Simulation Team

Generic Methodology for Verification and Validation

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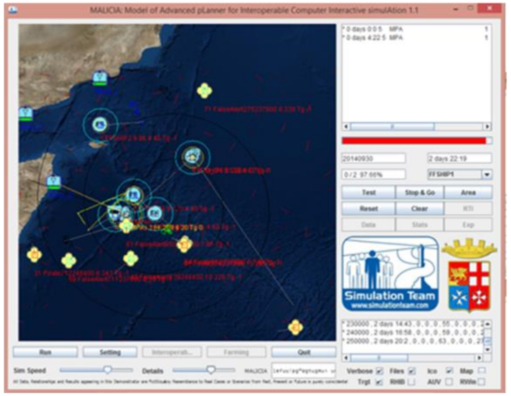
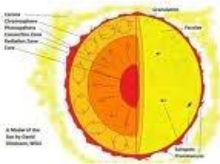
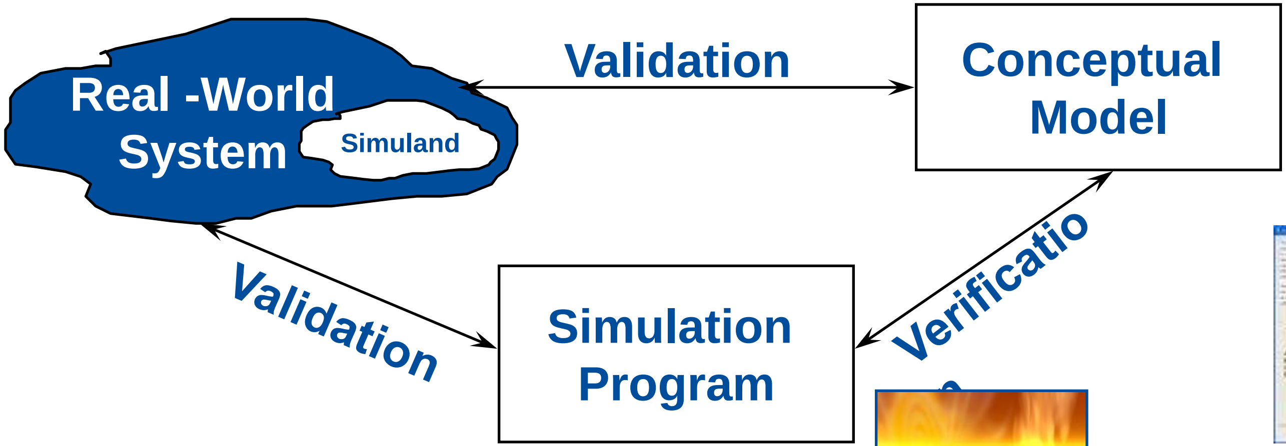
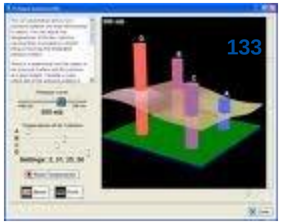


What are Validation and Verification?

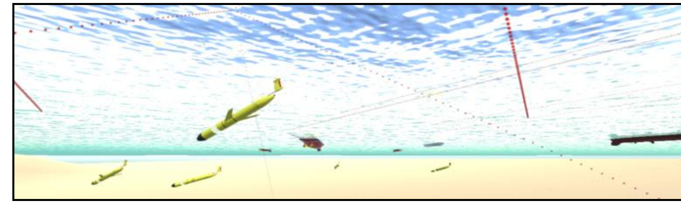
- Validation is the process of determining whether the conceptual model is an accurate representation of the actual system being analyzed. Validation deals with building the right model.
- Verification is the process of determining whether a simulation computer program works as intended (i.e., debugging the computer program). Verification deals with building the model right.







GM-VV Scope



The **Generic Methodology for Verification and Validation** (**GM-VV**) is devoted to:

- provide a generic framework to efficiently develop an argument
- provide a generic framework to justify why the product of M&S effort is acceptable for deployment in the target (intended) operational (use) context
- support stakeholders in their acceptance decision making process on the utilization of (M&S) products to satisfy their business goals
- provide support throughout the whole life-cycle of M&S product (development, employment and use/reuse)

GM-VV & M&S Community

- GM-VV has been designed to provide the M&S international community with a methodology for verification, validation and acceptance, which consistently embraces a wide variety of M&S technologies and application domains
- GM-VV support the community by a common language to better facilitate communication and co-operation between all participants in Verification, Validation and Acceptance endeavor

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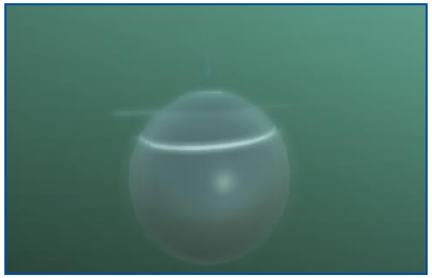
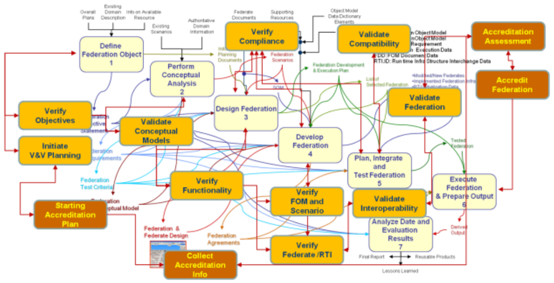
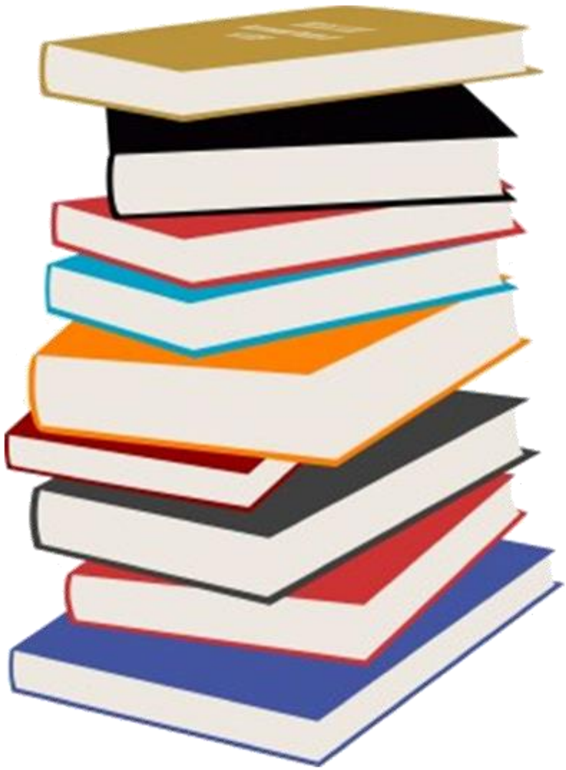
GM-VV Standard Base

- Many **Standards** for VV&A imply the use of a specific modeling and simulation (M&S) *System Engineering* paradigm, like for instance the (i.e. IEEE FEDEP)
- GM-VV is constructed over existing standards and common practices in *System Engineering* to facilitate the GM-VV application among M&S community







