The GM-VV: It's Relationship to the VV&A Overlay for the FEDEP

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ABSTRACT: *The Generic Methodology for Verification and Validation (GM-VV) is a generic methodology for VV&A to justify the acceptability of models, simulation, underlying data and results for an intended use. This methodology is currently in the processes of standardization within the SISO. The GM-VV attains its genericness from a framework approach, instead of trying to cover or merge all possible and existing VV&A methods into a single "one-size-fits-all" VV&A method implementation. This means that the GM-VV is not prescriptive in nature, nor directly tied to any specific M&S application domain, standard, technology, organization or other distinctive M&S context related implementation details for VV&A. The GM-VV's technical framework provides common semantics, concepts and tailorable building blocks for VV&A, which aims to facilitate communication, understanding and implementation of VV&A across and between such different M&S contexts. Moreover, this framework also provides the tailoring principles and guidance to cost-efficiently develop and apply VV&A method instantiations from its technical framework, which support the individual M&S organization, project, technology or application domain needs and constrains.*

This paper demonstrates how the existing VV&A overlay to the FEDEP can be derived from the GM-VV. The illustration shows the mapping between the VV&A overlay terminology, definitions and concepts, and the generic ones provided by the GM-VV technical framework. The presented detailed mappings of the VV&A overlay roles, processes and products onto the GM-VV generic building blocks illustrates the tailoring of the GM-VV towards a VV&A method instance that fits a specific M&S technology (i.e. FEDEP). As such the paper provides readers with an educational example to help understand the GM-VV purpose, usage and relationship to other VV&A standards.

1 Introduction

Increasingly, models and simulations (M&S) are developed and deployed as enabling technology to support system analysis, design, test and evaluation, acquisition, training and instruction. It is imperative to the M&S community that verification, validation and accreditation/acceptance (VV&A) has to be performed to ensure that both the development and utilization of M&S technologies are cost-effective, and their results are credible and do not pose unacceptable risks. The choice which method for VV&A works best in a given situation depends on the individual needs and constraints of an organization, project, application domain or technology. Moreover, VV&A of M&S still is a relatively new field of technology and practice. As a result many different approaches to VV&A exist that rely on a wide variety of different VV&A terms, concepts, products, processes, tools or techniques. In many cases the resulting proliferation restricts or even works against the transition of VV&A assets and results from one organization, project, and technology or application domain to the other.

This context was the key driver behind the development of the Generic Methodology for Verification and Validation (GM-VV) that is currently in process of being standardized within SISO [1]. The GM-VV aims not to replace any existing VV&A approaches, methodologies, standards or policies of M&S organizations, technology and application domains; nor it is intended to be prescriptive, in that it does not specify a single concrete or unique solution for all VV&A applications. Instead, the purpose of the GM-VV is to provide a general baseline and guidance for VV&A of M&S that:

- facilitates a common understanding, communication, comparison and interoperability of native VV&A practices and standards
- is applicable and tailorable towards individual VV&A needs of a wide variety of M&S technologies and application domains

In essence, the GM-VV serves a similar purpose as the IEEE/SISO recommended practices for the Distributed Simulation Engineering and Execution Process (DSEEP) that provides a generalized process-oriented framework to develop and execute distributed simulation environments [2]. The GM-VV does something similar for VV&A but is not limited to distributed simulations.

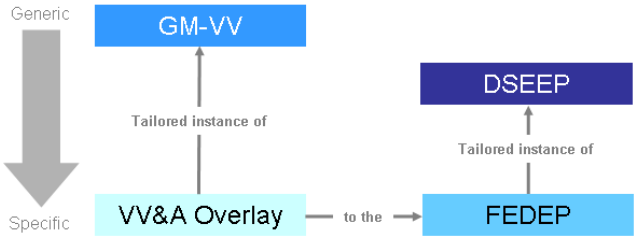

Figure 1 GM-VV, DSEEP, FEDEP and VV&A Overlay

In the DSEEP document it is shown how the IEEE/SISO Federation Development and Execution Process (FEDEP) is a specific tailored instance of the DSEEP [3].
The IEEE Recommended Practice for Verification, Validation and Accreditation of a Federation provides a VV&A overlay to the FEDEP [4]. The goal of this paper is to show how the VV&A overlay can be derived via tailoring of the GM-VV as an M&S technology specific VV&A application instance, in a similar manner as the DSEEP shows its relationship with the FEDEP. As such it helps the M&S community to better understand the purpose of the GM-VV, its usage, added value and relationship to other VV&A standards.

2 GM-VV and VV&A Overlay Overview

The purpose of this section is to provide a very high-level overview of both the GM-VV and the VV&A overlay to the FEDEP (in the rest of the paper simply referred to as "the VV&A Overlay"). It is beyond the scope of this paper to provide a detailed introduction to these two methods; the reader is referred to the original documents for more details [1] [4].

