evidence from that documentation.

Information Required:
• Description of the M&S capabilities and limitations from the Relevant and applicable documentation from prior uses (Source: Task 2.3.5)
• Acceptability criteria defining needed functionality (Source: Activity 1.1)
• Acceptability criteria defining needed quality (Source: Activity 1.1)
• V&V Plan (Source: Activity 1.5)

Information Produced:
• Description of the gaps and inconsistencies in the evidence from the documentation of prior uses

2.3.7   Interview the users, where needed and practical, to fill any gaps, resolve any inconsistencies, describe any gaps or inconsistencies that cannot be resolved and document the results of these interviews.

Information Required:
• Description of the gaps and inconsistencies in the evidence from the documentation of prior uses (Source: Task 2.3.6)
• Information from interviews with the users (Source: Users)

Information Produced:
• Description of the M&S capabilities and limitations from the use history
• Description of the unresolved gaps and inconsistencies in the evidence from the use history

2.3.8   Prepare citations of the relevant and applicable use history and resolve any citation problems.

Information Required:
• M&S configuration management history (Source: Developer)
• Relevant and applicable documentation from prior uses (Source: Task 2.3.4)
• Information from interviews with the users (Source: Users)

Information Produced:
• Citations of information from the use history

Activity 2.4 – Integrate and Employ the Historical Evidence

Activity Description: In this activity, the V&V practitioner integrates any relevant historical evidence into a coherent view of an M&S's capabilities and limitations.

Activity Tailoring Guidance: (Blank)

Activity Notes: Tasks identify the V&V Plan as input because they apply the techniques and tools identified in the V&V Plan to perform the analyses.

Activity Assumptions: (Blank)

Task Descriptions:

2.4.1   Analyze the historical evidence produced by the prior activities to generate an integrated description of the M&S capabilities and limitations.

Information Required:
- Description of the M&S capabilities and limitations from the Developer's accounts (Source: Activity 2.1)
- Description of the M&S capabilities and limitations from the VV&A and testing histories (Source: Activity 2.2)
- Description of the M&S capabilities and limitations from the use history (Source: Activity 2.3)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Integrated description of the M&S capabilities and limitations from the historical evidence

2.4.2   Analyze the gaps and inconsistencies identified by the prior activities using the integrated description of the M&S capabilities and limitations from the historical evidence to reconcile them and produce a description of the unresolved gaps and inconsistencies in the historical evidence.

Information Required:
- Integrated description of the M&S capabilities and limitations from the historical evidence (Source: Task 2.4.1)
- Description of the unresolved gaps and inconsistencies in the evidence from the Developer's accounts (Source: Activity 2.1)
- Description of the unresolved gaps and inconsistencies in the evidence from the VV&A and testing histories (Source: Activity 2.2)
- Description of the unresolved gaps and inconsistencies in the evidence from the use history (Source: Activity 2.3)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Description of the unresolved gaps and inconsistencies in the historical evidence

2.4.3   Analyze the integrated description of M&S capabilities and limitations, description of the unresolved gaps and inconsistencies in the integrated historical evidence, and acceptability criteria to estimate the coverage of the integrated historical evidence.

Information Required:
- Integrated description of the M&S capabilities and limitations from the historical evidence (Source: Task 2.4.1)
- Description of the unresolved gaps and inconsistencies in the historical evidence (Source: Task 2.4.2)
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Estimated coverage of the historical evidence

2.4.4   Analyze the integrated description of M&S capabilities and limitations, description of the unresolved gaps and inconsistencies in the integrated historical evidence, and estimated coverage in the historical evidence to estimate the uncertainties in the integrated historical evidence.

Information Required:
- Integrated description of the M&S capabilities and limitations from the historical evidence (Source: Task 2.4.1)
- Estimated coverage of the historical evidence (Source: Task 2.4.3)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Estimated uncertainties in the historical evidence

2.4.5   Analyze the acceptability criteria, the integrated description of M&S capabilities and limitations from the historical evidence and the estimated uncertainties in the historical evidence to identify the factors that may constrain use.

Information Required:
- Integrated description of the M&S capabilities and limitations from the historical evidence (Source: Task 2.4.1)
- Estimated uncertainties in the historical evidence (Source: Task 2.4.4)
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Factors that may constrain use implied by the historical evidence

2.4.6   Analyze the integrated description of the M&S capabilities and limitations from the historical evidence, the unresolved gaps and inconsistencies in the historical evidence, the estimated coverage of uncertainties in the historical evidence and the acceptability criteria to identify candidate output sampling areas.

Information Required:
- Integrated description of the M&S capabilities and limitations from the historical evidence (Source: Task 2.4.1)

- Description of the unresolved gaps and inconsistencies in the historical evidence
  (Source: Task 2.4.2)
- Estimated coverage of the historical evidence (Source: Task 2.4.3)
- Estimated uncertainties in the historical evidence (Source: Task 2.4.4)
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Candidate output sampling areas suggested by the historical evidence

2.4.7   Update the requirements traceability matrix with the historical evidence.

Information Required:
- Integrated description of the M&S capabilities and limitations from the historical evidence
  (Source: Task 2.4.1)
- Description of the unresolved gaps and inconsistencies in the historical evidence
  (Source: Task 2.4.2)
- Requirements traceability matrix (Source: Activity 1.6)
- M&S requirements (Source: Activity 1.1)

2.4.8   Prepare, from the individual citation lists, an integrated list of citations of relevant and applicable information and resolve any citation problems.

Information Required:
- Citations of information from Developer's accounts (Source: Activity 2.1)
- Citations of information from the VV&A and testing histories (Source: Activity 2.2)
- Citations of information from the use history (Source: Activity 2.3)

Information Produced:
- Integrated citations supporting the compilation and analysis of the historical evidence

A1.4 PHASE 3 – VERIFY AND VALIDATE THE M&S CONCEPTUAL MODEL

Activity 3.1 – Verify the Conceptual Model

Activity Description: This verifies the M&S conceptual model.

Activity Tailoring Guidance: (Blank)

Activity Notes:
- Analysis to discover computational anomalies is constrained to the conceptual model (specifically, the mathematical model) because that seems to be the only artifact that lends itself to analysis.
- Tasks identify the V&V Plan as input because they apply the techniques and tools identified in the V&V Plan to perform the analyses.

Activity Assumptions: An M&S conceptual model exists and is available to the V&V effort.

Task Descriptions:

3.1.1   Obtain the M&S conceptual model.

Information Required:
- M&S conceptual model (Source: Developer)

Information Produced:
- M&S conceptual model

3.1.2   Analyze the M&S conceptual model for the possible existence of computational anomalies.

Information Required:
- M&S conceptual model (Source: Task 3.1.1)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Computational anomalies discovered in the M&S conceptual model

3.1.3   Analyze the M&S conceptual model to determine its internal consistency.

Information Required:
- M&S conceptual model (Source: Task 3.1.1)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Inconsistencies discovered within the M&S conceptual model

3.1.4   Analyze the M&S requirements and the M&S conceptual model to determine the consistency between them.

Information Required:
- M&S requirements (Source: Activity 1.1)
- M&S conceptual model (Source: Task 3.1.1)

Information Produced:
- Inconsistencies discovered between the M&S requirements and the M&S conceptual model.

3.1.5   Analyze the M&S conceptual model to verify the input functionality that it represents.

Information Required:
- M&S conceptual model (Source: Task 3.1.1)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Inconsistencies discovered in the input design represented in the M&S conceptual model

3.1.6   Analyze the M&S conceptual model to verify the output functionality that it represents.

Information Required:
- M&S conceptual model (Source: Task 3.1.1)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Inconsistencies discovered in the output design represented in the M&S conceptual model

3.1.7   Analyze the computational anomalies and the inconsistencies discovered during the M&S conceptual model verification to develop an integrated description of the inconsistencies discovered in the M&S conceptual model.

Information Required:
- Computational anomalies discovered in the M&S conceptual model (Source: Task 3.1.2)
- Inconsistencies discovered within the M&S conceptual model (Source: Task 3.1.3)
- Inconsistencies discovered between the M&S requirements and the M&S conceptual model (Source: Task 3.1.4)
- Inconsistencies discovered in the input design represented in the M&S conceptual model (Source: Task 3.1.5)
- Inconsistencies discovered in the output design represented in the M&S conceptual model (Source: Task 3.1.6)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Integrated description of the inconsistencies discovered in the M&S conceptual model
- Verified M&S conceptual model

Activity 3.2 – Validate the Conceptual Model

Activity Description: This activity validates the M&S conceptual model.

Activity Tailoring Guidance: (Blank)

Activity Notes: Tasks identify the V&V Plan as input because they apply the techniques and tools identified in the V&V Plan to perform the analyses.

Activity Assumptions: This activity assumes that the M&S conceptual model has been obtained and verified as part of previous activities.

Task Descriptions:

3.2.1   Analyze the verified M&S conceptual model and the acceptability criteria defining needed functionality to determine the functionality needs that are met; identify those criteria that are not met; and identify those criteria for which insufficient information is available.

Information Required:
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)
- Verified M&S conceptual model (Source: Activity 3.1)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Acceptability criteria defining needed functionality that the M&S conceptual model meets
- Acceptability criteria defining needed functionality that the M&S conceptual model does not meet
- Acceptability criteria defining needed functionality for which insufficient information is available from the M&S conceptual model

3.2.2   Analyze the verified M&S conceptual model, the acceptability criteria defining needed quality and the validation referent to determine the quality needs that are met, identify those criteria that are not met and identify those criteria for which insufficient information is available.

Information Required:
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)
- Verified M&S conceptual model (Source: Activity 3.1)
- Validation Referent (Source: Preceding accreditation activity)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Acceptability criteria defining needed quality that the M&S conceptual model meets
- Acceptability criteria defining needed quality that the M&S conceptual model does not meet
- Acceptability criteria defining needed quality for which insufficient information is available from the M&S conceptual model

3.2.3   Analyze the acceptability criteria that the verified M&S conceptual model meets and the verified M&S conceptual model to determine the M&S capabilities that the valid M&S conceptual model supports.

Information Required:
- Acceptability criteria defining needed functionality that the M&S conceptual model meets (Source: Task 3.2.1)
- Acceptability criteria defining needed quality that the M&S conceptual model meets (Source: Task 3.2.2)
- Verified M&S conceptual model (Source: Activity 3.1)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- M&S capabilities that the valid M&S conceptual model can support

3.2.4   Analyze the acceptability criteria that the verified M&S conceptual model does not meet and the verified M&S conceptual model to determine the M&S limitations implied by the valid M&S conceptual model.

Information Required:
- Acceptability criteria defining needed functionality that the M&S conceptual model does not meet (Source: Task 3.2.1)
- Acceptability criteria defining needed quality that the M&S conceptual model does not meet (Source: Task 3.2.2)
- Verified M&S conceptual model (Source: Activity 3.1)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- M&S limitations implied by the M&S conceptual model validation
- Verified and validated M&S conceptual model

3.2.5   Analyze the acceptability criteria for which insufficient information is available and the verified M&S conceptual model to determine the information gaps implied by that model.

Information Required:
- Acceptability criteria defining needed functionality for which insufficient information is available from the M&S conceptual model (Source: Task 3.2.1)
- Acceptability criteria defining needed quality for which insufficient information is available from the M&S conceptual model (Source: Task 3.2.2)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Information gaps in the conceptual model validation evidence

Activity 3.3 – Verify and Validate the Use Scenarios

Activity Description: This activity verifies and validates the use scenarios.

Activity Tailoring Guidance: (Blank)

Activity Notes: Tasks identify the V&V Plan as input because they apply the techniques and tools identified in the V&V Plan to perform the analyses.

Activity Assumptions: An M&S conceptual model exists that has been verified and validated.

Task Descriptions:

3.3.1   Obtain the scenarios for the intended use.

      Information Required:
- User Scenarios (Source: User)

      Information Produced:
- Collected scenarios

3.3.2   Analyze the individual collected scenarios to determine their internal consistency.

      Information Required:
- Collected scenarios (Source: Task 3.3.1)
- V&V Plan (Source: Activity 1.6)

      Information Produced:
- Inconsistencies within the individual collected scenarios

3.3.3   Analyze the collected scenarios to determine the consistency between them.

      Information Required:
- Collected scenarios (Source: Task 3.3.1)
- V&V Plan (Source: Activity 1.6)

      Information Produced:
- Inconsistencies between the collected scenarios

3.3.4   Analyze the collected scenarios to determine their consistency with the intended use.

      Information Required:
- Statement of intended use (Source: Preceding accreditation activity)
- Collected scenarios (Source: Task 3.3.1)
- V&V Plan (Source: Activity 1.6)

      Information Produced:
- Inconsistencies between the collected scenarios and the intended use

3.3.5   Analyze the inconsistencies discovered during the scenario verification to develop an integrated description of the scenario inconsistencies and the verified scenarios.

      Information Required:
- Inconsistencies within the individual collected scenarios (Source: Task 3.3.2)
- Inconsistencies between the collected scenarios (Source: Task 3.3.3)
- Inconsistencies between the collected scenarios and the intended use (Source: Task 3.3.4)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Integrated description of the scenario inconsistencies
- Verified collected scenarios

3.3.6   Analyze the verified collected scenarios, scenario inconsistencies and the acceptability criteria defining needed functionality to determine the functionality needs that are met, identify those criteria that are not met and identify those criteria for which insufficient information is available.

Information Required:
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Integrated description of the scenario inconsistencies (Source: Task 3.3.5)
- Verified collected scenarios (Source: Task 3.3.5)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Acceptability criteria defining needed functionality that the scenarios meet
- Acceptability criteria defining needed functionality that the scenarios do not meet
- Acceptability criteria defining needed functionality for which insufficient information is available from the scenarios

3.3.7   Analyze the verified collected scenarios, scenario inconsistencies, the acceptability criteria defining needed quality and the validation referent to determine the quality needs that are met, identify those criteria that are not met and identify those criteria for which insufficient.

Information Required:
- Acceptability criteria defining needed quality (Source: Activity 1.1)
- Integrated description of the scenario inconsistencies (Source: Task 3.3.5)
- Verified collected scenarios (Source: Task 3.3.5)
- Validation Referent (Source: Preceding accreditation activity)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Acceptability criteria defining needed quality that the scenarios meet
- Acceptability criteria defining needed quality that the scenarios do not meet
- Acceptability criteria defining needed quality for which insufficient information is available from the scenarios

3.3.8   Analyze the acceptability criteria that the verified collected scenarios meet and the M&S conceptual model to determine the M&S capabilities that valid scenarios can support.

Information Required:
- Verified and validated M&S conceptual model (Source: Activity 3.2)
- Acceptability criteria defining needed functionality that the scenarios meet (Source: Task 3.3.6)
- Acceptability criteria defining needed quality that the scenarios meet (Source: Task 3.3.7)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- M&S capabilities that the valid scenarios can support

3.3.9   Analyze the acceptability criteria that the verified collected scenarios do not meet and the M&S conceptual model to determine the M&S limitations implied by the scenarios.

Information Required:
- Verified and validated M&S conceptual model (Source: Activity 3.2)
- Acceptability criteria defining needed functionality that the scenarios do not meet (Source: Task 3.3.6)
- Acceptability criteria defining needed quality that the scenarios do not meet (Source: Task 3.3.7)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- M&S limitations implied by the scenario validation

3.3.10   Analyze the acceptability criteria for which insufficient information is available from the scenario validation and the M&S conceptual model to determine the information gaps implied by those sets.

Information Required:
- Verified and validated M&S conceptual model (Source: Activity 3.2)
- Acceptability criteria defining needed functionality for which insufficient information is available from the scenarios (Source: Task 3.3.6)
- Acceptability criteria defining needed quality for which insufficient information is available from the scenarios (Source: Task 3.3.7)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Information gaps implied by the scenario validation

3.3.11   Assemble and communicate the results of the scenario verification and validation.

Information Required:
- Integrated description of the scenario inconsistencies (Source: Task 3.3.5)
- M&S capabilities that the valid scenarios can support (Source: Task 3.3.8)
- M&S limitations implied by the scenario validation (Source: Task 3.3.9)
- Information gaps implied by the scenario validation (Source: Task 3.3.10)

Information Produced:
- Integrated description of scenario verification and validation results
- Verified and validated collected scenarios

Activity 3.4 – Integrate and Employ the Conceptual Model V&V Evidence

Activity Description: This integrates the scenario and M&S conceptual model verification and validation results.

Activity Tailoring Guidance: (Blank)

Activity Notes: Tasks identify the V&V Plan as input because they apply the techniques and tools identified in the V&V Plan to perform the analyses.

Activity Assumptions: (Blank)

Task Descriptions:

3.4.1   Analyze 1) the scenarios and M&S conceptual model, 2) the descriptions of the scenario and M&S conceptual model inconsistencies, and 3) the M&S capabilities that the M&S conceptual model and scenarios support to produce an integrated description of the M&S capabilities supported by both the M&S conceptual model and scenarios.

Information Required:
- Verified and validated M&S conceptual model (Source: Activity 3.2)
- Verified and validated collected scenarios (Source: Activity 3.3)
- Integrated description of the M&S conceptual model inconsistencies (Source: Activity 3.1)
- Integrated description of the scenario inconsistencies (Source: Activity 3.3)
- M&S capabilities that the valid M&S conceptual model supports (Source: Activity 3.2)
- M&S capabilities that the valid scenarios supports (Source: Activity 3.3)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Integrated description of the M&S capabilities that the scenarios and M&S conceptual model can support

3.4.2   Analyze the scenarios and M&S conceptual model, the integrated descriptions of the scenario and M&S conceptual model inconsistencies, the M&S limitations implied by the scenario and M&S conceptual model validation to produce an integrated description of the M&S limitations implied the scenarios and M&S conceptual model.

Information Required:
- Verified and validated M&S conceptual model (Source: Activity 3.2)
- Verified and validated collected scenarios (Source: Activity 3.3)
- Integrated description of the M&S conceptual model inconsistencies (Source: Activity 3.1)
- Integrated description of the scenario inconsistencies (Source: Activity 3.3)
- M&S limitations implied by the M&S conceptual model validation (Source: Activity 3.2)
- M&S limitations implied by the scenario validation (Source: Activity 3.3)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Integrated description of the M&S limitations implied by the scenario and M&S conceptual model V&V

3.4.3   Analyze the integrated description of the M&S capabilities that the conceptual model can support and the integrated description of the M&S limitations implied by the scenario and the conceptual model V&V to produce an integrated description of the M&S capabilities and limitations implied by the scenario and conceptual model V&V.

Information Required:
- Integrated description of the M&S capabilities that the scenarios and M&S conceptual model can support (Source: Task 3.4.1)

- Integrated description of the M&S limitations implied by the scenario and M&S conceptual model V&V (Source: Task 3.4.2)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Integrated description of the M&S capabilities and limitations implied by the scenario and M&S conceptual model V&V

3.4.4   Analyze the scenarios and M&S conceptual model, the acceptability criteria, the integrated descriptions of the scenario and M&S conceptual model inconsistencies, the information gaps implied by the scenario and M&S conceptual model validation to produce an integrated description of the information gaps and inconsistencies in the evidence from the scenarios and the M&S conceptual model.

Information Required:
- Verified and validated M&S conceptual model (Source: Activity 3.2)
- Verified and validated scenarios (Source: Activity 3.3)
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)
- Integrated description of the M&S conceptual model inconsistencies (Source: Activity 3.1)
- Integrated description of the scenario inconsistencies (Source: Activity 3.3)
- Information gaps implied by the M&S conceptual model validation (Source: Activity 3.2)
- Information gaps implied by the scenario validation (Source: Activity 3.3)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Integrated description of the information gaps and inconsistencies in the evidence from the scenario and M&S conceptual model V&V

3.4.5   Analyze the acceptability criteria, integrated description of the M&S capabilities that the scenarios and M&S conceptual model can support, the integrated description of the limitations implied by the scenarios and M&S conceptual model and the information gaps implied by the scenario and M&S conceptual model validation to estimate the coverage of the scenario and M&S conceptual model V&V evidence.

Information Required:
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)
- Integrated description of the M&S capabilities and limitations implied by the scenario and M&S conceptual model V&V (Source: Task 3.4.3)
- Integrated description of the information gaps and inconsistencies in the evidence from the scenario and M&S conceptual model V&V (Source: Task 3.4.4)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Estimated coverage of the scenario and M&S conceptual model V&V evidence

3.4.6   Analyze the integrated descriptions of the M&S capabilities, limitations and information gaps implied by the scenarios and M&S conceptual model V&V evidence and the estimated coverage of the scenario

and M&S conceptual model V&V evidence to estimate the uncertainties in the scenario and M&S conceptual model V&V evidence.

