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Guide for Generic Methodology for Verification and Validation (GM-VV) to Support Acceptance of Models, Simulations, and Data

GM-VV Volume 2: Implementation Guide

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1. Introduction

Models, simulations, and associated data (hereinafter referred to collectively as "M&S") are developed and employed as enabling technologies to support system analysis, design, test and evaluation, acquisition, training and instruction, and many more areas. Today, a wide variety of M&S are in use across an even wider range of different application and problem domains. M&S is usually applied when certain user needs cannot be achieved (e.g., risks, availability) with the actual system or otherwise are achieved more efficiently (e.g., costs, effectiveness) than with the actual system. However, in essence, all M&S provide some sort of abstract representation of systems (e.g., entity, phenomenon, process) that are based on different types of approximation. As such, M&S capabilities cannot fully replace the actual system and, more importantly, their usage introduces uncertainties. In combination with the increasing complexity of M&S being developed and employed, risks for failures, wrong usage, and misinterpretation of results are increasingly difficult to judge. Therefore, the benefits of using M&S always come at some cost, i.e., use risks. The key question then for M&S stakeholders (e.g., user, sponsor, developer, the public at large) is to determine which M&S asset is acceptable for a particular intended use, and which is not. Verification and Validation (V&V) are the processes that are typically used to support M&S stakeholders to determine and assure that an M&S asset is acceptable for the intended use. Hence, V&V provides information to be used in an acceptance decision process by M&S stakeholders, and associated practices such as M&S accreditation or certification[1].

1.1 Purpose of the GM-VV

The choice of which V&V method works best in a given situation depends on the individual needs and constraints of an M&S organization, project, application domain or technology. Moreover, V&V usually requires a complex mixture of various activities, methods, tools, techniques and application domain knowledge, which are often tightly coupled with the M&S development process. Therefore, many different approaches to V&V exist that rely on a wide variety of different V&V terms, concepts, products, processes, tools or techniques. In many cases, the resulting proliferation restricts or even works against the transition of V&V results from one M&S organization, project, and technology or application domain to another. Furthermore, history shows that V&V is often more of an afterthought than a built-in part of an M&S development, employment and procurement policy.

The purpose of the Generic Methodology for V&V (GM-VV) is to address these issues by means of providing general applicable guidance for V&V that:

- Facilitates common understanding and communication of V&V within the M&S community.
- Is applicable to any phase of the M&S lifecycle (e.g., development, employment, and reuse).
- Is M&S stakeholders' acceptance decision-making process oriented.
- Is driven by the M&S stakeholders' needs and M&S use risks tolerances.
- Is scalable to fit any M&S scope, budget, resources and use-risks thresholds.
- Is applicable to a wide variety of M&S technologies and application domains.
- Will result in traceable, reproducible and transparent evidence-based acceptance arguments.
- Can be instantiated on enterprise, project or technical levels alike.
- Facilitates reuse and interoperability of V&V outcomes, tools and techniques.

GM-VV is not aimed to replace the existing V&V approaches, methodologies, standards or policies of M&S organizations, technology and application domains; nor is GM-VV's intent to substitute common enterprise or project management practices prevalent within M&S client or supplier organizations. In addition, GM-VV is not intended to be prescriptive, in that it does not specify a single concrete or unique solution for all V&V applications. Rather, the GM-VV should be tailored to meet the needs of individual V&V applications.

[1] In this document the term acceptance is the decision to use a model, simulation, and the associated data for a specific purpose. Note: in the United States the term accreditation is the official certification that a model, simulation and the associated data are acceptable for use for a specific purpose. Note: in other communities certification is the process of providing a written statement that a (M&S) system is acceptable for operational use. For the purposes of this document these three terms are equivalent.

1.2 Scope of the GM-VV

The GM-VV provides a technical framework that focuses on M&S V&V practices. Though interrelated, acceptance decision processes and associated practices such as M&S accreditation and certification are outside the scope of the methodology. GM-VV attains its generic quality from a technical framework that consists of three subparts: the conceptual, implementation and tailoring framework (Figure 1). This framework is rooted in established international standards and other related practices. The conceptual framework provides the terminology, concepts and principles to facilitate communication and a common understanding and execution of V&V within an M&S context. The implementation framework translates these concepts and principles into a set of generic components to develop consistent V&V solutions for an individual M&S organization, project, and technology or application domain. GM-VV provides a tailoring framework that utilizes these components to develop and cost-efficiently apply such V&V application instances. As such, the GM-VV provides a high-level framework for developing concrete V&V solutions and conducting V&V, into which lower-level practices (e.g., tools, techniques, tasks, acceptability criteria, documentation templates) native to each individual M&S organization, project, technology, or application domain can easily be integrated.

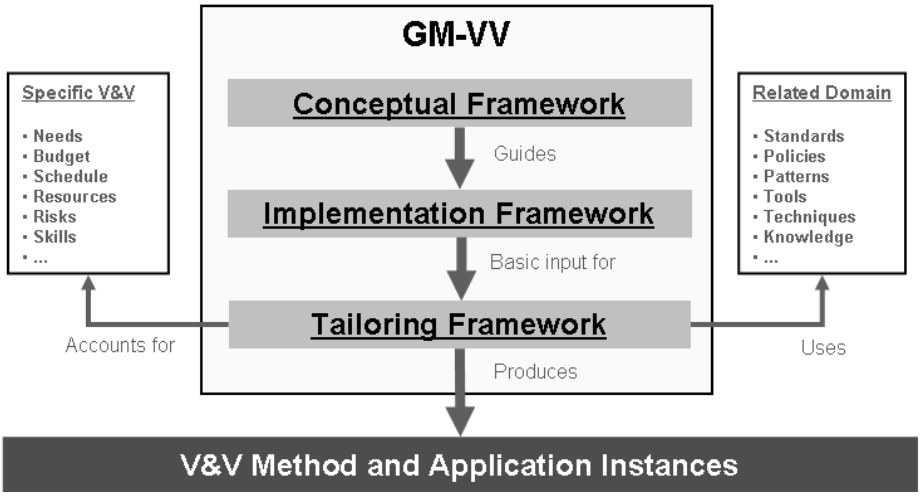

Figure 1 GM-VV Technical Framework Design and Operational Use Concept

1.3 Objective of the Document

The GM-VV is presented in three interrelated documents. The objective of volume 1 [SISO-GUIDE-001.1-2012] is to provide an introduction and an overview of the GM-VV conceptual framework. This document, volume 2, contains details on the implementation framework components, as well as detailed guidance on how to apply these components in conjunction with the tailoring framework to develop concrete V&V solutions. More technical and referential background information on the GM-VV, V&V in general and other related topics can be found in the "GM-VV Vol. 3: Reference Manual (DRAFT)".

1.4 Intended Audience of the Document

This document is intended for all M&S professionals and managers who want to apply GM-VV on technical, project and enterprise levels. More specifically, this document provides processes, activities and tasks to be performed by the roles defined.

1.5 Acknowledgements

This document was created as a community effort by the "Generic Methodology for Verification and Validation to Support Acceptance of Models, Simulations, and Data" Product Development Group (GM-VV PDG). This PDG was chartered by the Simulation Interoperability Standards Organization (SISO) Standards Activity Committee in 2007. The Technical Co-operation Agreement between the NATO Modelling and Simulation Group (NMSG) and SISO, which was also established in 2007,

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2. References

The following references are helpful for the understanding of this document.

2.1 SISO References

Document Number	Title
SISO-GUIDE-001.1-2012	GM-VV Volume 1: Introduction and Overview
SISO-REF-039-XXXX-Draft	GM-VV Volume 3: Reference Manual

2.2 Other References

Document Number	Title
IEEE Std 100-2000	The Authoritative Dictionary of IEEE Standards Terms, Seventh Edition, Current Version February 2007
IEEE Std 15288-2008 Second edition 2008-02-01	Systems and software engineering – System lifecycle processes
IEEE Std 1730™-2010 (Revision of IEEE Std 1516.3™-2003)	IEEE Recommended Practice for Distributed Simulation Engineering and Execution Process (DSEEP)
IEEE Std 1516.3™-2003 (superseded)	IEEE Recommended Practice for High Level Architecture (HLA) Federation Development and Execution Process (FEDEP)
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

3. Definitions

The table below lists the terminology used within the context of this methodology. Multiple definitions are provided where tailoring of the generic methodology is required to conform to organizational constraints. For terms not mentioned here, this document utilizes the standard definition as defined by IEEE 100 Dictionary of Standard Terms [IEEE Std 100-2000].

Acceptance: The process that ascertains whether an M&S system is fit for intended use [GM-VV].

Accreditation: The official certification that a model or simulation and its associated data are acceptable for use for a specific purpose. [B2].

Acceptability criteria: A set of criteria that a particular simulation, model or data has to be met to be acceptable for its intended use [GM-VV]. The criteria that the model, simulation, or federation of models and simulations needs to meet to be acceptable for its intended use [IEEE Std 1516.4™-2007]

Conceptual model: A statement of the content and internal representations that are the user's and developer's combined concept of the model. It includes logic and algorithms and explicitly recognizes assumptions and limitations [B9].

Correctness: The extent to which an M&S system implementation conforms to its specifications and is free of design and development errors [GM-VV].

Fidelity: The degree to which a model or simulation reproduces the state and behavior of a real world object or the perception of a real world object, feature, condition, or chosen standard in a measurable or perceivable manner; a measure of the realism of a model or simulation; faithfulness. Fidelity should generally be described with respect to the measures, standards or perceptions used in assessing or stating it [B5].

M&S system: A combination of interacting M&S elements organized to provide a representation of the simuland for an intended use. Examples of M&S elements are simulation hard- and software, models, data, simulation applications, human operators and procedures [GM-VV].

Referent: A codified body of knowledge about a thing being simulated [IEEE Std 1516.4™-2007].

Role: The specific set of responsibilities, obligations, and capabilities that are needed to perform an activity [GM-VV].

Simuland: The system being simulated by a simulation [B3].

Tailoring: The modification of V&V processes, V&V organization and V&V products to fit agreed risks, resources, and implementation constraints [GM-VV].

Utility: The property of an M&S system's application usefulness [GM-VV].

Validation: The process of providing evidence justifying the M&S system's validity [GM-VV]. Confirmation, through the provision of objective evidence that the requirements for a specific intended use or application have been fulfilled [IEEE Std 15288-2008]. 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. [B2]. The process of determining the degree to which a model, simulation, or data is an accurate representation of the real world, from the perspective of the intended purpose of the model, simulation or data [B1].

Validity: The property of an M&S system's representation of the simuland to correspond sufficiently enough with the referent for the intended use [GM-VV]. The property of a model, simulation or federation of models and simulations representations being complete and correct enough for the intended use [IEEE Std 1516.4™-2007].

Verification: The process of providing evidence justifying the M&S system's correctness [GM-VV]. Confirmation, through the provision of objective evidence that specified requirements have been fulfilled [IEEE Std 15288-2008]. The process of determining that a model or simulation implementation

and its associated data accurately represent the developer's conceptual description and specifications [B2]. The process of determining the degree that a model, simulation, or data accurately represent its conceptual description and its specifications [B1].

V&V client: The person or organization that acquires V&V products or services [GM-VV].

V&V supplier: The person or organization that develops and delivers V&V products or services [GM-VV].

4. Acronyms and Abbreviations

DoD	Department of Defense
DSEEP	Distributed Simulation Engineering and Execution Process
FEDEP	Federation Development and Execution Process
GM-VV	Generic Methodology for Verification and Validation
IEEE	Institute of Electrical and Electronics Engineers
IV&V	Independent Verification and Validation
M&S	Modeling and Simulation
NATO	North Atlantic Treaty Organization
NMSG	NATO Modelling and Simulation Group
REVVA	Referent for VV&A
SME	Subject Matter Expert
V&V	Verification and Validation
VV&A	Verification, Validation, and Accreditation

5. General Implementation Guidance for the GM-VV Framework

The GM-VV attains its generic quality from a three-part technical framework: the conceptual, implementation and tailoring framework (Figure 1). The conceptual framework has already been presented in GM-VV Vol. 1. The reader is referred to this volume to gain the details for this framework [SISO-GUIDE-001.1-2012]. This chapter provides an overview of the purpose, relationship and application of the GM-VV implementation and tailoring frameworks (Section 5.1). Furthermore, this chapter will provide general tailoring considerations for developing concrete V&V solutions using the GM-VV implementation framework on three organizational levels: technical (Section 5.2), project (Section 5.3) and enterprise (Section 5.4).

5.1 Implementation and Tailoring Frameworks Application Overview

The GM-VV conceptual framework comprises a set of terminology, semantics, concepts and principles for V&V of M&S, which are independent of specific organizations and application domains [SISO-GUIDE-001.1-2012]. This conceptual framework provides a common foundation for specific implementations of V&V for M&S. The GM-VV implementation framework is such a reference implementation for V&V of M&S, derived from the REVVA work [B4] [B5].

The GM-VV implementation framework provides a generic architectural template for developing *structured* and *well-organized* V&V solutions for specific M&S organizations, projects, and technologies or application domains. As such, the GM-VV implementation framework provides the reusable components arranged in a generic design pattern that underpins concrete V&V solutions. This generic design pattern consists of three component categories and is depicted in Figure 2. The products satisfy some needs or purpose, a process produces one or more products, and a process is executed by one or more organizational roles (e.g., persons, organization or organizational unit).

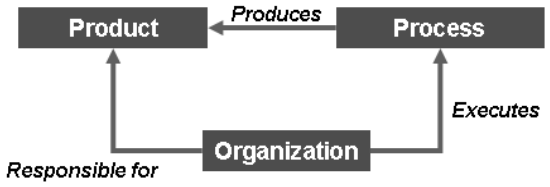

Figure 2 GM-VV Implementation Framework Component Categories

The aforementioned building components are a cost-efficient means of developing and applying specific V&V solutions using the four basic tailoring approaches of the GM-VV tailoring framework, namely:

- Tailoring by Extension: adaptation of the implementation framework by adding custom V&V products, processes, activities, tasks and roles. For example, a V&V Client organization or application domain may require additional custom artifacts not foreseen by the GM-VV.
- Tailoring by Reduction: adaptation of the implementation framework by deleting products, processes, activities, tasks and roles due to constraints such as inaccessibility of data and information protected by intellectual property rights, security or technical restrictions.
- Tailoring by Specialization: adaptation of the implementation framework by modifying domain specific V&V methods, techniques and data that are unique for a V&V project, organization or application.
- Tailoring by Balancing: adaptation of the implementation framework by fitting a suitable cost-benefit-ratio towards an acceptance recommendation. The level of acceptable M&S use risk should drive the rigor and resources employed for V&V. Therefore, in this approach one tries to balance aspects such as:
    - M&S use-risk tolerances and thresholds
    - criticality and scope of the acceptance decision
    - scale and complexity of the M&S system
    - information security, with

  V&V project resource variables (e.g., time schedule, budget, V&V personnel skills and infrastructure).

The GM-VV implementation framework provides a set of generic reusable components for each of the categories depicted in Figure 2. These components are grouped into three interrelated organizational levels (i.e., enterprise, project and technical) where V&V of M&S can be considered as depicted in Figure 3.