2.1 GM-VV Overview

The GM-VV attains its genericness by means of a reference model and architecture approach. This means that the GM-VV is not directly tied to any specific M&S application domain, standard, technology, organization or other distinctive M&S implementation details for VV&A. The GM-VV aims to provide common semantics and components for VV&A that can be used unambiguously across and between different M&S organizations, projects, technology or application domains. Therefore, the GM-VV comprises an abstract framework that consists of three parts (the Conceptual Framework, the Implementation Framework and the Tailoring Framework) that build upon existing VV&A methods and practices.

GM-VV Conceptual Framework

The GM-VV conceptual framework provides essential VV&A terminology, semantics, concepts and principles. The framework facilitates communication, understanding and implementation of VV&A across and between different M&S contexts. This framework is rooted in the premise that models and simulations are always developed and employed to fulfill specific needs of their stakeholders (e.g. trainers, decision makers). The GM-VV assumes that VV&A always takes place within such a context and uses a four-world view to structure this larger context (Figure 2).

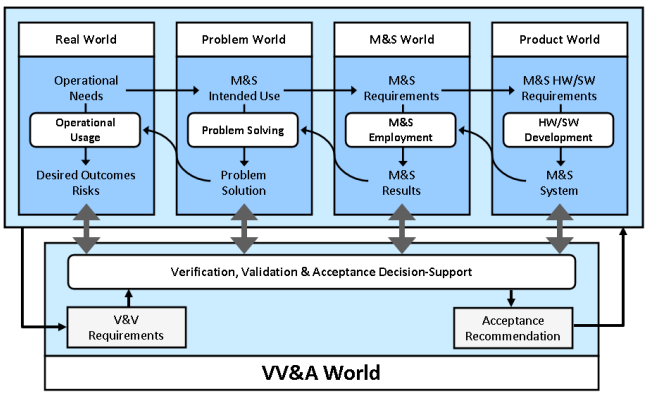

Figure 2 GM-VV Worlds View

Together, these four worlds define a generic M&S life-cycle and process view. The GM-VV considers VV&A as a specific domain of M&S and refers this domain as the VV&A World. The VV&A world groups the products, processes and organizational aspects that are needed to develop an *acceptance recommendation* for an M&S asset regarding its acceptability for an intended use. This effort is driven by the *VV&A requirements* that are linked to the stakeholders needs (e.g. budget, risks, liabilities).
From a technical perspective the GM-VV recognizes five conceptual activities in this effort. First, define a set of concrete and assessable *acceptability criteria* for the M&S asset. Second, collect or generate relevant *evidence* to demonstrate the satisfaction of the acceptability criteria. Third, assess the *evidential quality* of this demonstration. Fourth, develop arguments that underlie the claim whether or not the M&S asset is acceptable for an intended use (i.e. *acceptance claim*). Five, compile the information from the other four activities into an acceptance recommendation.
Acceptability criteria, items of evidence and arguments underlying an acceptance recommendation should be developed in a structured manner using a format where the reasoning is transparent, traceable and reproducible. This is accomplished by the GM-VV *VV&A goal-claim network* concept that encapsulates, manages and consolidates all underlying evidence and argumentation necessary for developing a defensible acceptance recommendation.

To increase the efficiency and quality the entire VV&A effort, VV&A should be executed in an organized way. The GM-VV defines three organizational levels at which VV&A efforts can be considered. The technical level concerns all technical aspects of a VV&A effort necessary to develop and deliver an acceptance recommendation for an M&S asset. The project level concerns all managerial aspects related to the execution of the technical work. In support of a *VV&A project*, the GM-VV defines the enterprise level, which establishes, directs and enables the execution of VV&A projects. On the VV&A project and enterprise levels the GM-VV applies the memory concept; a combination of an information and knowledge repository and a community of practice. These *VV&A project* and *enterprise memory* respectively retains information from the current and past efforts to support high quality, cost-effective execution of VV&A.

GM-VV Implementation Framework
The GM-VV implementation framework translates the GM-VV basic concepts into a set of generic VV&A components. These components are classified and designed according the three interrelated dimensions shown in Figure 3. All components are intended to be used and combined to implement tailored VV&A solutions that fit the needs of any particular M&S organization, application, and technology or problem domain. Each dimension contains building blocks that cover technical, project and enterprise level aspects of VV&A.

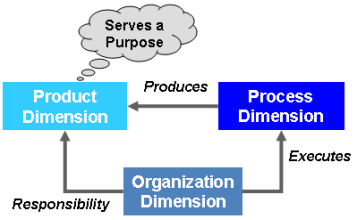

Figure 3 GM-VV Implementation Framework Dimensions

The product dimension contains information-based VV&A products that can have multiple instances, representational and documentation formats. These VV&A products are produced by the processes, activities and tasks defined by the process dimension. They can be executed recursively, concurrently and iteratively. The roles defined in the organization dimension are involved in the execution in one or more of the VV&A processes, activities and tasks. The roles are specified in terms of responsibilities of either people or organizations involved in VV&A. The roles can be played by separate organizations, teams of people in one organization or by a single person.