Information Required:
- Integrated description of the M&S capabilities and limitations implied by the scenario and M&S conceptual model V&V (Source: Task 3.4.3)
- Integrated description of the information gaps and inconsistencies in the evidence from the scenario and M&S conceptual model V&V (Source: Task 3.4.4)
- Estimated coverage of the scenario and M&S conceptual model V&V evidence (Source: Task 3.4.5)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Estimated uncertainties in the M&S conceptual model V&V evidence

3.4.7 Analyze the integrated description of the M&S limitations implied by the scenario and M&S conceptual model V&V, the integrated description of the information gaps implied by the scenario and M&S conceptual model V&V, and the acceptability criteria to identify the factors that may constrain use.

Information Required:
- Integrated description of the M&S capabilities and limitations implied by the scenario and M&S conceptual model V&V (Source: Task 3.4.3)
- Integrated description of the information gaps and inconsistencies in the evidence from the scenario and M&S conceptual model V&V (Source: Task 3.4.4)
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Factors that may constrain use implied by the scenario and M&S conceptual model V&V

3.4.8 Analyze the integrated description of the M&S limitations implied by the scenario and M&S conceptual model V&V, the integrated description of the information gaps implied by the scenario and M&S conceptual model V&V and the acceptability criteria to identify the candidate output sampling areas implied by the scenario and M&S conceptual model V&V.

Information Required:
- Integrated description of the M&S capabilities and limitations implied by the scenario and M&S conceptual model V&V (Source: Task 3.4.3)
- Integrated description of the information gaps and inconsistencies in the evidence from the scenario and M&S conceptual model V&V (Source: Task 3.4.4)
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Candidate output sampling areas implied by the scenario and M&S conceptual model V&V

3.4.9   Update the requirements traceability matrix with the evidence from the M&S conceptual model verification and validation.

Information Required:
- Integrated description of the M&S capabilities and limitations implied by the scenario and M&S conceptual model V&V (Source: Task 3.4.3)
- Integrated description of the information gaps and inconsistencies in the evidence from the scenario and M&S conceptual model V&V (Source: Task 3.4.4)
- Requirements traceability matrix (Source: Activity 1.6)
- M&S requirements (Source: Activity 1.1)

Information Produced:
- Requirements traceability matrix updated with the M&S conceptual model V&V evidence

3.4.10   Prepare citations of the M&S conceptual model and collected scenarios and resolve any citation problems.

Information Required:
- M&S conceptual model (Source: Activity 3.1)
- Collected scenarios (Source: Activity 3.3)

Information Produced:
- Integrated citations supporting the compilation and analysis of the M&S conceptual model and collected scenarios

A1.5   PHASE 4 – PERFORM SUPPLEMENTAL VERIFICATION

Activity 4.1 – Determine the Scope of Supplemental Verification Needed

Activity Description: This activity determines the scope of the verification that will be done by the V&V Team to supplement that done by the Developer.

Activity Tailoring Guidance: (Blank)

Activity Notes: Tasks identify the V&V Plan as input because they apply the techniques and tools identified in the V&V Plan to perform the analyses.

Activity Assumptions:
- The Developer has produced documentation of the verification activities that they have performed.
- The Developer has an up-to-date M&S configuration management history.

Task Descriptions:

4.1.1   Obtain the M&S configuration management history.

Information Required:
- M&S configuration management history (Source: Developer)

Information Produced:
- M&S configuration management history

4.1.2   Obtain the Developer's verification products.

Information Required:
- Developer's verification products (Source: Developer)

Information Produced:
- Developer's verification products

4.1.3   Analyze the Developer's verification products with the M&S configuration management history to identify those products that are relevant to the current M&S configuration.

Information Required:
- Developer's verification products (Source: Task 4.1.2)
- M&S configuration management history (Source: Task 4.1.1)

Information Produced:
- Relevant Developer's verification products

4.1.4   Analyze the relevant Developer's verification products, verified and validated M&S conceptual model and acceptability criteria to identify those products that apply to the intended use.

Information Required:
- Relevant Developer's verification products (Source: Task 4.1.3)
- Verified and validated M&S conceptual model (Source: Activity 3.2)
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)

Information Produced:
- Relevant and applicable Developer's verification products

4.1.5 Analyze the relevant and applicable Developer's verification products, verified and validated M&S conceptual model and acceptability criteria to determine the M&S capabilities and limitations implied by the Developer's verification products.

Information Required:
- Relevant and applicable Developer's verification products (Source: Task 4.1.4)
- Verified and validated M&S conceptual model (Source: Activity 3.2)
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- M&S capabilities and limitations implied by the Developer's verification products

4.1.6 Analyze the relevant and applicable Developer's verification products, acceptability criteria and the M&S capabilities and limitations implied by the Developer's verification products to determine the gaps and inconsistencies in the evidence from the Developer's verification products.

Information Required:
- Relevant and applicable Developer's verification products (Source: Task 4.1.4)
- M&S capabilities and limitations implied by the Developer's verification products (Source: Task 4.1.5)
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Gaps and inconsistencies in the evidence from the Developer's verification products

4.1.7 Analyze the M&S capabilities and limitations implied by the Developer's verification products, gaps and inconsistencies in the Developer's verification products and acceptability criteria to estimate the coverage of the Developer's verification products.

Information Required:
- M&S capabilities and limitations implied by the Developer's verification products (Source: Task 4.1.5)
- Gaps and inconsistencies in the evidence from the Developer's verification products (Source: Task 4.1.6)
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Estimated coverage of the Developer's verification products

4.1.8 Analyze the gaps and inconsistencies in the Developer's verification products and estimated coverage of the Developer's verification products and the V&V Plan to determine the supplemental verification needs.

Information Required:
- Estimated coverage of the Developer's verification products (Source: Task 4.1.7)
- Gaps and inconsistencies in the evidence from the Developer's verification products (Source: Task 4.1.6)
- V&V Plan (Source: Activity 1.5)

Information Produced:
- Supplemental verification needs

Activity 4.2 – Verify the M&S Design Products

Activity Description: (Blank)

Activity Tailoring Guidance: This activity need not be performed if the supplemental verification needs do not include any needs for verifying the M&S design products (e.g., the developer has already performed adequate verification of the M&S design products).

Activity Notes:
- Tasks identify the V&V Plan as input because they apply the techniques and tools identified in the V&V Plan to perform the analyses.
- All design products can only be analyzed for inconsistencies and cannot be tested because they cannot be executed (i.e., only the M&S executable can be executed).

Activity Assumptions: (Blank)

Task Descriptions:
4.2.1 Analyze the supplemental verification needs to determine the needs for verifying the M&S design products.

Information Required:
- Supplemental verification needs (Source: Activity 4.1)

Information Produced:
- M&S design product verification needs

4.2.2 Obtain the M&S design products from the Developer.

Information Required:
- M&S design products (Source: Developer)

Information Produced:
- M&S design products

4.2.3   Analyze the M&S design products for the possible existence of computational anomalies.

Information Required:
- M&S design product verification needs (Source: Task 4.2.1)
- M&S design products (Source: Task 4.2.2)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Computational anomalies discovered in the M&S design products

4.2.4   Analyze the M&S design products to determine their internal consistency.

Information Required:
- M&S design product verification needs (Source: Task 4.2.1)
- M&S design products (Source: Task 4.2.2)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Inconsistencies discovered within the M&S design products

4.2.5   Analyze the M&S design products to determine the consistency between them.

Information Required:
- M&S design product verification needs (Source: Task 4.2.1)
- M&S design products (Source: Task 4.2.2)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Inconsistencies discovered between the M&S design products
- Verified M&S design product

4.2.6   Analyze the M&S design products to verify the input functionality.

Information Required:
- M&S design product verification needs (Source: Task 4.2.1)
- M&S design products (Source: Task 4.2.2)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Inconsistencies discovered in the input design

4.2.7   Analyze the M&S design products to verify the output functionality.

Information Required:
- M&S design product verification needs (Source: Task 4.2.1)

- M&S design products (Source: Task 4.2.2)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Inconsistencies discovered in the output design

4.2.8 Analyze the inconsistencies discovered during the M&S design product verification to develop an integrated description of the M&S design product inconsistencies.

Information Required:
- Inconsistencies discovered within the M&S design products (Source: Task 4.2.4)
- Inconsistencies discovered between the M&S design products (Source: Task 4.2.5)
- Inconsistencies discovered in the input design (Source: Task 4.2.6)
- Inconsistencies discovered in the output design (Source: Task 4.2.7)

Information Produced:
- Integrated description of the inconsistencies discovered in the M&S design products
- Verified M&S design products

4.2.9 Update the requirements traceability matrix with the evidence from design verification.

Information Required:
- Integrated description of the inconsistencies discovered in the M&S design products (Source: Task 4.2.8)
- Requirements traceability matrix (Source: Activity 1.6)
- M&S requirements (Source: Activity 1.1)

Information Produced:
- Requirements traceability matrix updated with the design verification evidence

Activity 4.3 – Verify the M&S Object Code

Activity Description: In this activity, the V&V Team verifies the M&S object code if needed.

Activity Tailoring Guidance: This activity need not be performed if the supplemental verification needs do not include any needs for verifying the M&S object code (e.g., the Developer has already performed sufficient verification of the M&S object code).

Activity Notes: Tasks identify the V&V Plan as input because they apply the techniques and tools identified in the V&V Plan to perform the analyses.

Activity Assumptions: All object code products can only be analyzed for inconsistencies and cannot be tested because they cannot be executed (i.e., only the M&S executable can be executed).

Task Descriptions:

4.3.1 Analyze the supplemental verification needs to determine the needs for verifying the M&S object code.

Information Required:
* Supplemental verification needs (Source: Activity 4.1)

Information Produced:
* M&S object code verification needs

4.3.2   Obtain the M&S object code from the Developer.

Information Required:
* M&S object code (Source: Developer)

Information Produced:
* M&S object code

4.3.3   Analyze the M&S object code for the possible existence of computational anomalies.

Information Required:
* M&S object code verification needs (Source: Task 4.3.1)
* M&S object code (Source: Task 4.3.2)
* V&V Plan (Source: Activity 1.6)

Information Produced:
* Computational anomalies discovered in the M&S object code

4.3.4   Analyze the M&S object code to determine its internal consistency.

Information Required:
* M&S object code verification needs (Source: Task 4.3.1)
* M&S object code (Source: Task 4.3.2)
* V&V Plan (Source: Activity 1.6)

Information Produced:
* Inconsistencies discovered within the M&S object code

4.3.5   Analyze the M&S object code to verify its input functionality.

Information Required:
* M&S object code verification needs (Source: Task 4.3.1)
* M&S object code (Source: Task 4.3.2)
* V&V Plan (Source: Activity 1.6)

Information Produced:
* Inconsistencies discovered in the object code input functionality

4.3.6   Analyze the M&S object code to verify its output functionality.

Information Required:
* M&S object code verification needs (Source: Task 4.3.1)

- M&S object code (Source: Task 4.3.2)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Inconsistencies discovered in the object code output functionality

4.3.7 Analyze the verified M&S object code and the verified M&S design products to determine the consistency between them and to produce the verified symbolic code.

Information Required:
- M&S object code verification needs (Source: Task 4.3.1)
- M&S object code (Source: Task 4.3.2)
- Verified M&S design products (Source: Activity 4.2)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Inconsistencies discovered between the verified M&S design products and the M&S object code

4.3.8 Analyze the inconsistencies discovered during the M&S object code verification to develop an integrated description of the M&S object code inconsistencies.

Information Required:
- Inconsistencies discovered within the M&S object code (Source: Task 4.3.4)
- Inconsistencies discovered in the object code input functionality (Source: Task 4.3.5)
- Inconsistencies discovered in the object code output functionality (Source: Task 4.3.6)
- Inconsistencies discovered between the verified M&S design products and the M&S object code (Source: Task 4.3.7)

Information Produced:
- Integrated description of the inconsistencies discovered in the M&S object code
- Verified M&S object code

4.3.9 Update the requirements traceability matrix with the evidence from object code verification.

Information Required:
- Integrated description of the inconsistencies discovered in the M&S object code (Source: Task 4.3.8)
- Requirements traceability matrix (Source: Activity 1.6)
- M&S requirements (Source: Activity 1.1)

Information Produced:
- Requirements traceability matrix updated with the M&S object code verification evidence

Activity 4.4 – Verify the M&S Executable

Activity Description: The V&V Team verifies the M&S executable in this activity. Depending upon the available tools and personnel skill, verification of the M&S executable can be done through analysis, testing or both.

Activity Tailoring Guidance:

- This activity need not be performed if the supplemental verification needs do not include any needs for verifying the M&S executable (i.e., the Developer has already performed sufficient verification of the M&S executable).

- This activity can only be performed if the M&S executable is available from the Developer.

Activity Notes: Tasks identify the V&V Plan as input because they apply the techniques and tools identified in the V&V Plan to perform the analyses.

Activity Assumptions:

- The only development product that can be reasonably tested is the M&S executable.

- Analysis of the M&S executable is only possible if done with a suitable tool.

- Verification testing is performed as an activity separate from M&S results validation testing.

Task Descriptions:

4.4.1 Analyze the supplemental verification needs to determine the needs for verifying the M&S executable.

Information Required:
- Supplemental verification needs (Source: Activity 4.1)

Information Produced:
- M&S executable verification needs

4.4.2 Obtain the M&S executable from the Developer.

Information Required:
- M&S executable (Source: Developer)

Information Produced:
- M&S executable

4.4.3 Analyze the M&S executable for computational anomalies.

Information Required:
- M&S executable verification needs (Source: Task 4.4.1)
- M&S executable (Source: Task 4.4.2)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Computational anomalies in the M&S executable discovered through analysis

4.4.4 Analyze the M&S executable to determine its internal consistency.

Information Required:
- M&S executable verification needs (Source: Task 4.4.1)

- M&S executable (Source: Task 4.4.2)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Inconsistencies within the M&S executable discovered through analysis

4.4.5   Analyze the M&S executable and the verified M&S object code to determine the consistency between them.

Information Required:
- M&S executable verification needs (Source: Task 4.4.1)
- M&S executable (Source: Task 4.4.2)
- Verification M&S object code (Source: Activity 4.3)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Inconsistencies between the M&S executable and the verified M&S object code discovered through analysis

4.4.6   Analyze the M&S executable verification needs, the inconsistencies found in the M&S design products and the M&S object code, the inconsistencies found in the M&S executable through analysis and the V&V Plan to develop the M&S executable verification testing plan.

Information Required:
- M&S executable verification needs (Source: Task 4.4.1)
- Inconsistencies found in the M&S design products (Source: Activity 4.2)
- Inconsistencies found in the M&S object code (Source: Activity 4.3)
- Computational anomalies in the M&S executable discovered through analysis (Source: Task 4.4.3)
- Inconsistencies within the M&S executable discovered through analysis (Source: Task 4.4.4)
- Inconsistencies between the M&S executable and the verified M&S object code discovered through analysis (Source: Task 4.4.5)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- M&S executable verification testing plan

4.4.7   Analyze the M&S executable verification testing plan and the verified M&S design products to identify verification test cases and procedures.

Information Required:
- M&S executable verification testing plan (Source: Task 4.4.6)
- Verified M&S design products (Source: Activity 4.2)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- M&S executable verification test cases and procedures

4.4.8   Test the M&S executable with the verification test cases and collect the results specified in the M&S executable verification testing plan.

Information Required:
- M&S executable verification testing plan (Source: Task 4.4.6)
- M&S executable verification test cases and procedures (Source: Task 4.4.7)
- M&S executable (Source: Task 4.4.2)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- M&S executable verification testing results

4.4.9   Characterize the conditions under which the M&S executable verification testing was performed.

Information Required:
- M&S executable verification testing plan (Source: Task 4.4.6)
- M&S executable verification test cases and procedures (Source: Task 4.4.7)
- M&S executable (Source: Task 4.4.2)
- M&S executable verification testing results (Source: Task 4.4.8)

Information Produced:
- M&S executable verification testing conditions

4.4.10   Analyze the M&S executable verification testing results for computational anomalies.

Information Required:
- M&S executable verification testing results (Source: Task 4.4.8)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Computational anomalies in the M&S executable discovered through testing

4.4.11   Analyze the M&S executable verification testing results to determine the inconsistencies found in the M&S executable through testing.

Information Required:
- M&S executable verification testing results (Source: Task 4.4.8)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Inconsistencies in the M&S executable discovered through testing

4.4.12   Analyze the M&S executable verification testing results to identify interoperability and compatibility problems.

Information Required:
- M&S executable verification testing results (Source: Task 4.4.8)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Interoperability and compatibility problems discovered through testing

4.4.13 Analyze the computational anomalies discovered during the M&S executable verification to develop an integrated description of the M&S executable computational anomalies.

Information Required:
- Computational anomalies in the M&S executable discovered through analysis (Source: Task 4.4.3)
- Computational anomalies in the M&S executable discovered through testing (Source: Task 4.4.10)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Integrated description of the computational anomalies in the M&S executable

4.4.14 Analyze the inconsistencies and interoperability and compatibility problems discovered during the M&S executable verification to develop an integrated description of the M&S executable inconsistencies.

Information Required:
- Inconsistencies within the M&S executable discovered through analysis (Source: Task 4.4.4)
- Inconsistencies between the M&S executable and the verified M&S object code discovered through analysis (Source: Task 4.4.5)
- Inconsistencies in the M&S executable discovered through testing (Source: Task 4.4.11)
- Interoperability and compatibility problems discovered through testing (Source: Task 4.4.12)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Integrated description of the inconsistencies discovered in the M&S executable
- Verified M&S executable

4.4.15 Update the requirements traceability matrix with the evidence from M&S executable verification.

Information Required:
- Integrated description of the inconsistencies discovered in the M&S executable (Source: Task 4.4.14)
- Requirements traceability matrix (Source: Activity 1.6)
- M&S requirements (Source: Activity 1.1)

Information Produced:
- Requirements traceability matrix updated with the M&S executable verification evidence

Activity 4.5 – Verify the Development Products for Standards Compliance

Activity Description: The V&V Team verifies the compliance of all of the development products against the standards that have been chosen to guide the development process.

Activity Tailoring Guidance: (Blank)

Activity Notes: Tasks identify the V&V Plan as input because they apply the techniques and tools identified in the V&V Plan to perform the analyses.

Activity Assumptions: The User specifies any standards that have been chosen to guide the development process.

Task Descriptions:

4.5.1   Obtain the results of the Developer's standards compliance verification efforts.

Information Required:
- Standards compliance verification results from the Developer (Source: Developer)

Information Produced
- Standards compliance verification results

4.5.2   Analyze the supplemental verification needs and the standards compliance verification results from the Developer to determine the needs for standards compliance verification.

Information Required:
- Supplemental verification needs (Source: Activity 4.1)
- Standards compliance verification results from the Developer (Source: Activity 4.1)

Information Produced:
- Standards compliance verification needs

4.5.3   Analyze the standards compliance verification needs and the M&S requirements to determine the applicable standards needs.

Information Required:
- Standards compliance verification needs (Source: Task 4.5.2)
- M&S requirements (Source: Activity 1.1)

Information Produced:
- Applicable standards needs

4.5.4   Obtain the standards defined by the applicable standards needs from the standards organizations.

Information Required:
- Applicable standards needs (Source: Task 4.5.3)
- Library of standards (Source: Standards organizations)

Information Produced:
- Applicable standards

4.5.5   Analyze the M&S design products against the applicable standards to determine their compliance.

Information Required:
- Standards compliance verification needs (Source: Task 4.5.2)
- Validated and verified M&S conceptual model (Source: Activity 3.2)
- Verified and validated collected scenarios (Source: Activity 3.3)
- Verified M&S design products (Source: Activity 4.2)
- Verified M&S Object Code (Source: Activity 4.3)

- Verified M&S Executable (Source: Activity 4.4)
- Applicable standards (Source: Task 4.5.4)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Compliance of the M&S design products with the applicable standards

4.5.6   Analyze the M&S object code against the applicable standards to determine its compliance.

Information Required:
- Standards compliance verification needs (Source: Task 4.5.2)
- Verified M&S object code (Source: Activity 4.3)
- Applicable standards (Source: Task 4.5.4)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Compliance of the M&S object code with the applicable standards

4.5.7   Test the M&S executable against the applicable standards to determine its compliance.

Information Required:
- Standards compliance verification needs (Source: Task 4.5.2)
- Verified M&S executable (Source: Activity 4.4)
- Applicable standards (Source: Task 4.5.4)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Compliance of the M&S executable with the applicable standards

4.5.8   Analyze the compliance of the M&S design products, M&S object code, and M&S executable with the applicable standards to develop an integrated picture of M&S development product compliance with applicable standards.