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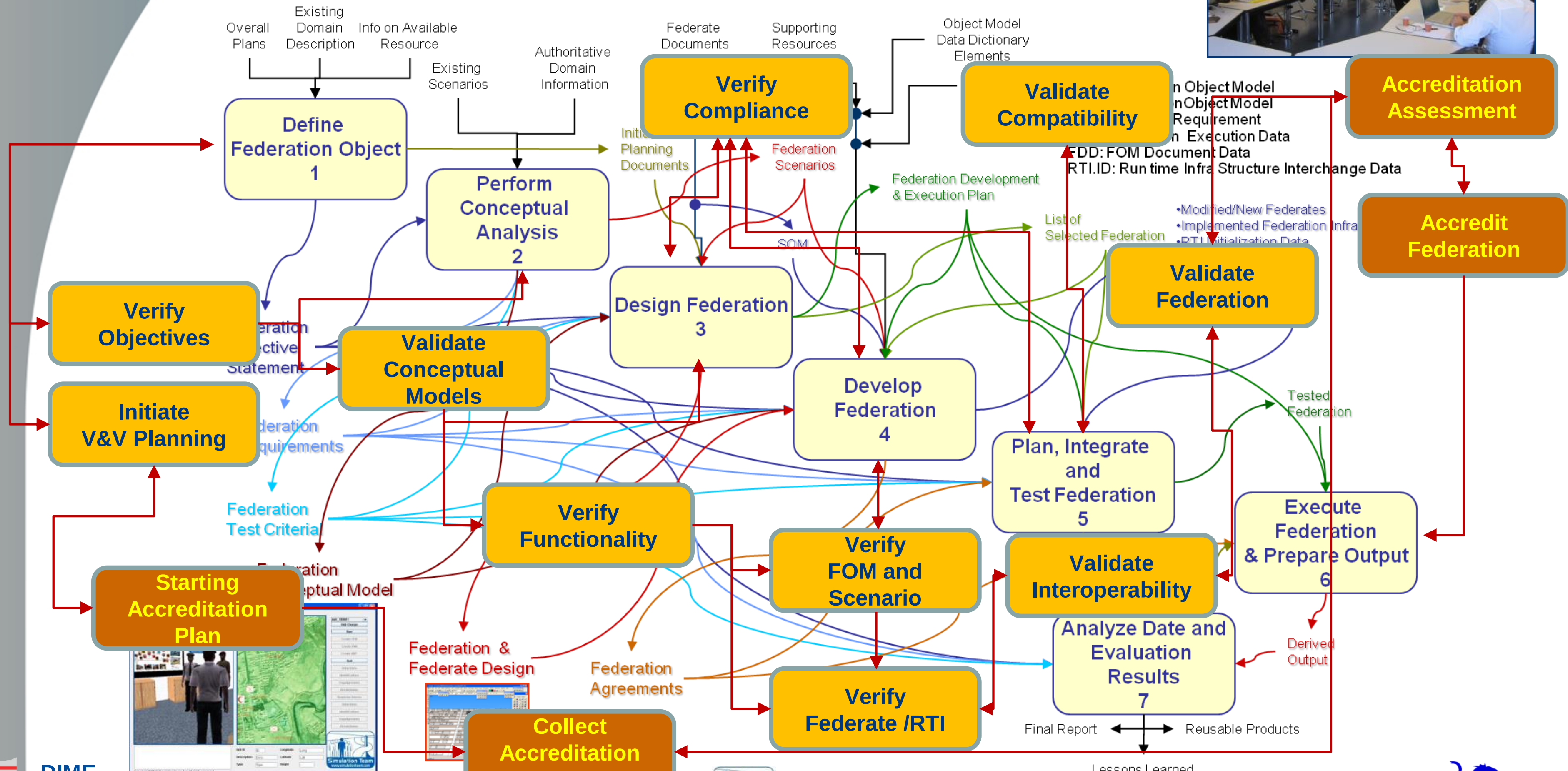
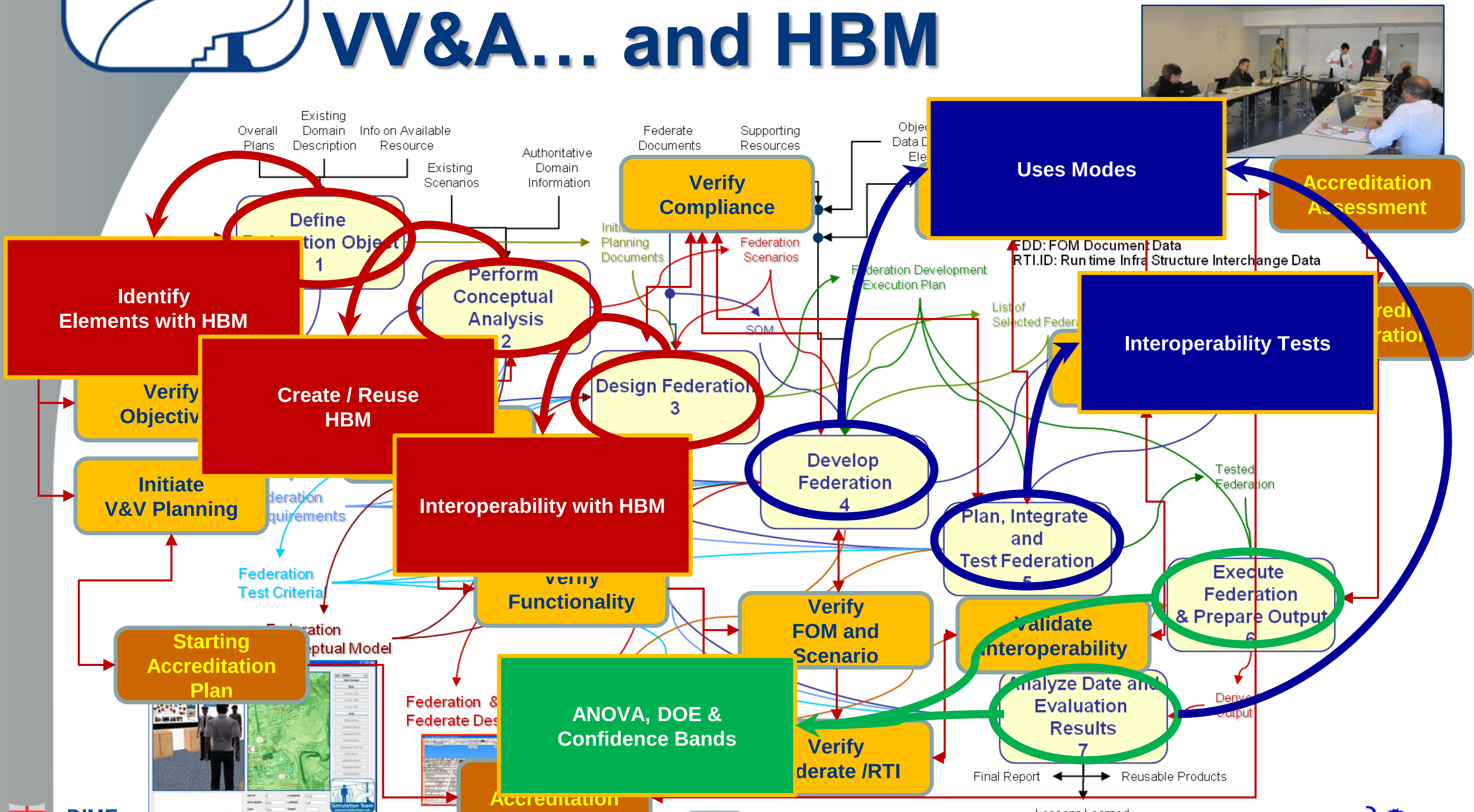
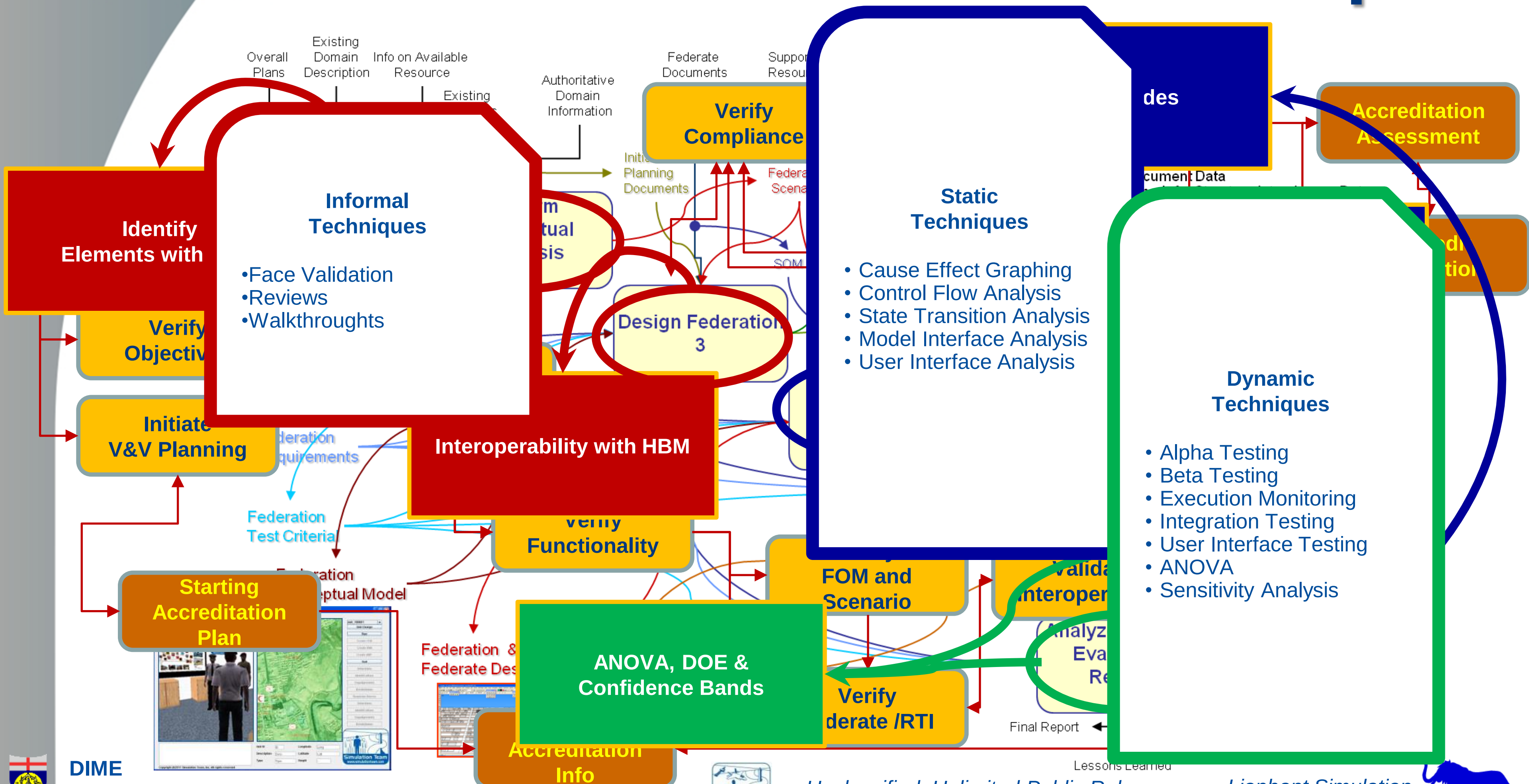
Simulation Development: VV&A…



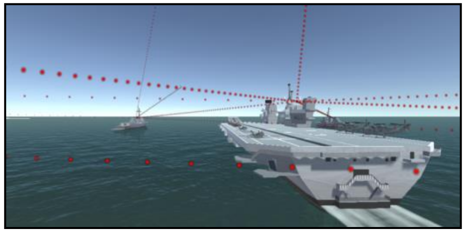
Simulation Development: VV&A… and HBM



Simulation Development: VV&A… and HBM & Techniques



GM-VV Structure



- The system of interest is organized into a hierarchical structure of sub-systems
- System components are defined to be the smallest parts of a system-of-interest the user wants to consider in the context of their own objectives
- A subsystem is considered to be a subset of components of a larger system
- The subsystem itself is a system on its own, which can subsequently be decomposed into subsystems as well

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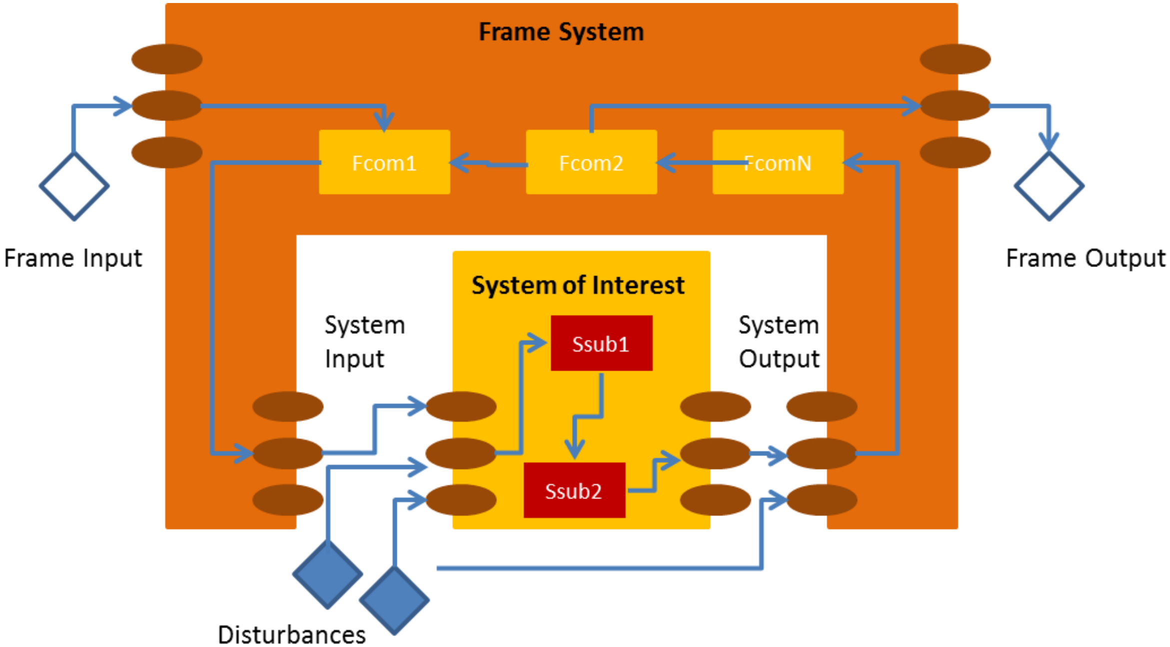
GM-VV Frame Structure

- Systems are used always within a certain operational context, frame system.
- A frame system is a formal specification of the operational use of a system-of-interest to meet its target objectives

- A frame system, or experimental frame, is a dynamic system in itself and is therefore formalized also in terms of a hierarchical decomposition of coupled and modular system components



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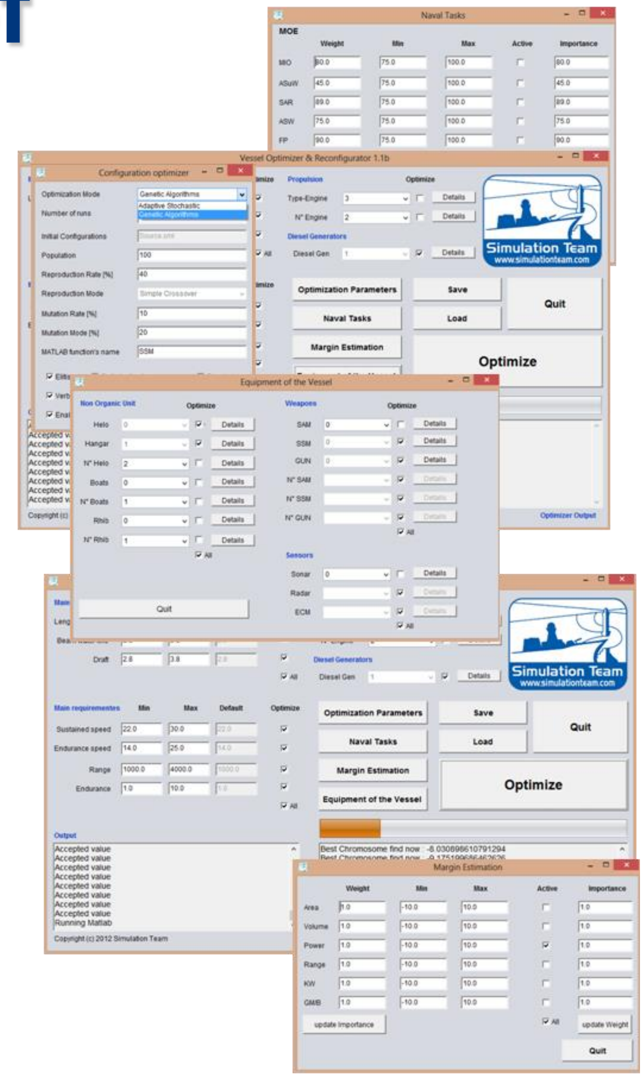
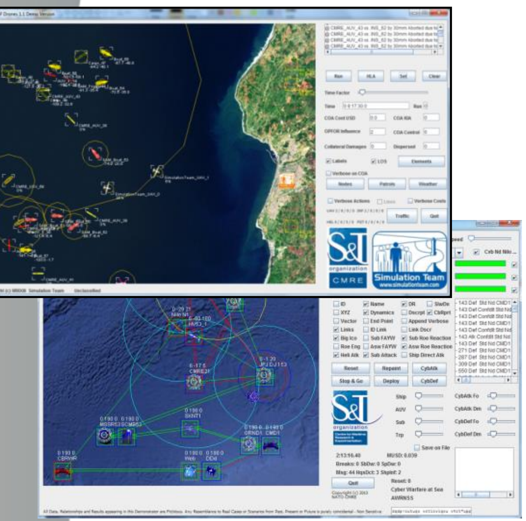
GM-VV Measure of Merits