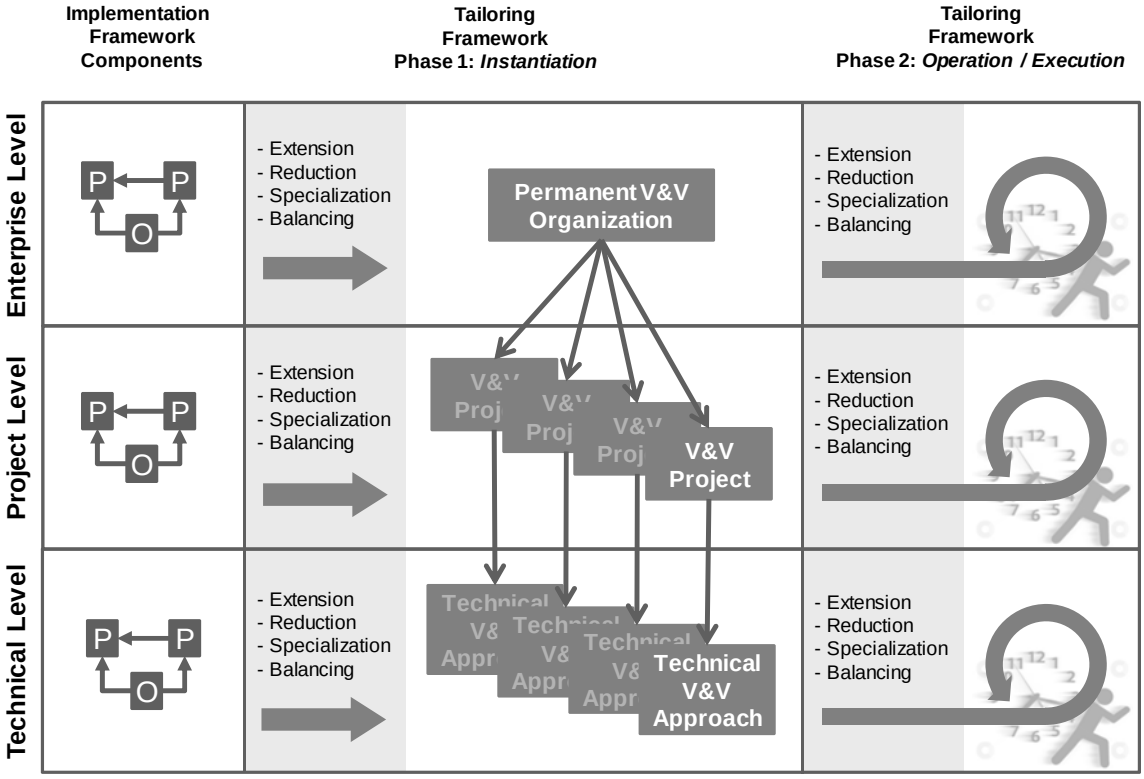

Figure 3 GM-VV Implementation and Tailoring Framework Application Overview

The technical level comprises a set of technical components that together constitute a generic engineering life-cycle template for structuring the technical V&V work necessary to develop and deliver an acceptance recommendation (i.e., the technical activities performed, the information artifacts produced and the roles fulfilled). To develop a quality (e.g., timely, accurate and relevant) acceptance recommendation, the technical V&V work should be executed in a well-controlled and organized manner. Therefore, the GM-VV recommends performing the technical V&V work as part of a managed project. The project level of the GM-VV implementation framework provides a set of project-oriented components that together constitute a generic project structure template for organizing and managing the technical V&V work. When a V&V supplier establishes, directs and supports the execution of multiple V&V projects and delivery of V&V products, the GM-VV recommends establishing a permanent V&V business environment. Such a permanent V&V organization helps to improve the quality, reduce costs and lead time of these V&V projects and products. The enterprise level of the GM-VV implementation framework provides a set of enterprise-oriented components that together constitute a generic enterprise level organization (i.e., a line organization) template for establishing and operating a permanent V&V organization

NOTE: The GM-VV implementation framework solely focuses on the V&V supplier perspective. The V&V client and its V&V User/Sponsor role are only identified to describe the involvement in and interaction with the V&V supplier.

The purpose of the GM-VV tailoring framework is to customize the GM-VV implementation framework components (i.e., products, processes, organizational roles) to satisfy the specific requirements and constraints of:

- An organization that is employing the GM-VV (*e.g., company policies, standards*),

- A domain in which the GM-VV is employed (*e.g., standards, regulations, technologies*),
- A M&S/V&V supplier delivering V&V products or services (*e.g., standards, processes*),
- A M&S/V&V project (*e.g., time, budget, scale, complexity, risk, resources*).

As depicted in Figure 3, this tailoring is accomplished in two phases. In the *first* phase of the GM-VV tailoring framework, the implementation framework components are utilized to establish concrete V&V solution instances on one or more of the three organizational levels (i.e., a V&V enterprise, V&V project or technical V&V approach). The GM-VV recognizes that a particular M&S organization, project, technology or problem domain may not need all three organizational levels or all components nor even use them directly as-is. Therefore, the GM-VV implementation framework organizational levels and components are selected, combined and modified accordingly, to obtain a tailored V&V solution. For instance an M&S organization may already have an M&S project and enterprise level in place, and only require technical level V&V (intermediate) products, processes and roles to conduct their technical V&V work. Successful application of the first phase of the tailoring framework results in a modified or new V&V solution instance conforming to the GM-VV architectural templates (i.e., in a structure and organizational manner). The aforementioned tailoring approaches should be used for this purpose: extension, reduction, specialization and balancing [SISO-GUIDE-001.1-2012].

In the s*econd phase* these same tailoring approaches are applied throughout the operational life-time (i.e., permanent organization or project) or execution (i.e., technical approach) of each V&V solution instance. This type of tailoring comprises run-time optimization of the instantiated V&V processes at all three organizational levels. At a technical level this could imply the application of a risk-based V&V approach, such as found in [B6], to prioritize the acceptability criteria, allocate specific V&V techniques and tools based on V&V User/Sponsor risk tolerance levels. On the project level this could be the alignment of technical V&V activities with the progress of the M&S system's life-cycle phases, and balancing the available V&V resources over each M&S life-cycle phase or (work) products. On the enterprise level this could mean balancing the cost-risk of new investments in training of personnel or V&V tool infrastructure development against a future V&V project order intake volume.

Sections 5.2, 5.3 and 5.4 give general tailoring considerations for instantiating each organizational level of the GM-VV implementation framework. This enables GM-VV users to determine whether they should instantiate each level and in what manner they should do so.

5.2 Tailoring Considerations for Instantiating the Technical Level

The technical-level components of the GM-VV implementation framework are typically the components that all users of the GM-VV should instantiate. This technical level provides a generic template for a structured execution of technical V&V activities and tasks. In this template technical-oriented V&V practices, tools and techniques native to each individual M&S organization, project, and technology or application domain should be integrated (Chapters 6 and 9). Among others such technical-oriented V&V practices, tools and techniques include:

- Informal, Formal, Static, and Dynamic V&V techniques to be used,
- Risk analysis techniques and methods,
- Argumentation structure formats, techniques and methods,
- Referent development techniques and methods,
- Domain specific or standard acceptability criteria,
- Domain specific or standard V&V documentation templates,
- Experimental design techniques and methods (DOE),
- Information management and configuration tools.

A more detailed discussion of such technical V&V practices, tools and techniques is beyond the scope of this document. The interested reader can find references on such technical-oriented V&V practices, tools and techniques in GM-VV Vol. 3 [SISO-REF-039-XXX-Draft]. The types of technically-oriented practices, tools and techniques selected and when they should be applied during the V&V of an M&S system, is an outcome of the run-time execution of a technical V&V approach (**Figure 3**). Such a

technical V&V approach is thus a tailored instance of the generic life-cycle for structuring the technical V&V work of the GM-VV implementation framework (Chapter 6). A technical V&V approach describes which technical V&V activities and tasks are executed and how they map onto the M&S system life-cycle phases or (work) products. It typically scopes the V&V technical work, structures the technical V&V activities and tasks to be performed in a logical order. Furthermore it identifies the technical standards to be used, the V&V design techniques to be applied and the associated completion criteria. The technical V&V approach depends strongly on the M&S application and problem domain, the M&S organization and project context in which the V&V is executed, and more importantly on the V&V needs of the V&V client. This means that the GM-VV technical level components must be tailored by specialization, reduction and extension to gain a suitable and matching technical V&V approach for the M&S system under consideration.

A structured V&V engineering life-cycle is obtained if the technical V&V approach has been instantiated correctly. This helps to assure that during the execution of the V&V work; the decisions, actions and information will be traceable, reproducible, transparent and documented. This is accomplished by a tailored (e.g., by specialization and extension) implementation of the V&V Argumentation Structure (Chapter 6 and Section 9.9), which is the practical implementation of the GM-VV evidence based and structured reasoning concept introduced in GM-VV Vol. 1 [SISO-GUIDE-001.1-2012]. How such decisions are made during the execution of this technical V&V approach depends on the V&V project context and involves the GM-VV tailoring approaches, in particular balancing.

Balancing approaches are needed during technical V&V activities since it is practically impossible to verify or validate an entire M&S system in any project. Exhaustive verification and validation (i.e., 100% coverage of all aspects) of an M&S system exists only in theory [B8]; requiring infinite time and V&V resources. In practice, there is always a limited time and budget available for a V&V project. Moreover, there is always the pressure on the M&S system development to provide the needed capabilities (i.e., functionality) on time and usually more capabilities (i.e., nice-to-have features). In practice this means that the original time and budget allocated for performing V&V is often reduced by such M&S system development requests and constraints. This requires continuously balancing the time schedule, budget and resources available for V&V against what should and could be verified or validated throughout the life-time of a V&V project (Section 5.3).

Risk-based techniques and methods are practical means of balancing. Risk-based V&V centers the verification and validation around the M&S use risks. M&S use risks are the risks directly related to usage of the M&S system and what the impact could be if the M&S system isn't (completely) fit for the intended use. Risk-based V&V identifies and analyzes the M&S use risks, and aims at addressing these risks by guiding the technical V&V activities towards the level of risk of each identified risk item. A risk-based approach responds to these M&S use risks as follows:

- *Target technical V&V activities*: allocating V&V effort and selecting V&V techniques based on the level of risk of each identified risk item; matching the rigor and extensiveness of V&V techniques to the level of risks.

- *Sequencing of technical V&V activities*: prioritizing the risk items, starting with verifying and validating the most important M&S use risk items first and work down to the less important ones.

- *Reduction of technical V&V activities*: if the initial time, budget and resources are limited or are reduced throughout the life-time of the V&V project, V&V activities and techniques (Chapter 6) can be reduced in reverse-risk priority order, starting with least important ones.

- *Reporting of technical V&V results*: reporting V&V results in terms of residual M&S use risks (e.g., V&V solutions executed, not executed, executed with limitations or omitted).

When applying a risk-based approach, V&V project managers should ensure that the risk-based V&V activities and techniques recommended by the M&S use-risk assessment corresponds to the overall V&V project organization and plan (Section 5.3).

Risk-based approaches have proven to be very effective for V&V of software, hardware and M&S systems alike, and are therefore recommended by GM-VV [B4] [B5] [B6]. However, it is beyond the scope of this guidance document to give a complete overview of risk-based techniques and methods. The interested reader is referred to the GM-VV Vol. 3 for references on this topic [SISO-REF-039-XXXX-Draft]. It must also be noted that a pure risk-based approach to V&V can leave blind spots [B4].

5.3 Tailoring Considerations for Instantiating the Project Level

The GM-VV concept of a V&V project can be viewed as a unique process comprised of coordinated and controlled activities that address: technical V&V work planning in terms of cost, timescales and milestones; measuring and checking progress against this planning; and selecting and taking corrective actions when needed [SISO-GUIDE-001.1-2012]. The project level of the GM-VV implementation framework provides the components to implement this V&V project concept (
Figure 3). It is inevitable that the project-level components provided by GM-VV do not directly match the way V&V is organized and managed in specific M&S organization or project. Nevertheless, these aspects are important for assuring the quality (e.g., timely, accurate and relevant) of the V&V products, and thus such aspects should be considered and addressed by all V&V suppliers; independent of whether the V&V is performed by an external organization (Section 5.4), a separate business unit in the M&S organization or solely from within the M&S development project. Therefore, the concept of a managed V&V project can be instantiated by tailoring the GM-VV project-level components as either a separate V&V project or as a sub-project or work package of a larger M&S project. This constitutes a generic organizational scheme to organize and manage the technical V&V work.

Independent V&V (IV&V) requires V&V projects that have the highest level of independence (See GM-VV Vol. 1 for more details on IV&V [SISO-GUIDE-001-1-2012]).In that case the V&V project organization and team are fully separated from the M&S development project. Such V&V projects are executed by a V&V supplier outside the own M&S organization. A less strict level of independence can be achieved by a having a dedicated V&V supplier organization unit inside the own M&S organization (Section 5.4). In this case the V&V project manager and his or her team have a V&V project budget which is separate from the M&S development budget, and reports to the higher enterprise management of the own M&S organization. In the case of a V&V sub-project , the V&V project manager and team usually work on the same level with the M&S development project manager and team under the direction of an overall M&S program/project manager. When the V&V is executed as a V&V work package in M&S project, the V&V team is usually integrated within the M&S development project, and there is no separate V&V project manager or project plan (Chapter 6). The V&V project manager role is assumed by the M&S project manager itself. In that case there is no independence.

Whether the V&V work should be executed as a separate project, a sub-project or a work package depends on the V&V client organization, what level of independence the V&V client requires and the scale of the M&S project. For instance, if the M&S supplier organization is the V&V client, conducts V&V on various projects and has high quality standards (e.g., for customer satisfaction and marketing perspective), a separate V&V project is recommended for the technical V&V work (See also Section 5.4). In cases where customers of M&S systems do not require a high-level of V&V independence, a V&V sub-project or work-package within a larger M&S project is recommended. When a dedicated V&V organization is contracted, a separate V&V project or sub-project within a larger M&S project is the most obvious option. A separate V&V (sub) project is in particular the best option when the V&V client is a different organization than the M&S supplier, and wants a fully independent V&V of the M&S system it acquires. All are forms of tailoring the V&V project level by specialization.

For large, complex or safety-critical M&S projects, usually multiple levels of V&V independence are required for the M&S system, meaning that the V&V team is a mix of permanent, temporary, internal and external personnel. Hence, having a separate V&V project, with a separate V&V manager and project plan from the M&S development project is then highly recommended to organize and manage the technical work properly. Good alignment, cooperation and communication should be maintained between both the V&V and M&S project to assure the right quality (i.e., fit for purpose) M&S system is delivered. In smaller M&S organizations or projects, where everybody contributes to every activity it is harder to differentiate the technical V&V work and roles from those of the M&S development. Hence, it is easier and cheaper to embed V&V as a work package inside the M&S project. In general, higher levels of independence or outsourcing to external V&V organizations comes with higher organizational

(i.e., managerial) effort and costs but on the other hand when done correctly provide more effective V&V. Therefore, the decision to setup and manage the technical V&V work as a separate project, sub-project or work packages should involve a careful analysis of the balance between aspects such as the project risks, scale of the M&S project or organization, cost, time and other resources required. This is a form of tailoring by balancing.

For Post-Hoc V&V projects the V&V is conducted in retrospect on an M&S legacy system after development or application. This is not the most efficient form of V&V. Post-Hoc V&V projects are often seen within organizations that reuse or acquire M&S systems (e.g., modified off the shelf, commercial off the shelf) from an external M&S supplier. In such case the acquiring organization usually wants an independent V&V to assure that the reused or acquired M&S system will fit the intended-use. V&V is then best executed as a separate V&V project by an external third-party V&V supplier. Since in this case the M&S supplier and the V&V supplier are separate entities, some alignment, cooperation and communication between them should be established. This is to ensure that the V&V supplier can access the M&S system itself and associated information (e.g., conceptual model, design specifications and test data), and address any M&S supplier intellectual property rights and security issues that may apply.

It must be stressed that the GM-VV project-level organizational pattern and components are not intended as a substitute for standard project management and organization practices; instead they contain complementary V&V project-level aspects that should be used in conjunction with standard practices [SISO-REF-039-XXXX-Draft]. Therefore, the GM-VV project-level components are not all inclusive and should be tailored to reflect the needs, objectives and constraints of an M&S project or M&S/V&V organization. For example in the case where the V&V effort is established as a standalone V&V project, all GM-VV project-level components may have to be implemented from scratch in order to organize and manage the V&V project. An M&S organization that already has similar processes in place, may only adapt these to meet the specific managerial needs of the M&S project. These are forms of tailoring the GM-VV by reduction, extension and specialization.

A prerequisite for instantiating the project-level components and successfully executing a V&V project is that technical V&V work is also executed in a structured manner. If no such approaches exist yet within the M&S project or organization, this should be first developed. For developing a structured technical V&V approach, instantiation of the GM-VV technical-level components is recommended (Chapter 6).

5.4 Tailoring Considerations for Instantiating the Enterprise Level

A permanent organization for supplying V&V services and products can be implemented as an autonomous company or as an organizational unit part of a larger company. The first type of V&V suppliers are companies who have as their core business the delivery of V&V products (e.g., V&V reports, services, expertise and tools) to M&S developer, user or regulation organizations (i.e., external V&V clients). The latter types of V&V suppliers are M&S developer, user or regulation organizations that have their own internal V&V organization unit to support their own M&S projects (i.e., internal V&V clients); and possibly also as an additional business for external V&V clients.

It is not necessary for all V&V suppliers to establish a permanent V&V organization. V&V products can be delivered using project-based approach on a case by case basis. However, if the V&V supplier executes V&V projects and delivers V&V products on a regular basis to one or more V&V clients it can become more cost-effective to set up a permanent organization for V&V. A V&V supplier should consider this option when there is:

- Increasing V&V efforts and costs,
- Quality reduction in V&V projects and products,
- Lack of internal V&V standards, policies and guidance,
- Lack of internal coordination of V&V projects and products,
- Insufficient reuse of prior knowledge, tools, techniques, facilities and lessons-learned,
- Lack of experienced V&V personnel or reduction of their knowledge and skills,
- Insufficient means to enhance V&V project and product quality,

- Confusion regarding V&V project responsibilities, and,
- Lack of V&V assessment objectivity and independence.

To determine if a permanent V&V organization is indeed worth the investment requires a cost benefit analysis between the resources required to setup, manage and maintain a permanent V&V organization, and resulting benefits such as improved V&V quality, cost savings and lead-time reduction. This determination must also consider the V&V supplier organization's own objectives, the problem and application domain in which it operates, and the V&V clients it serves. These are forms of tailoring the GM-VV by balancing.