GM-VV Tailoring Framework
The aforementioned GM-VV implementation framework should be tailored for each individual M&S organization, project or application domain. To do this the GM-VV provides a tailoring framework that supports the modification of the building blocks in the GM-VV product, process and organization dimensions to satisfy the specific VV&A requirements and constraints in the M&S environment in which the GM-VV is applied. The basic premise of this tailoring framework is that the implementation framework components should first be cast into a VV&A method instantiation suited for the organization or application domain, which is then optimized for the VV&A project at hand. For the optimization four tailoring approaches are defined:

- *Extension*: adding elements not specified in the GM-V&V (e.g. additional products.)
- *Reduction*: cutting out GM-VV elements (e.g. activities and tasks that are not to be executed.)
- *Specialization*: adaptation of GM-VV elements (e.g. using domain specific V&V methods.)

- *Balancing*: adaptation to find optimum cost-benefit-ratio (e.g. distributing project resources based on M&S use-risk.)

Tailoring by these four approaches should be performed across the three dimensions of the GM-VV implementation framework in such a way that a consistent and coherent VV&A method instance is obtained.

2.2 FEDEP VV&A Overlay Overview

The VV&A overlay to the FEDEP is a recommended practice for the VV&A of HLA-based federations that are being developed using the FEDEP [3] [4]. The purpose of the overlay is to provide a more detailed view of the VV&A processes implied by the FEDEP itself. The VV&A overlay is intended to be applied across a wide range of M&S applications that utilize HLA federations. Therefore, the overlay only provides a high level framework for VV&A into which individual VV&A practices, tools and techniques can be integrated to meet the needs of a specific application domain. However, such individual VV&A practices, tools and techniques are not described by the overlay. Moreover, the overlay only focuses on the VV&A aspects that apply to a federation as a whole. It assumes that each individual federate has been verified and validated in some manner, though the information from these efforts is taken into account by the VV&A overlay. As such the VV&A overlay identifies and describes a set of recommended processes for VV&A of federations along with its respective information and products that are exchanged between these VV&A and the FEDEP processes. In addition, the overlay defines those terms uniquely for the FEDEP VV&A processes but for the remainder it builds upon standard terms and definitions.

The VV&A overlay framework design consists of seven processes, referred as phases, see Figure 4. Each phase maps directly to a single process step inside the FEDEP. Each VV&A phase is defined in terms of lower-level activities and supporting information. These activities are performed by a VV&A team. The purpose of each VV&A phase can be summarized as:

- *Phase 1*: Verifies federation objectives. Assembles the federation referent and related acceptability criteria. Formulates the federation accreditation and V&V plan.
- *Phase 2*: Supports the development of the federation scenarios, conceptual model, and requirements. Contributes to verification of these products. Validates the federation conceptual model.
- *Phase 3*: Supports the selection of federates and federation design. Contributes to the verification of this design and updates the federation accreditation plan and V&V plan for inclusion into the federation development and execution plan.
- *Phase 4*: Supports the development of the FOM, federation agreements, and implementation of the federation infrastructure. Contributes to verification of these development assets. Furthermore, supports the verification and validation of the data sets needed for the federation execution.
- *Phase 5*: Supports the federation execution planning, integration and testing. Contributes to verifying the integrated federation. Validates the results produced by the integrated federation and develops the federation acceptance recommendations.

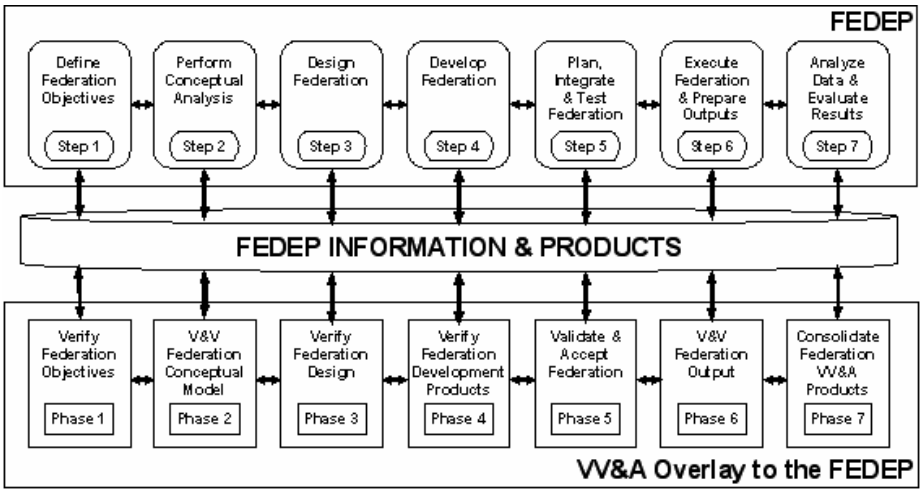

Figure 4 Top-level view of the VV&A overlay to the FEDEP [4]

- *Phase 6*: Supports the federation execution and contributes to verification of the output produced by these executions. Validate the federation output.
- *Phase 7*: Collects and assembles the products from the preceding VV&A activities into a consolidated package to support future reuse.