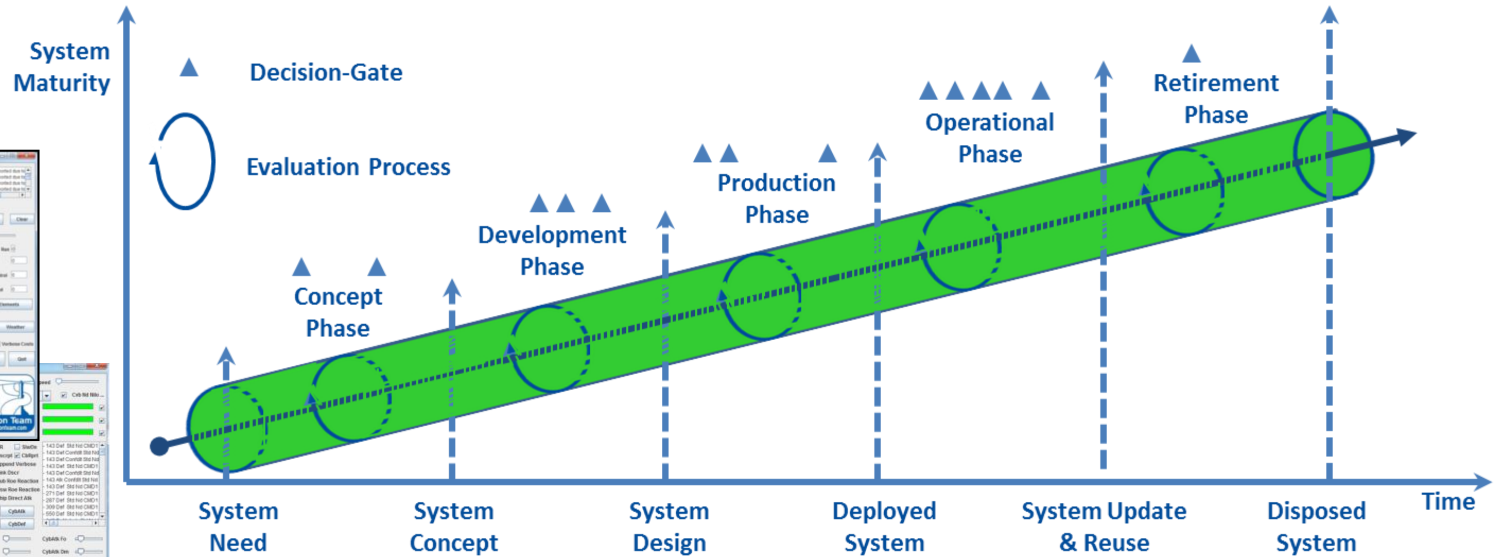
- The observed system output and the outcome measures could be utilized by the frame components for run-time assessment and feedback control of the system of interests
- Outcome measures could include **Measures of Efficiency, Effectiveness, Performance or Merit (e.g. MOE, MOP, MoM)**



GM-VV System Evolution

- The ***System of Interest evolves*** over time starting from defining the need for the system startup until its disposal. Such evolution consists of various phases in which the system maturity increases

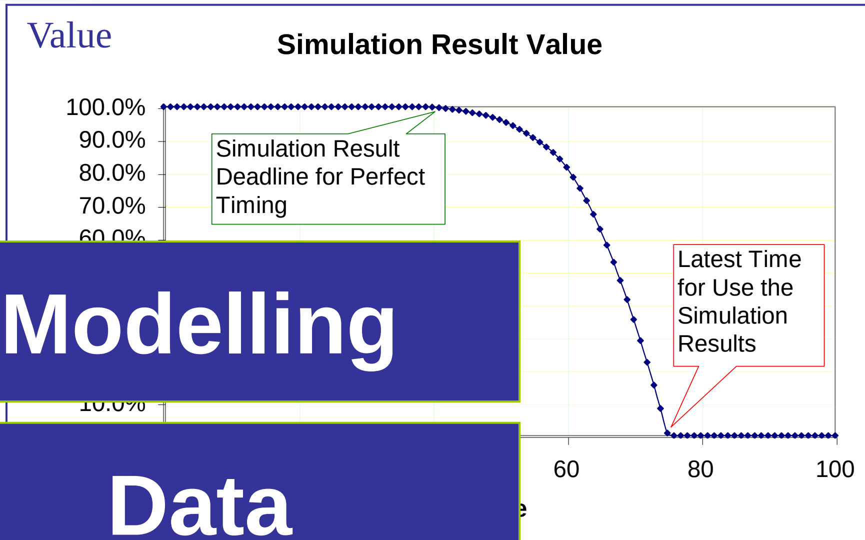


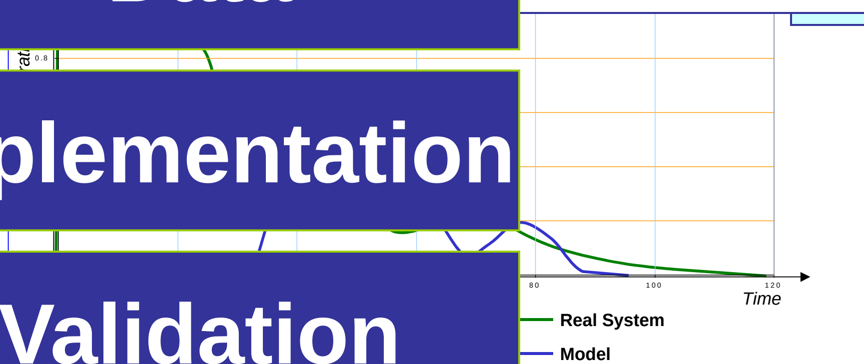


GM-VV System Evolution Phases

1. ***Concept Phase*** results in an agreed specification of the system concept that has the prospect of meeting the system-of-interest intended use
2. ***Development Phase*** allows to transform the system concept into a system design
3. ***Production Phase*** allows to produce the system in accordance the system design
4. ***Operation Phase*** include the deployment of the system and its put in operational service
5. ***Retirement Phase*** focuses on the timeframe when the system is taken out of service and any existing knowledge and experience gained with the system has to be consolidated in an archive

Simulator Development Needs





Modelling

Data

Implementation

Validation

Budget Planning Limitation

Length of Development Cycle

Communication during Development Cycle

Development Process

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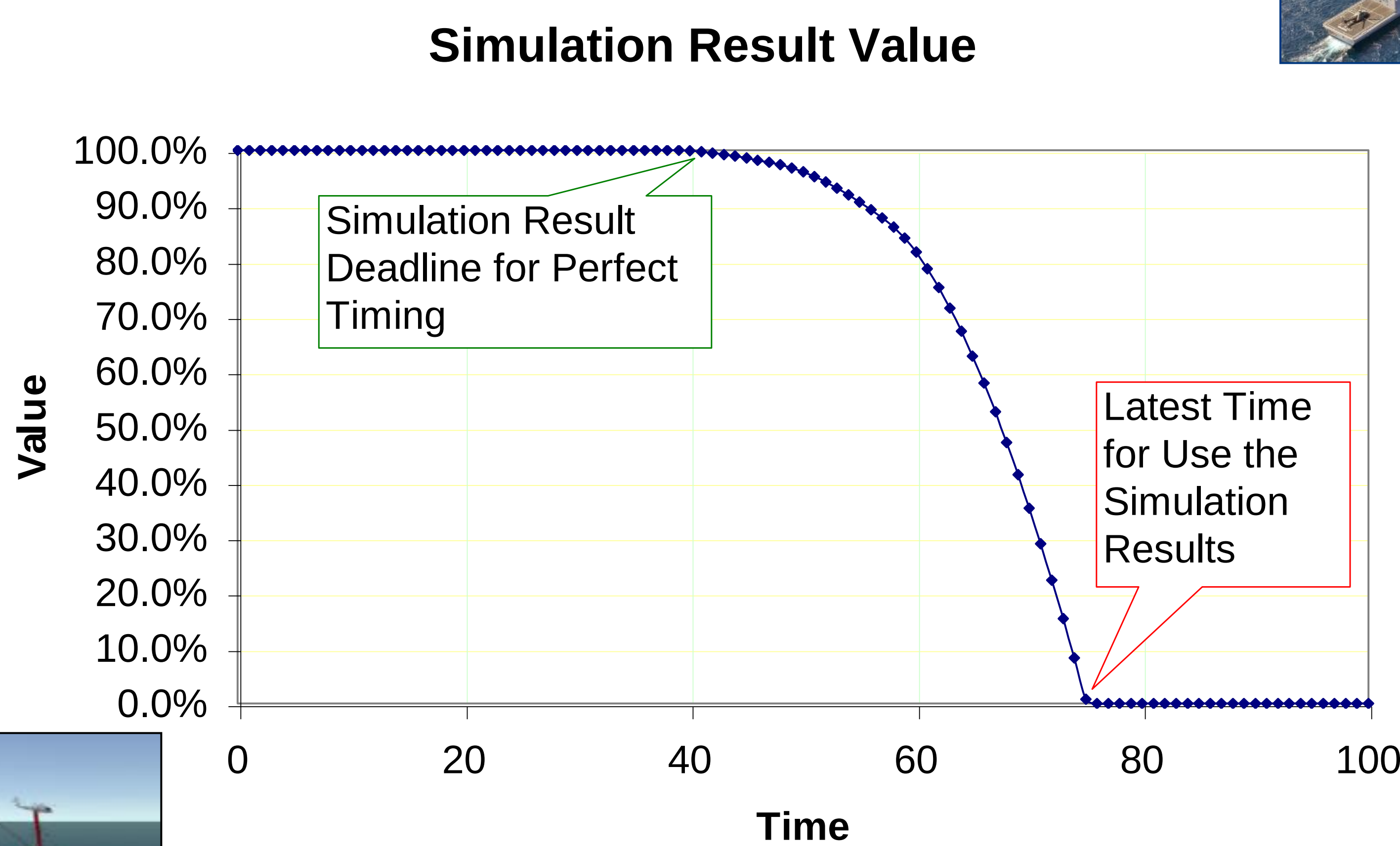
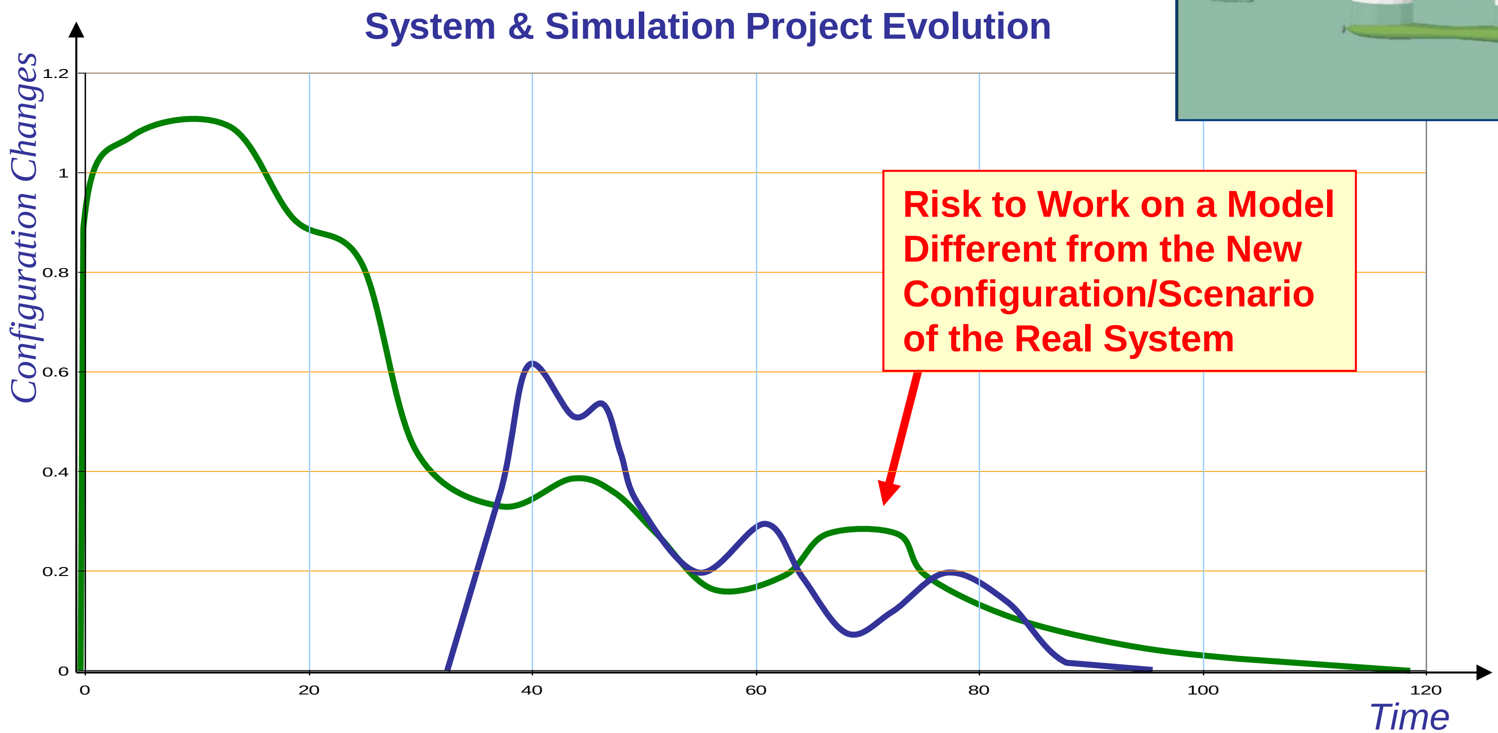
Just in Time on Simulator Deliverables