For a V&V supplier that has determined that a permanent V&V organization is a viable solution, chapter 8 provides the generic components (products, process and roles) to help setup, manage and maintain such a V&V enterprise organization. One must remember that there is neither a fixed set of requirements or rules to do so nor an ideal one size-fit-all blue print for the implementation of a permanent V&V organization. Therefore, the GM-VV enterprise-level components may not all be required and should be tailored to reflect the needs, objectives and constraints of a specific V&V supplier. For example in the case where a permanent V&V supplier is established as a new standalone company, it may have to implement all enterprise-level components from scratch. For an existing company that wants to establish permanent V&V supplier within its own organization may already have similar enterprise products, processes and organizational roles in place and may only adapt these to meet the specific needs of this internal V&V unit. These are forms of tailoring the GM-VV by reduction, extension and specialization.

A prerequisite for instantiating the enterprise-level components and to successfully sustain a permanent V&V organization is that V&V projects are executed in a structured manner on both project organizational and technical level. If no such approaches or methods exist yet within the V&V supplier, they should be first developed. For developing a new structured V&V approach or method it is recommended to instantiate the GM-VV project and technical-level components (Chapter 6 and 7).

6. GM-VV Technical Level Implementation Guidance

This chapter provides detailed implementation guidance for instantiating the technical level of the GM-VV. The technical level comprises the technical processes to perform the technical V&V work (Figure 4). The technical-level processes are executed from the project level (Chapter 7). It is the Project Planning process from this project level that starts and controls their execution.

The technical work begins with the V&V Requirements Definition process. It takes the V&V User/Sponsor needs as expressed by the V&V Agreement as input and sets the groundwork for the other technical processes. The V&V Requirements and Context Information from this process are used as input for the Acceptance Planning process which delivers the acceptability criteria for the M&S system along with the first part of the V&V Argumentation Structure. In the V&V Planning Process a specification for a V&V experimental frame is derived from the acceptability criteria, and a V&V Plan[3] is developed. The V&V Execution process implements and executes the specified V&V experimental frame (see section 6.1 of GM-VV Volume 1 and Volume 2, section 9.7) according to this V&V plan. In the V&V Assessment and Integration process the V&V results from the V&V Execution process, are assessed and integrated into acceptability claims regarding whether or not the M&S system satisfies the acceptability criteria. Next, the Acceptance Assessment and Integration process assesses and integrates the acceptability claims into claims regarding to what extent the M&S system is acceptable for the intended use (i.e., the Acceptance Recommendation). This process also develops the complete V&V Argumentation Structure underlying this Acceptance Recommendation. Finally, in the V&V Product Delivery process, the V&V Report is compiled and delivered to the V&V client.

[3] The V&V plan (Section 9.6) is an information artifact of the V&V Planning process not to be confused with the aforementioned V&V Project Plan (Section 9.2).

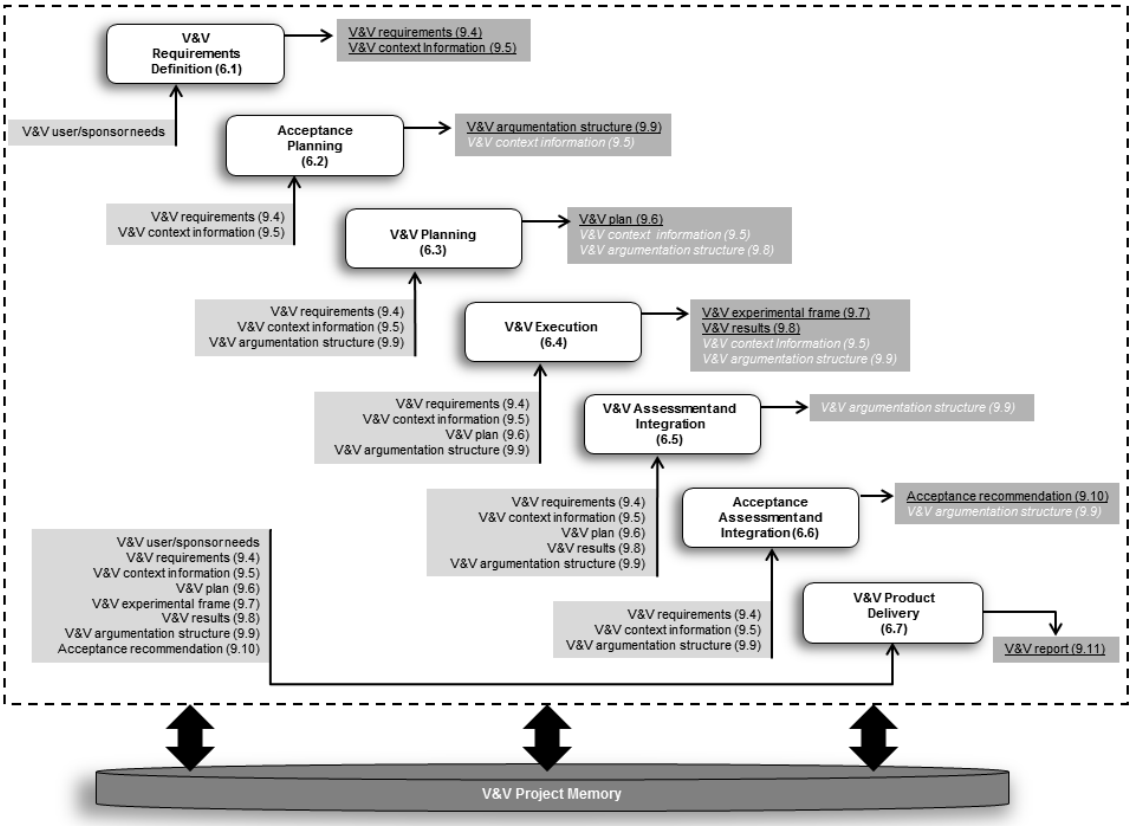

Figure 4 V&V Technical level product and process components overview[4]

Instantiation and use of a V&V Project Memory on the technical level is recommended. (See also Chapter 7). A V&V project memory provides the means to manage both project and technical level information produced and used during the life-time of an individual V&V project. A V&V project memory provides technical support by keeping track of historical data, such in case of consecutive V&V information artifact configurations and versions.

Execution of the technical process in the sequence described above (Figure 4) is recommended. However, like all GM-VV processes, the technical processes can be carried out recursively, concurrently, and iteratively. This depends on the M&S project life-cycle type (e.g., sequential, incremental, iterative, or spiral) and associated processes upon which the V&V project should be mapped and aligned. This mapping and alignment of processes is done from the Project Planning process and should be documented in the V&V Project Plan (Chapter 7); an activity which is done continuously during the execution of a V&V project using a classical Plan, Do, Check, Act (PDCA) loop. In accordance with the V&V agreement, the V&V client should be kept informed of the current status of the technical V&V processes.

In Table 1, the relations between the technical level processes and the information artifacts are presented, according to the following conventions:

I = the information artifact is an input to the process,
O = the information artifact is an output from the process,
C = the process contributes to the information artifact.

[4] Annex B provides the conventions fort his diagram

Table 1 Relations between technical level processes and information artifacts

	V&V Agreement	V&V User/Sponsor Needs	V&V Requirements	V&V Context Information	V&V Plan	V&V Experimental Frame	V&V Results	V&V Argumentation Structure	Acceptance Recommendation	V&V Report
V&V Requirements Definition	I	I	O	O						
Acceptance Planning			I	IC				O		
V&V Planning			I	IC	O			IC		
V&V Execution			I	IC	I	O	O	IC		
V&V Assessment and Integration			I	I	I		I	IC		
Acceptance Assessment and Integration			I	I				IC	O	
V&V Product Delivery		I	I	I	I	I	I	I	I	O

NOTE: V&V User/Sponsor Needs is not a GM-VV formal recommended information artifact. Nevertheless, since those needs constitute a major source of information to conduct the V&V project, they appear in the above table.

The following sections offer detailed guidance for implementing the technical processes. Each process is described in terms of its purpose, recommended information artifacts required and produced, roles involved, and the recommended activities and tasks. Each process may be tailored to reflect the needs and constraints of the specific V&V project at hand (Chapter 5). The technical level information artifacts and roles are described in Chapter 9 and 10 respectively.

6.1 V&V Requirements Definition Process

6.1.1 Purpose

The purpose of the V&V Requirements Definition Process is to define the V&V requirements and the associated V&V context information for the V&V project based on the V&V User/Sponsor needs. The following are recommended for consideration:

6.1.2 Information Required

- V&V User/Sponsor needs[5],
- V&V Agreement.

6.1.3 Information Provided

- V&V Requirements,
- V&V Context Information.

6.1.4 Roles Involved

- Acceptance Leader,
- V&V Project Manager,
- V&V User/Sponsor.

6.1.5 Activities & tasks

The activities recommended for this process include the following:

[5] NOTE: V&V needs themselves are not a GM-VV formal recommended information artifact.

Activity T1.1: Provide the V&V Context Information

In this activity all relevant context information needed prior to or during the V&V project should be identified, collected and consolidated (See GM-VV Vol. 1 [SISO-GUIDE-001.1-2012]).

The recommended tasks for this activity include the following:

- Identify the M&S (sub)systems that are within the scope of the V&V project.
- Identify the M&S intended use from the V&V User/Sponsor.
- Identify M&S use risks and their impact on the M&S intended use.
- Identify the M&S system requirements from the V&V User/Sponsor.
- Identify M&S constraints (e.g., on M&S system, M&S life-cycle process, M&S project and M&S organization) from the V&V client enterprise .
- Identify any relevant development documentation for the M&S system (e.g., specifications and conceptual models) and the real-world system represented by the M&S system (e.g., referent information).
- Identify any relevant SMEs that can provide relevant information regarding the M&S system, its employment and application domains.
- Identify existing relevant V&V products (e.g., Acceptance Plans, V&V plans or V&V results).

Activity T1.2: Provide the V&V Requirements

V&V requirements are not requirements placed on the M&S system but are requirements placed upon the V&V project itself. These requirements determine the objectives and scope of the V&V project, and the constraints in which these objectives have to be achieved. The starting point for providing good V&V requirements is the V&V agreement in which, from a high level, the majority of such requirements can be found. Furthermore, it is the V&V User/Sponsor who has to (help) provide and endorse these V&V requirements.

The recommended tasks for this activity include the following:

- Specify the V&V intended use in terms of how the outcomes of the V&V project are going to be used by the V&V User/Sponsor.
- Specify V&V requirements related to the V&V intended use focusing on what capabilities, characteristics or qualities a V&V process, intermediate work products and final deliverables must have to satisfy this use.
- Specify V&V constraints (e.g., schedule, human resources and budget) on the V&V process, intermediate work products and final deliverables.
- Tailor anticipated V&V activities based on the V&V constraints: V&V activities suggested by the available information must be in balance with the available resources.

Activity T1.3: Provide the acceptance goal

Based on the outcomes of activities T1.1 and T1.2 provide an acceptance goal for the M&S system under consideration. Depending on the V&V intended use one or more acceptance goals could be set. The defined acceptance goals scope the V&V effort and serves as the basis for developing the V&V Argumentation Structure. Furthermore, it is the V&V User/Sponsor who has to (help) set and endorse the acceptance goals.

The recommended tasks for this activity include the following:

- Transform the V&V intended use into the acceptance goal for the M&S system.
- Apply tailoring to the acceptance goal to make the anticipated V&V work feasible given the resources (e.g., budget, schedule, personnel and infrastructure).
- Specify the level of confidence required on meeting the acceptance goal.

6.2 Acceptance Planning Process

6.2.1 Purpose

The purpose of the Acceptance Planning Process is to transform the V&V requirements and context information into acceptability criteria for the M&S system. The following are recommended for consideration:

6.2.2 Information Required

- V&V Requirements,
- V&V Context Information.

6.2.3 Information Provided

- V&V Argumentation Structure,
- V&V Context Information.

6.2.4 Roles Involved

- Acceptance Leader,
- V&V Leader,
- V&V Project Manager,
- V&V User/Sponsor.

6.2.5 Activities & tasks

The activity recommended for this process includes the following:

Activity T2.1: Provide the acceptability criteria

The acceptability criteria express utility, validity and correctness requirements for the M&S system as a whole, its constituent components or subsystems, as well as the associated M&S life-cycle artifacts (e.g., M&S requirements, conceptual model or M&S development specifications). Moreover, acceptability criteria impose a certain level M&S use risk when they are not met by the M&S system. Such M&S use risk should be made explicit for each of the acceptability criteria, in order for the V&V User/Sponsor to decide which of the acceptability criteria are more critical and what level of M&S use risk is acceptable. Based on this risk-based prioritization the available V&V project budget, schedule and resource can be deployed optimally and the best possible V&V results obtained (i.e., tailoring by balancing). The acceptability criteria should be traceable to the acceptance goals defined in T1.3 and documented with an associated argument. Acceptability criteria should be developed in close cooperation with and endorsed by the V&V User/Sponsor. This endorsement should be documented in the V&V project memory. Employment of application and problem domain SMEs is recommended to help develop the acceptability criteria and the rationale for their relevance.

The recommended tasks for this activity include the following:

- Develop acceptability criteria from the acceptance goals for each relevant V&V system of interest (e.g., M&S system, subsystems or components, and life-cycle artifacts). Provide a traceable argumentation for their existence and add quality criteria (e.g., completeness, consistency and correctness) where needed.

- Use risk assessment methods and techniques to determine the M&S use risk. Prioritize the acceptability criteria based on the M&S user's risks level[6].

- Document the development of the acceptance goals into traceable, reproducible and transparent acceptability criteria in the V&V Argumentation Structure.

- Document any newly found relevant V&V Context Information.

6.3 V&V Planning Process

6.3.1 Purpose

The V&V Planning Process transforms the acceptability criteria into the V&V Experimental Frame specification and the V&V plan. The following are recommended for consideration:

6.3.2 Information Required

- V&V Argumentation Structure,
- V&V Context Information,
- V&V Requirements.

6.3.3 Information Provided

- V&V Plan,
- V&V Context Information,
- V&V Argumentation Structure.

6.3.4 Roles Involved

- V&V Leader,
- Acceptance Leader,
- V&V Project Manager.

6.3.5 Activities & tasks

The activities recommended for this process include the following:

Activity T3.1: Provide the evidence solutions

To demonstrate whether or not acceptability criteria for an M&S system are met, requires adequate evidence. This requires a specification of solutions to obtain such evidence for each acceptability criterion. These solutions are called Evidence Solutions in GM-VV. Evidence Solutions encompass the specification of tests/experiments, referent for the simuland (e.g., expected results, observed real data), methods for comparing and evaluating the test/experimental results against the referent. Many different evidence solutions exist. If the M&S system doesn't meet an acceptability criterion, an evidence solution must be selected that can provide sufficient evidential strength for the M&S use risk level tolerated by the V&V User/Sponsor.

In practice, there are limited V&V project resources, budget and schedule, and each evidence solution has its costs and time to complete. This means a balance must be found to provide an optimal set of evidence solutions within these project constraints (i.e., tailoring by balancing). The evidence solutions should be traceable to the acceptability criteria defined in T2.1 and documented with an associated argument. Evidence solutions should be provided in close cooperation with application and domain SME that are well experienced and familiar with experimental design methods and techniques (DOE), V&V (test) tools, methods and techniques, or both[7].

The recommended tasks for this activity include the following:

[6] NOTE: It is beyond the scope of this implementation guide to provide a complete overview or detailed discussion of such risk assessment methods and techniques. Interested readers are referred to the GM-VV Vol. 3 which provides references on this topic.

[7] NOTE: It is beyond the scope of this implementation guide to provide a complete overview or detailed discussion of such tools, methods and techniques. Interested readers are referred to the GM-VV Vol. 3 which provides references on this topic.

- Identify, for each acceptability criteria possible solutions for obtaining evidence (e.g., tests, referents, comparison and evaluation methods, tools and techniques) to demonstrate their satisfaction. Moreover, identify for each possible evidence solution the expected costs and time to complete, and the expected quality of the evidence (i.e., evidential strength).

- Balance the expected quality of the evidence, cost and time to gather the evidence solutions against the available V&V project budget, schedule and resources while taking the M&S use risk levels and priorities of the acceptability criteria into account. Select those evidence solutions that should result in the best overall quality of the evidence for the acceptability criteria given the available V&V project budget, schedule and resources. For this task similar use risk assessment methods and techniques can be used as indicated in T2.1.

- Document the development of the acceptance criteria into evidence solutions in a traceable, reproducible and transparent way in the V&V Argumentation Structure.

- Document any newly found relevant V&V Context Information.