The VV&A overlay phases are tailorable such that the VV&A effort meets the user needs, resources and risks of a specific federation application. This tailoring is achieved by deletion or modification of the activities inside each of the seven VV&A overlay phases. Moreover, tailoring is also achieved by selecting and employing the proper application domain specific VV&A practices, tools and techniques within the VV&A overlay framework.

3 GM-VV Tailored to the VV&A Overlay

This chapter shows that the VV&A overlay can be considered as an instance of the GM-VV, as indicated in *Figure 1*, derived by applying the GM-VV tailoring framework. First a terminology mapping between the VV&A overlay and the GM-VV is given as well as a comparative analysis of their definitions. Next the relationships between the GM-VV conceptual framework and the VV&A overlay concepts are considered. Finally, its is shown how the VV&A overlay products, processes and organizational roles can be derived from the GM-VV implementation building blocks using the four GM-VV tailoring approaches.

3.1 Terminology Mappings and Definitions

The GM-VV terminology list includes 17 terms for which one or more definitions are provided. For some terms more than one definition is provided to facilitate understanding and applicability of the GM-VV across different communities. In total 25 definitions are given of which 10 are specific to the GM-VV, the rest is taken from literature.

A number of terms are the same between the GM-VV and the VV&A overlay, but they do not always have the same semantics. Additionally, due to the different purposes of the methodologies, their terminology includes different terms, e.g. the GM-VV includes *utility* whereas the VV&A overlay does not; the VV&A overlay includes *federation* whereas the GM-VV does not. Both the GM-VV and the VV&A overlay state that for all terms not included in their terminology list, one is referred to the IEEE Dictionary of Standard Terms [5].

Terms that are shared between the GM-VV and the VV&A overlay are:

- *Acceptance*: The GM-VV refers acceptance to the process of ascertaining the M&S is fit for an intended use which can be used to support the decision to use the M&S. This is similar to how the VV&A overlay addresses acceptance.
- *Acceptability Criteria*: the GM-VV definition is equal to that of the VV&A overlay.
- *Accreditation*: the GM-VV defines this as giving an organization a formal recognition for conducting the certification of a model, simulation and data. In here certification is the process of providing an official written guarantee that the M&S system is acceptable for its intended use.
- *Conceptual Model:* This is similar to the VV&A Overlay definition of *Federation conceptual model.*
- *Fidelity*: The *accuracy of the representation*, mentioned in the GM-VV, refers to *the description of a model, simulation or federation of models and simulations and its associated data representational capabilities*, as mentioned in the VV&A overlay.
- *Referent:* This definition is exactly the same.
- *Validity:* The *M&S system* mentioned in the GM-VV refers to *the models, simulations or federation of models and simulations*, mentioned in the VV&A overlay. Validity as defined in the VV&A overlay calls for the M&S system's *representation being complete and correct enough for the intended use*, which in the GM-VV entails the combination of utility and validity.
- *Validation:* In the GM-VV, validation calls for evidence justifying the M&S system being accurate enough towards the referent for the intended use (see GM-VV's validity), which is equivalent to the VV&A overlay definition that calls for evaluation of the M&S system during development and execution to determine how well it satisfies the acceptability criteria (for an intended use) within the context of the referent.
- *Verification:* In the GM-VV, verification calls for evidence justifying that the M&S system implementation conforms to its specifications; and is free of design and development errors. This definition is equivalent to the VV&A overlay that calls for the M&S system to be evaluated for completeness and correctness against the developer's conceptual model and specifications, and this can be done either overall or for each phase, as suggested by the VV&A overlay.

VV&A overlay terms not included in the terminology of the GM-VV are addressed below:

- *Federate, Federation, Federation Object Model, Federation Scenario*: the GM-VV calls for a more generic term of M&S system, which refers to a combination of interacting M&S elements (models, simulations and data) organized to achieve one or more uses. Therefore, the VV&A overlay's federate, federation, federation object model, and federation scenario are instance of M&S (sub) systems.
- *Federation objectives and requirements*: Federation objectives map to the GM-VV's more generic M&S intended use, and the federation requirements map to the GM-VV's M&S requirements
- *Credibility:* The definition of acceptance in the GM-VV refers to the *process that ascertains an M&S system is fit for the intended use*, which includes both the VV&A overlay's credibility, *the belief that an M&S system can serve an intended use*, and acceptance (the decision) as discussed earlier.
- *Error Characteristics:* Within the GM-VV's evidence solutions the error characteristics are considered by defining satisfaction conditions for each test.
- *Representational Requirements:* the VV&A overlay defines a particular subset of M&S requirements focusing on the representational aspects of the M&S System. This is embodied by the GM-VV concept of M&S requirements as well.
- *Results sampling strategy:* This kind of test strategy is one example of a GM-VV evidence solution.
- *Activity:* the GM-VV follows the process structure of 15288.2008 [6], where a process is composed of activities, and activities are composed by tasks, which is equivalent to the VV&A overlay's activity definition.
- *Risk and uncertainty:* These terms map to the concepts of risks and uncertainty of the GM-VV conceptual framework.