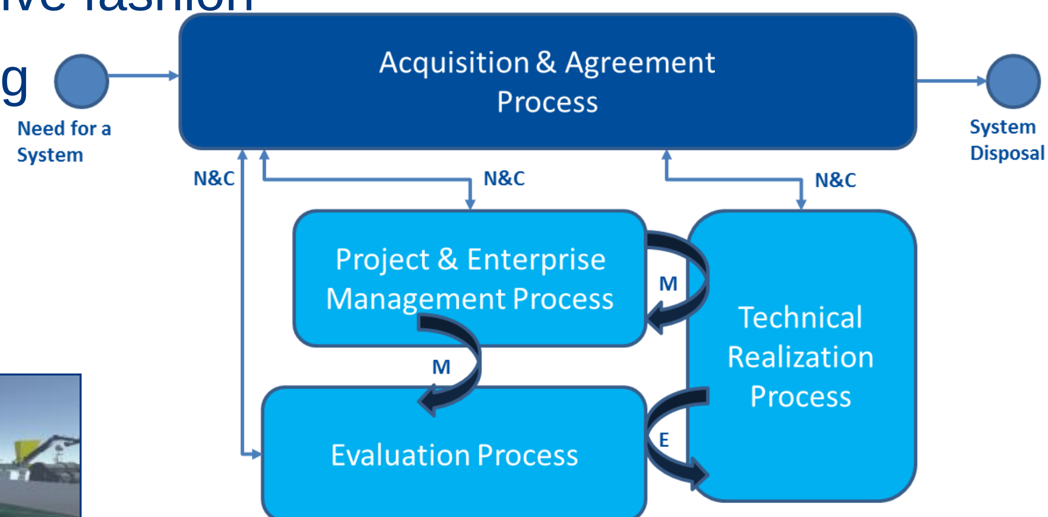
System Configuration Dynamics



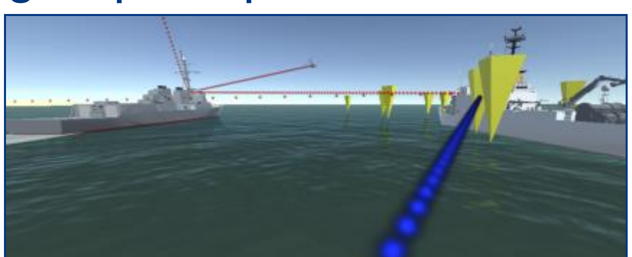
i.e. Human Behavior Analysis introduces Drastic Changes in the Model Infrastructure

GM-VV Life Cycle

- A system progression through its life-cycle is obtained through coupled activities that may be invoked at any time of a system life-cycle by an organization
- Activities are not necessarily sequential, but are often performed parallel and in an iterative fashion
- The system engineering process can be subdivided in four significant interrelated groups of processes



N&C Negotiation and Communications
E Evaluation Process Loop
M Management Process Loop



GM-VV Organization Design

- The ***ORDIT*** (Organizational Requirements Definition Tool) in our case, for organizational requirements modeling technique, is a methodology for requirements and design specification of organizations
- Organizations are considered as an agent entity which is any size of group from an individual to a whole organization that takes part in a socio-technical system
- An agent can have a structural relationship with other agents in the socio-technical system, which implies a communication link to exchange information
- Structural relationships embody responsibility relationships between agents

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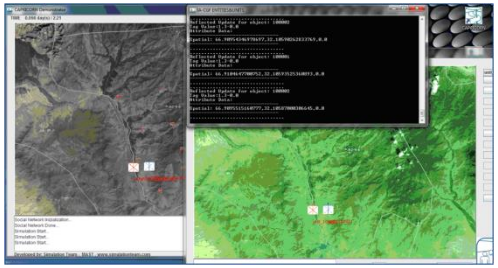
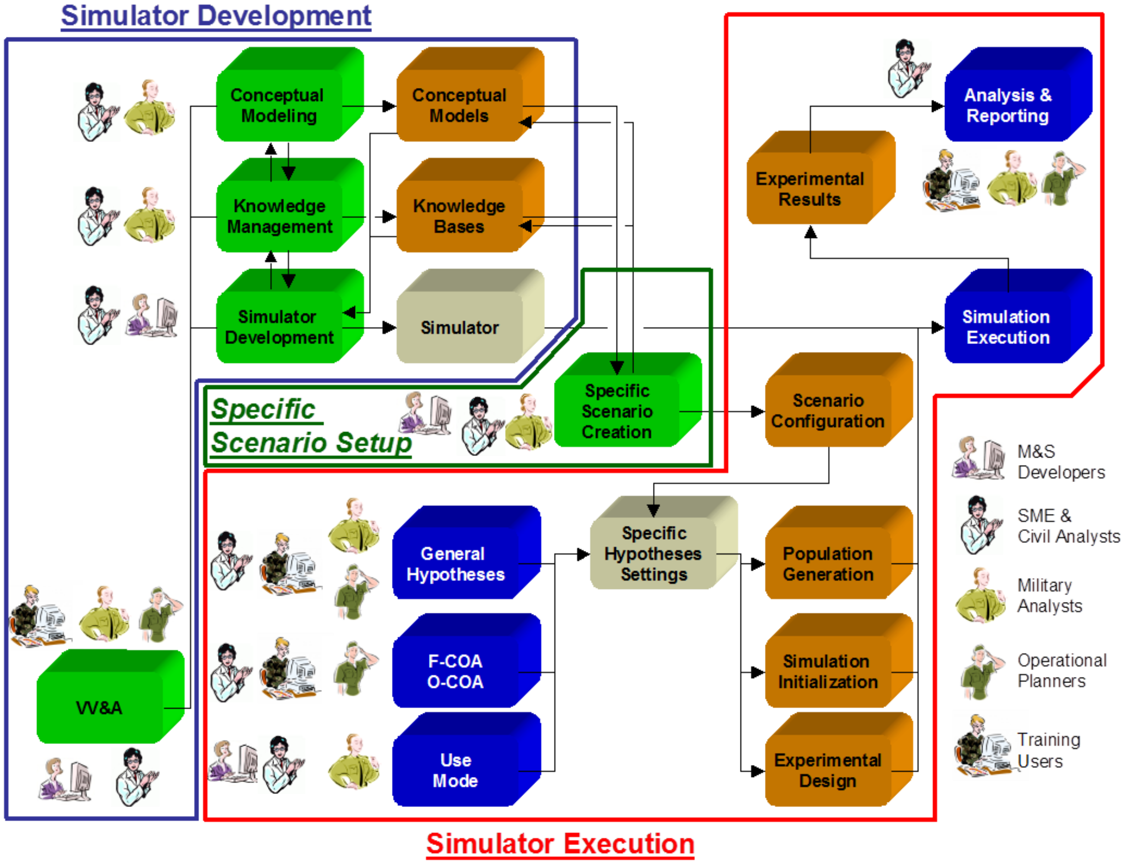
ORDIT & Responsibilities



Responsibilities are specified in ORDIT in terms of: who is responsible to whom, state of affairs for which responsibility is held, list of obligations of responsibility holder and type or responsibility. In here obligations define in what way the responsibility holder is responsible, and what must be done to fulfill this responsibility



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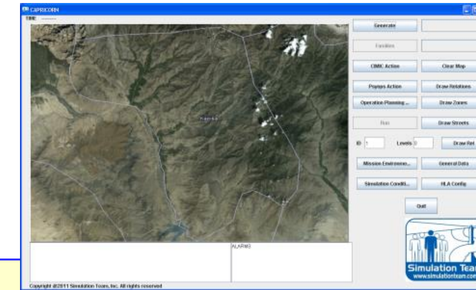
RAM



VV&A-Document	V&V Agent	M&S Developer	Sponsor	Accred. Agent
The V&V-acceptability criteria report	A	U	R	A
The accreditation plan	U		U	R
The V&V-plan	R	A	U	U
The V&V-report	R	A	U	U
The acceptability assessment-report	A			R
The accreditation report	A			R

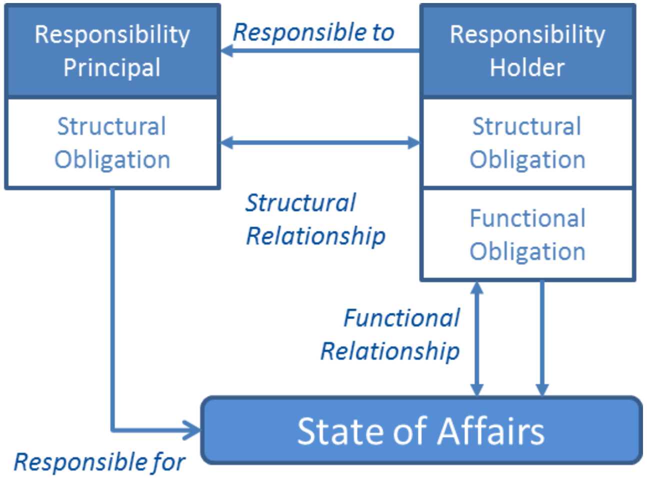
RAM Responsibility Assignment Matrix

A=assist
P=perform
U=use
R=responsible

The Responsibilities of the 4 actor types in context with the generation of the essential VV&A documents are shown in the table.