Activity T3.2: Provide the V&V Plan

A well-defined plan for implementing selected evidence solutions into an executable V&V Experimental Frame is important for efficiently acquiring the required evidence. The implementation of the environment, tools and techniques to execute the V&V Experimental Frame requires a clear specification that can be used by the V&V Implementers. Both the implementation and execution of the V&V Experimental Frame requires alignment of its activities and tasks with the process of the overall M&S project within the context that the V&V is performed. Moreover, the required resources for these activities and tasks must be available at the right time. Therefore, these activities and tasks must be carefully planned.

The recommended tasks for this activity are the following:

- Specify the V&V Experimental Frame based on the selected evidence solutions.

- Identify and plan the activities and tasks for implementing the V&V experimental frame in terms such as setting-up test environments, infrastructure, tools and other resources.

- Identify the experimental frame execution activities and tasks and align them with the V&V project plan and the availability of resources. Align the V&V plan with the M&S Project Plan when concurrent development of M&S takes place.

- Document the V&V Experimental Frame specification, planned execution process activities and tasks in the V&V plan and distribute it to all relevant stakeholders.

6.4 V&V Execution Process

6.4.1 Purpose

The V&V Execution Process implements and executes the V&V Experimental Frame according to the V&V Plan to produce V&V Results; it integrates them into items of evidence for the M&S system. The following are recommended for consideration:

6.4.2 Information Required

- V&V Requirements,
- V&V Context Information,
- V&V Plan,
- V&V Argumentation Structure.

6.4.3 Information Provided

- V&V Context Information,
- V&V Experimental Frame,

- V&V Results,
- V&V Argumentation Structure.

6.4.4 Roles Involved

- V&V Leader,
- V&V Implementer,
- V&V Project Manager.

6.4.5 Activities & tasks

The activities recommended for this process include the following:

Activity T4.1: Implement the V&V Experimental Frame

Before the V&V experimental frame can be executed, the V&V Experimental Frame should be implemented according to the V&V Plan.. This means that the complete experimental hardware and software set-up, scripts, configuration files, tools and techniques as specified by the V&V plan must be implemented and ready to be used. The V&V implementers, in close cooperation with the V&V leader, translate the V&V Experimental Frame specification into an operational V&V test environment that can be executed. Prioritize the V&V Experimental Frame implementation activities by M&S use risk, beginning with the implementation of those parts of the experimental frame that incur the most M&S use risk.

The recommended tasks for this activity are the following:

- Obtain the resources needed to develop the V&V Experimental Frame and continue with the implementation.

- Analyze and assess whether the V&V Experimental Frame complies with the specification in the V&V Plan.

- Re-iterate the V&V Planning Process when practical issues and other constraints hamper the correct implementation of the specified V&V Experimental Frame.

Activity T4.2: Execute the V&V Experimental Frame

This activity comprises the actual execution of the implemented V&V Experimental Frame to obtain the needed V&V Results. Depending on the alignment with the M&S project, as specified in the V&V plan, the V&V Experimental Frame can be executed in the various phases of the M&S life-cycle on various M&S system components or subsystems, and M&S life-cycle artifacts (i.e., V&V system of interest). A typical example of such a phased implementation of a V&V experimental frame is the following:

  - Collect, analyze and apply relevant M&S system historical information
  - Verify M&S requirements
  - Verify and validate the conceptual model
  - Perform verification on the M&S system design and/or implementation
  - Verify and validate the M&S data and knowledge sets
  - Validate the M&S results

Therefore, the availability of the associated M&S system of interest in its executable state is the precondition for executing the V&V Experimental Frame.

The recommended tasks for this activity are the following:

- Check whether each V&V system of interest is available and meets the preconditions.

- Check whether the V&V Experimental Frame \ integration with the V&V system of interest has been performed correctly.

- Execute the V&V Experimental Frame according the V&V plan and monitor the progress.

- Process raw data from the V&V Experimental Frame execution as specified in the V&V plan to obtain the final V&V Results.

- Store all V&V Results in the project memory.

Activity T4.3: Provide the items of evidence

All V&V Results coming from the V&V experimental frame must be assessed on completeness and quality, and whether they have been properly obtained. This is done in accordance with the V&V Experimental Frame specification and information from the V&V plan. In practice, the execution of the V&V Experimental Frame will not always be conducted as planned due to unforeseen circumstances or events and human errors. Another possible source for deviation is when an explorative V&V approach is deliberately adopted. In any case this may result in missing or unexpected V&V Results in terms of quality and evidential strength. Therefore, prior to using the V&V Results as items of evidence in the V&V Argumentation Structure, deviations from the original V&V plan must be identified, analyzed, and documented.

The recommended tasks for this activity include the following:

- Perform the comparison of data items in the V&V Results with the referent data from the corresponding evidence solution in the V&V Experimental Frame specification.

- Check if all obtained V&V Results are free of human and other execution errors, comply with the procedures and quality criteria of the evidence solutions as defined in the V&V Experimental Frame; re-iterate the V&V Planning Process if necessary.

- Check if all V&V Results defined in the V&V plan have been obtained; re-iterate the V&V Planning Process if necessary.

- Analyze and report any deviation from the V&V plan as well as any encountered unexpected event (e.g., relevant observations during experiments that were unanticipated) to the V&V leader; re-iterate the V&V Planning Process if necessary.

- Document and deliver the final V&V results (i.e., the items of evidence).

6.5 V&V Assessment and Integration Process

6.5.1 Purpose

The purpose of the V&V Assessment and Integration Process is to assess and integrate the items of evidence into acceptability claims regarding whether or not the M&S system satisfies the acceptability criteria. The following are recommended for consideration:

6.5.2 Information Required

- V&V Requirements,
- V&V Context Information,
- V&V Plan,
- V&V Results,
- V&V Argumentation Structure.

6.5.3 Information Provided

- V&V Argumentation Structure.

6.5.4 Roles Involved

- V&V Leader,
- V&V Implementer,
- Acceptance Leader,
- V&V Project Manager.

6.5.5 Activities & tasks

The activities recommended for this process includes the following:

Activity T5.1: Assess the items of evidence

As discussed in T4.3 the eventual items of evidence elicited during the V&V Execution process may in practice deviate from the original intended items of evidence as would be expected from the V&V plan. Therefore, each delivered item of evidence must be assessed for whether it can be used and how it can be used as evidence inside the V&V Argumentation.

The recommended tasks for this activity are the following:

- Assess the items of evidence against the V&V Experimental Frame specification as documented in the V&V plan. Determine if items of evidence are admissible or not admissible, and its evidential strength.

- Assess the possible impact of the admissibility and evidential strength of the items of evidence on proving the acceptability criteria with sufficient confidence; sufficient in relationship to the V&V User/Sponsor tolerable M&S use risk levels. When necessary, re-execute parts of the V&V Experimental Frame or modify parts of the V&V Experimental Frame and re-execute, taking available V&V project budget and schedule in consideration (i.e., tailoring by balancing). Consult and employ application and domain SMEs in support of this task.

- Document the argumentation why an item of evidence is or is not admissible as evidence, and its evidential strength. This should be done in a traceable, reproducible and transparent way in the V&V Argumentation Structure.

Activity T5.2: Provide acceptability claims

Based on the items of evidence developed in activity T5.1, the complete argumentation underlying the claims of whether or not the acceptability criteria have been met should be well-documented.

The recommended tasks for this activity are the following:

- Integrate the relevant admissible items of evidence into an acceptability claim for each acceptability criteria using an argumentation between these claims and the items of evidence. Address any possible uncertainties or assumptions in the acceptability claims that may have impact on the V&V User/Sponsor M&S use risk tolerance level. Consult and employ application and domain SMEs as a reference while executing this task.

- Document the items of evidence into acceptability claims in a traceable, reproducible and transparent way in the V&V Argumentation Structure.

- Document any newly found V&V Context Information needed to understand the acceptability claims and its underlying argumentation.

6.6 Acceptance Assessment and Integration Process

6.6.1 Purpose

The Acceptance Assessment and Integration Process assesses and integrates the acceptability claims to determine to what extent the M&S system is acceptable for the intended use (i.e., acceptance recommendations). The following are recommended for consideration:

6.6.2 Information Required

- V&V Requirements,
- V&V Context Information,
- V&V Argumentation Structure.

6.6.3 Information Provided

- V&V Argumentation Structure,
- Acceptance Recommendation.

6.6.4 Roles Involved

- V&V Leader,
- Acceptance Leader,
- V&V Project Manager.

6.6.5 Activities & tasks

The activities recommended for this process includes the following:

Activity T6.1: Provide the Acceptance Claims

Based on the set of acceptability claims developed in activity T5.2, the complete argumentation underlying the acceptance claim should be constructed and provided in a well-documented format.

The recommended tasks for this activity are the following:

- Check if there is a complete match between the acceptability criteria and the acceptability claims, and otherwise (e.g., in case of missing or additional acceptability claims) assess the impact on the acceptance claims and the confidence that can be placed upon them; in relationship to the V&V User/Sponsor tolerance for M&S use risk. For this assessment, consult and employ application and domain SMEs. When necessary and when the V&V project schedule and budget allow it, consult the V&V Leader for modifying the V&V plan and (re-) execute parts of the V&V Experimental Frame.

- Integrate all the available acceptability claims into respective acceptance claims (i.e., acceptance recommendations) using the argumentation between these acceptance and acceptability claims. Address any possible uncertainties or assumptions in the acceptance claims that may have an impact on the V&V User/Sponsor M&S use risk tolerance level. Consult and employ application and domain SMEs to support in this task.

- Document the development of the acceptability claims into acceptance claims in a traceable, reproducible and transparent way in the V&V Argumentation Structure.

- Document any newly found V&V Context Information needed to understand the acceptance claims and its underlying argumentation.

Activity T6.2: Provide the Acceptance Recommendation

The V&V User/Sponsor requires a clear and understandable Acceptance Recommendation to make informed (acceptance) decisions throughout the whole or in some phases (e.g., the M&S system acceptance phase) of the M&S life cycle. How the V&V User/Sponsor uses the Acceptance Recommendation is specified in the V&V Requirements by the V&V intended use-statement.
The recommended tasks for this activity include the following:

- Identify the audience profile of the V&V User/Sponsor and other users listed in the V&V Requirements identified to receive the Acceptance Recommendation

- Determine the best method to deliver the Acceptance Recommendation, adhering to the V&V Requirements, which should define the format, structure and delivery method for the recommendation.

- Compile the Acceptance Recommendation based on the acceptance claims and its rationale and resource limits, and report relevant unexpected events.

- Add a statement on the (non)conformance to the acceptance goals; along with a statement on the quality of the Acceptance Recommendation in relationship with the M&S use risks and the tolerance levels of the V&V User/Sponsor.

- Consolidate the Acceptance Recommendation according to the desired audience profile in the required format and structure.

6.7 V&V Product Delivery Process

6.7.1 Purpose

The purpose of the V&V Product Delivery Process is to package the information artifacts into the V&V Report, deliver it to the V&V User/Sponsor, and archive the information artifacts in appropriate repositories. The following are recommended for consideration:

6.7.2 Information Required

- All information artifacts.

6.7.3 Information Provided

- V&V Report.

6.7.4 Roles Involved

- V&V User/Sponsor
- V&V Leader,
- Acceptance Leader,
- V&V Project Manager.

6.7.5 Activities & tasks

The activity recommended for this process includes the following:

Activity T7.1: Provide the V&V Report

Deliver the V&V Report to the V&V User/Sponsor. The V&V report should be presented during a final face-to-face technical meeting with the V&V User/Sponsor and other involved stakeholders. When the report is approved by the V&V User/Sponsor the V&V project can be closed (Activity P1.6 in Section 7.1.5). .

The recommended tasks for this activity include the following:

- Assemble the V&V Report, which incorporates the Acceptance Recommendation.

- Deliver the V&V Report to the V&V Client.

Archive the V&V Report and all technical information artifacts in the V&V project memory

7. GM-VV Project Level Implementation Guidance

The project level is instantiated by the enterprise-level Agreement Management process as soon as the V&V Agreement has been signed (Section 8.1). Before actually signing the V&V Agreement, some project and technical-level tasks may have already been performed to obtain information necessary to develop a feasible V&V agreement. At the end of the Initiate Agreement activity of the Agreement Management process, the V&V Agreement is made and the Project Planning process is started. From the Project Planning process, the other project-level processes (left side of Figure 5) and the technical-level processes are started (right side of Figure 5).

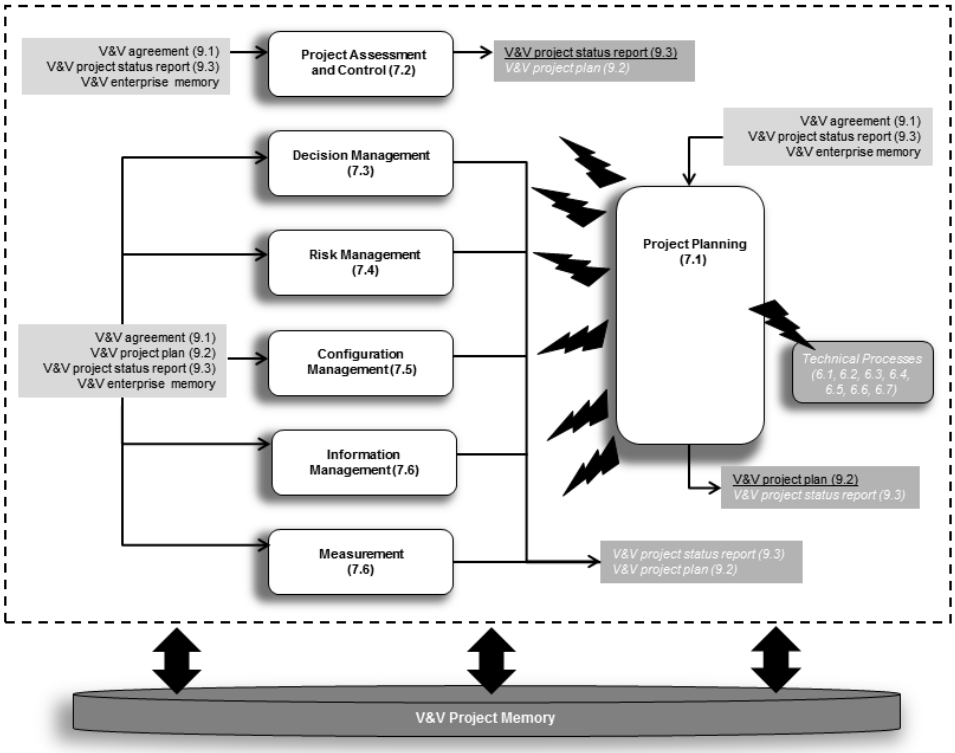

Figure 5 V&V Project level product and process components overview[8]

The activities inside the Project Planning process are shown in Figure 5, but the activities for the other processes are not shown for brevity of the figure. All other project level processes necessary to effectively and efficiently execute a V&V project are started from Project Planning process. Also the technical level processes are started from the Project Planning process (See also Section 7.1). All project level processes are typically executed concurrently and therefore no particular time order is supposed for their execution during the life-time of a V&V project.

The V&V Project Memory should be instantiated on the project level. A V&V project memory provides the means to manage both project and technical level information produced and used during the life-time of an individual V&V project. V&V is a process aligned with an M&S system's life-cycle that could be iterative or incremental; hence the V&V information artifacts for an M&S system may have different configurations and versions as well. Therefore, a V&V project memory also supports keeping track of possible different V&V information artifact configurations and versions.

The V&V Project Manager has the responsibility for the execution of the V&V project by means of the project level processes, and the underlying technical level processes and deliverables (Chapter 6). During the V&V project life-time, the V&V Project Manager serves as the V&V supplier principle point of contact (POC) for the V&V client. He or she uses V&V Project Status Reports to inform the V&V

[8] Annex B provides the conventions fort his diagram

User/Sponsor or other V&V client appointed stakeholders on a regular basis about the progress of the V&V project. When necessary a V&V Project Status Report is provided to the V&V User/Sponsor to resolve urgent issues, problems and risk contingencies that impact the outcome of the project. These activities should be performed in accordance with the V&V Agreement on status reporting to the V&V client. The V&V Project Manager also uses V&V Project Status Reports to inform his V&V team members (e.g., Acceptance Leader, V&V Leader and V&V implementer) and V&V supplier management (e.g., V&V Enterprise Manager) in order to make internal decisions and steer the direction of the V&V project execution

In Table 2, the relationship between the project level processes and the information artifacts are presented, according to the following conventions:

I = the information artifact is an input to the process,
O = the information artifact is an output from the process,
C = the process contributes to the information artifact.

Table 2 relations between project level processes and information artifacts

	V&V Agreement	V&V Project Plan	V&V Project Status Report	V&V Enterprise Memory	V&V Project Memory
Project Planning	I	O	IC	I	IC
Project Assessment and Control		IC	O	I	IC
Decision Management		IC	IC	I	IC
Risk Management		IC	IC	I	IC
Configuration Management		IC	IC	I	IC
Information Management	I	IC	IC	I	O
Measurement		IC	IC	I	IC

NOTE: V&V Project Memory and V&V Enterprise Memory are not formal GM-VV recommended information artifacts. However, both are a combination of an information and knowledge repository and a community of practice (i.e., V&V professionals) that are maintained on respectively project and enterprise level.