Information Required:
- Compliance of the M&S design products with the applicable standards (Source: Task 4.5.5)
- Compliance of the M&S object code with the applicable standards (Source: Task 4.5.6)
- Compliance of the M&S executable with the applicable standards (Source: Task 4.5.7)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Integrated description of the M&S development product compliance with applicable standards

4.5.9   Update the requirements traceability matrix with the evidence from verification against applicable standards.

Information Required:
- Integrated description of the M&S development product compliance with applicable standards (Source: Task 4.5.8)

- Requirements traceability matrix (Source: Activity 1.6)
- M&S requirements (Source: Activity 1.1)

Information Produced:
- Requirements traceability matrix updated with the standards verification evidence

Activity 4.6 – Integrate the Supplemental Verification Evidence

Activity Description: This activity collects and integrates the evidence produced by the supplemental verification activities.

Activity Tailoring Guidance: (Blank)

Activity Notes: Tasks identify the V&V Plan as input because they apply the techniques and tools identified in the V&V Plan to perform the analyses.

Activity Assumptions: The M&S configuration management history has been obtained in a previous activity.

Task Descriptions:

4.6.1 Analyze the Developer's verification products and the M&S configuration management history to produce a description of the computational anomalies discovered by the Developer's verification.

Information Required:
- Developer's verification products (Source: Activity 4.1)
- M&S configuration management history (Source: Activity 4.1)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Description of the computational anomalies discovered by the Developer's verification

4.6.2 Analyze the computational anomalies discovered by the supplemental verification of the design, object and executable products and the Developer's verification products to produce an integrated description of the computational anomalies discovered by the supplemental verification.

Information Required:
- Description of the computational anomalies discovered by the Developer's verification (Source: Task 4.6.1)
- Computational anomalies discovered in the M&S design products (Source: Activity 4.2)
- Computational anomalies discovered in the M&S object code (Source: Activity 4.3)
- Integrated description of the computational anomalies discovered in the M&S executable (Source: Activity 4.4)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Integrated description of the computational anomalies discovered in the M&S development products

4.6.3 Analyze the Developer's verification products and the M&S configuration management history to produce a description of the inconsistencies discovered by the Developer's verification.

Information Required:
- Developer's verification products (Source: Activity 4.1)
- M&S configuration management history (Source: Activity 4.1)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Inconsistencies discovered by the Developer's verification

4.6.4   Analyze the inconsistencies found in the M&S design products, symbolic code and executable to produce an integrated description of the inconsistencies in the M&S development products.

Information Required:
- Inconsistencies discovered by the Developer's verification (Source: Task 4.6.3)
- Inconsistencies discovered within the M&S design products (Source: Activity 4.2)
- Inconsistencies discovered between the M&S design products (Source: Activity 4.2)
- Inconsistencies discovered within the M&S object code (Source: Activity 4.3)
- Inconsistencies discovered between the verified M&S design products and the M&S object code (Source: Activity 4.3)
- Inconsistencies discovered within the M&S executable (Source: Activity 4.4)
- Inconsistencies discovered between the verified M&S symbolic code and the M&S executable (Source: Activity 4.4)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Integrated description of the inconsistencies discovered in the M&S development products

4.6.5   Prepare citations of the verification documentation and resolve any citation problems.

Information Required:
- M&S configuration management history (Source: Activity 4.1)
- Developer's verification products (Source: Activity 4.1)
- M&S design products (Source: Activity 4.2)
- M&S object code (Source: Activity 4.3)
- M&S executable (Source: Activity 4.4)
- Standards compliance verification results from the Developer (Source: Activity 4.5)

Information Produced:
- Integrated citations supporting the development of the verification evidence

A1.6   PHASE 5 – APPLY THE VERIFICATION PRODUCTS TO VALIDATION

Activity 5.1 – Determine the Effects of Developmental Product Inconsistencies

Activity Description: This activity verifies the consistency of the development products against the verified and validated M&S conceptual model.

Activity Tailoring Guidance: (Blank)

Activity Notes: Tasks identify the V&V Plan as input because they apply the techniques and tools identified in the V&V Plan to perform the analyses.

Activity Assumptions:
- An M&S conceptual model exists and that it has been validated against the acceptability criteria.
- None of the inconsistencies discovered through the verification of the development products have been corrected and therefore their effects still exist in the M&S executable.

Task Descriptions:

5.1.1   Analyze the supplemental verification needs to determine the needs for verifying against the M&S conceptual model.

Information Required:
- Supplemental verification needs (Source: Activity 4.1)

Information Produced:
- Needs for verifying against the M&S conceptual model

5.1.2   Analyze the computational anomalies discovered in the M&S conceptual model and the combined verification products with the M&S conceptual model to determine the possible effects of computational anomalies discovered.

Information Required:
- Needs for verifying against the M&S conceptual model (Source: Task 5.1.1)
- Computational anomalies discovered in the M&S conceptual model (Source: Activity 3.1)
- Integrated description of the computational anomalies discovered in the M&S development products (Source: Activity 4.6)
- Verified and validated M&S conceptual model (Source: Activity 3.2)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Possible effects of computational anomalies upon the M&S capabilities and limitations

5.1.3   Analyze the inconsistencies discovered in the M&S development products with the M&S conceptual model to determine the possible effects of those inconsistencies.

Information Required:
- Needs for verifying against the M&S conceptual model (Source: Task 5.1.1)

- Integrated description of the inconsistencies discovered in the M&S conceptual model (Source: Activity 3.1)
- Integrated description of the inconsistencies discovered in the combined verification effort (Source: Activity 4.6)
- Verified and validated M&S conceptual model (Source: Activity 3.2)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Possible effects of inconsistencies within the M&S development products upon the M&S capabilities and limitations

5.1.4   Analyze the verified M&S design products and the M&S conceptual model to identify any inconsistencies between them.

Information Required:
- Needs for verifying against the M&S conceptual model (Source: Task 5.1.1)
- Verified M&S design products (Source: Activity 4.2)
- Verified and validated M&S conceptual model (Source: Activity 3.2)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Inconsistencies discovered between the M&S conceptual model and the design products
- Verified and validated M&S design products

5.1.5   Analyze the inconsistencies discovered between the M&S conceptual model and the M&S development products with the M&S conceptual model to determine the possible effects of those inconsistencies.

Information Required:
- Needs for verifying against the M&S conceptual model (Source: Task 5.1.1)
- Inconsistencies discovered between the M&S conceptual model and the design products (Source: Task 5.1.4)
- Integrated description of the inconsistencies discovered in the M&S development products (Source: Activity 4.6)
- Verified and validated M&S conceptual model (Source: Activity 3.2)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Possible effects of inconsistencies between the M&S conceptual model and the development products upon the M&S capabilities and limitations

5.1.6   Analyze the possible effects of computational anomalies and development product inconsistencies upon the M&S capabilities and limitations to determine the capabilities and limitations of the verified M&S executable.

Information Required:
- Possible effects of computational anomalies upon the M&S capabilities and limitations (Source: Task 5.1.2)
- Possible effects of inconsistencies within the M&S development products upon the M&S capabilities and limitations (Source: Task 5.1.3)

- Possible effects of inconsistencies between the M&S conceptual model and the development products upon the M&S capabilities and limitations (Source: Task 5.1.5)

Information Produced:
- Description of the capabilities and limitations of the verified M&S executable

Activity 5.2 – Evaluate M&S Validity from the Verification Products

Activity Description: This activity compares the description of M&S capabilities and limitations of the verified M&S executable with the acceptability criteria to identify the needed capabilities that the M&S executable could support and the limitations implied by the development product verification evidence, and estimate the coverage and uncertainties in the development product verification evidence.

Activity Tailoring Guidance: (Blank)

Activity Notes: Tasks identify the V&V Plan as input because they apply the techniques and tools identified in the V&V Plan to perform the analyses.

Activity Assumptions: (Blank)

Task Descriptions:

5.2.1 Analyze the description of the capabilities and limitations of the verified M&S executable and the acceptability criteria that define the required functionality to determine the functionality needs that are met, identify those criteria that are not met, and identify those criteria for which insufficient information is available.

Information Required:
- Description of the capabilities and limitations of the verified M&S executable (Source: Activity 5.1)
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Acceptability criteria that define the required functionality that the verified M&S executable meets
- Acceptability criteria that define the required functionality that the verified M&S executable does not meet
- Acceptability criteria that define the required functionality for which insufficient information is available from the verified M&S executable

5.2.2 Analyze the description of the capabilities and limitations of the verified M&S executable and the acceptability criteria that define the required quality to determine the quality needs that are met, identify those criteria that are not met, and identify those criteria for which insufficient information is available.

Information Required:
- Description of the capabilities and limitations of the verified M&S executable (Source: Activity 5.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Acceptability criteria that define the required quality that the verified M&S executable meets
- Acceptability criteria that define the required quality that the verified M&S executable does not meet
- Acceptability criteria that define the required quality for which insufficient information is available from the verified M&S executable

5.2.3   Analyze the acceptability criteria that the M&S executable meets and the M&S conceptual model to determine the needed M&S capabilities that the M&S executable could support.

Information Required:
- Acceptability criteria that define the required functionality that the verified M&S executable meets (Source: Task 5.3.1)
- Acceptability criteria that define the required quality that the verified M&S executable meets (Source: Task 5.3.2)
- Verified and validated M&S conceptual model (Source: Activity 3.1)

Information Produced:
- Needed M&S capabilities that the M&S executable could support

5.2.4   Analyze the acceptability criteria that the M&S executable does not meet and the M&S conceptual model to determine the M&S limitations implied by the M&S executable verification.

Information Required:
- Acceptability criteria that define the required functionality that the verified M&S executable does not meet (Source: Task 5.2.1)
- Acceptability criteria that define the required quality that the verified M&S executable does not meet (Source: Task 5.2.2)
- Verified and validated M&S conceptual model (Source: Activity 3.1)

Information Produced:
- M&S limitations implied by the development product verification evidence
- Verified and validated M&S executable

5.2.5   Analyze the acceptability criteria for which insufficient information is available to determine the information gaps in the evidence from the development product verification.

Information Required:
- Acceptability criteria that define the required functionality for which insufficient information is available from the verified M&S executable (Source: Task 5.2.1)
- Acceptability criteria that define the required quality for which insufficient information is available from the verified M&S executable (Source: Task 5.2.2)

Information Produced:
- Information gaps in the development product verification evidence

5.2.6   Analyze the M&S capabilities, limitations and information gaps implied by the development product verification evidence and the acceptability criteria to estimate the coverage of the development product verification evidence.

Information Required:
- Needed M&S capabilities that the M&S executable could support (Source: Task 5.2.3)
- M&S limitations implied by the development product verification evidence (Source: Task 5.2.4)
- Information gaps in the development product verification evidence (Source: Task 5.2.5)
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Estimated coverage of the development product verification evidence

5.2.7   Analyze the M&S capabilities and limitations implied by the development product verification evidence, the information gaps in the development product verification evidence and the estimated coverage of the development product verification evidence to estimate the uncertainties in the development product verification evidence.

Information Required:
- Needed M&S capabilities that the M&S executable could support (Source: Task 5.2.3)
- M&S limitations implied by the development product verification evidence (Source: Task 5.2.4)
- Information gaps in the development product verification evidence (Source: Task 5.2.5)
- Estimated coverage of the development product verification evidence (Source: Task 5.2.6)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Estimated uncertainties in the development product verification evidence

5.2.8   Update the requirements traceability matrix with the development product verification evidence.

Information Required:
- Needed M&S capabilities that the M&S executable could support (Source: Task 5.2.3)
- M&S limitations implied by the development product verification evidence (Source: Task 5.2.4)
- Information gaps in the development product verification evidence (Source: Task 5.2.5)
- Requirements traceability matrix (Source: Activity 1.6)
- M&S requirements (Source: Activity 1.1)

Information Produced:
- Requirements traceability matrix updated with the development product verification evidence

Activity 5.3 – Employ the Verification Evidence

Activity Description: This activity employs the development product verification evidence to identify factors that may constrain use and candidate output sampling areas.

Activity Tailoring Guidance: (Blank)

Activity Notes: Tasks identify the V&V Plan as input because they apply the techniques and tools identified in the V&V Plan to perform the analyses.

Activity Assumptions: (Blank)

Task Descriptions:

5.3.1   Analyze the M&S limitations implied by the development product verification evidence, the information gaps in the development product verification evidence and the acceptability criteria to identify the factors that may constrain use.

Information Required:
- M&S limitations implied by the development product verification evidence (Source: Activity 5.2)
- Information gaps in the development product verification evidence (Source: Activity 5.2)
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Factors that may constrain use implied by the development product verification evidence

5.3.2   Analyze the M&S capabilities and limitations implied by the development product verification evidence, the information gaps in the development product verification evidence and the acceptability criteria to identify the candidate output sampling areas suggested by the development product verification evidence.

Information Required:
- Needed M&S capabilities that the M&S executable could support (Source: Activity 5.2)
- M&S limitations implied by the development product verification evidence (Source: Activity 5.2)
- Information gaps in the development product verification evidence (Source: Activity 5.2)
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Candidate output sampling areas implied by the development product verification evidence

A1.7   PHASE 6 – VERIFY AND VALIDATE THE DATA AND KNOWLEDGE SETS

Activity 6.1 – Identify the Data and Knowledge Sources and Their Pedigrees

Activity Description: All M&S consist of the executable or computational models and the data or knowledge that those models require. In this activity, the V&V practitioner identifies the different data and knowledge sets that an M&S needs, the available sources of those data sets and the pedigrees of those sources.

Activity Tailoring Guidance: (Blank)

Activity Notes: This activity has tasks for collecting the descriptions of the data and knowledge and their sources (i.e., meta-data) because these tasks take time and the required information is commonly not easily available in a single place.

Activity Assumptions: (Blank)

Task Descriptions:

6.1.1   Obtain the M&S data model.

Information Required:
- M&S data model (Source: Developer)

Information Produced:
- M&S data model

6.1.2   Analyze the M&S data model to determine what data and knowledge sets the M&S needs to support the intended use.

Information Required:
- M&S data model (Source: Task 6.1.1)
- Statement of intended use (Source: Preceding accreditation activity)

Information Produced:
- Data and knowledge sets needed to support the intended use

6.1.3   Obtain the available data and knowledge sets needed to support the intended use.

Information Required:
- Available data and knowledge sets needed to support the intended use (Source: External data sources)

Information Produced:
- Available data and knowledge sets

6.1.4   Obtain descriptions of the data and knowledge sets available to support the intended use.

Information Required:
- Descriptions of the data and knowledge sets available to support the intended use (Source: External data sources)

Information Produced:
- Descriptions of the data and knowledge sets

6.1.5   Obtain the V&V history for the available data and knowledge sets.

Information Required:
- V&V history for the available data and knowledge sets (Source: External data sources)

Information Produced:
- V&V history for the available data and knowledge sets

6.1.6   Analyze the descriptions of the available data and knowledge sets to identify their sources if possible.

Information Required:
- Descriptions of the data and knowledge sets available to support the intended use (Source: Task 6.1.4)

Information Produced:
- Possible sources of the available data and knowledge sets

6.1.7   Obtain descriptions of the identified sources for the available data and knowledge sets.

Information Required:
- Descriptions of the data and knowledge set sources (Source: External data sources)

Information Produced:
- Descriptions of the data and knowledge set sources

6.1.8   Analyze the descriptions of the data and knowledge set sources to identify the pedigrees of those sources.

Information Required:
- Descriptions of the data and knowledge set sources (Source: Task 6.1.7)

Information Produced:
- Data and knowledge set source pedigrees

6.1.9   Analyze the descriptions of the available data and knowledge sets and their sources to identify the data and knowledge sets for which the sources cannot be identified.

Information Required:
- Descriptions of the data and knowledge sets available to support the intended use (Source: Task 6.1.4)
- Descriptions of the data and knowledge set sources (Source: Task 6.1.7)

Information Produced:
- Data and knowledge set sources that cannot be identified

6.1.10 Analyze the descriptions of the available data and knowledge sets and their sources to identify the data and knowledge sets that come from sources with no pedigrees.

Information Required:
- Descriptions of the data and knowledge sets available to support the intended use (Source: Task 6.1.4)
- Descriptions of the data and knowledge set sources (Source: Task 6.1.7)

Information Produced:
- Data and knowledge set sources with no pedigrees

6.1.11 Analyze the M&S data model and the available data and knowledge set descriptions to identify the data or knowledge sets needed to support the intended use that are not available.

Information Required:
- M&S data model (Source: Task 6.1.1)
- Descriptions of the data and knowledge sets available to support the intended use (Source: Task 6.1.4)

Information Produced:
- Unavailable data and knowledge sets needed to support the intended use

6.1.12 Prepare the source reference list of data and knowledge set pedigrees and resolve any citation problems.

Information Required:
- M&S data model (Source: Task 6.1.1)
- Available data and knowledge sets needed to support the intended use (Source: Task 6.1.3)
- Descriptions of the data and knowledge sets available to support the intended use (Source: Task 6.1.4)
- V&V history for the available data and knowledge set (Source: Task 6.1.5)
- Descriptions of the data and knowledge set sources (Source: Task 6.1.7)

Information Produced:
- Data and knowledge set pedigree citation list

Activity 6.2 – Verify the Data and Knowledge Sets

Activity Description: In this activity, the V&V practitioner verifies the internal consistency of the data and knowledge sets with which the M&S will be accepted for the intended use. Data and knowledge sets can be very large so the V&V practitioner may need to take advantage of the numerous tools available for checking data and knowledge set consistency. These tools may be applicable to many different types of data sets from disparate sources or they may be specific for particular data sets from individual sources. The knowledge-based systems community has produced several tools to check the consistency of knowledge bases. These are usually specific for the knowledge representation used.

Activity Tailoring Guidance: (Blank)

Activity Notes: Tasks identify the V&V Plan as input because they apply the techniques and tools identified in the V&V Plan to perform the analyses.

Activity Assumptions: (Blank)

Task Descriptions:

6.2.1   Analyze the data and knowledge sets needed to support the intended use for consistency within sets and identify any inconsistencies that exist.

Information Required:
- Available data and knowledge sets needed to support the intended use (Source: Activity 6.1)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Inconsistencies within the available data and knowledge sets

6.2.2   Analyze the data and knowledge sets needed to support the intended use for consistency between sets and identify any inconsistencies that exist.

Information Required:
- Available data and knowledge sets needed to support the intended use (Source: Task 6.2.1)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Inconsistencies between the available data and knowledge sets

6.2.3   Analyze the data and knowledge sets needed to support the intended use for consistency with the M&S data model and identify any inconsistencies that exist.

Information Required:
- Available data and knowledge sets needed to support the intended use (Source: Task 6.2.1)
- M&S data model (Source: Activity 6.1)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Inconsistencies between the available data and knowledge sets and the M&S data model

6.2.4   Analyze the M&S design products to identify the data transformations used.

Information Required:
- Verified M&S design products (Source: Activity 4.2)

Information Produced:
- Data transformations used in the M&S

6.2.5   Analyze the data and knowledge sets needed to support the intended use and the data transformations used to verify the correctness of those transformations with that data.

Information Required:
- Available data and knowledge sets needed to support the intended use (Source: Task 6.2.1)
- Data transformations used in the M&S (Source: Task 6.2.5)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Inconsistencies between the data and knowledge sets and the data transformations used

6.2.6   Analyze the inconsistencies discovered during the data and knowledge set verification to develop an integrated description of the data and knowledge set inconsistencies.

Information Required:
- Inconsistencies within the available data and knowledge sets (Source: Task 6.2.1)
- Inconsistencies between the available data and knowledge sets (Source: Task 6.2.2)
- Inconsistencies between the available data and knowledge sets and the M&S data model (Source: Task 6.2.3)
- Inconsistencies between the data and knowledge sets and the data transformations used (Source: Task 6.2.5)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Integrated description of the data and knowledge set inconsistencies

Activity 6.3 – Validate Data and Knowledge Sets Where Needed

Activity Description: In this activity, the V&V practitioner validates the data and knowledge sets with which the M&S will be accepted for the intended use. The V&V practitioner should take advantage of the pedigree information associated with the data and knowledge sets to reduce the validation burden and validate those sets only where sufficient pedigree information is not available.

Activity Tailoring Guidance: (Blank)

Activity Notes:
- Gaps and inconsistencies in both the data itself and the validation coverage of the data. These are different but related concepts.