3.2 Conceptual Framework

The GM-VV four world views serve as a generic M&S engineering life-cycle process and view to which the VV&A is applied (Figure 2). The FEDEP represents a HLA technology related instance of such a life-cycle process (Figure 3). The FEDEP is an M&S technology oriented development process and is therefore placed in the GM-VV M&S and product worlds. Within the GM-VV M&S world the FEDEP steps 2 (conceptual analysis) and 6 (execute federation) can be placed. The GM-VV product world comprises FEDEP steps 3 (design), 4 (develop) and 5 (integrate and test). From such a conceptual level perspective the FEDEP federation objectives, federation requirements, and federation design map to the next GM-VV world-view products of M&S intended use, M&S requirements and M&S hardware/software requirements respectively. The M&S system in the GM-VV system view represents the HLA federation. HLA federates in this regard can be considered as M&S subsystems using the GM-VV's systems of systems approach to M&S systems. Finally the GM-VV M&S results map to the FEDEP federation output.

The GM-VV groups and structures all VV&A products, processes and organizational roles into the VV&A world. This world is clearly separated from the four world M&S engineering life-cycle but interacts with it by means of coordination, cooperation and exchanging products or information. From a conceptual level the VV&A overlay seems to follow the same approach as depicted in Figure 3. However, there are certain notable differences:

- Though both the GM-VV and the VV&A overlay define VV&A products, processes and roles, the GM-VV is product-oriented while the VV&A overlay is strongly process oriented.
- Unlike in the GM-VV, the VV&A overlay places the verification itself not inside the VV&A world, but in the M&S and problem world. The VV&A overlay explicitly states that verification activities are not the responsibility of the VV&A team but federation development team. This is reflected by the fact that from the 37 activities specified by the VV&A overlay only 10 are really lead or performed by the VV&A team (Section 3.3). For the other 26 activities the VV&A team is guided to actively participate in the M&S engineering work the federation development team is conducting.
- The VV&A overlay focuses on verifying and validating the federation as a whole. It is assumed that V&V has already been done for the federates and that their results are available. This means that conceptually only a portion of the V&V of the product world is covered by the VV&A overlay.

The deliverable of the VV&A world is an acceptance recommendation. For the VV&A overlay this is similar but it only is a recommendation for the federation as a whole. The GM-VV can produce multiple acceptance recommendations at different time instances and for

different M&S products, depending on the requirements that drive the VV&A effort. The VV&A overlay does not explicitly refer to or uses the concept of VV&A requirements as the GM-VV does. Instead these are more or less implicitly imposed by the FEDEP that states when, where and what VV&A activities shall be conducted. The VV&A overlay builds on this by refining and expanding these activities in more detail.

The GM-VV indentifies multiple types of timeframes related to the execution of VV&A. The VV&A overlay is solely a concurrent VV&A process due to its strong integration with the timeframe imposed by the FEDEP activities. This in combination with the previously mentioned fact that all verification activities are done by the federation development team, and that validation data should primarily be produced by federation developers' test procedures mean that a full level of independence, IVV, is hard to attain when the VV&A overlay is applied as-is. The level of independence of the VV&A overlay matches more the level of: V&V conducted by a separate V&V team within the M&S developer organization.

The GM-VV conceptually defines three levels on which VV&A should be considered, organized and managed. The VV&A overlay has no real VV&A enterprise level as embodied by the GM-VV concept of a VV&A enterprise memory, except that it mentions to consolidate VV&A information along with the federation itself. Due to the fact that the VV&A overlay is so tightly coupled to the FEDEP, there is no explicit VV&A project instantiated. The project planning and management of the VV&A activities are driven or executed by means of federation planning and other management activities of the FEDEP. The VV&A overlay mentions accreditation and V&V planning but these activities are sub activities within the larger federation development and execution planning. The same holds for the GM-VV concept for VV&A project information and configuration management. The VV&A overlay mentions that this should be done, but doesn't have a concept such as the GM-VV VV&A project memory. The VV&A overlay implicitly assumes that this is accomplished by means of using a data storage provided by the federation development project in combination with adhering to the FEDEP information and configuration management related activities. The VV&A products, activities and roles provided by the VV&A overlay thus primarily map to technical level GM-VV products, processes and roles.