GM-VV Responsibility Management

- The ORDIT responsibility relationship provides the opportunity to delegate responsibilities by means of transferring obligations from one agent to another agent. When an agent transfers obligations to another agent he retains his initial responsibility for ensuing the state of affairs. This agent becomes a principle for this responsibility



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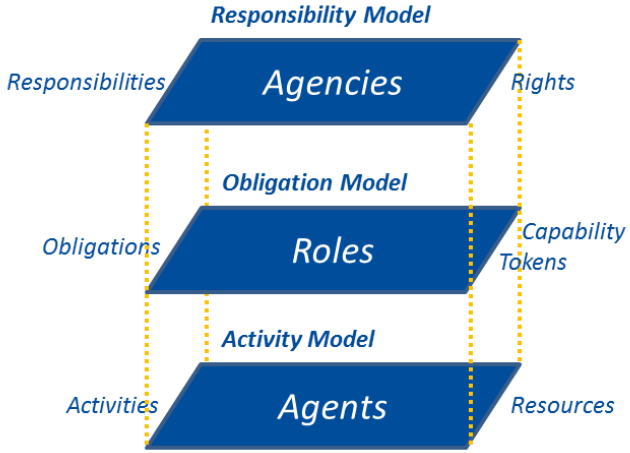
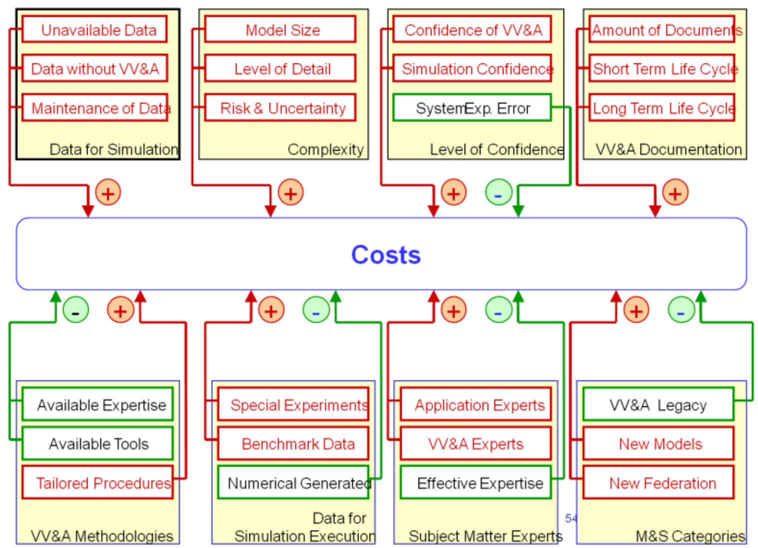
GM-VV Agency

- ***Agencies*** are specification of agents in terms of responsibilities and rights. Rights are the permissions or authorizations required to fulfill the agencies' responsibilities. Roles are specifications of agents in terms of obligations that they hold and capability tokens. Capability tokens specify the required access to resources in order to discharge the roles obligations. Resources specify the means for an agent needed to execute the activities. Rights capabilities tokens and resources thus specify organizational requirements to fulfill responsibilities



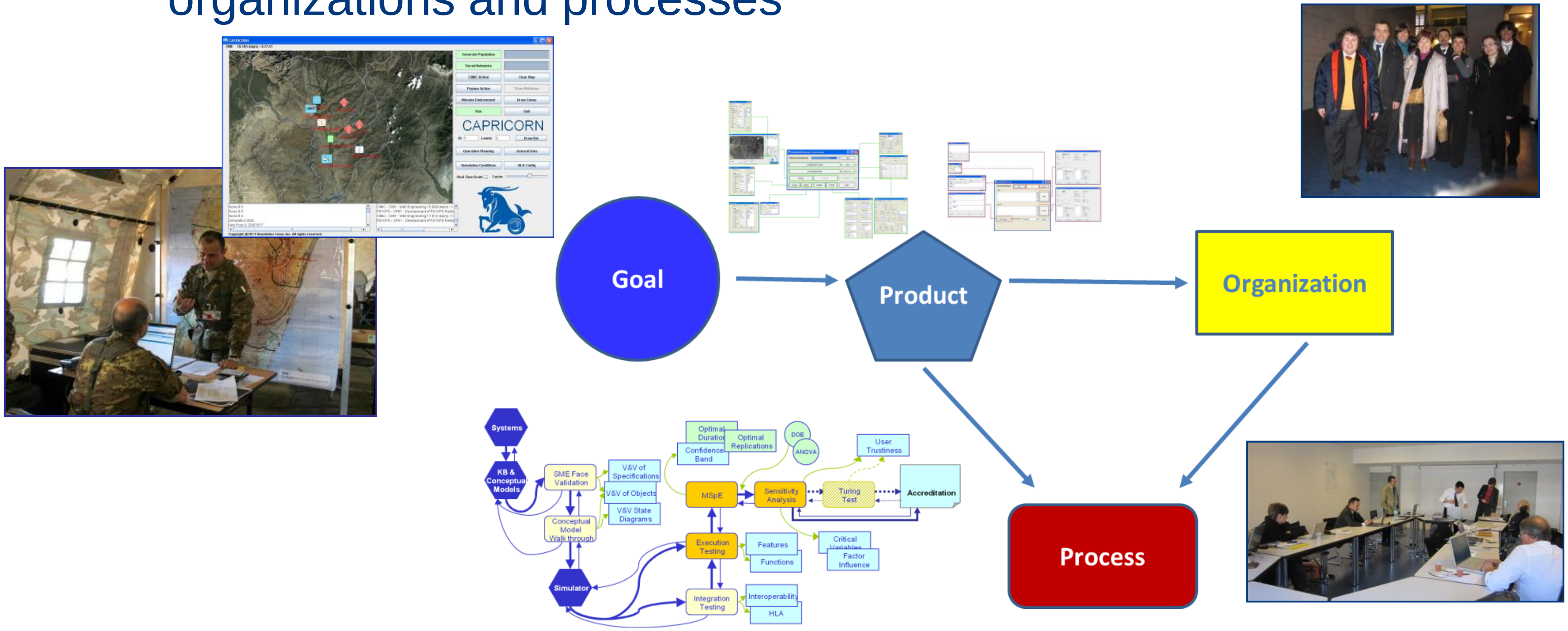
GM-VV Configuration Management

- VV&A of M&S is an iterative process within a M&S system life-cycle. In particular the reuse of M&S systems. ***Configuration Management*** of the VV&A products produced in this process is essential for a cost effective implementation of VV&A



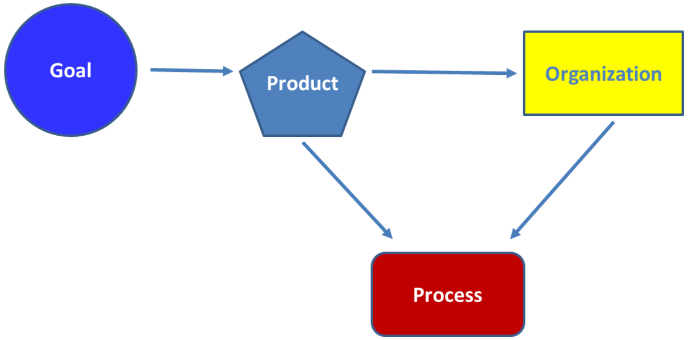
GM-VV Three Pillars Paradigm

- The ***Three Pillars Paradigm*** is the important and virtual concept of GM-VV. The three pillars paradigm address the theory and standards based on goal-driven project and quality management, organizations and processes



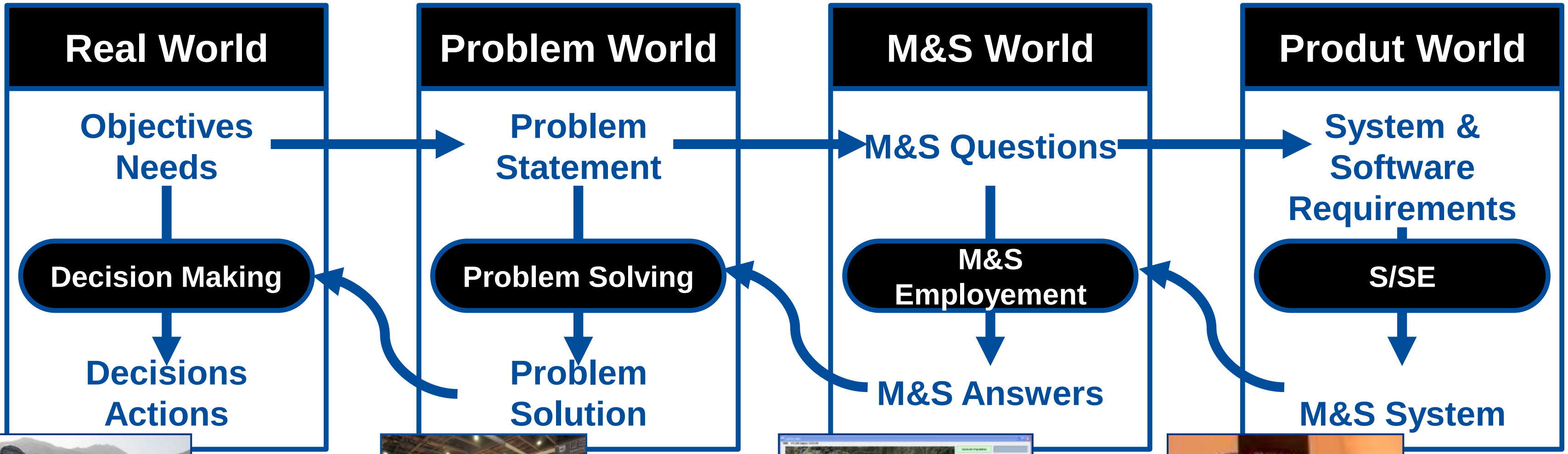
GM-VV Pillars

- The paradigm addresses three different interrelated components, called pillars:
  - Product pillar contains one or more products that have to fulfill one or more goals in a target environment in which they will be employed. Products can have a life-cycle
  - Organizational pillar contains a social system of one or more agents (i.e. agencies and roles)
  - Process pillar contains one or more processes. A process is defined as a set of interrelated and interacting activities which transform inputs into outputs



GM-VV Frames

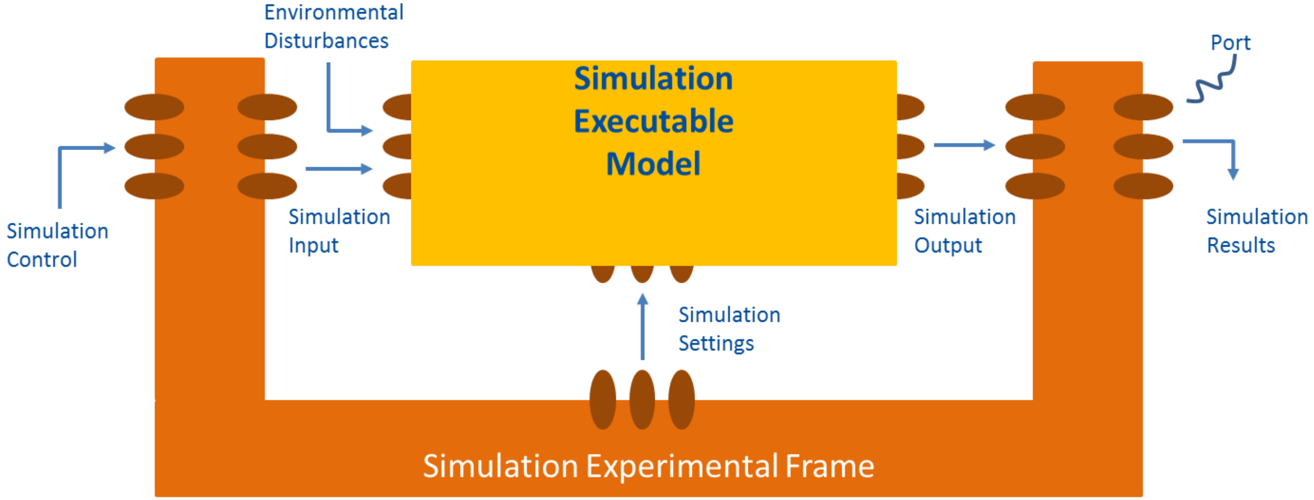
- There are four world view inside GM-VV that represents the concept of ***Problem Frame***. A problem frame is defined as a description of a recognizable class of problems which has a known solution. Problem frames provide a means to structure the world in which a problem is located and has to be solved