The next sections offer detailed guidance on the implementation of the project level processes. Each project level process is decomposed into a set of activities and tasks, along with the recommended information artifacts that are required and provided. The roles involved in each process are also described. Each process may be tailored to reflect the needs and constraints of the specific V&V project at hand (Chapter 5). The project level information artifacts and roles are described in respectively Chapter 9 and 10.

NOTE: The focus of the guidance presented is on specific V&V project level aspects. It is not within the scope of the GM-VV to provide basic and common applicable guidance on project management and organization aspects, since these are well covered in other project management or organizational standards and literature [SISO-REF-039-XXXX-Draft].

7.1 Project Planning Process

7.1.1 Purpose

The purpose of the Project Planning process is to produce, maintain and communicate an effective V&V Project Plan.

This process is the core of the V&V Project. The V&V Project Manager determines how the V&V Project should be organized and planned based on the V&V Agreement, and initiates all necessary project-level processes. One of the decisions to be made is which roles are instantiated and by whom they have to be performed. The V&V Project Manager collects contributions from all other project-level processes to compose the V&V Project Plan. Next the technical-level processes should be initiated and controlled (Chapter 6); starting with the V&V Requirements Definition process. Throughout the whole V&V project life-time the V&V Project Manager keeps the V&V Project Plan up to date and (re)schedules the execution of the technical processes accordingly.

The Project Planning process activities should be executed in the logical sequence suggested in Section 7.1.5. However, like all GM-VV processes, activities and tasks, these Project Planning process activities can be carried out recursively, concurrently, and iteratively. This depends on whether the V&V is executed post-hoc or concurrently to the M&S development [SISO-GUIDE-001-1-2012], the M&S project life-cycle type (e.g., sequential, incremental, iterative, or spiral) and associated processes upon which the V&V project should be mapped and aligned. This mapping and alignment of processes is an important aspect of the Project Planning process and should be documented in the V&V Project Plan. This is a continual activity during the execution of a V&V project using a classical Plan, Do, Check, Act (PDCA) loop (See also Section 7.2). The following are recommended for consideration:

7.1.2 Information Required

- V&V Agreement.
- V&V Project Status Report
- V&V Project Memory
- V&V Enterprise Memory

7.1.3 Information Provided

- V&V Project Plan.
- Updated V&V Project Status Report
- Updated V&V Project Memory

7.1.4 Roles Involved

- V&V Project Manager.
- V&V Enterprise Manager.

7.1.5 Activities & tasks

The recommended activities in this process include the following:

Activity P1.1: Start project processes

This activity starts the other needed project-level processes (Sections 7.2, 7.3, 7.4, 7.5, 7.6 and 7.7), depending on the needs of the V&V Project. Procedures for the communication and synchronization between all project processes must be set up and documented in the V&V Project Plan. Depending on the environment (i.e., post-hoc V&V or concurrent V&V) in which the V&V Project is executed, some of the project-level processes may (partly) be implemented outside of the V&V Project. For example, the configuration Management may be taken care of in the M&S project in which the V&V Project is embedded as specific work package.

The recommended tasks for this activity include the following:

- Tailor the GM-VV project and technical processes, roles and products in order to obtain an appropriate V&V project organization. This can be done by analyzing the V&V Agreement and

determining which project-level processes need to be instantiated while considering what has already been achieved by the M&S project and its life-cycle in the case of a concurrent V&V project. For post-hoc V&V, the latter are usually not available and therefore should be instantiated by the V&V project accordingly.

- Formulate a communication and synchronization plan between the project-level processes.
- Contribute this formulation to the procedures in the V&V Project Plan.
- Start the Project Assessment and Control process (Section 7.2).
- Start the Decision Management process (Section 7.3).
- Start the Risk Management process (Section 7.4).
- Start the Configuration Management process (Section 7.5).
- Start the Information Management process (Section 7.6).
- Start the Measurement process (Section 7.7).

Activity P1.2: Provide the V&V Project Plan

The V&V Project Plan should scope the management of the V&V Project and establishes technical process activities, deliverables and schedule, as well as project reports reflecting the effort, along with relevant motivation, supporting the confidence on final project outcomes. Special care should be taken to the mapping and alignment of the technical process activities (Chapter 6) to the M&S project and its life-cycle in case of concurrent V&V, or to M&S system acceptance or delivery phase in case of a post-hoc V&V project. This requires clear and open communication and well defined cooperation with the M&S development supplier or maintenance team. In particular if intellectual property rights and security constraints are applicable. Furthermore, the V&V Project Manager collects contributions from other project-level processes and compiles the V&V Project Plan. This plan is then communicated to all relevant internal and external stakeholders of the V&V project. This activity remains active during the whole V&V project in order to keep the V&V Project Plan up to date.

The recommended tasks for this activity include the following:

- Provide the V&V Project Plan describing the project's scope, objectives, deliverables, milestones, resources, and constraints.
- Communicate and synchronize the V&V Project Plan with possible other external M&S development project or M&S supplier delivery processes and plans.
- Communicate and synchronize with other V&V project processes.
- Keep the V&V Project Plan up to date.
- Select and apply a risk-based approach to support risk-based decisions on both project level and technical level (e.g., selection of V&V activities and techniques).

Activity P1.3: Start technical processes to initialize the project

It is advised to structure the V&V project in three phases: initialize project, execute project and close project. In each of these phases a number of technical processes are started. In this activity the first technical process is started, thereby initializing the technical work.

The recommended task for this activity includes the following:

- Start the V&V Requirements Definition Process (section 6.1).

Activity P1.4: Start technical processes to execute the project

Once the project initialization ends, the execution phase begins. In this phase a number of technical-level processes begin. The technical processes are executed according to the time sequence as specified in the V&V Project Plan (Activity P1.2) and by applying the identified risk-based method for the technical V&V activities. Note that this is the project phase where the majority of the technical V&V work is performed.

The recommended tasks for this activity include the following:

- Start the Acceptance Planning process (section 6.2).
- Start the V&V Planning process (section 6.3).
- Start the V&V Execution process (section 6.4).
- Start the V&V Assessment and Integration process (section 6.5).
- Start the Acceptance Assessment and Integration process (section 6.6).

Activity P1.5: Start technical processes to close the project

Once the V&V project execution ends the closure phase begins. On a technical level, this comprises the activation of the process that assembles and delivers the V&V Report to the V&V Client.

The recommended task for this activity includes the following:

- Start the V&V Product Delivery process (section 6.7).

Activity P1.6: Stop the project

Once the V&V Product Delivery process is complete, the final tasks are performed to end the project. In this last activity all V&V project-level processes are stopped. All project and technical information produced by the V&V Project is archived. Care is taken for appropriate disposal of possible classified information that the V&V Agreement states must be disposed of at the end of the V&V project.

The recommended tasks for this activity include the following:

- Stop all technical-level processes.
- Stop all project-level processes.
- Dispose any classified information that may not be retained by the V&V Supplier.
- Archive all technical and project information in the V&V Project Memory.

7.2 Project Assessment and Control Process

7.2.1 Purpose

The purpose of the Project Assessment and Control process is to prepare and present the V&V Project Status Report and to support V&V Project Plan execution to ensure that the schedule, costs, deliverables and objectives specified in a V&V Agreement are met.

This process should monitor, via a Measurement process (Section 7.7), and evaluate the execution of a project against the V&V Project Plan and the overall business objectives with respect to the V&V Agreement. Information should be communicated to involved project level processes (e.g., Decision Management and Project Planning) for action when deviations are acknowledged. Furthermore, this process should steer the V&V project and technical processes to correct any deviations and variations identified. Reporting takes place through the V&V Project Status Report: internally to the V&V project

team and enterprise management, externally to the V&V User/Sponsor and other involved stakeholders (e.g., M&S development team). The following are recommended for consideration:

7.2.2 Information Required

- V&V Project Plan.
- V&V Project Memory.
- V&V Enterprise Memory

7.2.3 Information Provided

- V&V Project Status Report.
- Updated V&V Plan.
- Updated V&V Project Memory.

7.2.4 Roles Involved

- V&V Project Manager.
- V&V Enterprise Manager.
- V&V User/Sponsor.
- Acceptance Leader.
- V&V Leader.

7.2.5 Activities & tasks

The recommended activities in this process include the following:

Activity P2.1: Contribute to the V&V Project Plan

The V&V Project Plan contains a section on how project assessment and quality control is performed during the project (e.g., procedures, internal and external communication patterns and schedule). This activity completes the project assessment section of the V&V Project Plan. It may be that during the execution of the project revisions are necessary.

The recommended tasks for this activity include the following:

- Tailor (e.g., by specialization, extension and reduction) the V&V project assessment and quality control to the M&S project or life-cycle in which the V&V Project is executed. Formulate how this should be performed and revise when necessary during the V&V project life-time.

- Ad this formulation to the procedures in the V&V Project Plan.

Activity P2.2: Monitor the execution of the V&V Project Plan

In this activity the measurements regarding the V&V project progress are compared to the V&V Project Plan in order to identify deviations.

The recommended tasks for this activity include the following:

- Monitor the V&V project execution based on the information provided by the project level Measurement process (Section 7.7).

- Assess measurement results to identify deviations from the V&V Project Plan.

Activity P2.3: React on deviations from the V&V Project Plan

When deviations from the V&V Project Plan are identified that need corrective actions, this activity will make sure a response is formulated and communicated to the adequate stakeholders (e.g., V&V team, V&V Enterprise Manager, V&V User/Sponsor, M&S development team). If complicated decisions are needed, the decision management process can be used (Section 7.3).
The recommended tasks for this activity include the following:

- Initiate the corrective actions needed to achieve the goals and outputs of the V&V project tasks that have deviated outside acceptable or defined limits.
- Communicate with the other relevant V&V project stakeholders to find the best response to deviations.

- Communicate with the project planning process to update the V&V Project Plan.

Activity P2.4: Provide V&V Project Status Reports

The V&V Project Plan specifies the frequency of V&V Project Status Reports and possibly other conditions that warrant a new V&V Project Status Report.

The recommended tasks below are to be executed for each V&V Status Report.

- Collect relevant information for the V&V Project Status Report from other project level and technical level processes.

- Compose the V&V Project Status Report based on the collected information and the V&V Project Plan.

- Deliver the V&V Project Status Report to all relevant stakeholders (e.g., V&V team, V&V Enterprise Manager, V&V User/Sponsor, M&S development team).

- Schedule the next V&V Project Status Report.

7.3 Decision Management Process

7.3.1 Purpose

The purpose of the decision management process is to provide information to determine the most beneficial course of action for the V&V project where alternatives exist.

This process should respond to any request for a decision encountered during a V&V project life-time, whatever its nature or source, in order to reach specified, desirable or tailored outcomes. Established enterprise policies and procedures should include provisions for preferred courses of action when a decision is needed. The following are recommended for consideration:

7.3.2 Information Required

- V&V Project Plan,
- V&V Project Status Report,
- V&V Project Memory,
- V&V Enterprise Memory

7.3.3 Information Provided

- Updated V&V Project Plan,
- Updated V&V Project Status Report,
- Updated V&V Project Memory.

7.3.4 Roles Involved

- V&V Project Manager,
- V&V Enterprise Manage,
- Acceptance Leader,
- V&V Leader.

7.3.5 Activities & tasks

The recommended activities in this process include the following:

Activity P3.1: Contribute to the V&V Project Plan

The V&V Project Plan contains a section on how decision management is executed during the project (e.g., procedures, internal and external communication patterns and involved stakeholders). This activity completes the decision management section of the V&V Project Plan. It may be that during the execution of the V&V project revisions are necessary.

The recommended tasks for this activity include the following:

- Tailor (e.g., by specialization, extension and reduction) the V&V project decision management to the M&S project or life-cycle in which the V&V Project is executed.
- Contribute this formulation of the procedures to the V&V Project Plan.

Activity P3.2: Make decisions

When a need for a decision emerges, this process is invoked to analyze the problem and make a decision. In order to be able to make a good decision all relevant information should be examined and relevant involved stakeholders (e.g., V&V team, V&V Enterprise Manager, V&V User/Sponsor, M&S development team) should be consulted. Then as quickly as possible a decision must be made and implemented. The changes are reflected by changes in the V&V Project Plan and communicated through a V&V Project Status Report.

The recommended tasks for this activity include the following:

- Analyze the request for a decision.
- Obtain all relevant and available data needed for a decision.
- Communicate with relevant stakeholders to reach a decision.
- Track the decision.
- Contribute to the V&V Project Plan.
- Communicate the decision to all relevant stakeholders using a V&V Project Status Report.

7.4 Risk Management Process

7.4.1 Purpose

The purpose of the risk management process is to identify, analyze, monitor and manage V&V project risk. This process deals with project-level risk, not M&S use risk which plays a role on the technical-level V&V work. This project process is continuously active since project risks may come and go during the execution of the V&V Project. The following are recommended for consideration:

7.4.2 Information Required

- V&V Project Plan,
- V&V Project Status Report,
- V&V Project Memory,
- V&V Enterprise Memory.

7.4.3 Recommended Information Provided

- Updated V&V Project Plan,
- Updated V&V Project Status Report,
- Updated V&V Project Memory.

7.4.4 Roles Involved

- V&V Project Manager,
- V&V Enterprise Manager,

- Acceptance Leader,
- V&V Leader.

7.4.5 Activities & tasks

The recommended activities in this process include the following:

Activity P4.1: Contribute to the V&V Project Plan

The V&V Project Plan contains a section on how risk management is executed during the project (e.g., procedures, internal and external communication patterns and schedule). This activity completes the risk management section of the V&V Project Plan. Revisions may be necessary during the execution of the V&V project.

The recommended tasks for this activity include the following:

- Tailor (e.g., by specialization, extension and reduction) the V&V risk management to the M&S project or life-cycle in which the V&V Project is executed.

- Contribute this formulation to the procedures to the V&V Project Plan.

Activity P4.2: Manage risk

In this activity the V&V project risk is managed. Risk management is a continuous activity. In addition to standard project risk factors, some factors exist that are specific to V&V projects. Typical examples of potential V&V project risk factors may be retrieved from the V&V Enterprise Memory. Newly identified V&V project risk factors should be stored in the V&V Project Memory for later inclusion in the V&V Enterprise Memory.

The recommended tasks for this activity include the following:

- Identify risk.

- Assess risk.

- Prepare mitigation plans.

- Incorporate the mitigation plans into an update of the V&V Project Plan.

- Monitor risk.

- Contribute to the V&V Project Status Report.

7.5 Configuration Management Process

7.5.1 Purpose

The purpose of the configuration management process is to define the mechanism to establish and maintain the integrity of all project deliverables, associated intermediate products, and information during the V&V Project Execution. The following are recommended for consideration:

7.5.2 Information Required

- V&V Project Plan,
- V&V Project Status Report,
- V&V Project Memory,
- V&V Enterprise Memory.

7.5.3 Information Provided

- Updated V&V Project Plan,
- Updated V&V Project Status Report,
- Updated V&V Project Memory.

7.5.4 Roles Involved

- V&V Project Manager,
- Acceptance Leader,
- V&V Leader.

7.5.5 Activities & tasks

The recommended activities in this process include the following:

Activity P5.1: Contribute to the V&V Project Plan

The V&V Project Plan contains a section on how configuration management is executed during the project (e.g., procedures, internal and external communication patterns and schedule). This activity completes the configuration management section of the V&V Project Plan. It may be that during the execution of the project revisions are necessary.

The recommended tasks for this activity include the following:

- Tailor (e.g., by specialization, extension and reduction) the configuration management of the M&S project or life-cycle in which the V&V Project is executed.

- Contribute this formulation to the procedures of the V&V Project Plan.

Activity P5.2: Perform configuration management

This activity makes sure all information is correctly stored and available to appropriate roles.

The recommended tasks for this activity include the following:

- Monitor how information is stored in and retrieved from the V&V Project Memory to see if it adheres to the configuration management guidelines.

- Take corrective actions if deviations are observed.

7.6 Information Management Process

7.6.1 Purpose

The purpose of the information management process is to manage the information exchange among all processes, stakeholders and roles involved in the V&V project execution.

An important aspect of this process is the establishment of the required infrastructure for information management including the V&V Project Memory. The following are recommended for consideration:

7.6.2 Information Required

- V&V Project Plan,
- V&V Project Status Report,
- V&V Agreement,
- V&V Project Memory
- V&V Enterprise Memory

7.6.3 Information Provided

- Updated V&V Project Plan.
- Updated V&V Project Status Report.
- Updated V&V Project Memory.