Acceptability of an M&S for an intended use is proven in the GM-VV by means of five conceptual steps (Section 2.1). Within the VV&A overlay the same steps are followed. It also starts with defining acceptability criteria. However, the VV&A overlay doesn't distinguish between utility, validity and correctness criteria. Acceptability criteria as used by the VV&A overlay are primarily addressing the validity criteria type of the GM-VV and secondary utility criteria. No correctness criteria, which relate to verification activities, are explicitly defined. Instead these are implicitly imposed by the FEDEP and the VV&A overlay by stating what verification tasks the federation development team must be perform and what verification information must be made available to the VV&A team. To demonstrate that a federation meets these acceptability criteria the VV&A overlay requires that a federation referent is available. The GM-VV also uses the referent concept for demonstrating M&S validity. The VV&A overlay creates this in a single activity which results in one monolithic referent. The GM-VV concept to develop a referent is a modular approach, where smaller en locally referents are defined in conjunction with a V&V method or technique (i.e. evidence solution) for one or more associated acceptability criteria. The development of a referent in the VV&A overlay is treated as separate activity from the acceptability criteria definition activity and precedes the development of these criteria.
Though, the VV&A overlay states that there must be documented traceable relationship between the VV&A artifacts, no concepts are mentioned to achieve this in a structured manner. For this purpose the GM-VV explicitly uses the VV&A goal network concept. Similarly, the VV&A overlay states that the argumentation and the underlying collected V&V evidence must be traceable as well, no concepts are provided like the GM-VV VV&A claim network. It must be noted that traceability in the VV&A overlay is very frequently used in the context of supporting or assuring that M&S development artifacts are traceable to one another and well document by the federation development team.

3.3 Implementation and Tailoring Framework

The GM-VV implementation framework translates the GM-VV conceptual framework into a set of generic building blocks or components suitable for the VV&A of M&S (Section 2.1). These components are classified in three interrelated dimensions: product, process and organization. These implementation dimensions have to be tailored. This section shows how the VV&A overlay products, processes and roles can be derived from these dimensions using the four GM-VV tailoring approaches presented earlier (i.e. tailoring framework).

Tailoring the GM-VV Product Dimension

In this section it is shown how the VV&A overlay products are covered by the GM-VV products. Although some statements in Phase 7 of the VV&A overlay suggest an enterprise level, we will stick to a technical instantiation of the GM-VV. This for example means that no GM-VV VV&A Plan is instantiated. A VV&A plan is a project level planning for the whole of the VV&A work, and differs from the VV&A overlay Federation V&V Plan that primarily plans the V&V activities to obtain evidence.

The VV&A Goal-Claim Network of the GM-VV is an argumentation structure that consists of goals, strategies, claims, arguments and evidence. On one side, this structure captures the acceptability criteria, V&V experimental frame specification and their rationale. On the other side, this structure recomposes the V&V results in supporting evidence and arguments for the acceptance claim on the intended use of the M&S system and results. The Goal network part is built top down, typically resulting in a hierarchical structure of goals. If the GM-VV is tailored towards the VV&A overlay products, it means that in the Goal Network a specific de-aggregation is used: one with branches containing goals and criteria for the conceptual model, the design, the development and the output. For these separate branches the appropriate parts of the Experimental Frame can be constructed and executed piece by piece as the FEDEP progresses, allowing the construction of the Claim network in parts.

Below for each of the VV&A overlay products the corresponding GM-VV product is described in a coarse grained fashion. A brief overview is presented in Table 1.

right: GM-VV Products **below: VV&A overlay Products**	VV&A Requirements Specification	VV&A Context Information	VV&A Experimental Frame	V&V Results	VV&A Goal-Claim Network	Acceptance Recommendation	VV&A Project Memory
Accreditation Plan	X	X			X		
Acceptability Criteria					X		
Referent			X				
V&V Plan			X		X		
CM V&V Results				X	X		
Design verification Results				X	X		
Development Verification Results				X	X		
Validation and Acceptance Results				X	X	X	
Output V&V Results				X	X		
VV&A Archive Products			X	X	X	X	X

Table 1: Relationship between the GM-VV and the VV&A overlay products

The information in the Federation Accreditation Plan is found distributed over three GM-VV products. User/Sponsor Needs and limitations are located in the *VV&A Requirements Specification*, statements on the impact and risk assessment are located in the *VV&A Context Information*. The top part of the *VV&A Goal-Claim Network* contains an elaboration of the User/Sponsor perspective of what they want the federation to do.

All Acceptability Criteria, including those of the Federation Acceptability Criteria are found in the *VV&A Goal-Claim Network*.

The Federation Referent in the GM-VV is distributed over the test definitions (i.e. evidence solutions) in the *VV&A Experimental Frame*. Each test specifies what data needs to be obtained, what referent it is to be compared with and how possible differences are to be evaluated.

The Federation V&V Plan is distributed over two GM-VV products. The bottom part of the Goal Network (the first part of the *VV&A Goal-Claim Network*) is where are Acceptability Criteria are derived from the user level perspective. Prioritization (which is a form of tailoring by balancing) can be performed during this derivation. For each of the Acceptability Criteria a test is specified to obtain evidence (which together form the *VV&A*

Experimental Frame). The test specification includes further tailoring to choose optimal cost-effective methods, tools, and techniques, based on estimates of resource usage vs. expected quality of the *V&V Results*.