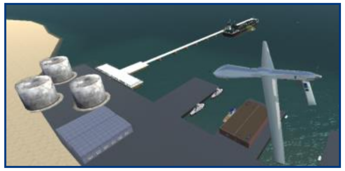





GM-VV SEM-SEF

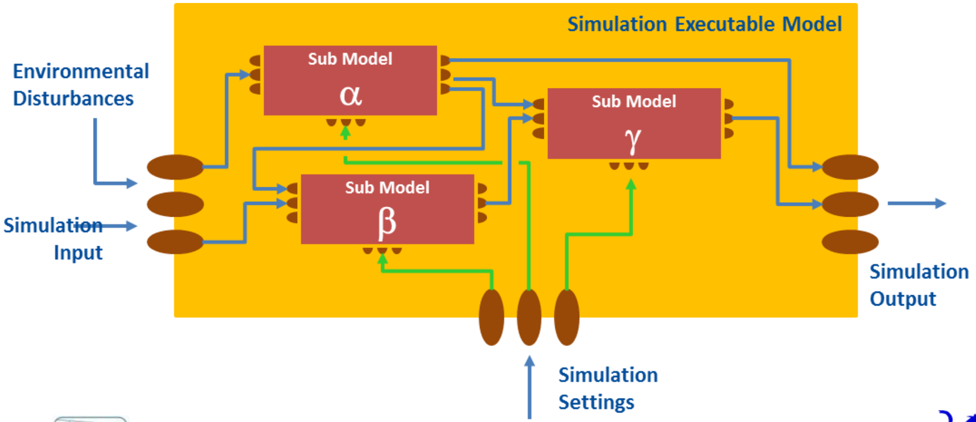
- Within GM-VV there are two distinct models: the ***Simulation Executable Model*** (***SEM***) and the **Simulation Experimental Frame** (***SEF***). These together are referred within GM-VV as the *M&S system*. This M&S system is considered in GM-VV to be a system that is the outcome of a system's life-cycle production phase. The SEM is the M&S development outcome that enables the actual replication of the ***simuland*** over time





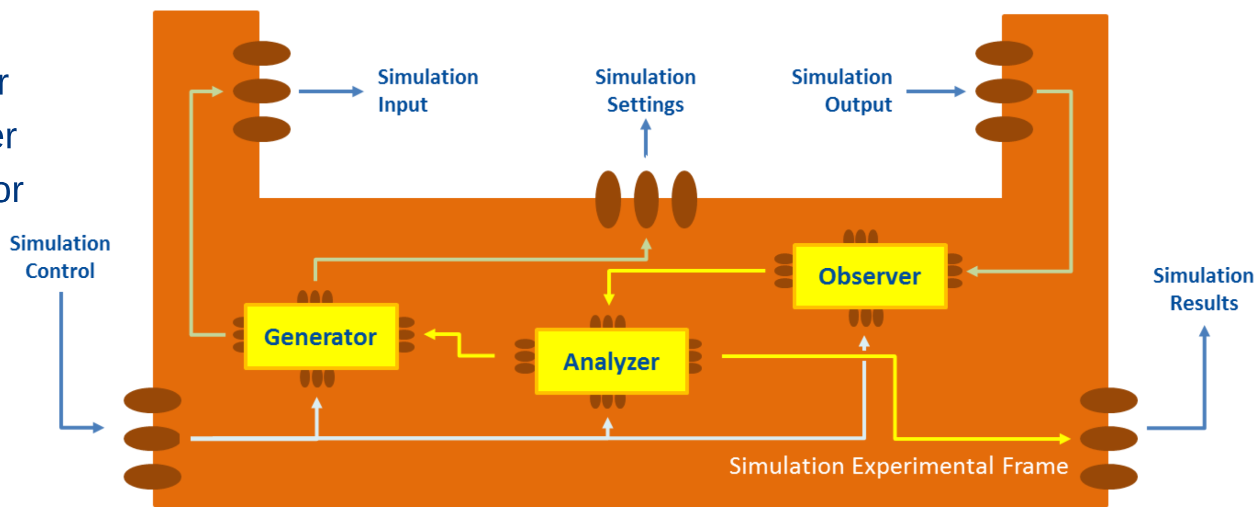
GM-VV
Simulation Executable Model

- The **SEM** is a complex dynamic system, which is composed of a set of coupled (sub) systems (federates, terrain model, weather model, visual system, motion system, etc.).
- A **SEM** is controlled and observed by ports (gray ovals). Through these ports simulation input and settings are entered, and simulation output leaving the **SEM** is observed
- The whole internal behavioral space of a **SEM** may not be controllable or observable or both. This poses certain limitations on VV&A endeavor



GM-VV
Simulation Experimental Frame

- To be able to simulate the real-world properlies, the SEM is configured, controlled and stimulated by the simulation experimental frame (**SEF**) in terms of input trajectories, scenario’s, parameters, experimental control settings, etc. As such the **SEF** is the operational implementation of the M&S intended use.
- In a **SEF** three possible interconnected components have been identified:
  - the observer
  - The analyzer
  - the generator

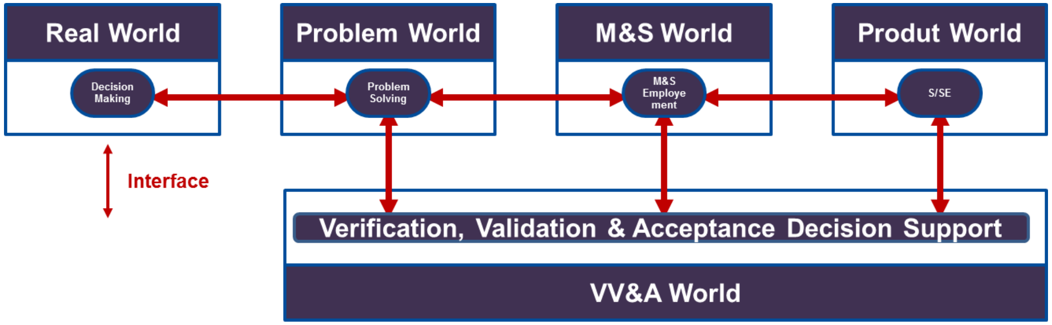


GM-VV Components

- The ***Observer*** watches, within the SEF, the SEM simulation output and preprocesses it before to send it to the Analyzer.
- This second object, the ***Analyzer***, is the core of the SEF and is responsible for analyzing the preprocessed simulation output and transforming it into the required simulation results. Depending on the M&S intended use at hand, this transformation could be directly derived from a single simulation output trajectory or from multiple trajectories coming from different SEM runs. It is the analyzer object who decides on whether the user goals have been accomplished
- The ***Generator*** object stimulates the SEM with both simulation settings and input trajectories, based upon the output of the analyzer object

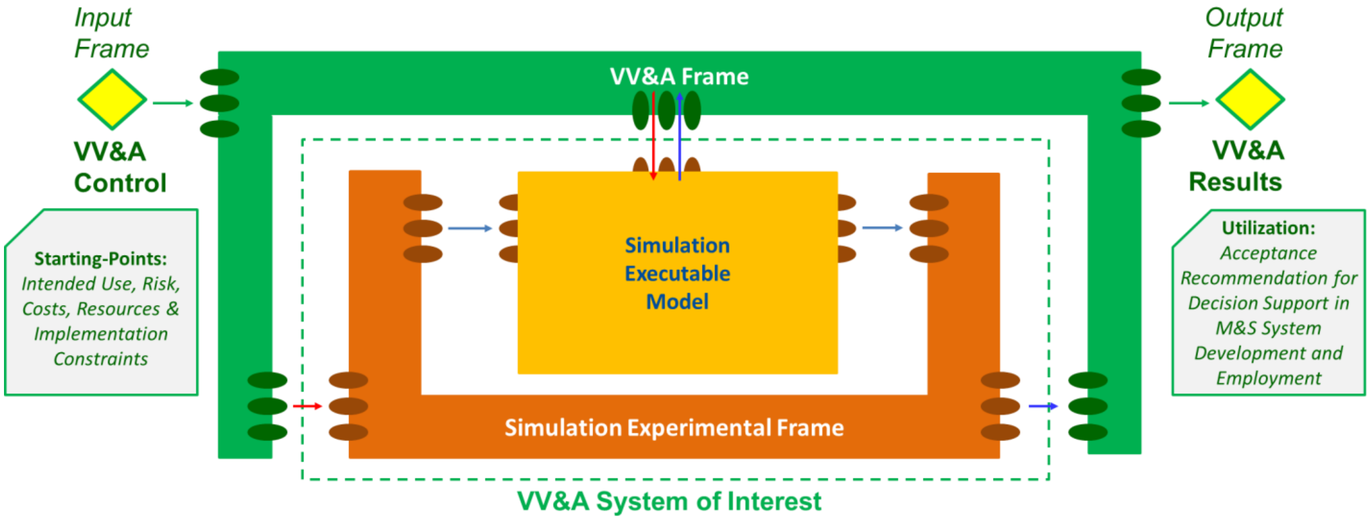
GM-VV VV&A World

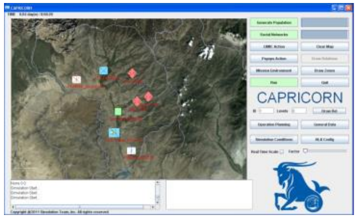
- GM-VV considers **VV&A** of M&S as a separate problem frame or world with its own specific problems, issues and concerns though related with the M&S based problem solving approach,
- The objective of this **VV&A** world is the to provide the M&S system users and other stakeholders in the problem world a well-informed or well-argued acceptance recommendation to support their acceptance decision process needs regarding an M&S system in any phase of its life-cycle
- A **VV&A** stakeholder is an agent that will use the **VV&A** problem world outcome, being the acceptance recommendation, in the acceptance decision procedure to support decisions in the area of M&S system development, actual M&S employment and its results.



GM-VV VV&A Intended Use

- **VV&A intended use,** defines from the VV&A problem owner perspective, the usage of this acceptance recommendation and determines at which level the VV&A endeavor must be performed
- Depending on the VV&A intended use, the VV&A system of interest could be the simulation executable model, the simulation experimental frame, the M&S results, or any part(s) or combination(s)





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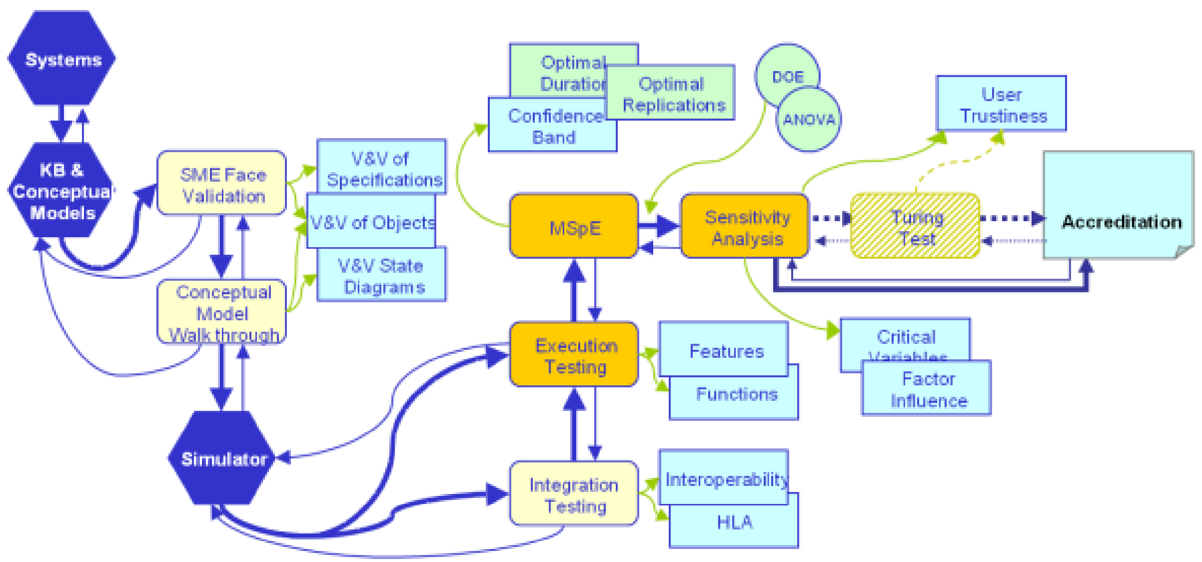
GM-VV VV&A Frames