7.6.4 Roles Involved

- V&V Project Manager,
- Acceptance Leader,
- V&V Leader.

7.6.5 Activities & tasks

The recommended activities in this process include the following:

Activity P6.1: Contribute to the V&V Project Plan

The V&V Project Plan contains a section on how information management is executed during the project (procedures, communication patterns, time schedule, etc.). This activity completes the information management section of the V&V Project Plan. It may be that during the execution of the project revisions are necessary.

The recommended tasks for this activity include the following:

- Tailor (e.g., by specialization, extension and reduction) the information management to the M&S project or life-cycle in which the V&V Project is executed.
- Contribute this formulation to the procedures to the V&V Project Plan.

Activity P6.2: Provide the V&V Project Memory

The infrastructure for storing all V&V Project information must be set up and maintained.

The recommended tasks for this activity include the following:

- Collect requirements for the V&V Project Memory from the V&V Agreement and M&S project or life-cycle needs.
- Build and provide the V&V Project Memory.
- Maintain the V&V Project Memory.

Activity P6.3: Perform information management

In this activity the actual information management takes place.

The recommended task for this activity includes the following:

- Obtain, store, check, maintain, retrieve all V&V project information as needed.

7.7 Measurement Process

7.7.1 Purpose

The purpose of the measurement process is to collect, analyze, and report data related to the overall V&V project, its performance and the quality of its deliverables.

All other project-level processes use the results of this process for the effective and efficient management of the V&V project. The following are recommended for consideration:

7.7.2 Information Required

- V&V Project Status Report,
- V&V Project Plan,
- V&V Project Memory
- V&V Enterprise Memory,

7.7.3 Information Provided

- Updated V&V Project Status Report,
- Updated V&V Project Plan
- Updated V&V Project Memory

7.7.4 Roles Involved

- V&V Project Manager,
- Acceptance Leader,
- V&V Leader.

7.7.5 Activities & tasks

The recommended activities in this process include the following:

Activity P7.1: Contribute to the V&V Project Plan

The V&V Project Plan contains a section on how measurements are executed during the project (procedures, communication patterns, time schedule, etc.). This activity completes the measurement section of the V&V Project Plan by identifying measurement metrics and procedures. It may be that during the execution of the project revisions are necessary in accordance with the enterprise policies

The recommended tasks for this activity include the following:

- Tailor (e.g., by specialization, extension and reduction) the measurement metrics and procedures to the M&S project or life-cycle in which the V&V Project is executed.

- Contribute this formulation to the procedures to the V&V Project Plan.

Activity P7.2: Perform Measurement

In this activity the measurements are performed and results are obtained.

The recommended tasks for this activity include the following:

- Collect data and calculate the metrics.

- Send results to the other project and technical processes.

8. GM-VV Enterprise Level Implementation Guidance

This chapter provides detailed implementation guidance on establishing and operating a permanent V&V organization. As discussed in Chapter 5 such a permanent V&V organization provides the V&V supplier's business environment to establish, direct and support the execution of multiple V&V projects and delivery of V&V products. More importantly, it provides the V&V supplier with an enterprise-level organization (i.e., line organization) to sustain and improve the quality, reduce costs and lead time of these V&V projects and products.

A prerequisite for instantiating the enterprise-level components and to successfully realize a permanent V&V organization is that V&V projects are executed in a structured manner, both on a project organizational and technical level (Chapter 6 and 7). Such structured V&V approaches or methods should be used as the basis to establish V&V life-cycle models that can be applied across multiple V&V projects. To develop and maintain V&V life-cycle models a life-cycle model management process should be instantiated on enterprise level (Section 8.3). Together with an instantiation of a quality management process (Section 8.5) this will help to reduce V&V project initiation costs, enhance and assure the quality of the V&V products delivered by the V&V supplier (
Figure 6).

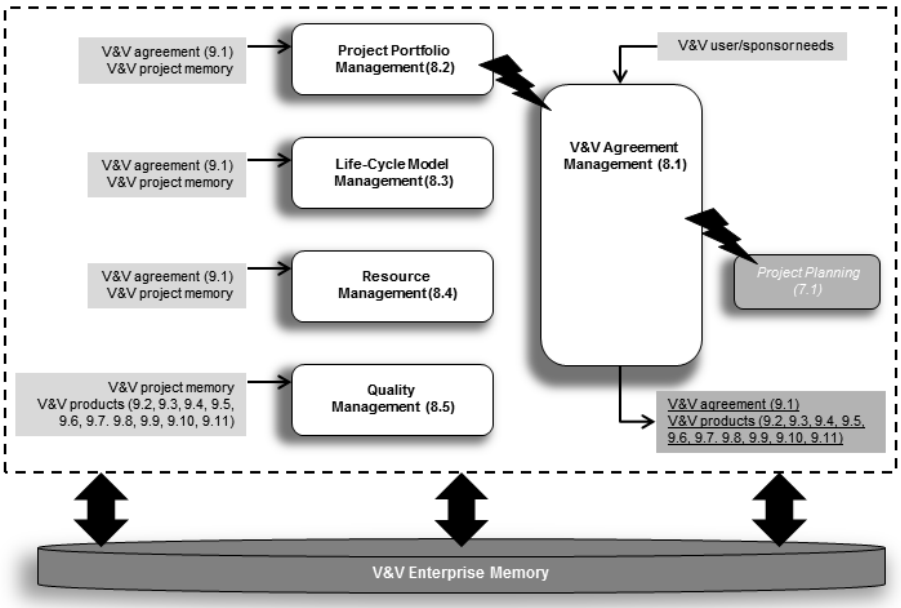

Figure 6 V&V Enterprise level product and process components overview[9]

To sustain the delivery of good quality V&V products by a V&V supplier the availability of sufficient V&V professionals (e.g., V&V project managers, V&V leaders and V&V implementers) and adequate infrastructure (e.g., V&V tools, techniques and templates) is required. Therefore, a permanent V&V organization should implement a Resources Management process (Section 8.4) to assure that the right personnel and infrastructure are available for the current and future V&V projects. A profitable permanent V&V organization requires a continuous flow of adequate V&V projects. To acquire V&V projects and to sustain a stable flow of V&V projects that meet the strategic V&V business objectives, a permanent V&V supplier organization should implement a Project-Portfolio Management process (Section 8.2). If in the Project-Portfolio process a business opportunity for a V&V project is identified, the V&V supplier will have to begin a process to initiate, execute and close the V&V Agreement with the potential V&V client. For this purpose a permanent V&V supplier organization should implement a common V&V Agreement Management process (Section 8.1). Multiple V&V Agreement Management processes could be invoked by the V&V supplier overtime, either in parallel or sequential to each other. From within the V&V Agreement Management process the V&V project organization is established (Chapter 7) and the technical V&V work is executed (Chapter 6). The Quality, Life-cycle, Resource and Project-portfolio processes are the processes that support the V&V Agreement Management process instances.

It must be noted, that there is no one size-fit-all blue print for the implementation of a permanent V&V organization (Chapter 5). Therefore, the GM-VV enterprise level components (process, products and roles) are not all inclusive and consideration should be given to extending these components as the need arises. By the same argument, not all components may be necessary for the needs, objectives and constraints of the V&V supplier and should be tailored. Which V&V enterprise level components and how they are implemented in the V&V organization highly depends on the existing organizational structure of the company. This is tailoring by reduction, extension and specialization.

A V&V Enterprise Memory should be implemented within a permanent V&V supplier organization [SISO-GUIDE-001.1-2012]. Such a V&V Enterprise Memory facilitates the management and maintenance of the total body of V&V information artifacts, knowledge, resources, life-cycle models and products required to sustain the delivery of V&V products by a V&V supplier. All V&V enterprise level processes should share their information through the V&V Enterprise Memory (Figure 6).

The V&V enterprise manager is responsible for managing the aforementioned permanent V&V supplier, including the V&V projects that are conducted by the V&V supplier. Since all GM-VV project

[9] Annex B provides the conventions fort his diagram

and technical level roles are part of a permanent V&V supplier organization, these roles contribute to or are involved in one or more of the V&V enterprise level processes (Chapter 6 and 7). More details about these roles, their responsibilities and obligations can be found in Chapter 10.

In Table 3, the relations between the enterprise level processes and the information artifacts are presented, according to the following conventions:

I = the information artifact is an input to the process,
O = the information artifact is an output from the process,
C = the process contributes to the information artifact.

Table 3 Relations between enterprise level processes and information artifacts

	V&V User/Sponsor Needs	V&V Agreement	V&V Enterprise Memory	V&V Project Memory	V&V Products
Agreement Management	I	O	IC		O
Project Portfolio Management		I	IC	I	
Life-Cycle Management		I	IC	I	
Resource Management		I	IC	I	
Quality Management			IC	I	I

NOTE: V&V Project Memory and V&V Enterprise Memory are not formal GM-VV recommended information artifacts. However, both are a combination of an information and knowledge repository and a community of practice (i.e., V&V professionals) that are maintained on respectively project and enterprise level.

NOTE: V&V User/Sponsor Needs is not a GM-VV formal recommended information artifact. Nevertheless, since those needs constitute a major source of information to conduct the Agreement Management process, they appear in the above table.

NOTE: V&V products comprise those GM-VV project and technical level recommended information artifacts that have to be delivered to the V&V User/Sponsor in accordance to the V&V Agreement (See Chapter 9).

The next sections offer detailed guidance on the implementation of the enterprise level processes. Each enterprise level process is decomposed into a set of activities and tasks, along with the recommended information artifacts that are required and provided. The roles involved in each process are also described. Each process may be tailored to reflect the needs and constraints of a specific enterprise that wants to implement permanent V&V organization (Chapter 5). The enterprise level information artifacts and roles are described in respectively Chapter 9 and 10.

8.1 Agreement Management Process

8.1.1 Purpose

The purpose of the agreement management process is to establish and manage the V&V Agreement between the V&V client and the V&V supplier.

The V&V Agreement management process is initiated from the project portfolio management process when a profitable business opportunity for a V&V project has been identified. During the agreement process the V&V supplier should communicate extensively with the V&V client to translate the V&V needs into a V&V Agreement. Once a V&V Agreement is established and authorized by both

organizations, the V&V project should be initiated. Its execution should be internally monitored by the V&V supplier from an enterprise level to assure the V&V Agreement is executed properly and issues solved when needed. When the V&V products have been delivered and accepted by the V&V client, the V&V supplier can close the V&V Agreement. During this closure activity the V&V project should be evaluated and reusable information from the project should be consolidated in the V&V Enterprise Memory. The following are recommended for consideration:

8.1.2 Information Required

- V&V User/Sponsor Needs[10]
- V&V Enterprise Memory.

8.1.3 Information Provided

- V&V Agreement,
- V&V Products[11],
- Updated V&V Enterprise Memory.

8.1.4 Roles Involved

- V&V Enterprise Manager,
- V&V User/Sponsor,
- V&V Project Manager.

8.1.5 Activities and Tasks

The recommended activities in this process include the following:

Activity E1.1: Initiate V&V Agreement

In this activity, good insight must be gathered on the client's V&V needs, context and constraints (e.g., budget and time) placed on the future V&V project. Based on this information a satisfactory response to the V&V client request should be made based on evaluating feasibility of the requested V&V project deliverables (e.g., products) in terms of resources, risks and project benefits. A V&V Agreement should then be negotiated.

The recommended tasks for this activity include the following:

- Start a high-level V&V Requirements Definition process (Section 6.1) to identify the V&V needs, context and constraints of the V&V client.
- Evaluate the V&V client request and information to prepare a response in the form of a V&V Agreement draft.
- Assess its feasibility using Project Portfolio Management process activities (Section 8.2).
- Negotiate the content of the draft V&V Agreement with the V&V client.
- Gain authorization (Section 8.2) and enter into a legal V&V Agreement with the V&V client.

Activity E1.2: Execute V&V Agreement

This activity should initiate the actual V&V project. Regularly, internal reviews should be conducted from an enterprise management to monitor the V&V project progress and possible issues with the V&V client. Such issues could be the overrun of project costs and schedule due to various reasons. Therefore, the V&V client should always be closely involved in this activity

The recommended tasks for this activity include the following:

[10] NOTE: V&V needs themselves are not a GM-VV formal recommended information artifact.
[11] NOTE: V&V products comprise those GM-VV project and technical levels recommended information artifacts that have to be delivered to the V&V User/Sponsor in accordance to the V&V Agreement.

- Prepare a project set up by tailoring (extension, reduction and specialization) in accordance with the V&V Agreement.

- Execute the V&V project by starting the V&V Project Planning process (Section 7.1).

- Monitor and evaluate the execution of the V&V Agreement internally for cost, quality, schedule, resources, mutual responsibilities and risks.

Activity E1.3: Close V&V Agreement

Once the V&V client has accepted the V&V Report, the V&V supplier should formally close the V&V Agreement. Time should be spent evaluating the V&V project, acquiring lessons learned and archiving all reusable information from the current V&V project to improve the efficiency and effectiveness of the V&V client organization operation.

The recommended tasks for this activity include the following:

- Accept and acknowledge payment or other agreed consideration from the V&V supplier to obtain closure of the V&V Agreement.

- Assess the archived V&V Project Memory to retain reusable knowledge, information and lessons-learned to improve the V&V enterprise processes, life-cycle models, policies and standards.

- Consolidate the reusable knowledge, information and lessons-learned in the V&V Enterprise Memory for future V&V projects.

8.2 Project Portfolio Management Process

8.2.1 Purpose

The purpose of the project portfolio management process is to initiate and sustain necessary, sufficient and suitable V&V projects in order to meet the strategic V&V supplier objectives.

To sustain a viable and profitable permanent V&V supplier organization, appropriate V&V business opportunities with possible new and existing V&V clients should be generated. This process should drive the acquisition of suitable V&V projects and commit the necessary V&V supplier organization resources needed to establish and perform the acquired V&V projects. The V&V supplier organization should also perform continued qualification of the currently running V&V projects to justify continued commitment of resources. The following are recommended for consideration:

8.2.2 Information Required

- V&V Agreement,
- V&V Project Memory,
- V&V Enterprise Memory.

8.2.3 Information Provided

- Updated V&V Enterprise Memory.

8.2.4 Roles Involved

- V&V Enterprise Manager,
- V&V Project Manager.

8.2.5 Activities and Tasks

The recommended activities in this process include the following:

Activity E2.1: Acquire V&V Business and Authorize V&V Agreements

A permanent V&V supplier should perform marketing and sales to acquire new V&V projects. Once a new business opportunity is generated, the V&V agreement should be established. The V&V enterprise management should make a trade-off decision of cost-benefits of a new V&V project and assure that the V&V supplier organization can fulfill the V&V Agreement, prior to authorizing the agreement and commence with the V&V project.

The recommended tasks for this activity include the following:

- Prioritize, select and establish V&V business opportunities with the business strategy of the V&V organization and current portfolio of V&V projects.
- Start a V&V Agreement Management process with a future V&V client (Section 8.1).
- Determine required resources for the fulfillment of the V&V Agreement objectives.
- Perform resource management activities (Section 8.4) to assure the availability of resources.
- Authorize the V&V Agreement and commence with the V&V project execution.
- Add the approved V&V project to the V&V Project Portfolio of the V&V Enterprise Memory.

Activity E2.2: Monitor and Control the Portfolio of V&V Projects

The V&V projects in the V&V supplier organization project portfolio should be constantly monitored for their progress, V&V Agreement issues, compliancy with the V&V life-cycle policies and other possible issues that may harm the V&V supplier business. Appropriate corrective actions should be taken to address such issues.

The recommended tasks for this activity include the following:

- Evaluate ongoing V&V projects to confirm that they are making progress conform the V&V Agreement and remain viable.
- Act to properly continue, redirect or close projects where the V&V Agreement permits it.

8.3 Life-Cycle Management Process

8.3.1 Purpose

The purpose of the life-cycle management process is to define, maintain and ensure availability of V&V life-cycle models suitable for carrying out any V&V project.

This process should provide V&V project life cycle models that are tailored for and consistent with the permanent V&V organization business goals. V&V life-cycle models should be instantiated and applied across multiple V&V projects. Examples of V&V life-cycle models include V&V supplier tailored V&V policies, processes, products, standards or cost models. Every V&V life-cycle model should be well defined, adapted, improved and maintained to support individual V&V project needs executed by the V&V supplier organization, and that they are capable of being applied in conjunction with effective, proven methods and tools. The following are recommended for consideration:

8.3.2 Information Required

- V&V Agreement,
- V&V Enterprise Memory,
- V&V Project Memory.

8.3.3 Information Provided

- Updated V&V Enterprise Memory.

8.3.4 Roles Involved

- V&V Enterprise Manager.

8.3.5 Activities & tasks

The recommended activities in this process include the following:

Activity E3.1: Establish V&V Life-Cycle Models

The V&V life-cycle models should be established specifically for the V&V supplier organization and V&V clients it serves. For instance, in case the V&V supplier organization operates for a dedicated M&S organization the V&V project and technical process models should be adapted to meet the V&V policies and document templates of that M&S organization. Such information should be identified from the V&V Agreement and the selected V&V life-cycle models for the project should be stored in the V&V Project Memory.