The V&V results as the VV&A overlay interprets them for Federation CM V&V Results, Federation Design verification Results, Federation Development Verification Results and the Federation Output V&V Results are all found in the bottom part of the Claim Network (the second part of the *VV&A Goal-Claim Network*).

The aggregation and evaluation of evidence found in the Federation Validation and Acceptance Results is placed in Claim Network. The "recommended conditions of federation use and their rationale" is typically found in the *Acceptance Recommendation*.

Finally, the Federation VV&A Products contains reusable information containing a number of products. In the GM-VV this is collected in the *VV&A Project Memory*. If an enterprise level is present the project memory can – possibly after some cleaning – be put into an enterprise memory.

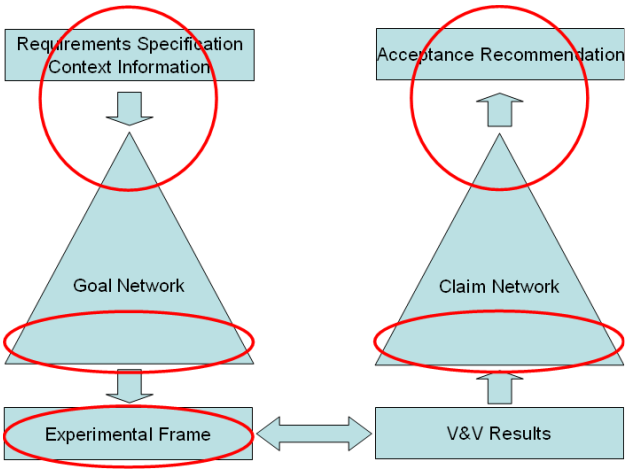

Figure 5 The GM-VV products (blue) and its coverage by the VV&A overlay products (red)

From the red ovals in Figure 5 it becomes clear that the VV&A overlay products do not cover certain aspects that are covered by the GM-VV. If the GM-VV is to be tailored towards the VV&A overlay one can leave out the uncovered parts of the products, or - which is preferred - use the full GM-VV. The additional product make explicit what should, and probably is, done for the VV&A overlay anyway.

Similar to the GM-VV product dimension, tailoring the GM-VV to the VV&A overlay requires no processes on management level or support processes to be instantiated, only the GM-VV technical processes are executed (Table 2). As outlined in Section 3.2 the VV&A overlay assumes that project management activities related to the VV&A effort are part of the overall federation development and execution planning as executed by the federation manager.

Tailoring the GM-VV Process Dimension

right: GM-VV Processes **below: VV&A overlay Processes**	Verify federation objectives	V&V federation conceptual model	Verify federation design	Verify federation development products	Validate and accept federation	Verify and validate federation output	Consolidate federation VV&A products
VV&A Requirements Definition Process							
Acceptance Design Process							

V&V Design Process	X	X	X	X	X	X	
V&V Implementation Process	X	X	X	X	X	X	
V&V Assessment Process	X	X	X	X	X	X	
Acceptance Assessment Process					X		X
VV&A Transition Process					X		X

Table 2 Relationship between the GM-VV and the VV&A overlay processes

The GM-VV VV&A Goal-Claim Network is a linked network starting with the top goal via the hierarchically derived Acceptability Criteria, via the Experimental Frame with V&V Results, to the hierarchically structured claim network. In the Goal network, and correspondingly the Claim network, branches can be dedicated to specific topics as derived from the top goal. For the VV&A overlay instantiation of the GM-VV those topics are the federation objectives, conceptual model, design, development products and output. Part of the topics that are examined in the activities of the VV&A overlay Phase 5: Validate and accept federation, are also included in the GM-VV activities that build the VV&A Goal-Claim Network. Other activities in Phase 5 are executed in the GM-VV Acceptance Assessment and Transition Process.

Although no enterprise level processes are instantiated, the VV&A overlay does have activities that prepare V&V products for reuse. This reuse would in the GM-VV typically be enabled by an enterprise, namely by the use of a VV&A Corporate Memory.

In the VV&A overlay activities are found where the V&V team supports the M&S team in their effort to make the M&S development traceable from the User/Sponsor needs to the federation objectives, criteria, scenarios, etc. In the GM-VV there are no activities of that kind due to the separation between V&V and M&S. However this imposes no problem when the "support documenting <some M&S artifact>" type of activities can be interpreted as "define criteria on <M&S artifact>", check those criteria and report back to the M&S team if criteria are not met. In this manner the M&S team can correct their work using the V&V team input, in a VV&A overlay context.

Tailoring the GM-VV Organization Dimension

The GM-VV organization dimension describes the organizational components that may be used to facilitate the organization of VV&A enterprises and VV&A projects, which are specified in terms of roles played either by people or by organizations.