- Tasks identify the V&V Plan as input because they apply the techniques and tools identified in the V&V Plan to perform the analyses.

Activity Assumptions: (Blank)

Task Descriptions:

6.3.1   Analyze the sensitivity of the M&S to the data and knowledge sets to determine the importance of the data and knowledge coverage.

Information Required:
- Available data and knowledge sets needed to support the intended use (Source: Activity 6.1)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Relative importance of data and knowledge sets for the intended use

6.3.2   Analyze the descriptions of the data and knowledge sets available to support the intended use, their pedigrees, their relative importance and the integrated description of the data, and knowledge set inconsistencies to identify only the data and knowledge sets that need to be validated for the current M&S configuration.

Information Required:
- Descriptions of the data and knowledge sets available to support the intended use (Source: Activity 6.1)
- Data and knowledge set source pedigrees (Source: Activity 6.1)
- Relative importance of data and knowledge sets for the intended use (Source: Task 6.3.1)
- Integrated description of the data and knowledge set inconsistencies (Source: Activity 6.2)

Information Produced:
- Data and knowledge sets that need to be validated for the current M&S configuration

6.3.3   Analyze the acceptability criteria and M&S design products to determine the acceptability criteria that define the required functionality and quality of the data and knowledge sets and the acceptability criteria upon which the data and knowledge sets have no impact.

Information Required:
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)
- Verified M&S design products (Source: Activity 4.2)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Acceptability criteria that define the required functionality and quality of the data and knowledge sets

6.3.4   Analyze the data and knowledge sets that need to be validated against the acceptability criteria that define the functionality needs to determine the functionality needs that are met, identify those criteria that are not met, and identify those criteria for which insufficient information is available.

Information Required:
- Data and knowledge sets that need to be validated for the current M&S configuration (Source: Task 6.3.2)
- Acceptability criteria that define the required functionality of the data and knowledge sets (Source: Task 6.3.3)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Acceptability criteria that define the required functionality that the data and knowledge sets meet

6.3.5   Analyze the data and knowledge sets that need to be validated, the acceptability criteria that define the quality needs and the M&S referent to determine the quality needs that are met, identify those criteria that are not met and identify those criteria for which insufficient information is available.

Information Required:
- Data and knowledge sets that need to be validated for the current M&S configuration and intended use (Source: Task 6.3.2)
- Acceptability criteria that define the required quality of the data and knowledge sets (Source: Task 6.3.3)
- Validation Referent (Source: Preceding accreditation activity)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Acceptability criteria that define the required quality that the data and knowledge sets meet

6.3.6   Analyze the acceptability criteria that the data and knowledge sets meet and the M&S design products to determine the M&S capabilities that valid data and knowledge sets support.

Information Required:
- Verified M&S design products (Source: Activity 4.2)
- Acceptability criteria that define the required functionality that the data and knowledge sets meet (Source: Task 6.3.4)
- Acceptability criteria that define the required quality that the data and knowledge sets meet (Source: Task 6.3.5)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- M&S capabilities that the valid data and knowledge sets can support

6.3.7   Analyze the acceptability criteria that the data and knowledge sets do not meet and the M&S design products to determine the M&S limitations implied by the data and knowledge sets.

Information Required:
- Verified M&S design products (Source: Activity 4.2)
- Acceptability criteria that define the required functionality that the data and knowledge sets do not meet (Source: Task 6.3.4)
- Acceptability criteria that define the required quality that the data and knowledge sets do not meet (Source: Task 6.3.5)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- M&S limitations implied by the data and knowledge set validation

6.3.8   Analyze the acceptability criteria for which insufficient information is available from the data and knowledge set validation and the M&S design products to determine the information gaps implied by those sets.

Information Required:
- Verified M&S design products (Source: Activity 4.2)
- Acceptability criteria upon which the data and knowledge sets have no impact (Source: Task 6.3.3)
- Acceptability criteria that define the required functionality for which insufficient information is available (Source: Task 6.3.4)

- Acceptability criteria that define the required quality for which insufficient information is available (Source: Task 6.3.5)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Information gaps implied by the data and knowledge set validation

Activity 6.4 – Integrate and Employ the Data and Knowledge V&V Evidence

Activity Description: In this activity, the V&V practitioner integrates the evidence gained from the prior data and knowledge V&V activities into an integrated description of the M&S's capabilities and limitations.

Activity Tailoring Guidance: (Blank)

Activity Notes: Tasks identify the V&V Plan as input because they apply the techniques and tools identified in the V&V Plan to perform the analyses.

Activity Assumptions: (Blank)

Task Descriptions:

6.4.1 Analyze the descriptions of the pedigreed data and knowledge sets, the integrated descriptions of the data and knowledge set inconsistencies, the M&S capabilities that the data and knowledge sets support to produce an integrated description of the M&S capabilities that the data and knowledge sets can support.

Information Required:
- Descriptions of the data and knowledge sets available to support the intended use (Source: Activity 6.1)
- Integrated description of the data and knowledge set inconsistencies (Source: Activity 6.2)
- M&S capabilities that the valid data and knowledge sets can support (Source: Activity 6.3)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Integrated description of the M&S capabilities that the data and knowledge sets can support

6.4.2 Analyze the descriptions of the pedigreed data and knowledge sets, the integrated description of the data and knowledge set inconsistencies, the M&S limitations implied by the data and knowledge set validation to produce an integrated description of the M&S limitations implied the data and knowledge sets.

Information Required:
- Descriptions of the data and knowledge sets available to support the intended use (Source: Activity 6.1)
- Integrated description of the data and knowledge set inconsistencies (Source: Activity 6.2)
- M&S limitations implied by the data and knowledge set validation (Source: Activity 6.3)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Integrated description of the M&S limitations implied by the data and knowledge V&V

6.4.3   Analyze the descriptions of the pedigreed data and knowledge sets, the M&S design products, the acceptability criteria, the integrated descriptions of the data, and knowledge set inconsistencies, the information gaps implied by the data and knowledge set validation to produce an integrated description of the information gaps implied by the data and knowledge sets.

Information Required:
- Descriptions of the data and knowledge sets available to support the intended use (Source: Activity 6.1)
- M&S design products (Source: Activity 4.2)
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)
- Integrated description of the data and knowledge set inconsistencies (Source: Activity 6.2)
- Information gaps implied by the data and knowledge set validation (Source: Activity 6.3)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Integrated description of the information gaps implied by the data and knowledge set V&V

6.4.4   Analyze the acceptability criteria integrated description of the M&S capabilities that the data and knowledge can support, the integrated description of the limitations implied by the data and knowledge sets and the information gaps implied by the data and knowledge set validation to estimate the coverage of the data and knowledge set V&V evidence.

Information Required:
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)
- Integrated description of the M&S capabilities that the data and knowledge sets can support (Source: Task 6.4.1)
- Integrated description of the M&S limitations implied by the data and knowledge V&V (Source: Task 6.4.2)
- Integrated description of the data and knowledge set inconsistencies (Source: Activity 6.2)
- Integrated description of the information gaps implied by the data and knowledge V&V (Source: Task 6.4.3)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Estimated coverage of the data and knowledge set V&V evidence

6.4.5   Analyze the integrated description of the M&S capabilities that the data and knowledge sets can support, the integrated description of the M&S limitations implied by the data and knowledge sets and the estimated coverage of the data and knowledge set V&V evidence to estimate the uncertainties in the data and knowledge set V&V evidence.

Information Required:
- Integrated description of the M&S capabilities that the data and knowledge sets can support (Source: Task 6.4.1)

- Integrated description of the M&S limitations implied by the data and knowledge set V&V (Source: Task 6.4.2)
- Estimated coverage of the data and knowledge set V&V evidence (Source: Task 6.4.3)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Estimated uncertainties in the data and knowledge set V&V evidence

6.4.6 Analyze the integrated description of the M&S limitations implied by the data and knowledge set V&V, the integrated description of the information gaps implied by the data and knowledge set V&V, and the acceptability criteria to identify the factors that may constrain use.

Information Required:
- Integrated description of the M&S limitations implied by the data and knowledge V&V (Source: Task 6.4.2)
- Integrated description of the information gaps implied by the data and knowledge set V&V (Source: Task 6.4.3)
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Factors that may constrain use implied by the data and knowledge set V&V

6.4.7 Analyze the integrated description of the M&S limitations implied by the data and knowledge set V&V, the integrated description of the information gaps implied by the data and knowledge set V&V and the acceptability criteria to identify the candidate output sampling areas implied by the data and knowledge set V&V.

Information Required:
- Integrated description of the M&S limitations implied by the data and knowledge V&V (Source: Task 6.4.2)
- Integrated description of the information gaps implied by the data and knowledge set V&V (Source: Task 6.4.3)
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Candidate output sampling areas implied by the data and knowledge set V&V

6.4.8 Update the requirements traceability matrix with the data and knowledge set V&V evidence.

Information Required:
- Integrated description of the M&S capabilities that the data and knowledge sets can support (Source: Task 6.4.1)
- Integrated description of the M&S limitations implied by the data and knowledge V&V (Source: Task 6.4.2)

- Integrated description of the information gaps implied by the data and knowledge set V&V (Source: Task 6.4.3)
- Requirements traceability matrix (Source: Activity 1.6)
- M&S requirements (Source: Activity 1.1)

Information Produced:
- Requirements traceability matrix updated with the data and knowledge set V&V evidence

A1.8   PHASE 7 – VALIDATE THE M&S RESULTS

Activity 7.1 – Leverage the Developer Test Results for Results Validation

Activity Description: In this activity, the V&V practitioner uses the Developer's test results to tailor the results validation effort.

Activity Tailoring Guidance: (Blank)

Activity Notes:
- Again, even though the Developer's test plan and test results are input to this activity, it contains a task for collecting that information because it is seldom presented to the V&V practitioner without any action. Often, the V&V practitioner must make several requests, sometimes through official channels, follow-up on those requests and ensure that the information that is delivered is complete and current. Unlike the configuration management documentation, test results can be managed by several individuals.

- Tasks identify the V&V Plan as input because they apply the techniques and tools identified in the V&V Plan to perform the analyses.

Activity Assumptions: (Blank)

Task Descriptions:

7.1.1   Obtain the test plan from the Developer.

Information Required
- Developer's test plan (Source: Developer)

Information Produced:
- Developer's test plan

7.1.2   Obtain the testing results from the Developer.

Information Required
- Developer's testing results (Source: Developer)

Information Produced:
- Developer's testing results

7.1.3   Obtain the M&S configuration management history from the Developer.

Information Required
- M&S configuration management history (Source: Developer)

Information Produced:
- M&S configuration management history

7.1.4   Analyze the Developer testing results and test plan and the M&S configuration management history to identify those test results that are relevant to the current M&S configuration.

Information Required:
- Developer's test plan (Source: Task 7.1.1)
- Developer's testing results (Source: Task 7.1.2)
- M&S configuration management history (Source: Task 7.1.3)

Information Produced:
- Relevant Developer's testing results

7.1.5   Analyze the relevant Developer testing results and the acceptability criteria to identify the Relevant and applicable Developer test results.

Information Required:
- Relevant Developer's testing results (Source: Task 7.1.4)
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)

Information Produced:
- Relevant and applicable Developer's testing results

7.1.6   Analyze the Relevant and applicable Developer testing results and the acceptability criteria to determine the capabilities and limitations of the current M&S configuration.

Information Required:
- Applicable Developer's testing results (Source: Task 7.1.5)
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Description of the M&S capabilities and limitations from the Developer's testing

7.1.7   Analyze the M&S capabilities and limitations from the Developer's testing and the acceptability criteria to identify any gaps and inconsistencies that may exist in those results.

Information Required:
- Description of the M&S capabilities and limitations from the Developer's testing (Source: Task 7.1.6)
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Description of the gaps and inconsistencies in the Developer's testing results

7.1.8 Analyze the description of M&S capabilities and limitations from the Developer's testing and the description of the gaps and inconsistencies in the Developer's testing results to estimate the coverage of the Developer's testing.

Information Required:
- Description of the M&S capabilities and limitations from the Developer's testing (Source: Task 7.1.6)
- Description of the gaps and inconsistencies in the Developer's testing results (Source: Task 7.1.7)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Estimated coverage of the Developer's testing results

7.1.9 Analyze the description of the M&S capabilities and limitations from the Developer's testing and the estimated coverage of the Developer's testing to estimate the uncertainties in the Developer's testing.

Information Required:
- Description of the M&S capabilities and limitations from the Developer's testing (Source: Task 7.1.6)
- Estimated coverage of the Developer's testing (Source: Task 7.1.8)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Estimated uncertainties in the Developer's testing results

7.1.10 Analyze the description of the M&S capabilities and limitations from the Developer's testing, the description of the gaps and inconsistencies in the Developer's testing results, the estimated coverage of, and uncertainties in, the Developer's testing results and the acceptability criteria to identify candidate output sampling areas.

Information Required:
- Description of the M&S capabilities and limitations from the Developer's testing (Source: Task 7.1.6)
- Description of the gaps and inconsistencies in the Developer's testing results (Source: Task 7.1.7)
- Estimated coverage of the Developer's testing results (Source: Task 7.1.8)
- Estimated uncertainties in the Developer's testing results (Source: Task 7.1.9)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Candidate output sampling areas suggested by the Developer's testing

Activity 7.2 – Plan for Results Validation

Activity Description: In this activity, the V&V practitioner plans the results validation effort. This can involve applying design of experiments techniques to build the test cases used to sample the M&S's output.

Activity Tailoring Guidance: (Blank)

Activity Notes:

- This planning activity requires solving the problem of describing the planning process in a way general enough to admit a number of techniques, including SMEs.

- Tasks identify the V&V Plan as input because they apply the techniques and tools identified in the V&V Plan to perform the analyses.

Activity Assumptions: (Blank)

Task Descriptions:

7.2.1   Obtain the M&S user documentation from the Developer.

Information Required:
- M&S user documentation (Source: Developer)

Information Produced:
- M&S user documentation

7.2.2   Analyze the candidate output sampling areas from the prior V&V activities and the Developer's testing to produce an integrated set of output sampling areas.

Information Required:
- Candidate output sampling areas suggested by the historical evidence (Source: Activity 2.4)
- Candidate output sampling areas implied by the scenario and M&S conceptual model V&V (Source: Activity 3.4)
- Candidate output sampling areas implied by the development product verification evidence (Source: Activity 5.3)
- Candidate output sampling areas implied by the data and knowledge set V&V (Source: Activity 6.4)
- Candidate output sampling areas suggested by the Developer's testing (Source: Activity 7.1)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Integrated set of output sampling areas

7.2.3   Analyze the integrated set of output sampling areas and the acceptability criteria to identify the M&S capabilities and limitations that will be tested.

Information Required:
- Integrated set of output sampling areas (Source: Task 7.2.2)
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)

Information Produced:
- M&S capabilities and limitations that will be tested

7.2.4   Analyze the M&S capabilities and limitations that will be tested, verified and validated collected scenarios and the acceptability criteria to determine test scenarios that adequately represent the intended use.

Information Required:
- M&S capabilities and limitations that will be tested (Source: Task 7.2.3)
- Verified and validated collected scenarios (Source: Activity 3.3)
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Test scenarios that represent the intended use

7.2.5   Analyze the M&S user documentation, integrated set of output sampling areas, M&S capabilities that will be tested and test scenarios that represent the intended use to design the test cases for results validation.

Information Required:
- M&S user documentation (Source: Task 7.2.1)
- Integrated set of output sampling areas (Source: Task 7.2.2)
- M&S capabilities and limitations that will be tested (Source: Task 7.2.3)
- Test scenarios that represent the intended use (Source: Task 7.2.4)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Test cases for results validation testing

7.2.6   Analyze the M&S user documentation, test scenarios that represent the intended use, the test cases for results validation and the M&S design products to design the test procedures for results validation.

Information Required:
- M&S user documentation (Source: Task 7.2.1)
- Test scenarios that represent the intended use (Source: Task 7.2.4)
- Test cases for results validation (Source: Task 7.2.5)
- Verified M&S design products (Source: Activity 4.2)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Test procedures for results validation testing

7.2.7   Prepare the results validation test plan.

Information Required:
- Integrated set of output sampling areas (Source: Task 7.2.2)
- M&S capabilities and limitations that will be tested (Source: Task 7.2.3)
- Test scenarios that represent the intended use (Source: Task 7.2.4)
- Test cases for results validation testing (Source: Task 7.2.5)
- Test procedures for results validation testing (Source: Task 7.2.6)

Information Produced:
- Results validation test plan

Activity 7.3 – Collect M&S Output for Results Validation

Activity Description: In this activity, the V&V practitioner executes the results validation test cases and collects the output needed for results validation.

Activity Tailoring Guidance: (Blank)

Activity Notes: Tasks identify the V&V Plan as input because they apply the techniques and tools identified in the V&V Plan to perform the analyses.

Activity Assumptions: (Blank)

Task Descriptions:

7.3.1   Test the M&S according to the results validation plan.

Information Required:
• Results validation test plan (Source: Activity 7.2)

Information Produced:
• M&S output from V&V testing

7.3.2   Obtain the M&S output from the T&E testing.

Information Required:
• M&S output from T&E testing (Source: T&E Team)

Information Produced:
• M&S output from T&E testing

7.3.3   Obtain the conditions under which the T&E testing was performed.

Information Required:
• M&S T&E testing conditions (Source: T&E Team)

Information Produced:
• M&S T&E testing conditions

7.3.4   Characterize the conditions under which the M&S results were collected.

Information Required:
• Results validation test plan (Source: Activity 7.2)
• M&S output from V&V testing (Source: Task 7.3.1)

Information Produced:
• M&S validation testing conditions

7.3.5   Analyze the output produced by the results validation testing and the validated M&S conceptual model to determine the M&S capabilities and limitations implied by that output.

Information Required:
- M&S output from V&V testing (Source: Task 7.3.1)
- M&S output from T&E testing (Source: Task 7.3.2)
- Verified and validated M&S design products (Source: Activity 4.2)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Description of M&S capabilities and limitations implied by results validation testing

7.3.6   Analyze the M&S capabilities and limitations implied by the results validation testing and the acceptability criteria to identify any gaps and inconsistencies that may exist in those testing results.

Information Required:
- Description of M&S capabilities and limitations implied by results validation testing (Source: Task 7.3.5)
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Description of the gaps and inconsistencies in the results validation testing

7.3.7   Analyze the descriptions of M&S capabilities and limitations and the gaps and inconsistencies in the results validation testing and the acceptability criteria to estimate the coverage of the results validation testing.

Information Required:
- Description of M&S capabilities and limitations implied by results validation testing (Source: Task 7.3.5)
- Description of the gaps and inconsistencies in the results validation testing (Source: Task 7.3.6)
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Estimated coverage of the results validation testing

7.3.8   Analyze the description of M&S capabilities and limitations implied by and the estimated coverage of the results validation testing to estimate the uncertainties in the results validation testing.

Information Required:
- Description of M&S capabilities and limitations implied by results validation testing (Source: Task 7.3.5)
- Estimated coverage of the results validation testing (Source: Task 7.3.7)
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Estimated uncertainties in the results validation testing

7.3.9 Repeat until the results validation testing has produced complete and confident enough results.

Information Required:
- Estimated coverage of the results validation testing (Source: Task 7.3.7)
- Estimated uncertainties in the results validation testing (Source: Task 7.3.8)
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Completed set of test results

Activity 7.4 – Integrate and Employ the Validation Testing Results

Activity Description: In this activity, the V&V practitioner infers the validity of the M&S from the collected M&S output.

Activity Tailoring Guidance: (Blank)

Activity Notes: Tasks identify the V&V Plan as input because they apply the techniques and tools identified in the V&V Plan to perform the analyses.

Activity Assumptions: (Blank)

Task Descriptions:

7.4.1 Analyze the results from the Developer's testing and the results validation testing to produce an integrated description of the M&S capabilities and limitations from results validation.

Information Required:
- Description of the M&S capabilities and limitations from the Developer's testing (Source: Activity 7.1)
- Description of M&S capabilities and limitations implied by results validation testing (Source: Activity 7.3)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Integrated description of the M&S capabilities and limitations from results validation

7.4.2 Analyze the gaps and inconsistencies identified by the Developer's testing and the results validation testing using the integrated description of the M&S capabilities and limitations from the M&S testing to reconcile them and produce a description of the unresolved gaps and inconsistencies in the results validation evidence.