The recommended tasks for this activity include the following:

- Identify the lifecycle models required for facilitating the V&V supplier's projects and its clients.
- Develop and implement the identified V&V life-cycle models.
- Consolidate the V&V life-cycle model descriptions within the V&V Enterprise Memory.
- Identify and modify V&V life-cycle models for a particular V&V project.

Activity E3.2: Improve V&V Life-Cycle Models

In this activity the V&V life-cycle models are assessed on whether they still meet the V&V supplier organization business and V&V project needs. Such assessment should be performed on a regular basis to keep the V&V life-cycle models up to date, since business goals and customer needs may change over time. Moreover, data, feedback and lessons learned from the V&V projects and project memories should be elicited to identify issues and possible improvements to enhance the effectiveness and efficiency of the V&V life-cycle models in use.

The recommended tasks for this activity include the following:

- Monitor and conduct periodic reviews of the V&V life-cycle models usage in V&V projects.
- Identify, prioritize and plan improvement opportunities from assessment results.
- Implement the improvements and consolidate the changes in the V&V Enterprise Memory.
- Communicate the improvements through the V&V supplier organization.

8.4 Resource Management Process

8.4.1 Purpose

The purpose of the resource management process is to ensure that necessary resources are provided for executing V&V projects and that skills, competencies, and infrastructure are maintained, consistent with the V&V supplier organization needs.

Two types of resources should be managed in this process: personnel and infrastructure. V&V personnel comprise the pool of skilled and experienced personnel qualified to fulfill one or more V&V roles (e.g., V&V Project manager, V&V Implementer or Acceptance Leader) at enterprise, project and technical level. Infrastructure could comprise a set of V&V test hardware and software, services, methods, tools, techniques, standards, and facilities that a V&V supplier organization owns and uses to execute V&V projects and manage V&V supplier organization at enterprise level. This process should provide tailored V&V personnel function profiles based upon the GM-VV role definitions

(Chapter 10) that match the specific needs of the V&V supplier organization. The following are recommended for consideration:

8.4.2 Information Required

- V&V Agreement,
- V&V Project Memory,
- V&V Enterprise Memory.

8.4.3 Information Provided

- Updated V&V Enterprise Memory.

8.4.4 Roles Involved

- V&V Enterprise Manager.

8.4.5 Activities and Tasks

The recommended activities in this process include the following:

Activity E4.1: Assure Adequate Skill Level of Personnel

In this activity the pool of the required V&V personnel for the V&V supplier organization should be determined, hired and employed with the organization. V&V personnel function profiles should be defined and required number of employee positions determined to enable the hiring and employment of the right amount of personnel with the right skill. Attention should be given in the process to the development of V&V personnel skills through training and education, as well to evaluation and rating the V&V personnel capabilities and performance. Trade-off assessment should be made to distribute the available V&V personnel efficiently over multiple V&V projects that may run concurrently within the permanent V&V supplier organization.

The recommended tasks for this activity include the following:

- Identify required skills of personnel for current and future V&V projects.
- Identify currently available skills of personnel.
- Develop skills of personnel and record newly obtained skills in the V&V Enterprise Memory.
- Maintain the pool of skilled personnel available to staff V&V projects.
- Assess the V&V projects needs and trade-off against the available pool of V&V personnel.
- Assign personnel with appropriate skill level to right V&V projects at the right moment.

Activity E4.2: Assure Adequate Infrastructure for V&V Projects

In this activity the needed V&V infrastructure should be identified, developed or acquired and maintained to meet the specific V&V supplier business goals and V&V project needs. Besides an assessment of the technical requirements, a cost-effectiveness analysis should be performed to acquire the most appropriate infrastructure for V&V projects. In a similar fashion a trade-off assessment should be made to distribute the available V&V infrastructure efficiently over multiple V&V projects that may run concurrently within the permanent V&V supplier organization.

The recommended tasks for this activity include the following:

- Identify infrastructure requirements to enable current and future V&V projects.
- Develop or acquire the required V&V project infrastructure.
- Record the availability of the new infrastructure in the V&V Enterprise Memory.

- Maintain currently available infrastructure within the V&V organization.
- Assess the V&V projects needs and trade-off against the available pool of V&V infrastructure.
- Provide the needed infrastructure at the right time to the right V&V project.

Activity E4.3: Provide the V&V Enterprise Memory

The provision of the V&V enterprise memory should require special attention within a permanent V&V organization. By means of this memory the whole V&V supplier organization history, knowledge and expertise is managed. Moreover, data and information from enterprise processes used in the daily operation of the V&V supplier is managed using the enterprise memory. Special emphasis should be put on the networking and interoperability with the V&V project memories.

The recommended tasks for this activity include the following:

- Collect requirements on the V&V Enterprise Memory from the V&V organization goals.
- Develop, provide and maintain the V&V Enterprise Memory.
- Maintain the V&V Enterprise Memory.

8.5 Quality Management Process

8.5.1 Purpose

The purpose of the quality management process is to ensure that the delivered V&V products meets the V&V supplier quality standards and achieves V&V client satisfaction.

The quality of V&V products delivered by a V&V project is influenced by the quality of the processes and means (e.g., tools and personnel) involved to produce these products. Therefore, quality management of a permanent V&V organization should not only focus on quality of the V&V products, but also on the associated production processes and means. This process should also develop a quality culture where quality of V&V is everyone's responsibility inside the V&V organization to achieve and maintain a consistent level of quality of V&V products delivered by the organization. Quality management should be implemented more thoroughly with emphasis on more formal documentation for V&V organizations that execute large-scale V&V projects involving complex M&S systems. For smaller V&V projects and M&S systems quality management should focus on quality culture rather than implementing formal documentation and associated recording systems. Quality management should be separate from project-level management to ensure independence. The following are recommended for consideration:

8.5.2 Information Required

- V&V Enterprise Memory,
- V&V Project Memories,
- V&V Products.

8.5.3 Information Provided

- Updated V&V Enterprise Memory.

8.5.4 Roles Involved

- V&V Enterprise Manager.

8.5.5 Activities & tasks

The recommended activities in this process include the following:

Activity E5.1: Plan Quality Management

In this activity organizational quality policy, procedures and standards should be identified and defined that meet the V&V organization business goals and V&V projects. The standards and procedures should be made available for the whole organization through the V&V Enterprise Memory. V&V quality standards and procedures that apply for a V&V project should be stored in the V&V project memory.

The recommended tasks for this activity include the following:

- Establish V&V quality goals, management policies, standards and procedures.
- Define responsibilities and authority for implementation of quality management.
- Implement the V&V quality standards and procedures in the V&V enterprise memory
- Select and modify quality procedures and standards for a particular V&V project.

Activity E5.2: Assess and Control Quality Management

This activity should be conducted to ensure that the V&V supplier organization quality procedures and standards are followed properly during V&V project executions. When necessary, corrective actions should to be taken to guarantee the right quality of the V&V products produced in the project.

The recommended tasks for this activity include the following:

- Conduct periodic quality reviews of V&V projects, the V&V Project Memory and products.
- Perform corrective actions when V&V quality goals are not achieved on project level.
- Assess V&V client satisfaction and store it in the V&V Enterprise Memory.

Activity E5.3: Improve Quality Management

In this activity the quality policies, standards and procedures are assessed to determine whether they still meet the V&V supplier organization business and V&V project goals. Such assessment should be performed on a regular basis to keep the quality management up-to-date, since business goals and customer needs may change over time, and new improvements may need to be implemented from lessons learned.

The recommended tasks for this activity include the following:

- Evaluate the current V&V supplier quality management policies, standards and procedures.
- Identify, prioritize and plan improvements opportunities.
- Implement the improvements and consolidate the changes in the V&V Enterprise Memory.
- Communicate the improvements through the V&V supplier organization.

9. Information Artifacts and Recommended Templates

In this chapter the products of the GM-VV Implementation Framework (Chapter 5) are described in terms of its information artifacts, and templates for building the products.

Products are the information artifacts that should be delivered, developed or used throughout a V&V project life-time by the V&V supplier. These are the results of the recommended activities and tasks described in Chapters 6, 7, and 8. These artifacts can have multiple instances, representational and documentation formats. Examples of such tailored documentation formats are the US DoD accreditation plan and report templates, and the V&V plan and report templates [B1]. Here a GM-VV specific set of generic templates is presented.

The GM-VV information artifacts are provided for each of the three organizational levels (Chapter 5):

Enterprise-level artifact
- V&V Agreement (Section 9.1),

Project-level artifacts
- V&V Project Plan (Section 9.2),
- V&V Project Status Report (9.3),

Technical-level artifacts
- V&V Requirements (Section 9.4),
- V&V Context Information (Section 9.5),
- V&V Plan (Section 9.6),
- V&V Experimental Frame (Section9.7),
- V&V Results (Section 9.8),
- V&V Argumentation Structure (Section 9.9),
- Acceptance Recommendation (Section 9.10),
- V&V Report (Section 9.11).

NOTE: Even though the V&V Enterprise Memory and V&V Project Memory have been taken into account in this implementation guide to describe their role and relationships within the GM-VV processes, activities and tasks, they are not formal GM-VV information artifacts. Therefore, they will not be described in detail in this chapter.

It is recommended that all produced information artifacts should include a set of meta-data to facilitate information management aspects such as: version control, configuration management, consolidation and discovery of information. This meta-data can include:

- Document title
- Document date
- Authors
- Distribution list
- Revision history (version, date, remarks, authors)
- Identification of V&V Project
- Classification (if required)
- Purpose of information artifact
- Executive summary
- Definitions, interpretation and scope
- Signatures of authorized representatives of all parties

9.1 V&V Agreement

9.1.1 Definition

A contract, statement of work or any type of agreement between a V&V client and a V&V supplier for the delivery of a V&V products.

9.1.2 Information items and recommended template

A V&V agreement is the outcome of negotiations between a V&V client and a V&V supplier on the delivery of one or more V&V products or servicess by the V&V supplier to the V&V client. A V&V agreement is the formal agreement between these two entities stating each other's reciprocal responsibilities and obligations in executing and closing the agreement. The V&V agreement addresses both technical and managerial aspects of the agreement. A V&V agreement serves as the basis for the V&V project manager at the V&V supplier side to start and execute a V&V project that will deliver the requested V&V services or products. For the V&V client it provides the guiding means to monitoring and managing the agreement with the V&V supplier.

The recommended V&V Agreement outline is the following:

1. Identification of V&V client and V&V supplier
2. Description of requested V&V service
3. Specification of V&V Intended Use
4. Specification of scope of work
5. Specification of V&V method to be used
6. Specification of Deliverables
7. Specification of required level of independence
8. Specification of resources (time, budget, SMEs, access to facilities, etc.)
9. Rights and Obligations
10. Fees and Payment Terms
11. Applicable Law
12. Term of Agreement
13. Warranties
14. Limitation of Liability
15. Procedures for handling (classified) information
16. Termination conditions and procedures
17. Closing page (date and signatures)

9.2 V&V Project Plan

9.2.1 Definition

A V&V project plan is a coherent arrangement of activities and tasks to guide both the V&V project execution and control. It can incorporate or reference the technical-level V&V plan.

9.2.2 Information items and recommended template

A V&V project plan is the vehicle to control, communicate and manage the V&V project. Among other things a V&V project plan describes the project deliverables, milestones, resources, risks and decision points, and the processes, activities and tasks that have to be performed. The preliminary project planning information used for the V&V agreement (Section 9.1) is elaborated upon to build the V&V project plan. A V&V project provides a schedule to which all aforementioned aspects are allocated to a specific time stamp or period. A V&V project plan is a projection into the future and inherently has an amount of uncertainty. In reality most projects work-out differently. Therefore the V&V project plan has to be continuously adjusted and refined with status information coming from the project itself. This includes building contingencies and criteria for re-planning.

The recommended V&V Project Plan outline is the following:

1. Project estimates
   1.1. People
   1.2. Resources
2. Risk management
   2.1. Description of risk i
   2.2. Risk table (probability and impact for risk i)
3. Project schedule
   3.1. Availability of resources (e.g., experts, simulator facilities)
   3.2. Deliverables and milestones
   3.3. Decision points
4. Project team organization
   4.1. Team structure
   4.2. Additional member responsibilities
5. Project support procedures
   5.1. Project assessment and quality control procedures
   5.2. Decision management procedures
   5.3. Risk management procedures
   5.4. Configuration management procedures
   5.5. Information management procedures
   5.6. Measurement procedures

9.3 V&V Project Status Report

9.3.1 Definition

A V&V project status report is an account or record to provide information on the conduct of the V&V project, its status and issues.

9.3.2 Information items and recommended template

A V&V project status report provides an account of how the project has been executed so far, its current status and identified issues. The V&V project status report can be used by the V&V supplier organization to steer V&V project execution when necessary. A V&V project status report (possibly adapted,) can also be sent to the V&V client to monitor the actual execution of the V&V agreement and give a good insight in the V&V project. The V&V project status report documents and gives motivations for any discrepancies, problems, issues, contingency decisions and resolutions in relationship to the V&V agreement. Therefore, a V&V project status report also contributes to the assessment of the return of investment of a V&V project from both the V&V client and supplier perspective.

The recommended V&V Project Status Report outline is the following:

1. Accomplishments since the last V&V Project Status Report
2. Deliverables status
3. Major issues
   3.1. Description of issues that need to be addressed
   3.2. Identification of the underlying causes of the issues
   3.3. Identification of impact of issues
   3.4. Description of taken and planned corrective actions
4. Schedule status
   4.1. Schedule status of V&V project
   4.2. Provide reasons for any variance and planned corrective actions
   4.3. List milestone and important events and activities for the upcoming reporting period
   4.4. Identify planned schedule activities for the next reporting period
5. Resource status
   5.1. Resource status (e.g., budget, personnel availability) of V&V project
   5.2. Provide reasons for any variances and planned corrective actions
   5.3. List planned resource usage for the upcoming reporting period
6. Project risks
   6.1. List and describe any existing risks that need to be addressed
   6.2. List and describe any potential risks that need to be addressed
   6.3. Provide plans for risk mitigation

9.4 V&V Requirements

9.4.1 Definition

A V&V requirement includes requirements placed on the V&V project deliverables and execution, including constraints. Note that these are not the M&S requirements for the M&S system.

9.4.2 Information items and recommended template

The V&V requirements are a complete description of all V&V requirements that apply to the V&V project. It serves as the vehicle to clearly identify, document, communicate and negotiate all requirements placed upon the whole V&V project life-cycle. To this extent a V&V requirements product specifies how the V&V products or services are intended to be used by the V&V User/Sponsor. From these V&V intended uses a set of V&V requirements for the V&V products and services can be developed. Furthermore, a V&V requirements product specifies the constraints placed upon the realization of these V&V products and services. A V&V requirements product is the V&V counterpart of the classical software or systems engineering requirements.

The recommended V&V Requirements outline is the following:

1. For each V&V product:
   1.1. Description of the V&V User/Sponsor's intended use
   1.2. list the requirements
      1.1.1. on the V&V Project
      1.1.2. on the V&V Deliverables
   1.3. list the constraints
      1.3.1. on the V&V Project
      1.3.2. on the V&V Deliverables

9.5 V&V Context Information

9.5.1 Definition

A V&V context information describes M&S information needed prior to or during the V&V project. It captures information regarding the M&S problem-solving life-cycle and process such as the M&S system requirements, intended use and risks.

9.5.2 Information items and recommended template

The V&V context information consists of a number of information items that are relevant for the V&V work. Some of this information should be available before the start of the V&V project, e.g., for initial planning purposes, while other information is added to the V&V context information during the execution of the V&V project. Information items include:

- M&S Intended Use: an account of how the M&S User/Sponsor intends to utilize an M&S results.
- M&S Use Risks: an account of the risks associated to the (intended) utilization of an M&S results by the M&S User/Sponsor.
- M&S Requirements: statements of singular necessary attribute, capability, characteristic, or quality that an M&S system must possess in order to have utility to the M&S User/Sponsor.
- M&S Constraints: restrictions placed upon the realization of an M&S system by either the M&S client or M&S supplier.
- M&S System: the system that is the result or deliverable of the M&S project including all instructions for its use.

The recommended V&V Context Information outline is the following:

2. M&S Intended Use
   2.1. Specification of the utilization of the results coming from actual exploitation of the M&S system
3. M&S Use Risk
   3.1. For each M&S intended use, a specification of its associated risk factors
   3.2. For each M&S use risk factor, a specification of its impact and probability
4. M&S Requirements

4.1. Place upon the M&S system itself
4.2. Placed upon the M&S process and organization
5. M&S Constraints
5.1. Placed upon M&S system performance, qualities and features
5.2. Placed upon the M&S process and organization
6. M&S System description

9.6 V&V Plan

9.6.1 Definition

A V&V plan specifies the V&V execution process, tasks and experimental frame to be implemented as well as the associated resources.