For the instantiation of the GM-VV towards the VV&A overlay it is clear that no VV&A enterprise or project roles are instantiated. The overall management of an VV&A effort is in GM-VV the responsibility of the VV&A project manager. However, within the VV&A overlay it is unclear who has the overall responsibility of the VV&A effort. Instead, the VV&A overlay specifies a VV&A team which works in close cooperation with the federation development team in one overarching M&S Project (i.e. federation development and execution). In Table 3 an overview is presented of which GM-VV roles are to be tailored towards the VV&A overlay roles.

GM-VV Role	**VV&A overlay Role**
VV&A User/Sponsor	User/Sponsor
	Federation Manager
	Federation Developer
V&V Leader	V&V Agent
Acceptance Leader	Accreditation Agent
V&V Implementer	Subject Matter Expert
	Federation Developer

Table 3 Relationship between the GM-VV and the VV&A overlay roles

A number of differences are observed. The GM-VV does not include roles that are related to the M&S project. The GM-VV makes it possible to make a clear distinction between V&V activities and M&S development activities (see the concept on Levels of Independence), in the VV&A overlay no such distinction is present. There is,

however, no problem for the GM-VV to work closely together with federation managers and developers. For those two roles the standard VV&A overlay role specification can be used.
The Acceptance Leader role is very close to the VV&A overlay Accreditation Agent: both roles have responsibilities that sort of form the interface between the customer (VV&A User/Sponsor for the GM-VV and the User/Sponsor and the Federation Manager and Developer for the VV&A overlay) and the V&V team (the V&V Leader for the GM-VV and the V&V Agent for the VV&A overlay).

4 The VV&A Overlay in perspective to the GM-VV Technical Framework

In this section the VV&A overlay is placed in perspective to GM-VV technical framework as the underpinning basis of the current VV&A overlay.

Independence
The GM-VV shows the separation between M&S development and VV&A activities. Some of the VV&A Overlay activities where cooperation between the M&S team and VV&A team occurs are at to the center part of the GM-VV level of independence scale.

Choice of time frame
The GM-VV allows for different time frames for the execution of VV&A. The chosen concurrent V&V time frame of the V&V Overlay allows for the seamless integration of federation V&V with V&V of the existing or parallel developed federates.

Technical, project and enterprise level
The GM-VV provides the opportunity of choosing the level of V&V activities. The VV&A Overlay addresses mainly technical processes. This was an explicit design decision for the VV&A Overlay, that only attempt to detail and extent the technical VV&A aspects indicated by the FEDEP. With the GM-VV one can also execute project level processes to for instance facilitate independent V&V or when management and planning or other facilities from the M&S development are insufficient to properly execute all V&V activities. In order to allow for increasing quality of the V&V work the enterprise level can be invoked over the current and future V&V activities.

Utility, Validity, Correctness
The GM-VV explicitly distinguishes between utility, validity and correctness. This allows for a more structured derivation of acceptability criteria. In the GM-VV correctness criteria are also explicitly derived from both utility and validity, instead of leaving them to be handled by the M&S developers. The VV&A Overlay only speaks in acceptability criteria in general and does not impose such basic taxonomy of acceptability criteria. However, such taxonomy can easily be applied within the VV&A overlay when needed.

Traceability
The GM-VV provides structuring to the VV&A artifacts by providing the mechanisms to construct a completely traceable path from the M&S user's need (i.e. intended use) to the acceptance recommendation (through the V&V Goal-Claim Network). Although the VV&A overlay states that the V&V work must be traceable it does not specify any techniques to do so. In most of the VV&A overlay activities where traceability is mentioned, it concerns the traceability of M&S development artifacts (through a traceability matrix), not the traceability of the VV&A artifacts themselves.
The V&V Goal-Claim network allows for more explicit balancing of resources over the whole of the V&V effort to obtain the best cost-benefit. It can even contain an analysis as detailed as needed on why the federation is or is not suited for its intended purpose. The GM-VV V&V goal-claim network can be used in concert with the VV&A overlay to strengthen the traceability of the overlay information artifacts.

Conclusions

The most important conclusion of this paper is: the VV&A overlay can be considered to be a tailored instance of the GM-VV. However, it must be note that the overlay does delete almost all the VV&A aspects of GM-VV that relate to the VV&A enterprise and project level. Therefore, the VV&A overlay can be seen as a specialized implementation of the GM-VV technical level products, processes and roles.
Besides that the tailoring example provided in this paper proofs the genericness of the GM-VV, it also indicates that the VV&A overlay user could be benefit more from the overlay when it is used in concert with GM-VV. By using the GM-VV products, processes and roles on project and enterprise level they could increase the effectiveness and efficiency of the technical V&V work described by the VV&A overlay.

Since there is a close relation between the FEDEP and the new DSEEP standards, one can conclude from this

work that GM-VV might also be useful as a basis for the new to be developed DSEEP VV&A overlay.

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