Information Required:
- Integrated description of the M&S capabilities and limitations from results validation (Source: Task 7.4.1)
- Description of the gaps and inconsistencies in the Developer's testing results (Source: Activity 7.1)
- Description of the gaps and inconsistencies in the results validation testing (Source: Activity 7.3)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Description of the unresolved gaps and inconsistencies in the results validation evidence

7.4.3   Analyze the integrated description of M&S capabilities and limitations, the description of the unresolved gaps and inconsistencies in the results validation evidence and the acceptability criteria to estimate the coverage of the results validation evidence.

Information Required:
- Integrated description of the M&S capabilities and limitations from results validation (Source: Task 7.4.1)
- Description of the unresolved gaps and inconsistencies in the results validation evidence (Source: Task 7.4.2)
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)
- V&V Plan (Source: Activity 1.6)

Information Required:
- Estimated coverage of the results validation evidence

7.4.4   Analyze the integrated description of M&S capabilities and limitations and the estimated coverage of the results validation evidence to estimate the uncertainties in the integrated results validation evidence.

Information Required:
- Integrated description of the M&S capabilities and limitations from results validation (Source: Task 7.4.1)
- Description of the unresolved gaps and inconsistencies in the results validation evidence (Source: Task 7.4.2)
- Estimated coverage of the results validation evidence (Source: Task 7.4.3)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Estimated uncertainties in the results validation evidence

7.4.5   Analyze the acceptability criteria, the integrated description of M&S capabilities and limitations from the results validation evidence and the estimated uncertainties in the results validation evidence to identify the factors that may constrain use.

Information Required:
- Integrated description of the M&S capabilities and limitations from results validation (Source: Task 7.4.1)
- Estimated uncertainties in the results validation evidence (Source: Task 7.4.4)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Factors that may constrain use implied by the results validation evidence

7.4.6 Prepare the source reference list supporting results validation and resolve any citation problems.

Information Required:
- Developer's test plan (Source: Activity 7.1)
- Developer's testing results (Source: Activity 7.1)
- M&S user documentation (Source: Activity 7.2)
- M&S output from T&E testing (Source: Activity 7.3)
- M&S T&E testing conditions (Source: Activity 7.3)

Information Produced:
- Citations of information supporting results validation

7.4.7 Update the requirements traceability matrix with the results validation evidence.

Information Required:
- Integrated description of the M&S capabilities and limitations from results validation (Source: Task 7.4.1)
- Description of the unresolved gaps and inconsistencies in the results validation evidence (Source: Task 7.4.2)
- Requirements traceability matrix (Source: Activity 1.6)
- M&S requirements (Source: Activity 1.1)

Information Produced:
- Requirements traceability matrix updated with the results validation evidence

A1.9   PHASE 8 – INTEGRATE THE V&V EVIDENCE

Activity 8.1 – Integrate the V&V Evidence

Activity Description: This activity integrates the V&V evidence into a single consistent description.

Activity Tailoring Guidance: (Blank)

Activity Notes: (Blank)

Activity Assumptions: (Blank)

Task Descriptions:

8.1.1   Analyze the collected evidence produced by the V&V activities to generate an integrated description of the M&S capabilities and limitations.

Information Required:
- Integrated description of the M&S capabilities and limitations from the historical evidence (Source: Activity 2.4)
- Integrated description of the M&S capabilities that the scenarios and M&S conceptual model can support (Source: Activity 3.4)
- Integrated description of the M&S limitations implied by the scenario and M&S conceptual model V&V (Source: Activity 3.4)
- Needed M&S capabilities that the M&S executable could support (Source: Activity 5.2)
- M&S limitations implied by the development product verification evidence (Source: Activity 5.2)
- Integrated description of the M&S capabilities that the data and knowledge sets can support (Source: Activity 6.4)
- Integrated description of the M&S limitations implied by the data and knowledge V&V (Source: Activity 6.4)
- Integrated description of the M&S capabilities and limitations from results validation (Source: Activity 7.4)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Integrated description of the M&S capabilities and limitations from the collected V&V evidence

8.1.2   Analyze the gaps and inconsistencies identified by the prior V&V activities using the integrated description of the M&S capabilities and limitations from the collected V&V evidence to reconcile them and produce a description of the unresolved gaps and inconsistencies in the V&V evidence.

Information Required:
- Integrated description of the M&S capabilities and limitations from the collected V&V evidence (Source: Task 8.1.1)
- Description of the unresolved gaps and inconsistencies in the historical evidence (Source: Activity 2.4)
- Integrated description of the information gaps and inconsistencies in the evidence from the scenario and M&S conceptual model V&V (Source: Activity 3.4)

- Gaps and inconsistencies in the evidence from the Developer's verification products
  (Source: Activity 4.1)
- Integrated description of the inconsistencies discovered in the M&S development products
  (Source: Activity 4.6)
- Information gaps in the development product verification evidence (Source: Activity 5.2)
- Integrated description of the information gaps implied by the data and knowledge set V&V
  (Source: Activity 6.4)
- Description of the unresolved gaps and inconsistencies in the results validation evidence
  (Source: Activity 7.4)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Description of the unresolved gaps and inconsistencies in the collected V&V evidence

8.1.3   Analyze the integrated description of M&S capabilities and limitations, the description of the unresolved gaps and inconsistencies in the integrated V&V evidence and the acceptability criteria to estimate the coverage of the integrated V&V evidence.

Information Required:
- Integrated description of the M&S capabilities and limitations from the collected V&V evidence
  (Source: Task 8.1.1)
- Description of the unresolved gaps and inconsistencies in the collected V&V evidence
  Source: Task 8.1.2)
- Estimated coverage of the historical evidence (Source: Activity 2.4)
- Estimated coverage of the scenario and M&S conceptual model V&V evidence
  (Source: Activity 3.4)
- Estimated coverage of the Developer's verification products (Source: Activity 4.1)
- Estimated coverage of the development product verification evidence (Source: Activity 5.2)
- Estimated coverage of the data and knowledge set V&V evidence (Source: Activity 6.4)
- Estimated coverage of the results validation evidence (Source: Activity 7.4)
- Acceptability criteria defining needed functionality (Source: Activity 1.1)
- Acceptability criteria defining needed quality (Source: Activity 1.1)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Estimated coverage of the collected V&V evidence

8.1.4   Analyze the integrated description of M&S capabilities and limitations and the estimated coverage of the V&V evidence to estimate the uncertainties in the integrated V&V evidence.

Information Required:
- Integrated description of the M&S capabilities and limitations from the collected V&V evidence
  (Source: Task 8.1.1)
- Description of the unresolved gaps and inconsistencies in the collected V&V evidence
  (Source: Task 8.1.2)
- Estimated coverage of the collected V&V evidence (Source: Task 8.1.3)
- Estimated uncertainties in the historical evidence (Source: Activity 2.4)
- Estimated uncertainties in the M&S conceptual model V&V evidence (Source: Activity 3.4)
- Estimated uncertainties in the development product verification evidence (Source: Activity 5.2)

- Estimated uncertainties in the data and knowledge set V&V evidence (Source: Activity 6.4)
- Estimated uncertainties in the results validation evidence (Source: Activity 7.4)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Estimated uncertainties in the collected V&V evidence

8.1.5   Analyze the acceptability criteria, the integrated description of M&S capabilities and limitations from the V&V evidence and the estimated uncertainties in the V&V evidence to identify the factors that may constrain use.

Information Required:
- Integrated description of the M&S capabilities and limitations from the collected V&V evidence (Source: Task 8.1.1)
- Description of the unresolved gaps and inconsistencies in the collected V&V evidence (Source: Task 8.1.2)
- Estimated uncertainties in the collected V&V evidence (Source: Task 8.1.4)
- Factors that may constrain use implied by the historical evidence (Source: Activity 2.4)
- Factors that may constrain use implied by the scenario and M&S conceptual model V&V (Source: Activity 3.4)
- Factors that may constrain use implied by the development product verification evidence (Source: Activity 5.3)
- Factors that may constrain use implied by the data and knowledge set V&V (Source: Activity 6.4)
- Factors that may constrain use implied by the results validation evidence (Source: Activity 7.4)
- V&V Plan (Source: Activity 1.6)

Information Produced:
- Factors that may constrain use implied by the collected V&V evidence

8.1.6   Prepare, from the individual citation lists, an integrated list of citations of relevant and applicable information and resolve any citation problems.

Information Required:
- Citations of information used for V&V Planning (Source: Activity 1.5)
- Integrated citations supporting the compilation and analysis of the historical evidence (Source: Activity 2.4)
- Integrated citations supporting the compilation and analysis of the M&S conceptual model and collected scenarios (Source: Activity 3.4)
- Integrated citations supporting the development of the verification evidence (Source: Activity 4.6)
- Data and knowledge set pedigree citation list (Source: Activity 6.1)
- Citations of information supporting results validation (Source: Activity 7.4)

Information Produced:
- Integrated citations supporting the compilation and analysis of the collected V&V evidence

8.1.7   Update the requirements traceability matrix with the collected V&V evidence.

Information Required:
- Integrated description of the M&S capabilities and limitations from the collected V&V evidence (Source: Task 8.1.1)
- Description of the unresolved gaps and inconsistencies in the collected V&V evidence (Source: Task 8.1.2)
- Requirements traceability matrix (Source: Activity 1.6)
- M&S requirements (Source: Activity 1.1)

Information Produced:
- Requirements traceability matrix updated with the collected V&V evidence

Activity 8.2 – Derive the Conclusions from the Integrated V&V Evidence

Activity Description: This activity develops the conclusions, recommendations and lessons learned from the integrated V&V results and the V&V Plan. It also develops the presentations of the V&V results (e.g., graphics, tables).

Activity Tailoring Guidance: (Blank)

Activity Notes: (Blank)

Activity Assumptions: (Blank)

Task Descriptions:

8.2.1   Develop presentations of the collected V&V results (e.g., graphics, tables).

Information Required:
- Integrated description of the M&S capabilities and limitations from the collected V&V evidence (Source: Activity 8.1)
- Description of the unresolved gaps and inconsistencies in the collected V&V evidence (Source: Activity 8.1)
- Estimated coverage of the collected V&V evidence (Source: Activity 8.1)
- Estimated uncertainties in the collected V&V evidence (Source: Activity 8.1)

Information Produced:
- Presentations of the collected V&V results

8.2.2   Prepare a summary of the collected V&V results.

Information Required:
- Integrated description of the M&S capabilities and limitations from the collected V&V evidence (Source: Activity 8.1)
- Description of the unresolved gaps and inconsistencies in the collected V&V evidence (Source: Activity 8.1)
- Estimated coverage of the collected V&V evidence (Source: Activity 8.1)
- Estimated uncertainties in the collected V&V evidence (Source: Activity 8.1)

Information Produced:
- Summary of the collected V&V results

8.2.3   Prepare a summary of the lessons learned from the V&V effort.

Information Required:
- Collected lessons learned from exercising the V&V process (Source: Activity 1.6)

Information Produced:
- Summary of the lessons learned from the V&V effort

8.2.4   Analyze the summary of the collected V&V results, summary of the lessons learned from the V&V effort and M&S requirements to develop the V&V recommendations.

Information Required:
- Summary of the collected V&V results (Source: Task 8.2.2)
- Summary of the lessons learned from the V&V effort (Source: Task 8.2.3)
- M&S requirements (Source: Activity 1.1)

Information Produced:
- V&V recommendations

Activity 8.3 – Prepare the V&V Report

Activity Description: This activity prepares the V&V Report from the integrated V&V evidence.

Activity Tailoring Guidance: (Blank)

Activity Notes: (Blank)

Activity Assumptions: (Blank)

Task Descriptions:

8.3.1   Analyze the V&V Plan to develop the problem statement for the V&V effort.

Information Required:
- V&V plan (Source: Activity 1.5)

Information Produced:
- V&V effort problem statement

8.3.2   Prepare a summary of the M&S.

Information Required:
- V&V plan (Source: Activity 1.5)

Information Produced:
- Summary of the M&S

8.3.3   Prepare a summary of the techniques and tools applied to execute the V&V tasks.

Information Required:
• V&V plan (Source: Activity 1.6)

Information Produced:
• Summary of techniques and tools applied in the V&V effort

8.3.4   Prepare a summary of the conditions under which the M&S was tested.

Information Required:
• Documentation from prior testing efforts (Source: Activity 2.2)
• Relevant and applicable Developer's verification products (Source: Activity 4.1)
• M&S executable verification testing conditions (Source: Activity 4.4)
• M&S validation testing conditions (Source: Activity 7.3)

Information Produced:
• Summary of the conditions under which the M&S was tested

8.3.5   Describe the integrated evidence.

Information Required:
• Integrated description of the M&S capabilities and limitations from the collected V&V evidence (Source: Activity 8.1)
• Description of the unresolved gaps and inconsistencies in the collected V&V evidence (Source: Activity 8.1)
• Estimated coverage of the collected V&V evidence (Source: Activity 8.1)
• Estimated uncertainties in the collected V&V evidence (Source: Activity 8.1)
• Factors that may constrain use implied by the collected V&V evidence (Source: Activity 8.1)
• Integrated citations supporting the compilation and analysis of the collected V&V evidence (Source: Activity 8.1)

Information Produced:
• Description of the integrated V&V evidence

8.3.6   Analyze the problem statement and the description of integrated evidence to develop the V&V recommendations.

Information Required:
• V&V effort problem statement (Source: Task 8.3.1)
• Description of the integrated V&V evidence (Source: Task 8.3.5)

Information Produced:
• V&V recommendations

8.3.7   Describe the key participants in and contributors to the V&V effort.

Information Required:
• Key participants' background and expertise information

Information Produced:
- Key participants' description

8.3.8   Obtain the resources expended from the V&V project accounting team.

Information Required:
- V&V expenditure information (Source: V&V Project Accounting Team)

Information Produced:
- Resources expended in executing the V&V effort

8.3.9   Describe the resources expended in executing the V&V effort.

Information Required:
- Resources expended in executing the V&V effort (Source: Task 8.3.8)

Information Produced:
- Description of the resources expended for the V&V effort

8.3.10   Summarize the lessons learned from the V&V effort.

Information Required:
- Collected lessons learned from exercising the V&V process (Source: Activity 1.6)

Information Produced:
- Lessons learned from the V&V effort

8.3.11   Prepare the V&V report executive summary.

Information Required:
- V&V effort problem statement (Source: Task 8.3.1)
- Summary of the M&S (Source: Task 8.3.2)
- Description of the integrated V&V evidence (Source: Task 8.3.5)
- V&V recommendations (Source: Task 8.3.6)
- Lessons learned from the V&V effort (Source: Task 8.3.10)

Information Produced:
- V&V report executive summary

8.3.12   Assemble the V&V Report.

Information Required:
- V&V effort problem statement (Source: Task 8.3.1)
- Summary of the M&S (Source: Task 8.3.2)
- Summary of techniques and tools applied in the V&V effort (Source: Task 8.3.3)
- Summary of the conditions under which the M&S was tested (Source: Task 8.3.4)
- Description of the integrated V&V evidence (Source: Task 8.3.5)
- V&V recommendations (Source: Task 8.3.6)

- Key participants description (Source: Task 8.3.7)
- Description of the resources expended for the V&V effort (Source: Task 8.3.9)
- Lessons learned from the V&V effort (Source: Task 8.3.10)
- V&V report executive summary (Source: Task 8.3.11)

Information Produced:
- Draft V&V Report

8.3.13 Analyze the draft V&V report for internal consistency and correct any inconsistencies.

Information Required:
- Draft V&V report (Source: Task 8.3.12)

Information Produced:
- Corrected draft V&V report

8.3.14 Circulate the corrected draft V&V report for review and collect comments and recommendations for change.

Information Required:
- Corrected draft V&V report (Source: Task 8.3.13)

Information Produced:
- Comments and recommendations for change received on draft V&V report

8.3.15 Modify the corrected draft V&V report from the comments and recommendations for change received.

Information Required:
- Corrected draft V&V report (Source: Task 8.3.13)
- Comments and recommendations for change received on draft V&V report (Source: Task 8.3.14)

Information Produced:
- Modified V&V report

8.3.16 Analyze the modified V&V report for internal consistency, correct any inconsistencies and prepare the final V&V report.

Information Required:
- Modified V&V report (Source: Task 8.3.15)

Information Produced:
- Final V&V Report

Activity 8.4 – Support any Archival of the V&V Products

Activity Description: This activity supports any needed archival of the V&V products.

Activity Tailoring Guidance: (Blank)

Activity Notes: (Blank)

Activity Assumptions: The Users will decide whether and where to archive the V&V products.

Task Descriptions:

8.4.1   Obtain the locations for the archived V&V products.

Information Required:
- Selected archive locations (Source: User)

Information Produced:
- Selected archive locations

8.4.2   Obtain the points of contact for the selected archive locations.

Information Required:
- Selected archive locations (Source: Task 8.4.1)

Information Produced:
- Archive location points of contact

8.4.3   Obtain the choices of resource catalogs within which to publish the V&V product descriptions.

Information Required:
- Applicable resource catalogs (Source: User)

Information Produced:
- Applicable resource catalogs' information requirements

8.4.4   Arrange for archival of V&V products through the archive points of contact.

Information Required:
- Archive location points of contact (Source: Task 8.4.2)

Information Produced:
- Requirements for V&V product archive

8.4.5   Determine required formats and media for archived material.

Information Required:
- Requirements for V&V product archive (Source: Task 8.4.4)

Information Produced:
- Archival format requirements
- Archival media requirements

8.4.6   Translate the V&V products into the required format.

Information Required:
• Archival format requirements (Source: Task 8.4.5)
• V&V Plan (Source: Activity 1.5)
• V&V Report (Source: Activity 8.3)

Information Produced:
• Formatted V&V Plan
• Formatted V&V Report

8.4.7   Transfer the V&V products onto the required media.

Information Required:
• Archival media requirements (Source: Task 8.4.5)
• Formatted V&V Plan (Source: Task 8.4.6)
• Formatted V&V Report (Source: Task 8.4.6)

Information Produced:
• Transferred V&V Plan
• Transferred V&V Report

8.4.8   Deliver the archival V&V products to the archival location.

Information Required:
• Selected archive locations (Source: Task 8.4.1)
• Transferred V&V Plan (Source: Task 8.4.7)
• Transferred V&V Report (Source: Task 8.4.7)

Information Produced:
• Delivered V&V Plan
• Delivered V&V Report

8.4.9   Determine the requirements for resource catalog descriptions.

Information Required:
• Applicable resource catalogs (Source: Task 8.4.3)

Information Produced:
• Resource description requirements

8.4.10 Prepare descriptions of the archived V&V products.

Information Required:
• Resource description requirements (Source: Task 8.4.9)
• V&V Plan (Source: Activity 1.1)
• V&V Report (Source: Activity 8.3)

Information Produced:
- V&V Plan description
- V&V Report description

8.4.11 Publish the archived product descriptions in the applicable resource catalogs.

Information Required:
- Applicable resource catalogs (Source: Task 8.4.3)
- V&V Plan description (Source: Task 8.4.10)
- V&V Report description (Source: Task 8.4.10)

Information Produced:
- Published V&V product descriptions

Appendix 2 – DECOMPOSING THE VV&A PROCESSES TO SUPPORT THEIR TAILORING

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ABSTRACT

Using risk as an effective tailoring mechanism for Verification, Validation and Accreditation (VV&A) processes depends on understanding the factors that drive the risk as well as the VV&A tasks and techniques that can and should be implemented to address the use risks. This paper describes one perspective of the activities and tasks that constitute the VV&A processes for simulations upon which to found risk-based VV&A tailoring. This perspective describes a VV&A process model that builds from the experience gained in developing the Validation Process Maturity Model (VPMM) and IEEE Std 1516.4-2007, IEEE Recommended Practice for Verification, Validation and Accreditation of a Federation. This model generalizes the guidance provided in IEEE Std 1516.4-2007 to apply to simulations beyond just federations, and extends that guidance to consider the broad range of possible sources of validation evidence. It also establishes the basis from which to extend the applicability of the VPMM to a more practical extent of circumstances. This model defines the accreditation process in terms of the activities for planning the accreditation effort, characterizing the simulation's use, constructing the validation referent and developing the acceptance recommendations. It defines the V&V process in terms of the activities for planning the V&V effort, applying historical information, validating the simulation conceptual model, leveraging the developer's verification products, performing supplemental verification, validating the simulation results and integrating the V&V results into a coherent set of validation evidence. This model of the VV&A processes defines a superset of the tasks that may then be tailored to best suit the limits of acceptable use risk and optimize the resources available for VV&A. This paper describes the components of the high level VV&A activities and the products that they produce.

Keywords: validation, verification, accreditation, tailoring.