- The **VV&A Frame** *Design* and its *Execution,* by means of a well defined and controlled set of VV&A experiments, depend not only on the VV&A intended use, but on M&S intended use, use risk, cost, available human resources, M&S requirements and implementation constraints.
- The outputs of the frame are VV&A results that are used for building an appropriate acceptance recommendation



GM-VV Acceptability Criteria

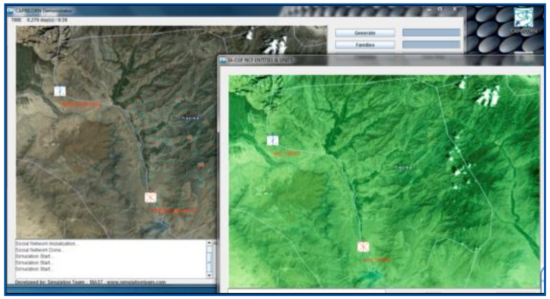
- The **Acceptability Criteria** are defined upon the VV&A observables
- Four types of acceptability criteria are defined as properties in GM-VV:

Utility: Assesses the effectiveness and efficiency of the M&S system in solving the problem statement in the problem world. Evaluation metrics for utility comprise three areas: value or benefits (measures of effectiveness, measures of performance, etc.), costs (money, time, etc.) and use risks (impact, probability, etc.)

Validity: Assesses the level of agreement of the M&S system behavioral representation with that of the simuland. Validity metrics are also used to assess the consequences of any behavioral discrepancies on the utility of the M&S system

Correctness**:** Assesses whether the M&S system implementation conforms to the conceptual model, is free of error and of sufficient precision. Correctness metrics are also used to assess the consequences of implementation discrepancies on both the validity and utility of the M&S system

Meta-properties: Assesses the quality with which the utility, validity and correctness properties of a M&S system have been assessed. Among other meta-properties address aspects like balance, uncertainty, completeness, consistency, relevance, independency, reliability, and assumptions.



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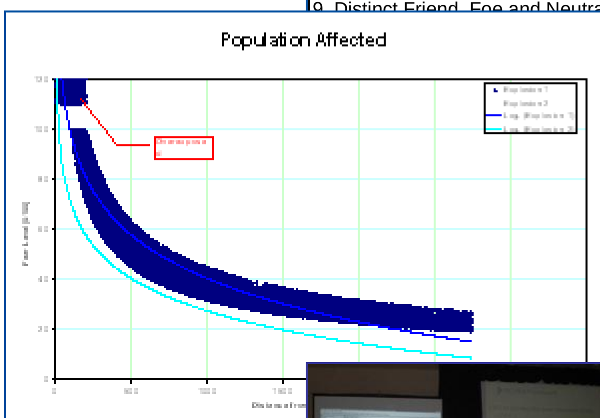
Criteria & Features

Feature/Objective	Present	Example and Note
1. User-Defined Initializing Parameters	YES	The user defined the profile of the Gang as well as the ROE to be used by Blue Units
2. Analyze Surrounding Envinronment and React Respectively Capability	YES	The Blue Units encountering the Riot and the Gang takes actions to stop the looting
3. Cooperation Capacity	YES	Some Blue unit are providing support on others reaching the demonstration/riot
4. Force Aggregating/Disaggregating Capability and relevant military hierarchy	YES	Disaggregation of Blue unit in two Squads after dissolution of the Riot
5. Resultant Aggregation Levels different from aggregating/disaggregating elements sum/subtraction	YES	The combination of Demonstration and Gang looting create impact on the area different from the sum of the single entities and introduces the generation of a riot
6. Limit Proper Autonomy to Achieve Common Objective Capability	YES	It is possible to enable/disable the possibility for the Blue Unit to request direct support to the other ones and to let the scenario evolve with this other condition
7. Stress Level Indicator applicable for the entities behavior definition	YES	These aspects affect both Population and Military Units all along the simulation
8. Implementation of Typical Human Behavior (survival instinct and moral/ethical motivations)	YES	It is possible to enable/disable the feature and check, versus critical riots, the different respect of ROE by Military Units
9. Distinct Friend, Foe and Neutral Units	YES	Distinction betweeen Gang and Militia
Behavior	YES	Each entity provides a Log including the conditions under what each different ROE applied
nmanders Capability	YES	Reporting that includes encounters with other units, Riots and situation evolution
	YES	Each entity provides a Log related to the factors affecting their actions
	YES	Blue Unit moving among cells of an ethnic group affects the population evolution and the eventual creation of a Riot
	YES	A single entity is representing the agitators that change the attitude of the demontration/riot
	YES	The militia unit is corresponding to a team
	YES	The Blue Unit in patrol corresponds to a Squad
	YES	The Blue Unit providing support corresponds to a Platoon
	YES	Reports about actions and events are distributed as interaction in the HLA Federation during Simulation Runs

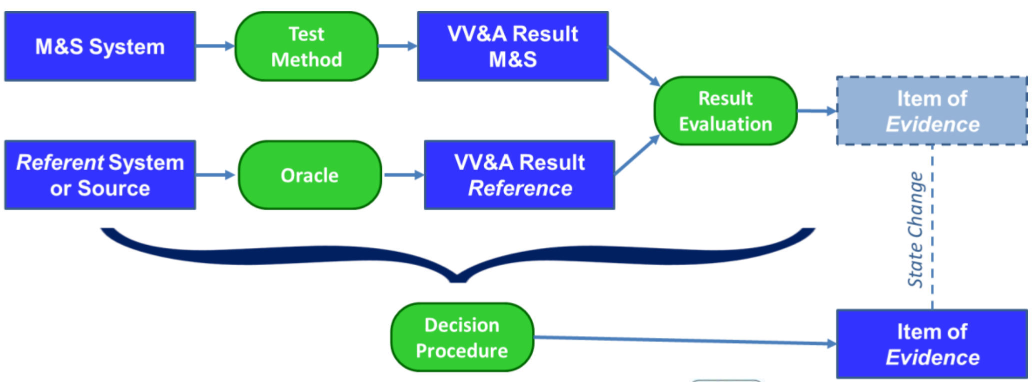


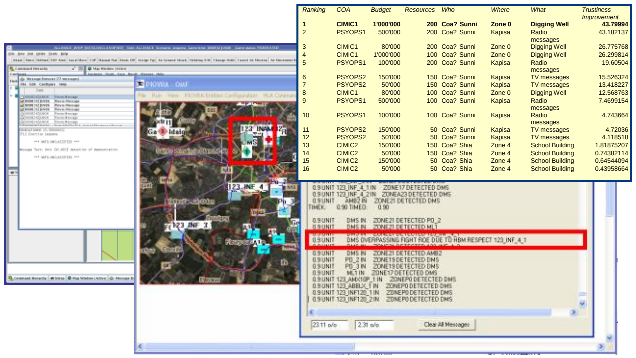
Example of Testing the Features of IA

It is critical to guarantee proper VV for models especially with presence of HBM and Interoperability Issues

GM-VV Evidence Generation Process: Collecting Evidences

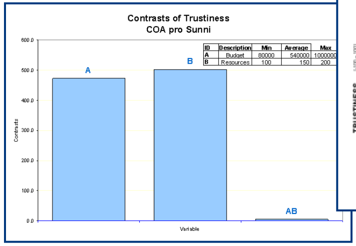
- For a proper demonstration of acceptability criteria, GM-VV should adopts an **Evidence based Approach**. This approach consists of two steps.
- The ***first step is collecting relevant evidence*** for the VV&A system of interest observables related to the utility, validity, correctness and meta-properties by execution of VV&A experiments. Such a VV&A frame is union sub-frames, which are called evidence solutions at the most atomic subsystem level.
- An ***Oracle is the mechanism to generate the expected VV&A results*** from a local referent system or source. This type of VV&A results provides a set of reference data for the M&S system, to evaluate each property. Such data set is also commonly known as the VV&A referent. This results evaluation comprises a comparative analysis of the actual results with the expected results, which gives a qualification or quantification how well both match

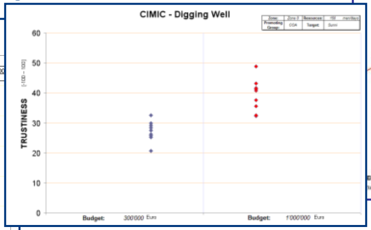


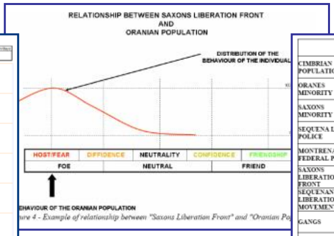


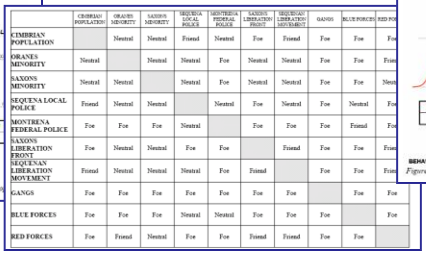
GM-VV Evidence Generation Process: Using Evidences

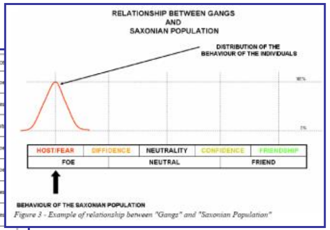
- The ***Usage of the Evidence in a semi-formal reasoning to develop an argument***(s) to justify the proposition or claim that a M&S system is acceptable or not is the second step. The resulting claim based argumentation network is known in GM-VV as the VV&A claim network. In this kind of reasoning also the quality of and the support by the collected data for utility, validity and correctness properties must be taken into account by assessment of their associated meta-property criteria
- Together with the VV&A intended use and VV&A goal network, this VV&A claim network provides the basis within GM-VV from which a well-informed and justified acceptance recommendation for the M&S system is developed. This acceptance recommendation is a VV&A problem owner oriented presentation of the VV&A claim network and all other relevant VV&A project information, which together comprise all needed information for adequate acceptance decision making on the M&S system and its deployment.