9.6.2 Information items and recommended template

The V&V Plan is a document that describes what evidence is to be obtained, and how. Based on the Acceptability Criteria, which define what needs to be shown, Evidence Solutions are defined (See Section 6.3). These Evidence Solutions state how evidence is to be obtained in order to show that the Acceptability Criteria are met or not. Thus the Evidence Solutions specify "tests" in the broadest sense of the word. The set-up needed to perform the tests is called the V&V experimental frame. The planning of the tests in terms of time and resources (SMEs, test subjects, measurement equipment, access to M&S facilities, etc.) is also part of the V&V Plan.

The recommended V&V Plan outline is the following:

1. Description of the acceptance goal
1.1. Argumentation for the traceability from e.g., the V&V Agreement, the V&V Requirements and the V&V context information to the acceptance goal
2. Description of acceptability criteria
2.1. Argumentation for the traceability from the acceptance goal to the acceptability criteria
3. Description of evidence solutions
3.1. Argumentation for the traceability from the acceptability criteria to the evidence solutions
4. Specification of the experimental frame, for each Evidence Solution:
4.1. Referent specification: expected results
4.2. Test specification: detailed specification of how the evidence is to be obtained and the necessary quality of the test results
4.3. Comparator specification: how to measure the difference between the referent and the test results
4.4. Evaluator specification: how to determine when the observed difference between referent and test results is sufficiently small
5. Schedule
5.1. Schedule of time frame for V&V activities, tasks and tests
5.2. Schedule of expenses
5.3. Schedule of other needed resources: e.g., SMEs, equipment and facilities

9.7 V&V Experimental Frame

9.7.1 Definition

A V&V experimental frame is a set of experiments, tests and conditions used to observe and experiment with the M&S system to obtain V&V results.

9.7.2 Information items and recommended template

The experimental frame specification is found in the V&V Plan as described above, The V&V experimental frame itself consists of hardware, software, configuration files, operators, test-subjects, test procedures, etc. needed for the execution of the tests. Note that the V&V experimental frame is how the tests are/have been actually executed, i.e., it may happen that for practical reasons it deviates from the V&V experimental frame specification in the V&V plan.

The recommended V&V Experimental Frame outline is the following:

1. For each implemented evidence solution (See Section 6.3),
   1.1. Referent: e.g., a collection of real world measurements and literature.
   1.2. Test set-up: e.g., a collection of hardware, software and procedures used in the test.
   1.3. Comparison/evaluation methods for comparing test results with the referent

9.8 V&V Results

9.8.1 Definition

A V&V results is the collection of data items produced by applying a V&V experimental frame to an M&S system.

9.8.2 Information items and recommended template

This information artifact contains all the results from the execution of the experimental frame, including the results of the comparison and evaluation of the test results with the referent, see 9.6.2. For reasons of traceability for each data item a reference should be provided to the V&V experimental frame used that precisely details how the data item was obtained, and to the V&V plan that specifies the required V&V Experimental Frame. Again, for reference purposes each data item should have a unique tag that can be used from within the V&V Argumentation Structure to reference to specific data items in the V&V Result.

Typically the V&V Results can be a diverse set of information items, therefore the physical shape of the V&V Results is likely not a document but rather a collection of logs from measurement devices, logs from M&S System runs, etc.

The recommended V&V Results outline is the following:

1. For each data item in the V&V Results
   1.1. Unique reference tag
   1.2. Reference to the V&V Experimental Frame specification in the V&V plan
   1.3. Description of the actual V&V Experimental Frame execution
   1.4. The results of the test
   1.5. Statement on the quality of the result
   1.6. Deviations observed in the comparison of the test results with the referent

9.9 V&V Argumentation Structure

9.9.1 Definition

A V&V Argumentation Structure captures the derivation of acceptability criteria from the acceptance goal, and the derivation of the V&V experimental frame specification from the acceptability criteria. It provides the rationale for these derivations. It integrates the V&V results into items of evidence, and provides argumentation for the acceptability claims underlying the acceptance recommendation.

9.9.2 Information items and recommended template

The V&V Argumentation Structure provides the traceability from acceptance goal to the acceptance recommendation, and back. It consists of two parts:

- The first part provides the technical vehicle to systematically develop a set of acceptability criteria, and evidence solutions based on the acceptance goal. The systematic development should be as complete as possible given the V&V project resource constraints. Choices on what to develop and what to leave undeveloped should be risk-based and documented in the V&V argumentation structure.
- The second part integrates the V&V results into items of evidence, and provides argumentation for the acceptability claims underlying the acceptance recommendation.

The recommended V&V Argumentation Structure outline is the following:

1. Description of the acceptance goal
   1.1. Argumentation for the traceability from e.g., the V&V Agreement, the V&V Requirements and the V&V context information to the acceptance goal
2. Description of acceptability criteria
   2.1. Argumentation for the traceability from the acceptance goal to the acceptability criteria
3. Description of evidence solutions
   3.1. Argumentation for the traceability from the acceptability criteria to the evidence solutions
4. Description of items of evidence
   4.1. Argumentation for the traceability from the items of evidence to the V&V Results
5. Description of acceptability claims
   5.1. Argumentation for the traceability from the acceptability claims to the items of evidence
6. Description of the acceptance claim
   6.1. Argumentation for the traceability from the acceptance claim to the acceptability claims

9.10 Acceptance Recommendation

9.10.1 Definition

An acceptance recommendation is an account or record containing the recommendations on the acceptability of the M&S system for the intended use.

9.10.2 Information items and recommended template

The acceptance recommendation is the information artifact that can be used by the V&V User/Sponsor during the acceptance decision procedures. It should therefore contain the actual recommendation, but also the basis for that recommendation. Most V&V User/Sponsors will not be able to use the V&V Argumentation Structure directly. Therefore the major findings with respect to the fitness for purpose should be included in a suitable format. In order for the V&V User/Sponsor to judge the quality of the acceptance recommendation itself, a statement on the rigor of the V&V work should be provided.

The recommended Acceptance Recommendation outline is the following:

1. Description of the acceptance recommendation in a format required by the V&V User/Sponsor
2. Argumentation for the traceability of the V&V Argumentation Structure to the acceptance recommendation
3. Most important findings with respect to its fitness for purpose (both negative and positive findings)
4. Rigor of the V&V work
   4.1. Statement on quality of the V&V process/activities/tasks
   4.2. Statement on quality of the employed personnel
   4.3. Statement on how the risk-based tailoring was applied
   4.4. Statement on remaining uncertainties

9.11 V&V Report

9.11.1 Definition

The V&V Report accumulates and documents the information generated throughout the V&V effort, along with information on how the V&V effort has been performed.

9.11.2 Information items and recommended template

The V&V Report contains the information artifacts and products generated throughout the execution of the V&V effort. This final document is delivered to the V&V Client before closing the V&V agreement.

The recommended V&V Report outline is the following:

1. Project overview
   - 1.1. Appropriate parts of the V&V Agreement, e.g., summaries of
     - 1.1.1. Deliverables
   - 1.2. Appropriate parts of the V&V Requirements, e.g., summaries of
     - 1.2.1. The V&V User/Sponsor's intended use
     - 1.2.2. Requirements and constraints on the V&V Project and deliverables
   - 1.3. Appropriate parts of the V&V Context information, e.g., summaries of
     - 1.3.1. M&S Requirements and Acceptability Criteria
     - 1.3.2. M&S Assumptions, Capabilities, Limitations and Risks/Impacts
2. V&V Project information
   - 2.1. Overview of executed V&V processes/activities/tasks
   - 2.2. Overview of expenses
   - 2.3. Overview of used resources: SMEs, equipment, facilities, etc.
   - 2.4. Overview of important project planning decisions
   - 2.5. Overview of important project risks and their resolution
3. V&V outcomes, summaries of and references to the stored
   - 3.1. V&V Argumentation Structure
   - 3.2. V&V Experimental Frame
   - 3.3. V&V Results
   - 3.4. Acceptance Recommendation
4. V&V Lessons Learned

10. Role responsibilities, obligations, processes and activities

In this chapter the organizational roles of the GM-VV Implementation Framework (Chapter 5) is described in terms of their responsibilities and obligations with respect to V&V activities described in Chapters 6, 7, and 8.

10.1 GM-VV Recommended Roles

On enterprise level, GM-VV defines the following V&V roles:

- The V&V User/Sponsor (client): responsible for specifying the V&V requirements from their needs and endorsing the delivered V&V products. This role contributes to the V&V Agreement from the client side.

- V&V Enterprise Manager; responsible for managing the environment in which V&V projects are conducted. This role contributes to the V&V Agreement from the supplier side.

On project level, GM-VV defines the following role:

- The V&V Project Manager: responsible for managing the V&V project to assure that the V&V Report and possibly other custom V&V products are developed and delivered according to the V&V Agreement.

On technical level, GM-VV defines the following roles:

- The Acceptance Leader, responsible for specifying the acceptability criteria, assessing the acceptability claims and constructing the Acceptance Recommendation,

- The V&V Leader, responsible for developing the V&V Plan, assessing and integrating the V&V Results into items of evidence, and constructing the acceptability claims,

- The V&V Implementer, responsible for implementing the V&V Experimental Frame and generating V&V Results. Examples of V&V implementers are SMEs, M&S developers and test engineers.

The roles are played either by people or by organizations. Depending on the M&S organization, project and application domain needs, several roles could be played by separate organizations, separate people in one organization or by a single person.

10.2 Recommended Role Responsibilities

The roles are defined in terms of responsibilities and obligations. Table 4, Table 5 and Table 6 identify the roles and their responsibilities and obligations with respect to each activity in the V&V processes. They are intended only as general guidelines. The following responsibilities and obligations are used in the aforementioned tables.

1. **Lead (L)**: Responsible for an activity,

2. **Perform (P)**: Responsible for performing an activity under the direction of the leader of the activity,

3. **Assist (A)**: Obligation to help a performer or a leader to complete an activity,

4. **Review (R)**: Obligation to review the work of others and to make suggestions for improvement where appropriate,

5. **Monitor (M)**: Obligation to watch the activities being performed or receive the products so that they can be aware of the V&V status.

6. **Endorse (E):** Obligation to endorse a V&V product.

Table 4 Roles and Responsibilities regarding Enterprise Processes

GM-VV processes and activities		V&V User/Sponsor	V&V Enterprise Manager	V&V Project Manager	Acceptance Leader	V&V Leader	V&V Implementer
Enterprise Processes							
Agreement Management Process (E1)							
Activity E1.1	Initiate V&V Agreement	**A, R**	**L, P**				
Activity E1.2	Execute V&V Agreement	**M**	**L, P**	**A**			
Activity E1.3	Close V&V Agreement	**A, R**	**L, P**				
Project Portfolio Management Project (E2)							
Activity E2.1	Acquire V&V business and Authorize V&V Agreements		**L, P**	**A**			
Activity E2.2	Monitor and Control the Portfolio of V&V Projects		**L, P**	**A**			
Life-Cycle Management Process (E3)							
Activity E3.1	Establish V&V Life-Cycle Models		**L, P**				
Activity E3.3	Improve V&V Life-Cycle Models		**L, P**				
Resource Management Project (E4)							
Activity E4.1	Assure Adequate Skill Level of Personnel		**L, P**				
Activity E4.2	Assure Adequate Infrastructure for V&V Projects		**L, P**				
Activity E4.3	Provide the V&V Enterprise Memory		**L, P**				
Quality Management Process (E5)							
Activity E5.1	Plan Quality Management		**L, P**				
Activity E5.2	Assess Quality Management		**L, P**				
Activity E5.3	Improve Quality Management		**L, P**				

Table 5 Roles and Responsibilities regarding Project Processes

GM-VV processes and activities		V&V User/Sponsor	V&V Enterprise Manager	V&V Project Manager	Acceptance Leader	V&V Leader	V&V Implementer
Project Processes							
Project Planning Process (P1)							
Activity P1.1	Start project processes		**A**	**L, P**			
Activity P1.2	Provide the V&V Project Plan			**L, P**			
Activity P1.3	Start technical processes to initialize the project			**L, P**			
Activity P1.4	Start technical processes to execute the project			**L, P**			
Activity P1.5	Start technical processes to close the project			**L, P**			
Activity P1.6	Stop the project		**A**	**L, P**			
Project Assessment and Control Process (P2)							
Activity P2.1	Contribute to the V&V Project Plan			**L, P**			
Activity P2.2	Monitor the execution of the V&V Project Plan	**M**	**M**	**L, P**	**A**	**A**	
Activity P2.3	React on deviations from the V&V Project Plan	**M**	**M**	**L, P**			
Activity P2.4	Provide V&V Project Status Reports	**R, E**	**M,R**	**L, P**	**A**	**A**	
Decision Management Process (P3)							
Activity P3.1	Contribute to the V&V Project Plan			**L, P**			
Activity P3.2	Make decisions		**M**	**L, P**	**A**	**A**	
Risk Management Process (P4)							
Activity P4.1	Contribute to the V&V Project Plan			**L, P**			
Activity P4.2	Manage risk		**M**	**L, P**	**A**	**A**	
Configuration Management Process (P5)							
Activity P5.1	Contribute to the V&V Project Plan			**L, P**			
Activity P5.2	Perform configuration management			**L, P**	**A**	**A**	
Information Management Process (P6)							
Activity P6.1	Contribute to the V&V Project Plan			**L, P**			
Activity P6.2	Provide the V&V Project Memory			**L, P**			
Activity P6.3	Perform information management			**L, P**	**A**	**A**	
Measurement Process (P7)							
Activity P7.1	Contribute to the V&V Project Plan			**L, P**			
Activity P7.2	Perform Measurement			**L, P**	**A**	**A**	

Table 6 Roles and Responsibilities regarding Technical Processes

GM-VV processes and activities		V&V User/Sponsor	V&V Enterprise Manager	V&V Project Manager	Acceptance Leader	V&V Leader	V&V Implementer
Technical Processes							
V&V Requirements Definition Process (T1)							
Activity T1.1	Provide the V&V Context Information	**A**		**M**	**L, P**		
Activity T1.2	Provide the V&V requirements	**A**		**M, R**	**L, P**		
Activity T1.3	Provide the acceptance goal	**A**		**M**	**L, P**		
Acceptance Planning Process (T2)							
Activity T2.1	Provide the acceptability criteria	**R**		**M**	**L, P**	**A**	
V&V Planning Process (T3)							
Activity T3.1	Provide the evidence solutions				**M, R, A**	**L, P**	
Activity T3.2	Provide the V&V Plan			**A, M, R**	**A, M**	**L, P**	
V&V Execution Process (T4)							
Activity T4.1	Implement the V&V Experimental Frame			**M**		**L, M**	**P**
Activity T4.2	Execute the V&V Experimental Frame			**M**		**L, M**	**P**
Activity T4.3	Provide items of evidence					**L, P, A**	**P**
V&V Assessment and Integration Process (T5)							
Activity T5.1	Assess the items of evidence			**M**		**L, P**	**A**
Activity T5.2	Provide acceptability claims				**R**	**L, P**	**A**
Acceptance Assessment and Integration Process (T6)							
Activity T6.1	Provide the acceptance claims				**L, P**	**A**	
Activity T6.2:	Provide the Acceptance Recommendation			**M, R**	**L, P**	**A**	
V&V Product Delivery Process (T7)							
Activity T7.1	Provide the V&V Report	**R, E**		**L, P**	**A, R**	**A**	

Annex A Bibliography

(Informative)

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[B5] Jacquart J., J. Voogd J., D. Brade, C. Yi, "WEAG THALES JP11.20 (REVVA-1) Results and Perspectives". 2005 European Simulation Interoperability Workshop, Paper 021, 2005.

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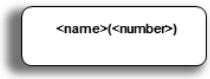
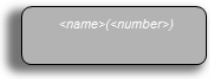
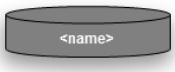
Annex B Conventions

The guidance described in Chapters 6, 7 and 8 uses diagrams that show the primary relationships between the GM-VV processes and products. These diagrams use particular symbols to identify the types of GM-VV processes and products, and their interactions. Table 6 below describes the meanings of these symbols.

Table 6 Symbol conventions used in the GM-VV Process and Product Diagrams

Symbol	Description
	A process at technical, project or enterprise level, with a name and section number where it is described in the document
	A process at different organizational level, with a name and section number where it is described in the document
	A product that is input to a process, with a name and section number where it is described in the document
	A product that is output of a process, with a name and section number where it is described in the document
	A product that is contributed to by a process, with a name and section number where it is described in the document
	A memory in which technical, project and/or enterprise level V&V information artifacts are managed, consolidated and maintained
	A process that invokes (i.e., starts) another process
	A bidirectional information exchange between memory and processes