1.0 INTRODUCTION

One approach to tailoring Verification, Validation and Accreditation (VV&A) processes begins with a model that defines the spectrum of activities and tasks that could be done when performing VV&A then selecting and assembling the components of that model to best match the risk and resource constraints of the simulation

effort while still adhering to the policies, standards and guidelines that may be relevant to the intended use [1]. This paper presents such a model of VV&A processes that practitioners can tailor to meet the needs and constraints of their particular situations. This model can help the VV&A community realize the goal of tailorability that several sources have cited [1]-[3].

Four assumptions underlie the construction of this VV&A process model:

- This general model represents the breadth of the VV&A process from user requirements to the acceptance decision for an intended use.

- Accreditation refers to the process for arriving at a decision to accept or accredit a simulation for an intended use.

- The primary purpose for performing Verification and Validation (V&V) is to collect the evidence needed to support an acceptance decision for an intended use.

- The simulation users or their representatives are responsible for ensuring the completeness and correctness of any statements of user needs or simulation requirements.

The model in this paper integrates several process models described in the VV&A literature with recent experiences in performing VV&A to support actual simulation programs. The result is a superset of the possible VV&A activities and tasks and the context in which those components can be assembled into a working VV&A process. This model is described in two parts: an accreditation process model that encompasses the V&V process as a part and the V&V process model that produces the validation evidence needed by the accreditation process.

2.0 ACCREDITATION PROCESS MODEL

The accreditation process takes the accreditation needs, user needs and referent source information as input and produces the acceptance recommendations. Figure A2-1 illustrates the top level of this proposed accreditation process model.
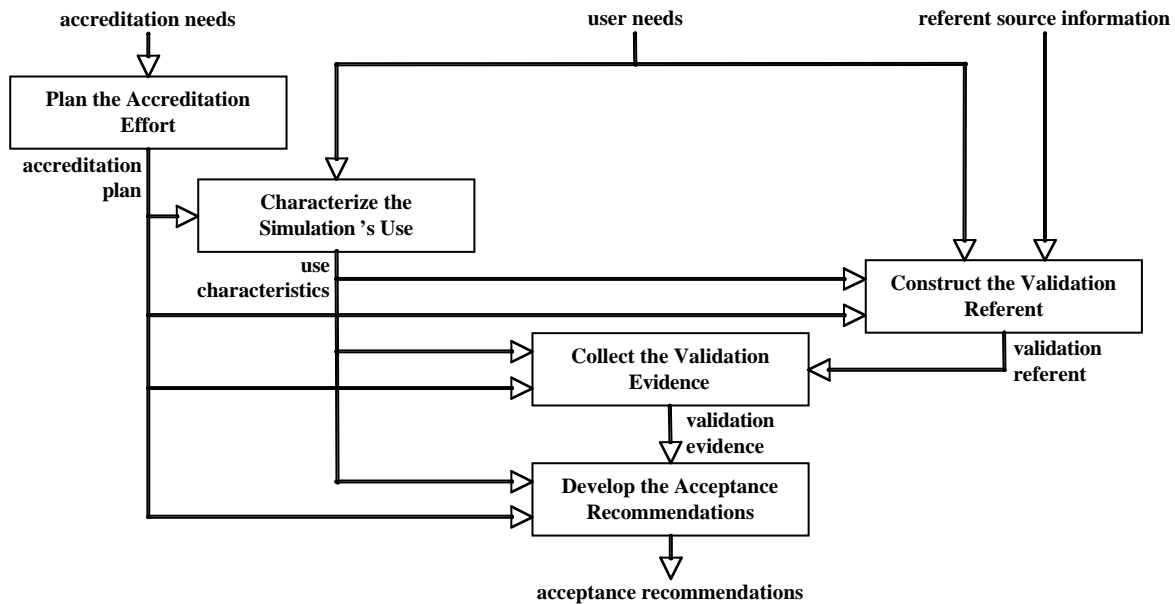
Figure A2-1: Top Level Diagram of the VV&A Processes and Their Products.

This model defines the accreditation process in terms of five activities:

- Plan the accreditation effort.
- Characterize the simulation's use.
- Construct the validation referent.
- Collect the validation evidence.
- Develop the acceptance recommendations.

The sections below describe each of these activities.

2.1   Plan the Accreditation Effort

Several authors have included accreditation planning as a critical part of their VV&A process models [1],[4]-[8]. Accreditation planning consists of six tasks:

- Assess the accreditation needs.
- Develop the accreditation approach.
- Build the accreditation schedule.
- Estimate the accreditation costs.
- Prepare the accreditation plan.
- Execute and evolve the accreditation plan.

In assessing the accreditation needs, the accreditation agent works with the program management to define the scope of the accreditation effort. This knowledge enables the accreditation agent to develop the accreditation

approach, schedule the accreditation tasks, estimate the costs of performing those tasks and capture this information in the accreditation plan. The accreditation agent executes and evolves the accreditation plan throughout the accreditation effort. This includes monitoring the accreditation and V&V efforts and adjusting the plans to better reflect any new information gained while executing the accreditation or V&V processes.

The task of developing the accreditation approach may include defining and prioritizing the application requirements and defining the needed level of objectivity as described in Reference [5].

As is true throughout this paper, the order of planning tasks given above does not necessarily imply either their order of execution or that there is no iteration involved within this activity or between the activities in the accreditation process. In some cases, the accreditation agent can only formulate a rough plan that is then revised throughout its execution.

2.2   Characterize the Simulation's Use

Characterizing the simulation's use includes several tasks that have been traditionally associated with the accreditation process [1],[4],[5],[9]:

- Collect the user needs.

- Verify the requirements/objectives.

- Document the intended use.

- Assess the use risks.

- Define the conditions of expected use.

- Develop the acceptability criteria.

- Specify the accreditation information requirements.

The first task collects and integrates the available documented requirements information (e.g., operational requirements document, capabilities development description) as well as elicits needs from the users or their representatives in order to develop as complete a picture of the user needs as possible. Several authors have suggested verifying the consistency of any user requirements or objectives as well [1],[4],[9]. However, this process purposely avoids the notion of validating the users' needs or requirements as suggested in Reference [10] because the authors feel that this intrudes sharply into the users' domain. As assumed above, the users or their representatives need to ensure the completeness and correctness of their requirements. The VV&A team can only check the requirements for consistency if desired. The consistency checking process may uncover problems in the requirements statements but the users or their representatives should resolve those problems. Similarly, the VV&A team cannot tailor the application requirements as suggested in Reference [5].

Knowledge of the user needs enables documenting the intended use, usually a brief statement of how the users will apply the simulation results. This task commonly requires considerable iteration with the users or their representatives and, possibly, other interested parties (e.g., developer). Iteration is also needed in assessing the use risks. This task includes identifying the risk areas and defining the impact levels as described in Reference [5]. The resolution of the use risk assessment depends upon the scope of the accreditation effort and the amount of information available at the time. In some cases, the risk assessment may only involve prioritizing the user needs. In other cases, the use risks can be explicitly described subjectively or quantitatively through such techniques as fault tree analysis [11]. The accreditation agent should understand the risks of using a

simulation as well as the simulation's capabilities and limitations [12]. Failure to do this will impact the subsequent accreditation and V&V activities and tasks [13].

The acceptability criteria specify the thresholds of functionality and error that a simulation needs to meet or exceed in order to be unconditionally accredited for an intended use [13]. Acceptability criteria may be derived entirely from user needs documentation (i.e., user requirements) [13], through an iterative review and interview process [12] or some combination of those techniques. If sufficient information is available, the acceptability criteria may be prioritized according to risk [12]. The assessment of tolerable use risks can contribute to this prioritization. Reference [13] discusses the derivation and properties of acceptability criteria in detail. The conditions of expected use complement the acceptability criteria by defining the properties of the inputs that the user expects to provide to the simulation and the outputs that they desire the simulation to produce. These conditions define the bounds of V&V testing [2], the domain of applicability of the acceptance recommendations [3],[14] and, thus, of the intended use [2],[3]. Like the acceptability criteria, the conditions of expected use need to be derived from the user needs documentation and interactions with the users or their representatives.

Finally, the accreditation agent assembles the assessment of use risks, conditions of expected use and acceptability criteria into the accreditation information requirements that, together with the accreditation plan, guide the V&V effort. In many cases, the accreditation agent may need to iterate between this activity and accreditation planning.

2.3   Construct the Validation Referent

The validation referent is the best available knowledge about the things being simulated [15],[16] and establishes the standard against which to measure simulation error. Constructing the validation referent involves three tasks:

- Identify practical referent information sources.

- Collect the applicable referent information.

- Assemble the validation referent.

The sources for validation referents exist in many forms, ranging from subjective and qualitative descriptions to objective and quantitative descriptions [4]:

- Data from controlled experiments describing the functionality and performance of a system or phenomenon under well-known conditions.

- Empirical data from observations of the behavior of a system or phenomenon under conditions ranging from unknown to well-characterized.

- Experience, knowledge and intuition of subject-matter experts.

- Mathematical models of the behavior of a system or phenomenon that have been validated against experimental or empirical data.

- Other simulations that have established credibility with the users for their particular intended uses.

- Combinations of the types described above.

The accreditation agent collects the information from these referent sources and assembles that information into a single consistent validation referent for the intended use. It is important to understand the uncertainties associated with any referent because those uncertainties add to those associated with the validation evidence.

In addition, validation referents need to be credible to a simulation's users since they will be impacted by the simulation's deviation from the behavior of the thing being simulated.

2.4   Collect the Validation Evidence

The accreditation process and the acceptance recommendations both depend upon the evidence that the V&V process produces [2],[5]. The collection of this evidence involves eight V&V activities:

- Plan the V&V effort.

- Apply relevant historical information.

- Verify and validate the simulation conceptual model.

- Perform supplementary verification on the development products.

- Leverage the verification products.

- Verify and validate the data and knowledge sets.

- Validate the simulation results.

- Integrate the validation evidence.

The V&V process model, presented in the following section, details these activities.

2.5   Develop the Acceptance Recommendations

The final step in the accreditation process develops the recommendations for the acceptance of the simulation [1],[4],[5],[7]-[9],[12],[17]. These are called the accreditation recommendations when a designated authority makes an official decision to accept a simulation for an intended use [4],[8],[9],[12]. Preparing these recommendations involves four tasks:

- Analyze the validation evidence.

- Develop the acceptance recommendations.

- Prepare the accreditation report and accreditation support package.

- Support the official decision to accredit.

Most authors who address the accreditation process realize that the accreditation agent should analyze the evidence produced by the V&V process to determine its implications for the intended use [4],[5]-[9],[17],[18]. Acceptance recommendations fall into five broad classes [2],[4],[5],[12]:

- Accept the simulation for the intended use without limitations.

- Accept the simulation with limitations on the use.

- Defer the recommendations until further validation evidence is available.

- Defer the recommendations until the simulation is further modified.

- Reject the simulation for the intended use.

In the many cases where the simulation is recommended for the intended use with limitations, the accreditation agent needs to identify the specific situations that the users should avoid to ensure that the simulation results will

be sufficiently complete and correct for the intended use. Regardless of the recommendations, the accreditation agent should assemble the accreditation plan, V&V Plan, V&V report, accreditation report and acceptance recommendations into an archival package [1],[6],[12],[18].

3.0 V&V PROCESS MODEL

From the assumptions above, the primary purpose for the V&V process is to collect the evidence upon which to base the acceptance recommendations. Figure A2-2 illustrates the proposed model for the V&V process. This figure aggregates the activities for performing supplementary verification and leveraging the verification products into a single box for verifying the development products. However, these two activities are discussed in separate sections below.
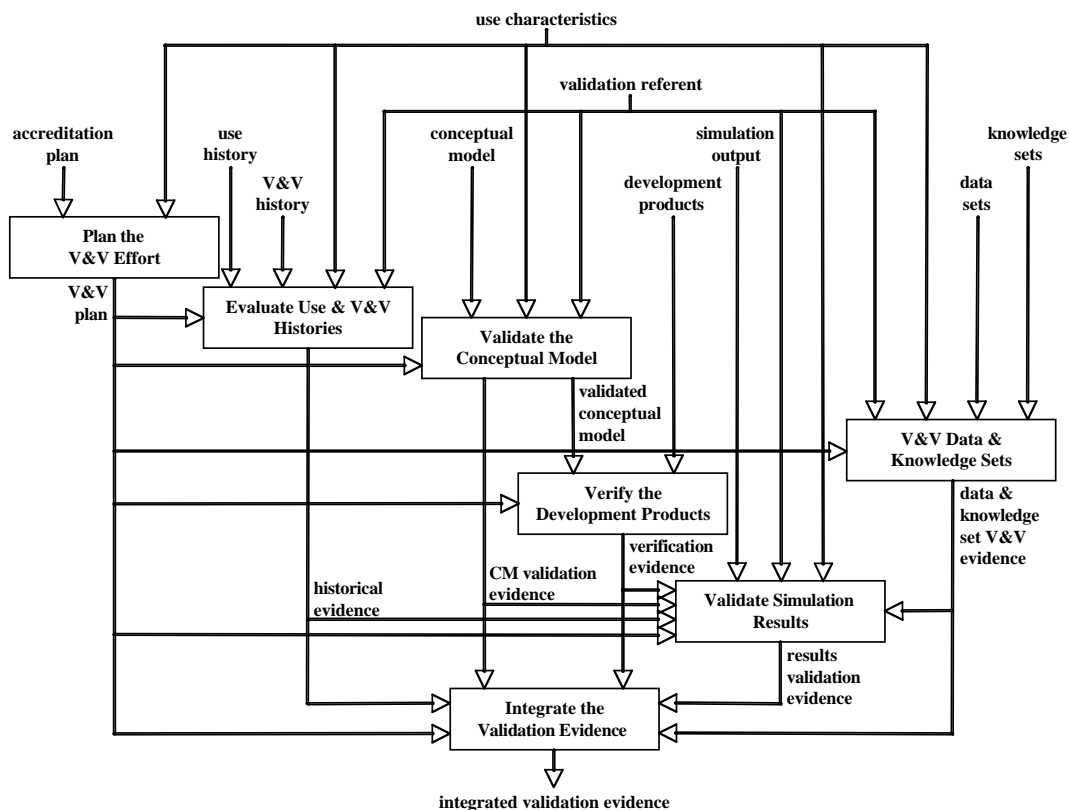

Figure A2-2: Top Level View of the V&V Process and Its Products.

3.1 Plan the V&V Effort

Most sources on VV&A processes addressed V&V Planning [2],[4],[5]-[8],[12],[17]. The tasks for planning the V&V effort mirror those for accreditation planning with one exception:

- Develop the V&V approach.
- Build the V&V effort schedule.
- Estimate the V&V costs.

- Prepare the V&V Plan.

- Execute and evolve the V&V Plan.

Unlike the accreditation process, the V&V process does not need a task for collecting the V&V needs since the accreditation agent supplies those as the accreditation information requirements. As with the accreditation process, the V&V practitioner executes and evolves the V&V Plan throughout the V&V effort. This includes monitoring the V&V effort and adjusting the V&V Plan to better reflect any new information gained while executing the V&V processes.

3.2   Apply Relevant Historical Information

In those situations where a legacy simulation is applied directly to a new intended use or modified for an intended use, considerable historical information may exist upon which to base acceptance recommendations. In fact, the entire V&V effort may focus upon the collection and analysis of historical information. Applying the relevant historical information includes six tasks:

- Collect and analyze the V&V and testing history.

- Collect and analyze prior use history.

- Collect and analyze developer accounts of simulation capabilities and limitations.

- Identify factors that may constrain use from the historical information.

- Integrate the historical evidence.

- Identify effective output sampling areas from the integrated historical evidence.

Applying any historical information begins by determining how closely the prior intended uses match the current one. In effect, this decides what part of the history is relevant to the current problem. Historical information can come from prior V&V and testing activities, the records of prior uses, and the developer's accounts of the simulation's capabilities and limitations. The V&V practitioner should then analyze the relevant historical record to identify the factors that may constrain use. Then, a coherent picture of the simulation's capabilities and limitations that the historical evidence depicts can be assembled. If results validation will be performed, the V&V practitioner should use the historical evidence to identify possible output sampling areas to improve its efficiency.

Only the availability of relevant historical information can reliably substitute for results validation since it will include the results of past V&V efforts. This is only possible when the prior uses either individually or in combination cover the current intended use.

3.3   Verify and Validate the Simulation Conceptual Model

Most of the surveyed sources recommended verifying and validating the simulation conceptual model [1],[2],[4],[6]-[10],[12],[14],[16],[18]-[20]. Pace has described the structure and content of a prototypical simulation conceptual model [21]-[23]. Eight tasks are associated with verifying and validating the conceptual model:

- Characterize conceptual model coverage.

- Check the internal consistency of the conceptual model.

- Infer the intended representational capabilities from the conceptual model.

- Evaluate the conceptual model validity.

- Verify and validate the available scenarios.

- Identify factors that may constrain use from the conceptual model.

- Identify effective output sampling areas from the conceptual model.

- Integrate the conceptual model validation evidence.

As with all models, the simulation conceptual model abstracts the functionality of the simulation. As a result, the V&V practitioner should begin by characterizing its coverage of the intended use and infer the simulation's capabilities from the information that the conceptual model contains. In between these tasks, the conceptual model verification involves checking it for internal consistency problems. Depending upon the detail of the conceptual model, these tasks can vary from trivial to complex and time consuming. After that, the V&V practitioner can evaluate the conceptual model against the acceptability criteria to determine its validity. If available, the V&V practitioner should also verify and, if needed, validate the use scenarios [8]. The remainder of the tasks parallels those in applying the relevant historical information.

As discussed earlier, the level of detail of conceptual models can vary wildly. If the conceptual model includes the mathematical or theoretical model in addition to a high level description of the functionality of the simulation, it can be used to assess the simulation's correctness against the validation referent.

3.4   Perform Supplemental Verification

This is the first of two development product verification activities. How much the V&V practitioner contributes to development product verification depends strongly upon the amount and quality of verification that the developer performs (or has performed for legacy simulations). The nature and degree of the verification that can be performed depends largely upon the development products available [24]. While most sources recommended verifying the simulation design products [1],[2],[4],[7],[9],[10],[12],[18] and the implementation products or executable model [1],[2],[4],[8]-[10],[12],[14],[18],[20], the developer may perform some fraction of the verification needed to support a simulation's validation. The V&V practitioner should leverage as much of the developer's verification as possible and only perform what supplemental verification is needed to increase the confidence in the validation evidence to the desired degree. Supplemental verification includes eight tasks:

- Collect the developer's verification products.

- Determine the scope of supplemental verification needed.

- Check for computational anomalies.

- Analyze the development products.

- Test the development products.

- Verify the development products for standards compliance.

- Verify the interoperability and compatibility of the development products.

- Verify the development products against the conceptual model.

In the tasks given above, the development products cover both the simulation design products (e.g., architectural design [1],[6],[7],[24], formal model [20], detailed design specification [1],[14],[20],[24]) and its implementation products (e.g., simulation code [2], interfaces [8]). Design and implementation verification can serve many purposes but the V&V practitioner performs supplemental verification primarily to bolster the

validation evidence. As mentioned, the V&V practitioner begins the supplemental verification by collecting the developer's verification products and determining how much additional verification is needed to achieve the desired confidence.

The next three tasks address the types of verification that the V&V practitioner could perform including checking for computational anomalies (e.g., stability, convergence, representational errors), analysis (e.g., control sequence, data flow) and testing (e.g., static, dynamic). Often standards play an important role in simulation development and the adherence to some standards could significantly affect validity. Thus, the V&V practitioner may need to assure the compliance to those standards [6]-[8],[24] if the developer has not already done so to the desired degree. Similarly, the V&V practitioner may need to verify the interoperability and compatibility of the implementation components both internally and externally (e.g., with other simulations in a federation) [7],[8],[24]. These supplemental activities produce evidence to assure that the simulation executable model is functioning correctly and could, therefore, perform validly. After having gained confidence that the simulation's execution is free from error, the V&V practitioner needs to verify that the development products faithfully reproduce the functionality described in the simulation conceptual model. This task links verification firmly to the simulation's validity (limited by the conceptual model's level of abstraction) but depends upon the traceability information that exists. The detail of this traceability information between the development products and the requirements through the conceptual model will ultimately determine what the V&V practitioner can infer about simulation validity from the verification products.

The list of tasks given above does not include all of the verification tasks that some authors have suggested. One source recommended validating the detailed design [6] and another recommended validating the executable model [23]. These steps were excluded because of their difficulty and limited value to the accreditation process. Another source included the software quality and documentation assessments with the verification efforts [18]. Although this is a reasonable idea, these tasks are not simulation-specific and should be applied to all software regardless of its type.