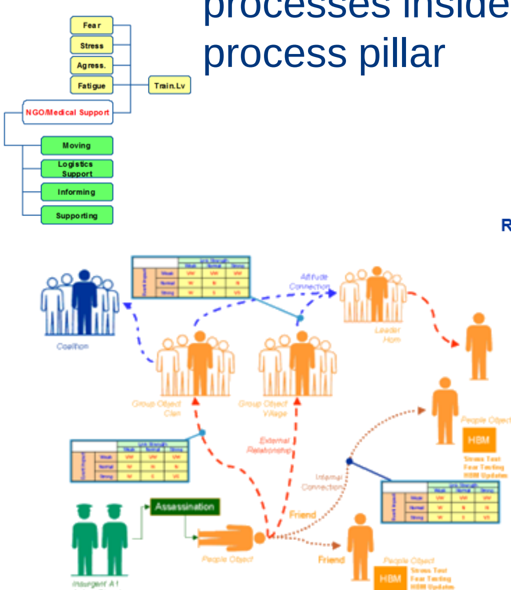


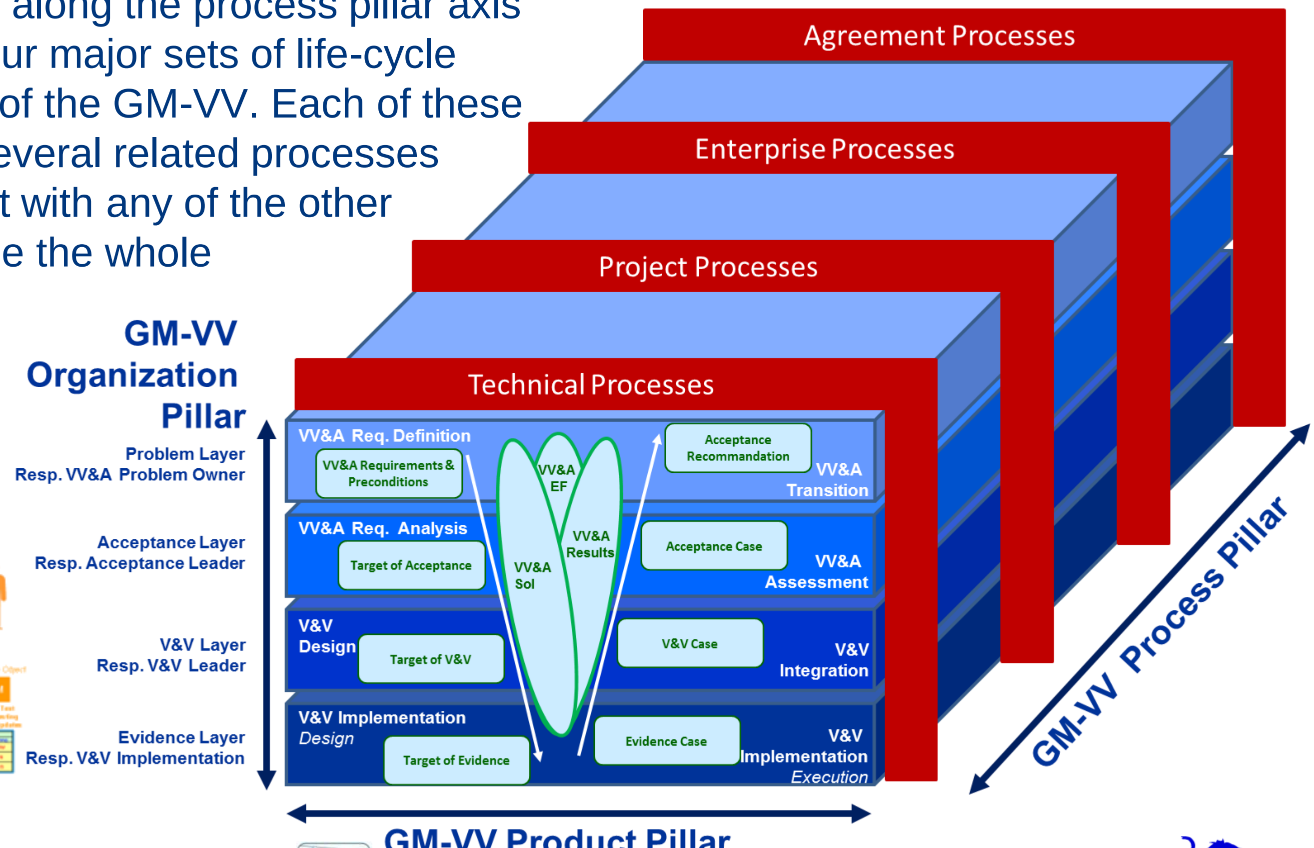




GM-VV Matrix View

- Matrix View is A layered view adopted to further structure the GM-VV Three Pillar to design and to facilitate the actual deployment of the methodology
- The purple tabs along the process pillar axis resemble the four major sets of life-cycle processes part of the GM-VV. Each of these sets contains several related processes that can interact with any of the other processes inside the whole process pillar





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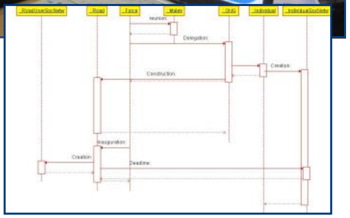
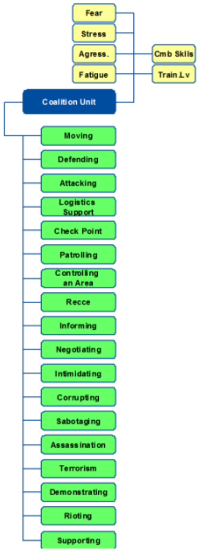
GM-VV Matrix Processes



The GM-VV life-cycle processes consist are structured as following:

- *Agreement Processes*: comprises of two processes needed to establish a (sub)contractual agreement between a VV&A acquirer and supplier agency:
  - Acquisition Process
  - Supply Process
- *Enterprise Processes*: comprises of five process needed to establish and maintain an enterprise or service-oriented environment within any VV&A agency:
  - Life Cycle Mngt. Process
  - Infrastructure Mngt. Process
  - Project Portfolio Mngt. Process
  - Human Resource Mngt. Process
  - Quality Management Process
- *Project Processes*: comprises of seven processes needed to establish and maintain a VV&A project environment in which the technical processes are conducted
  - Project planning process
  - Project assessment and control process
  - Decision management process
  - Risk management process
  - Configuration management process
  - Information management process
  - Measurement process
- *Technical Processes*: comprises seven processes needed to do the actual technical work in order to produce or employ the required VV&A deliverables
  - VV&A requirements definition process
  - VV&A requirements analysis process
  - VV design process
  - VV implementation process
  - VV integration process
  - Acceptance assessment process
  - VV&A transition process



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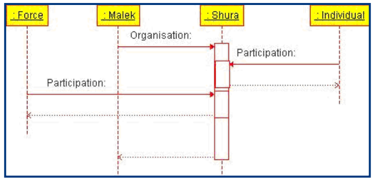
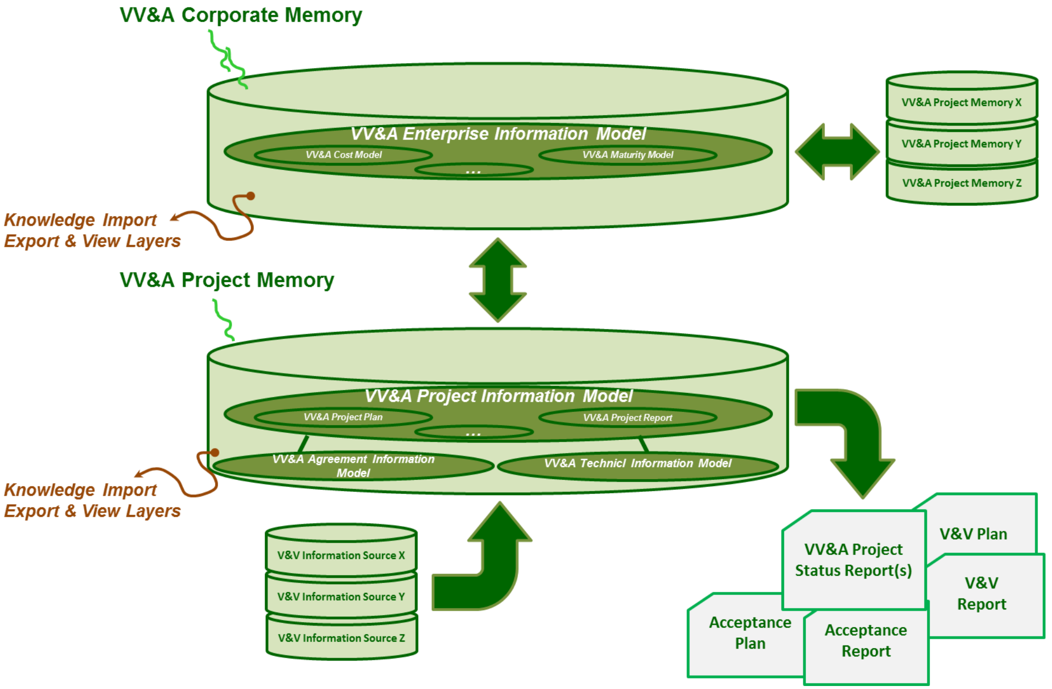
GM-VV Memory View

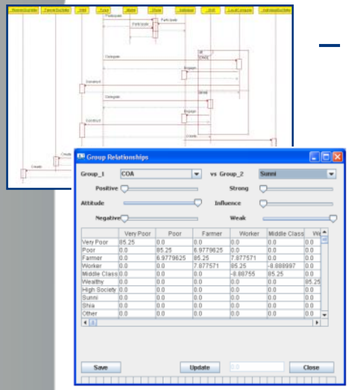


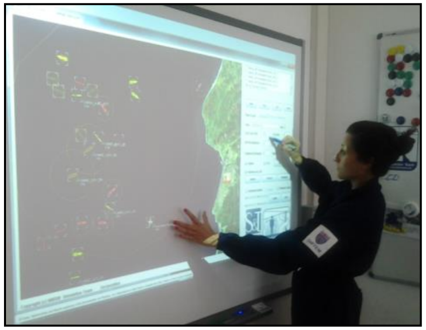
- During VV&A projects a large amount of data and information needs to be processed and managed. This management and processing is a complex and time consuming task that is hard to be done by hand. Therefore, practical and cost-effective implementations of a rigorous and systematic VV&A methodology requires the availability of automated tools for information, knowledge, and configuration management.
- GM-VV specifies as an integral part of its methodology two VV&A enabling components; the VV&A corporate and project memory enabling components embody the pragmatic implementation of the VV&A information and knowledge management, and VV&A product configuration management in both project and enterprise environment modes.



GM-VV Enterprise & Project Information Models

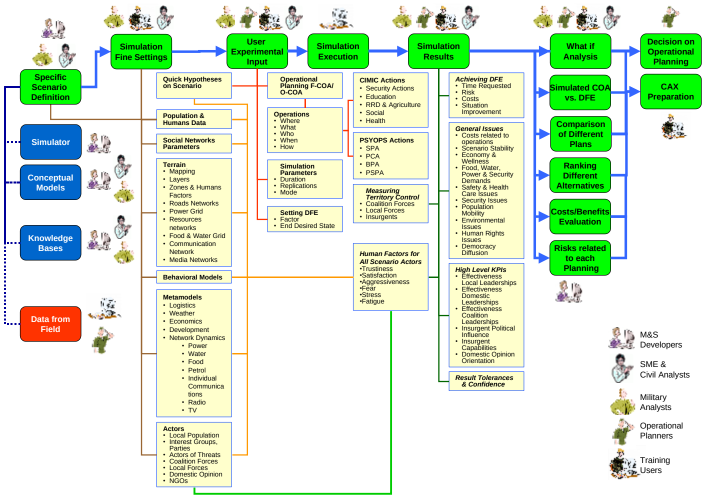
- The VV&A information models must facilitate both projects and enterprise environments, therefore two sets of interconnected information sub models are required:
  - ***VV&A Enterprise Information Model***: shall specify and consolidate all enterprise management related information that is used to facilitate the execution of VV&A projects by a VV&A supplier agency. Among other things the core and VV&A specific subsystems of this information model are a VV&A cost model and a VV&A maturity model.
  - ***VV&A Project Information Model***: shall specify and consolidate all project management related information that has to be produced and managed during the execution of a VV&A project. Among other things the core and VV&A specific subsystems of this information model are a VV&A project plan and project report. Furthermore, the VV&A project information model aggregates two other important sub-models: the VV&A agreement information model and VV&A technical information model. The VV&A agreement information model contains the VV&A contract and other contractual agreement information for the VV&A project. The VV&A technical information model specifies all technical information that will be developed during the execution of a VV&A project.





Conclusions

- GM-VV represents a methodology proposing process, guidelines, criteria and a common vocabulary for supporting acceptability of models, simulations
- GM-VV refers to System Engineering Standards to guarantee the widest generic approach to be applied to M&S Products
- GM-VV embraces among the others the VV&A processes



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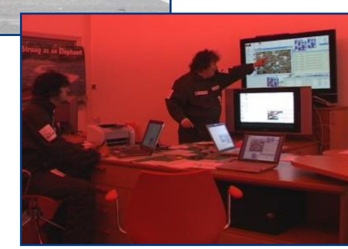

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