3.5   Leverage the Verification Products

Prior to this activity, the V&V practitioner has collected the developer's verification products, assessed their coverage to determine what supplemental verification is needed and performed that supplemental verification. In this activity, the V&V practitioner applies the collected verification information to develop evidence on the simulation's validity, add to the information to support the acceptance recommendations and provide guidance for output sampling. This includes the following six tasks:

- Characterize the collective verification coverage.
- Infer the representational capabilities from the verification products.
- Evaluate development product validity from the verification products.
- Identify effective output sampling areas from the verification products.
- Identify factors that may constrain use from the verification products.
- Integrate the verification evidence.

In the first task, the V&V practitioner maps the verification information onto the simulation's representational space to determine what of the required functional inventory that information addresses, what parts of that inventory are not covered and what parts that evidence from other sources (e.g., conceptual model validation) also considers. With the verification coverage, the V&V practitioner can then ascertain the simulation's representational capabilities and deduce the simulation's validity from the development product verification

by comparing those capabilities against the acceptability criteria. The outcomes from these tasks create a foundation from which to develop effective output sampling guidance and identify factors that may constrain use. Finally, the V&V practitioner needs to compile the evidence produced both by analysis of the developer's verification activities and the supplemental verification into a coherent picture of the simulation's validity painted from the verification products.

As mentioned earlier, development product verification can improve the confidence in the entire body of validation evidence. At this level, the V&V practitioner actually quantifies the impact on confidence that the verification evidence carries in its contribution. Estimates of the verification coverage of the simulation's completeness and correctness can also be used to estimate the probability that any other independent verification activities will produce the same conclusions. Correlated verification results that produce consistent conclusions about the simulation's capabilities improve the confidence in the evidence describing those capabilities. Likewise, uncorrelated results weaken the confidence in that evidence and may require further exploration to resolve any disagreements. In some cases, further verification can provide the information to resolve these problems and once again improve confidence in the combined evidence.

3.6   Verify and Validate the Data and Knowledge Sets

VV&A requires analysis of both models and data [14]. The activities heretofore have concentrated upon the simulation model. This activity focuses upon the data that is input to that model or upon which that model sits to derive its output (e.g., capabilities description files). Many of the sources surveyed emphasized the importance of verifying and validating the data that the simulation uses [1],[2],[12],[14]. The authors of this paper distinguish data and knowledge even though some could argue that knowledge is simply a type of data. Knowledge differs from data when it employs a specific knowledge representation (e.g., production rules, semantic networks, neural networks). Intelligent systems and human behavior representations commonly employ knowledge bases just as simulations of simpler physical phenomena employ databases. The V&V of knowledge differs from that for data because it can leverage the vast resources of techniques, tools and guidance from knowledge-based system verification, validation, evaluation and testing [25]. Verifying and validating the data and knowledge sets includes the following eight tasks:

- Identify the data and knowledge sources and their pedigrees.
- Find authoritative sources for data and knowledge with none.
- Verify the internal consistency of data and knowledge.
- Verify all data transformations.
- Validate data and knowledge sets where needed.
- Identify effective output sampling areas from the data and knowledge sets.
- Identify factors that may constrain use from data and knowledge V&V.
- Integrate the data and knowledge V&V evidence.

Data and knowledge set V&V should be performed because of the independence of those sets from the simulation and because the simulation relies upon those sets to produce its output. Invalid data or knowledge will lead to invalid simulation results. A data set essentially represents another form of model, a model that will affect the validity of the simulation's results, and therefore needs to be validated.

The tasks for data and knowledge V&V begin by identifying their sources and the pedigrees of those sources. This takes into account the fact that in many cases the organizations responsible for producing the data for a

simulation differ from the organizations that either develop or use the simulations. The credibility of those data-producing organizations often weighs heavily in determining the credibility of the data itself. Sometimes, data and knowledge comes to a simulation program without any obvious pedigrees. In those cases, the V&V practitioner needs to trace the history of the data (through configuration management documentation if available) to identify the sources and describe the authority of those sources. In some instances, the V&V practitioner may need to recommend using other data with pedigrees that are credible to the users.

After establishing the pedigrees of the data and knowledge, the V&V practitioner should verify the internal consistency of the data sets, verify any transformations used to make the data accessible and meaningful to the simulation (e.g., units transformations, coordinate transformations) then validate the completeness and correctness of the data sets against the acceptability criteria. The V&V practitioner can then use the data validation information to identify output sampling guidance and factors that may constrain simulation use. The V&V practitioner then assembles the products from the data and knowledge V&V into a consistent package of evidence.

3.7   Validate Simulation Results

Simulation results validation is almost universally included in VV&A process models [1],[4], [6]-[10],[12],[14],[16]-[18],[20]. In this activity the simulation produces output through the execution of test scenarios, the V&V practitioner interprets the simulation's representational capabilities from that output and then compares those capabilities against the acceptability criteria to determine validity. Results validation involves seven tasks:

- Plan for results validation.

- Leverage developer test results for validation.

- Collect simulation output for validation.

- Verify the simulation output.

- Infer the simulation's validity from its output.

- Identify factors that may constrain use from results validation.

- Integrate the results validation evidence.

On the surface, results validation appears straightforward. That would be true if complete testing of the simulation was possible but, most times, complete testing is impractical and, many times, infeasible [3]. Therefore, results validation can only sample from the simulation's behavior space and the V&V practitioner needs to infer validity from that limited sample. The first task, planning for results validation, addresses the deliberate choice of where and when to sample. This can be done through design of experiments techniques [26] among others. The previous V&V activities should produce guidance for sampling simulation output. The conditions of expected use can further constrain simulation testing by defining the boundaries of use. This guidance can make a computationally intractable output-sampling problem tractable. The V&V practitioner should also use the developer's test results to improve the efficiency of output sampling.

Some authors suggest that the V&V practitioner should verify the output that will be used for results validation [1],[7],[20]. This task can identify problems with the output before expending the resources needed for results validation. Finally, the V&V practitioner needs to infer the simulation's validity from its output, identify factors that may constrain use and integrate the results validation products into a coherent evidence package.

3.8   Integrate the Validation Evidence

The preceding V&V activities produce the evidence that this activity integrates into a lucid description of the simulation's validity to support the acceptance recommendations. This activity involves the four tasks:

- Infer simulation validity from collective V&V results.

- Form the validation conclusions.

- Prepare the V&V report.

- Support any archival of the V&V products.

The V&V practitioner should examine the evidence produced by the preceding activities, form a consistent picture of the simulation's validity and estimate the confidence in that determination if needed and possible. The V&V practitioner can also assemble the factors that may constrain use into a single set of use constraints then combine those constraints with the assessments of the simulation's completeness and correctness for the intended use. Then, the V&V practitioner assembles the results of this integration with the evidence produced by the prior V&V activities into the V&V report [1],[5],[6],[12],[17],[18]. The information in the V&V report should present the evidence upon which the accreditation agent can base the acceptance recommendations. This activity may include any post-execution follow-up and archival performed [1],[9].

4.0   SUMMARY AND CONCLUSIONS

This paper presents a comprehensive model of the VV&A processes and describes the activities and tasks that could be performed to meet a simulation program's accreditation needs. However, the authors do not intend VV&A practitioners to apply this model in totality or universally. This model only supplies the cloth from which to cut the VV&A processes needed to suit the demands and resource availability of specific programs. The authors also intend VV&A practitioners to use their knowledge of the risks that their simulation users can and cannot accept in their judgments of which VV&A activities and tasks to perform and at which maturity level to perform them.

Research is ongoing to develop a comprehensive model of VV&A process maturity to accompany and complement this VV&A process model. As Balci has observed "No rigid 'cookbook' simulation VV&A process can fit all situations all the time." [3] The process model presented in this paper is aimed at helping VV&A practitioners tailor their processes to best fit their situations.

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6.0 ACKNOWLEDGMENTS

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Appendix 3 – VV&A COMPOSITE MODEL VERIFICATION RESULTS

Risk-Based Accreditation Methodology: an Ontology Implementation

(NATO MSG-054: "An Overlay Standard for VV&A of Federations")

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An international effort is currently under way towards developing a Risk-Based Accreditation (RBA) methodology for common VV&A frameworks for simulations and federations of simulations. Its goal is to better manage resources, to be able to account for risk and to support tailoring in the VV&A process. This work proposes an ontological implementation of the RBA methodology structure cleanly separating structure from data in order to promote coherent tailoring, to generate reliable documentation and to facilitate future methodology upgrades. A few detailed examples were implemented with the Web Ontology Language (OWL) [16] in order to demonstrate the basic implementation principles, however the RBA methodology is not yet finalized, and neither are the details of the individual RBA activities and tasks used for those examples.

1.0 INTRODUCTION

The Risk-Based Accreditation (RBA) methodology for common VV&A frameworks for simulations and federations of simulations is the result of an extensive international cooperation and convergence of efforts, as highlighted by DMSO [3], IEEE 1516.4 [4], NASA-STD-7009 [9], NATO MSG-054 [10], NDIA [2], REVVA [12], SISO [13], etc.

As its name implies, RBA is organized to identify and quantify various simulation risks (as well as resources) in order to optimize the VV&A process. Essential verifications and validations may thus be identified according to the importance of the corresponding risks and/or costs. Those parts of the VV&A process involving less risk are liable to be tailored out in order to keep a lid on costs while retaining an acceptable level of VV&A reliability.

The RBA methodology applies to the entire VV&A process, beginning with an Accreditation Plan in which the accreditation needs and resources are assessed in order to develop a suitable accreditation approach so as to determine optimal simulation acceptability criteria in light of the intended use and use risks. The V&V needs, risk, resources, schedule and cost resulting from this approach and criteria are then determined, and if appropriate, the thus determined VV&A procedure is carried out, ending with an Accreditation Decision with relevant supporting documents and evidence.

In other words, the goal of the RBA methodology is to devise and implement a VV&A approach which properly and efficiently determines the suitability (with respect to, e.g., cost, risk, utility, scheduling) of a model, simulation, or federation of simulations for the intended use, taking risk into account to optimize the efficiency and reliability of this determination and to adjust the complexity of the VV&A process in light of the available resources and constraints. In this context, risk refers in particular to the risk of using a simulation (i.e., use risk), but risks inherent to the development and VV&A process are also taken into account.

After a brief discussion in Part 2 of risk and its assessment in VV&A, Part 3 summarizes the current status of the international cooperation on the RBA methodology, Part 4 presents our implementation of RBA as an ontology and Part 5 concludes the presentation.

2.0   RISK IN VV&A OF SIMULATIONS

2.1   Different Types of Risk

"Risk is a measure of future uncertainties in achieving program performance goals and objectives within defined cost, schedule and performance constraints." [1]

Risks associated with simulation development and use can be categorized as development risks, operational risks, inherited risks, etc. [1],[5],[11]:

1) **Development Risks** (supported by program and developer managers) are related to the simulation development itself or to the modification of legacy simulations and typically relate to compromises made because the simulation does not exactly meet the needs of the intended application (e.g., inadequate representations, insufficient accuracy), or to potential problems in addressing the technical, scheduling, cost, or resourcing aspects, or to accreditation activities modifying these aspects during the course of development.

2) **Operational Risks** (supported by users and V&V practitioners, managed by accreditation agents) are risks arising from using simulation results that are incorrect and not believing simulation results that are correct, as well as risks arising from V&V activities when minimizing the effects (scheduling, budget, etc.) of potential failures and when producing the evidence of capability and credibility of M&S. Since the V&V activities are meant to provide evidence for the accreditation phase, ultimately the accreditation agent has to manage operational risk.

3) **Inherited Risks** (especially when reusing models, for instance in federations) are risks arising from effects carried forward from previous simulation development or usage, such as effects resulting from undocumented assumptions, limitations, and constraints, or errors and defects that were either undetected or considered insignificant in previous applications.

This list is not exhaustive. Other important risk categories relate for instance to the maintainability and reliability of the simulation.

2.2   Example of Risk Assessment

In order to objectively manage risk and establish risk-based priorities for VV&A according to the RBA methodology, it is essential not only to be able to identify all or most of the risks in the preliminary phase, but also to be able to (preferably quantitatively) compare the different risks with one another by using an established measure of risk (e.g., mathematical expectation of loss) due to an event, for instance as follows [5]:

(Measure of Risk due to an event) = (impact level) x (probability of occurrence)

In ordinary management decisions, "impact level" often is the estimated monetary cost of the average loss resulting from this risk, expressed either as a numerical value or as belonging to a predetermined range of values identified by a label (such as "high", "medium", "low"). Depending on the domain of use and goals of the simulation, other methods of determining risk may be more appropriate, for instance:

- The "impact level" may instead be a quantitative measure of potential loss of life or a measure of mission failure.

- The "probability of occurrence" of the event may be unknown or only subjective, in which case broad ranges of probability (such as "high", "medium", "low") are often used.

A detailed discussion of the various methods for determining the different types of risk in M&S is beyond the scope of this presentation; for more details, please refer to the appended literature resources on risk definition, risk types and risk assessment.

3.0   RBA METHODOLOGY STRUCTURE

3.1   RBA Methodology Activity Sequence

The RBA methodology consists of three major successive phases which are represented by the three columns of Table A3-1. The first phase, during which Activities 1, 2 and 3 are meant to be carried out in sequence, is meant to efficiently and coherently plan and prepare the actual VV&A effort as such, which is subsequently conducted in Phase 2 (V&V process as per Activity 4) and Phase 3 (Accreditation/acceptance decision process as per Activity 5).

Table A3-1: RBA Methodology Activity Overview (bullets refer to sub-activities) [10].

Prerequisite to V&V Process	V&V Process	Accreditation Decision
Activity 1 **Plan Accreditation Effort**: • Assess the Accreditation Needs • Develop the Accreditation Approach • Identify the Accreditation Resources • Build the Accreditation Schedule • Estimate the Accreditation Costs • Prepare the Accreditation Plan • Execute and Evolve the Accreditation Plan	**Activity 4:** **Collect Validation Evidence**: • Plan the V&V Effort • Apply Relevant Historical Information • Verify and Validate the Simulation Conceptual Model • Perform Supplemental Verification • Apply the Verification Products to Validation • Verify and Validate the Data and Knowledge Sets • Validate the Simulation Results • Integrate the Validation Evidence	**Activity 5:** **Recommendations for Use:** • Analyze the Validation Evidence • Develop the Recommendations for Use • Prepare the Accreditation Report and Accreditation Support Package • Support the Official Decision to Accredit
Activity 2 **Characterize Simulation's Use:** • Collect the User Needs • Verify the Requirements/ Objectives • Document the Intended Use • Assess the Use Risks • Define the Conditions of Expected Use • Develop the Acceptability Criteria		
Activity 3 **Construct Validation Referent:** • Identify Practical Referent Information Sources • Collect the Applicable Referent Information • Assemble the Validation Referent • Collect the Validation Evidence		

The RBA methodology is therefore just an overlay on traditional VV&A methodology permitting a more rational determination of acceptability criteria and more efficient planning of VV&A while taking risk and real-world constraints into account, at the expense of a few additional preparatory steps, essentially consisting of Activities 1, 2, and 3. The additional resource expenditure required by these additional preparatory steps is offset by better risk and resource control in the overall process, a more pragmatic and resource-effective VV&A process and more useful and relevant acceptability criteria yielding a more trustworthy accreditation.

Particulars of the individual Activities 1 – 5 are likely to change and have been specified in Table A3-1 only as a rough guide providing a more specific understanding of the overall philosophy of the RBA methodology and its influence on VV&A.

3.1.1   Prerequisite to the V&V Process: "Activities 1, 2 and 3"

Activities 1, 2 and 3 are instrumental in planning the entire VV&A process and its scope.

Specifically, Activity 1 (Accreditation Plan):

• Decides the scope of the accreditation effort;

• Influences the entire V&V effort concerning V&V approach, resources, schedule, costs, V&V Plan;

• Establishes priorities for the V&V effort; and

• Identifies required information to guide the accreditation assessment.

Activity 2 focuses on the use risks assessment and on the process of defining suitable acceptability criteria in light of those risks, the constraints and the intended uses. Acceptability refers to the decision to apply a simulation to an intended use, i.e., this defines on which basis the accreditation decision will have to be taken.

Activity 3 identifies, collects and assembles the validation referent, against which the simulation will be measured and evaluated.

3.1.2   V&V Process: "Activity 4"

Activity 4 corresponds to the V&V steps of traditional VV&A, but according to RBA these are defined by the results and outcomes of Activities 1, 2 and 3, and may be tailored according to these outcomes, thus taking risks and resource availability into account. The primary purpose of performing V&V, as in traditional VV&A, continues to be the collection of evidence indicating that the simulation is properly implemented and valid for its intended use.

3.1.3   Accreditation Decision: "Activity 5"

Activity 5 results in an Accreditation Decision with supporting documents, based on the evidence from Activity 4 according to the acceptability (acceptance) criteria defined in Activity 2 (in the light of risks and resource availability). As in traditional VV&A, the accreditation decision is a formal decision authorizing the application of the simulation for its intended use; it may include recommendations for limitations of use.

3.2   Detailed Tailorable RBA Methodology Examples

The RBA methodology as proposed in NATO MSG-054 is presented in the form of an Excel sheet having the format shown in Tables A3-2 – A3-5. It is structured using the following categories of items, or fields, which will be individually discussed below:

1) Description of activities and tasks of each activity (this includes the use risks assessment activity and its influences);

2) Information required, information sources and information interrelations;

3) Information produced by each activity and task; and

4) Tailoring guidance.

3.2.1 Description of Activities and Tasks

Each "Activity" corresponds to the performance of a specific function in the RBA methodology and normally includes a sequence of several "Tasks". These "Tasks" are assigned pieces of work which, unless tailored out, all need to be finished in order to complete the activity to which they belong. Each "Task" requires information from various sources (for instance from previous completed tasks) and provides information for documentation purposes and/or for use in subsequent tasks.

Table A3-2 and Table A3-3 reproduce a fragment of this Excel sheet corresponding to Task 4.1.1.1 of Activity 4.1.1 corresponding to Activity 4. Although the numbering scheme is likely to change as this work progresses, this example concretely shows that the RBA methodology must be implemented as a (tailorable) sequence of "Activities".

Table A3-2: Activity 4.1.1 "Develop the V&V Approach" Description.

Activity No.	Activity Title	Activity Description
Activity 4	Collect the Validation Evidence	The primary purpose of performing V&V is to collect evidence indicating that the simulation is valid for intended use.
Activity 4.1.1 (This activity corresponds to Activity 4)	Develop the V&V Approach	This activity selects the specific activities and tasks that will be performed as part of the V&V approach

Table A3-3: Tasks (4.1.1.1 – 4.1.1.5) Description of "Activity 4.1.1".

Task No.	Task Description
Task 4.1.1.1	Determine the V&V activities and tasks that could be performed
Task 4.1.1.2	Select level of validation process maturity
Task 4.1.1.3	Candidate V&V techniques
Task 4.1.1.4	Candidate tool needed to support V&V
Task 4.1.1.5	Estimate complexity of each of the V&V tasks to be performed

3.2.2 Information Sources and Interrelations

In order to perform a task, information may be required from one or more information sources. These belong to two categories: "internal information sources" and "external information sources" defined as follows:

1) Internal information sources correspond to activities and tasks: Information produced by each activity and task is mostly provided to other subsequent activities or tasks as information input required for carrying out these other tasks. The fields for internal information sources are therefore referring to an activity or task by the name and/or number of that activity or task providing the information.

2) External information sources are entities such as Sponsor, Developers, Users, VV&A Team, Test and Evaluation Team, etc. They are expected to provide appropriate information such as V&V personnel list, simulation configuration, management history, documentation from prior VV&A or testing activities, etc.

RBA guidance from open literature and standards information from standards organizations are also required.

Table A3-4 is an example description of Task 4.1.1.1 (which corresponds to Activity 4.1.1), listing the information inputs and outputs of this task.

Table A3-4: Detailed Description of "Task 4.1.1.1".

Task No.	Task Description	Information Required	Information Source	Information Produced
Task 4.1.1.1 (This task corresponds to Activity 4.1.1)	Analyze the Accreditation Plan, the acceptability criteria and the RBA guidance to determine the V&V activities and tasks that could be performed	Accreditation Plan	Activity 1.6	Candidate V&V activities and tasks
		Acceptability Criteria	Activity 2.6	
		Use Risk Assessment Report	Activity 2.4	
		RBA Guidance	Open Literature	

3.2.3 Information Produced by Each RBA Activity and Task

Information produced by each RBA activity and task must be documented in a report for documentation and traceability purposes.

3.2.4 Tailoring Guidance

The RBA process, like the resulting VV&A process, is tailorable.

"A general approach to VV&A tailoring is the selection and modification of VV&A activities to meet the needs of the intended use within the risk, resource and implementation constraints of the program and the simulation users and processes as follows:

1) Begin with a composite model that defines the entire spectrum of VV&A activities and tasks that could be done;

2) Select and modify the components of that model to best satisfy the risk and resource constraints of the simulation program; and

3) Assemble the selected components into a consistent process that satisfies the use risk goals of the simulation program while still adhering to the policies, standards or guidelines that may be relevant to the intended use." [17]

Since the individual activities and tasks rely on information produced by previously executed activities or tasks, ensuring a "consistent process" when an activity or task is tailored out requires identifying how this affects the remaining activities and tasks, either providing alternative information sources to those tasks depending on the tailored one, or tailoring them out as well. The corresponding instructions, taking only the first level of those cascading dependencies into account, are currently documented for some tailorable activities and tasks as "Activity Tailoring Guidance" and "Task Tailoring Guidance" (see Table A3-5).

Table A3-5: Task 4.4.1.3, Task 4.4.1.4 and Task 4.4.1.5 Descriptions.

Task No.	Information Required	Information Source	Information Produced	Task Tailoring Guidance
Task 4.4.1.3	Developer's verification products	Task 4.4.1.2	Simulation capabilities and limitations implied by the Developer's verification products	This task only needs to be performed if the Developer has supplied the products that its verification activities have produced
	Simulation configuration management history	Task 4.4.1.1		
	Acceptability Criteria Report	Activity 2.6		
Task 4.4.1.4		Task 4.4.1.2	Gaps and inconsistencies in the Developer's verification products	If the Developer has produced no verification products then the set of gaps consists of all of the acceptability criteria
		Task 4.4.1.3		
		Task 4.4.1.1		
		Activity 2.6		
Task 4.4.1.5		Task 4.4.1.3	Estimated coverage of the Developer's verification products	If the Developer has produced no verification products then the coverage of those products is none
		Task 4.4.1.4		
		Activity 2.6		

4.0   RBA METHODOLOGY ONTOLOGY STRUCTURE

4.1   Overview

Implementing the RBA methodology as a knowledge base, using an appropriate ontology (formal specification for a community of agents of the concepts and relationships forming the methodology) would make possible its automated use by agents in an intelligent network. In particular, an ontology facilitates the implementation of a reasoning mechanism in order to support tailoring processes of the RBA methodology.

The use of an ontology clearly separating structure from data and documentation in order to implement the RBA methodology guarantees a greater flexibility and upgradeability in case of RBA methodology changes or updates (this is particularly important so long as RBA is not finalized).

Furthermore, ontology representation tools [14]] and available search, navigation, visualization and reasoning support ontology tools [15] seem particularly suited to provide the documentation and exhaustive justifications of tailoring in a clear graphical manner as needed for VV&A.

(1) Conceptualization:

The RBA ontology modeling pattern is based on two corresponding, mirror image sub-ontologies named "Structure Description" and "Documentation (Data Description)" on Figure A3-1 below. The former consists of activities, tasks and their interrelations (information required and sources). The latter, as its name implies, consists of activity and task reports.
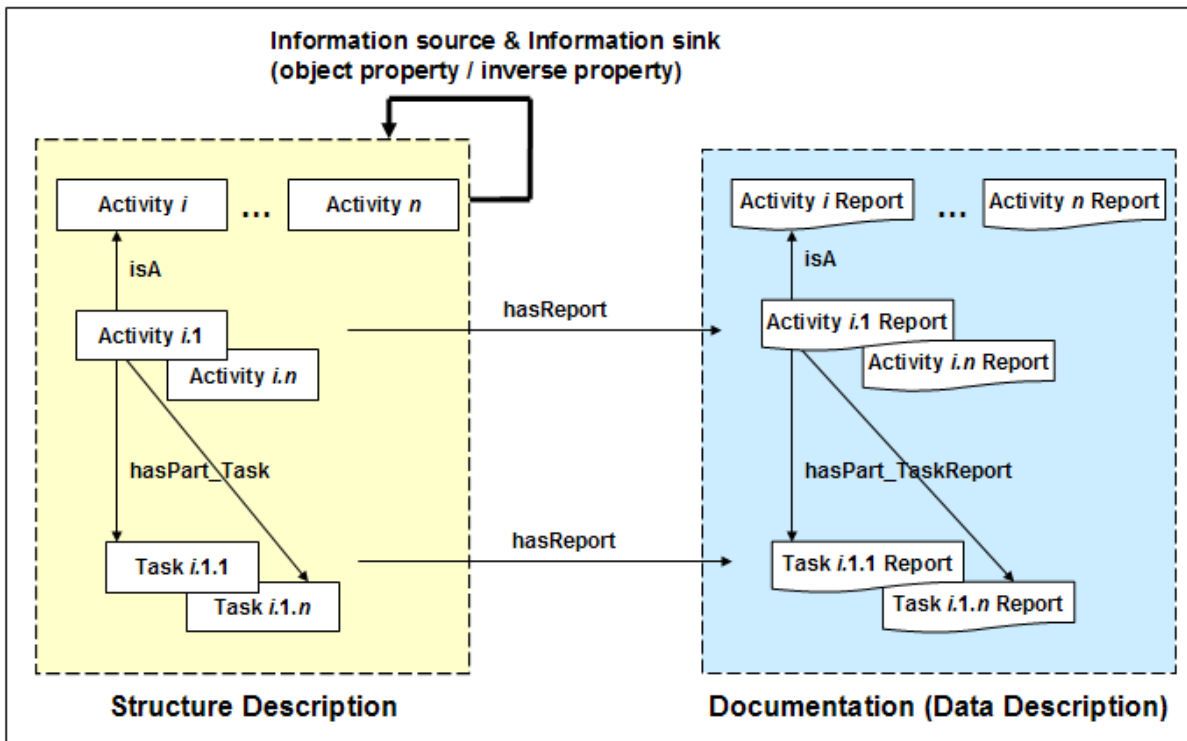

Figure A3-1: Overview of the RBA Methodology Ontology Structure.

(2) Formalization:

The RBA methodology was formalized as an OWL ontology [16], using Protégé version 3.4 as ontology editor [14], and using the essential OWL language features as follows (see Figure A3-2):

- Classes;
- Object properties / Inverse properties (the latter being especially useful in particular for the property information source/sink, thus permitting easy forward/backward navigation through the ontology for rapidly evaluating the consequences of RBA/VV&A tailoring);
- Data type properties; and
- Instances.
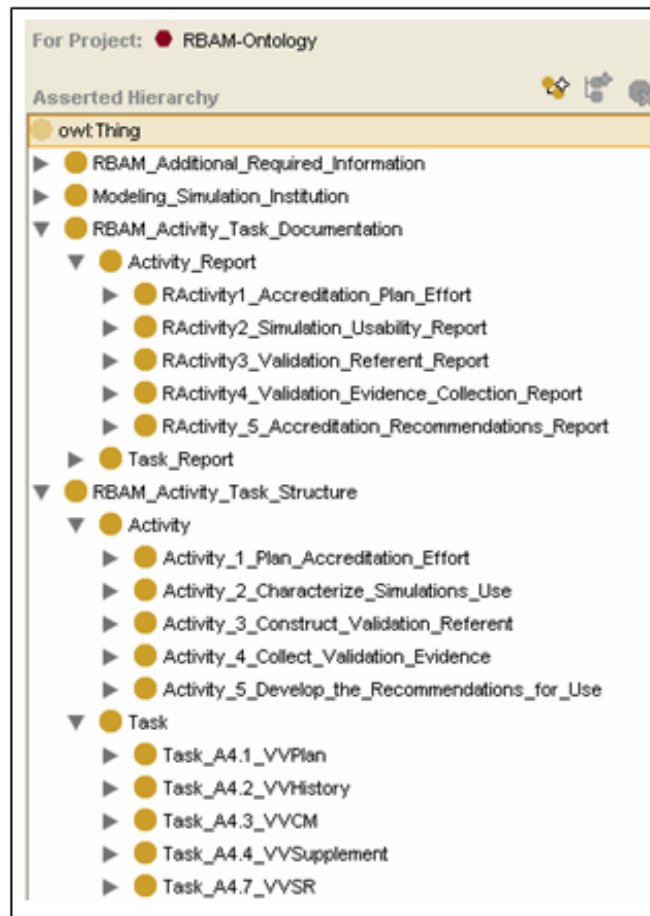
Figure A3-2: OWL Formalization: Overview of the RBA Methodology Ontology.

4.2 Concept "Activity"

The class "Activity" has sub-classes (linked by "isA" relations) of subordinated activities. Each class "Activity" has object and data type properties, for instance as shown in Figure A3-3.
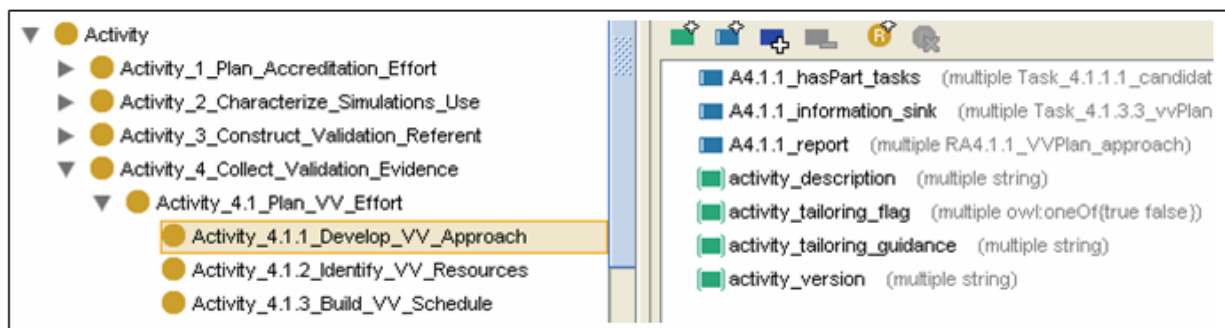

Figure A3-3: OWL Formalization: Class "Activity", its Sub-Classes and Properties of Class "Activity 4.1.1".

4.3 Concept "Task"

The class "Task" has sub-classes (linked by "isA" relations) of subordinated tasks. Each class "Task" has object and data type properties for instance:
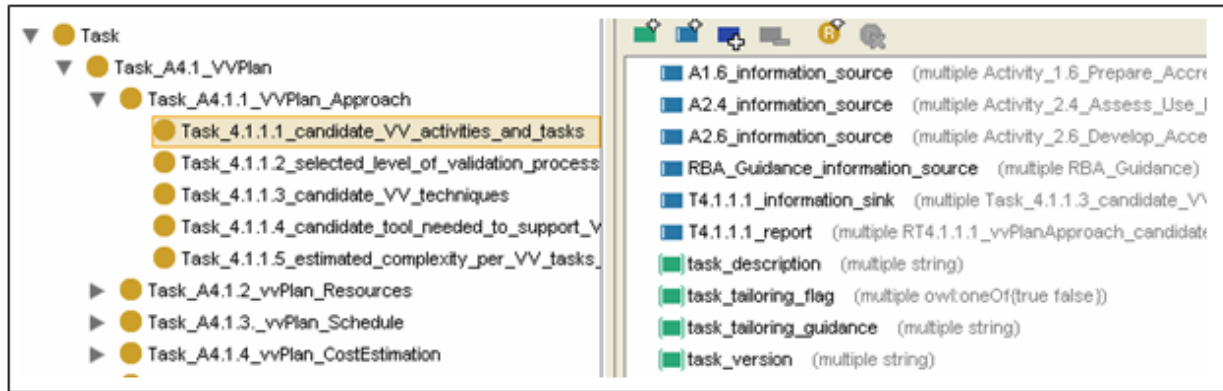
Figure A3-4: OWL Formalization: Class "Task", its Sub-Classes and Properties of Class "Task 4.1.1.1".

4.4 Concepts "Activity" and its "Tasks"

The relations (composition) between each class "Activity" and its corresponding tasks (class "Task") are defined by "hasPart" relations.

Figure A3-5: Ontology Visualization: Class "Activity 4.1.1" and Object Property "A4.1.1_hasPart_ tasks" (see also Figure A3-3).

4.5 Concepts "Information Source" and "Information Sink"

An "Information Source" denotes an activity or task which provides information to the current activity or task. An "Information Sink" denotes an activity or task which may need information from the current activity or task. The interrelations of information between (activity or task) and (activity or task) are defined by "_information source" as object property and "_information sink" as its inverse property, in order to permit navigation. This is crucial for tailoring needs.
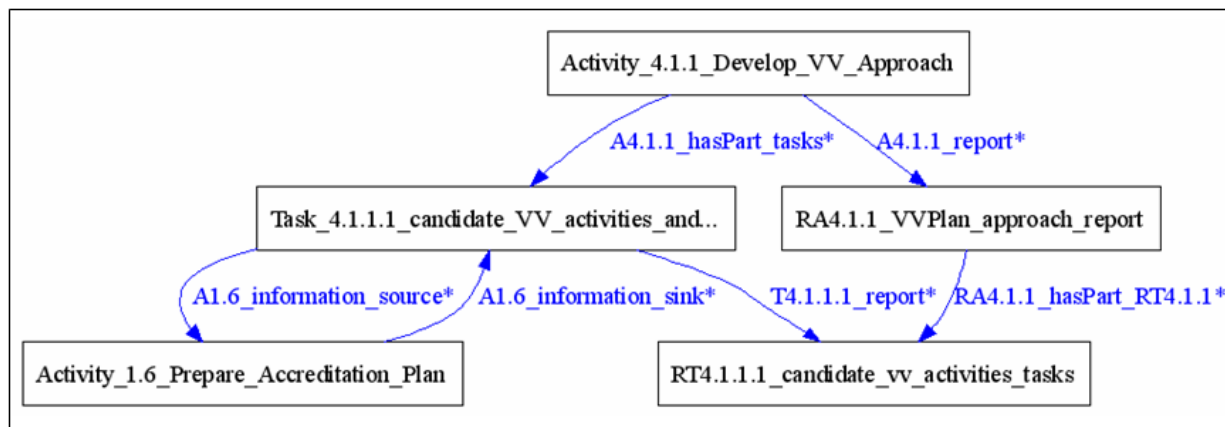
**Figure A3-6: Ontology Visualization: Class "Task 4.1.1.1", "Activity 1.6" and
Properties "A1.6 Information Source/Sink" (see also Figure A3-4).**

4.6 Concept "Information Produced"

The concept "Information produced" is defined as the property "_report" which links to the class "Activity_Report" or "Task _Report". This concept provides concrete documentation for traceability, model management, RBA and VV&A purposes.
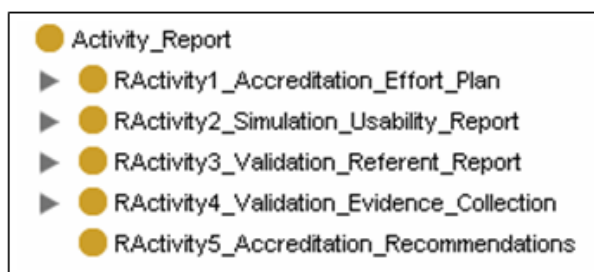

Figure A3-7: OWL Formalization: Class "Activity Report" and its Sub-Classes (see also Figure A3-6).

4.7 Concepts "Activity Tailoring Guidance" and "Task Tailoring Guidance"

The actual implementation of tailoring concepts remains outside of the scope of this work; however the example of Table A3-5 and Figure A3-8 describes how the concept "Tailoring Guidance" may be formalized for Task 4.4.1.4 using the "information_source" object property. Specifically, if Task 4.4.1.4 is tailored out then the information source to Task 4.4.1.5 is retrieved from Task 4.4.1.3 and Activity 2.6 only; the "Task Tailoring Guidance" of Task 4.4.1.4, retrieved by tracing the properties "information_source", specifies which information is to be used, namely the default value defined by "Set of gaps consists of all of the acceptability criteria" (instead of the information "Gaps and inconsistencies in the Developer's verification products" which would have been produced by Task_4.4.1.4). Thus in the event of tailoring the appropriate information can be retrieved from the previous information sources by tracing the "information_source" object property. Alternatively, in situations where the use of default values in the tailoring process is deemed likely to produce

inaccurate or misleading information, it may be desirable to cause the execution of the system to stop with a warning to the user that tailoring is not appropriate in this case.
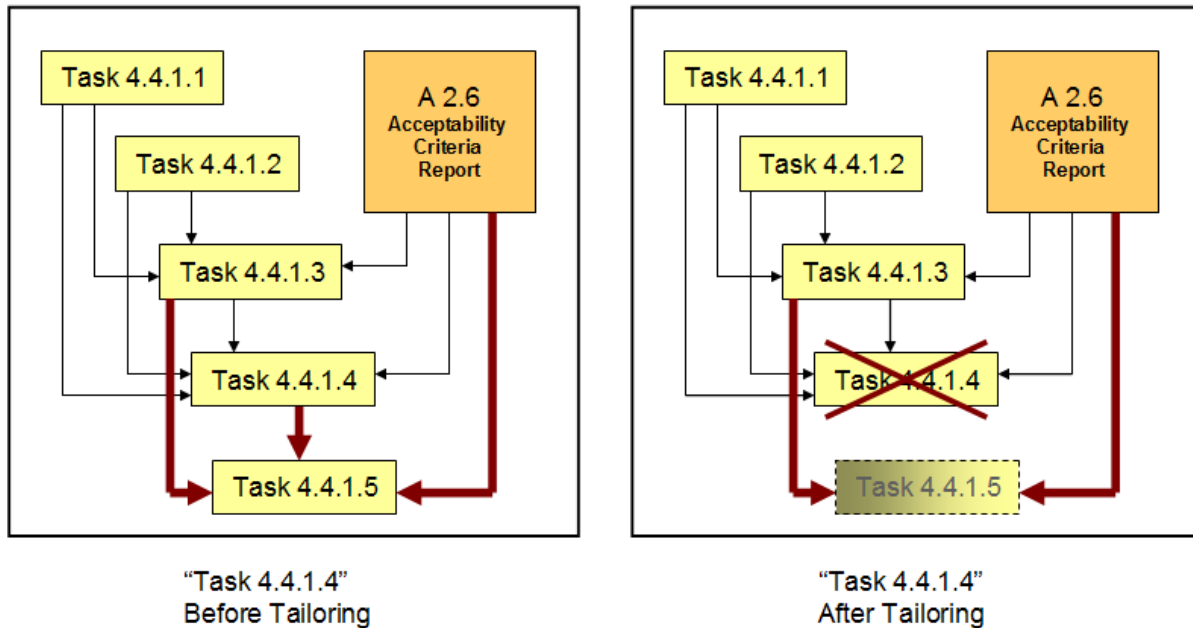

Figure A3-8: "Task 4.4.1.4" Before and After Tailoring (arrows represent the properties "information_source"). Information sources to "Task 4.4.1.5" are "Task 4.4.1.3" and "Activity 2.6" only after "Task 4.4.1.4" is tailored out.

An ontological approach makes it easier to obtain a complete picture of these cascading dependencies and their consequences beyond the first level.

The bulk of the remaining tailorable tasks is not discussed because its tailoring guidance is trivially implementable (this task need not be performed / only needs to be performed if some obvious condition) and does not require any tracing.

5.0   CONCLUSION

The implementation of the RBA methodology as an OWL ontology is feasible without making any compromise, and appears to promise a greater flexibility and upgradeability than more conventional approaches while preserving the fundamental advantages of the RBA methodology.

It will allow, with some additional work, a seamless integration in comprehensive ontology based modeling and simulation tool platforms under development at ITIS such as "Model Management System" [7] (including the "Leitfaden für Modelldokumentation" (Guidelines for model documentation) [6], and VV&A model documentation [8].

Ontological tools implementing reasoning mechanisms potentially can track tailoring effects throughout the RBA/VV&A sequence of activities and tasks: additional work might reveal whether sufficient quality assurance guarantees can be provided in this manner for deeper, more customized tailoring approaches. Further work

might also consider using such tools to visualize tailoring effects in a user friendly manner in order to facilitate tailoring decisions and to explore the relationships between risk constellations and the tailoring strategies most appropriate for them.

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14. Abstract

MSG-054/TG-037 was tasked to finalize an overlay standard for Verification, Validation, and Accreditation (VV&A) of Federations and then formalize the draft as an international industry standard by vetting the document through the Institute of Electrical and Electronics Engineers Standards Association's (IEEE-SA) standards processes. Additionally, foundational work was produced and documented on applying risk as a tailoring mechanism for the VV&A overlay.

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