# INCREASING M&S V&V EFFICIENCY WITH THE PROCESS MANAGEMENT TOOL VDOT™

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## ABSTRACT

To succeed in improving the efficiency of any team in the Verification and Validation (V&V) and Accreditation (VV&A) process, you must first capture the processes employed to a sufficient level of detail to understand the flow of information or deliverables required to produce your end product/s. To do this, most planning facilitators gather a group of subject matter experts together to create a process diagram or value stream map. At NASA's Marshall Space Flight Center (and including the Michoud Assembly Facility) a new tool is being utilized which combines the benefits of both PowerPoint and Visio V&V process planning diagrams and the Gantt and PERT scheduling attributes. It is called Vdot (coined after the first derivative of velocity, or acceleration) and is a COTS software product.

This tool has the attribute that it logs the time a task is ready to start and when it is completed, and maps the task process flows in hierarchal, nested maps. Since the tool actually links the work needing to be performed to the manager who needs real time information on task process status (and thus rolling up the overall project status) it gives a unique opportunity to increase the efficiency of the VV&A process. This paper discusses the Vdot tool and its ability to efficiently support V&V and VV&A processes. Specifically, the DoD VV&A process and the Air Force Operational Test and Evaluation Center (AFOTEC) Accreditation process are mapped into Vdot templates for review.

## INTRODUCTION

VV&A is the multi-disciplinary process of demonstrating credibility in simulation results. Credibility is built by collecting evidence that (1) the numerical model is being solved correctly and (2) the simulation model adequately represents the appropriate physics. The former activity is called Verification and the latter, termed Validation is accomplished by comparing simulation output with experimental data and quantifying the uncertainties in both. Methods to allow the user to judge "how well" the simulation model was V&V'ed is accomplished by considering the chosen type of comparison data used in the validation effort. V&V levels or credibility levels are related to the criticality of the user's simulation based decision. This definition is based on two aspects: (1) An extended concept of risk analysis, where different kinds of information insufficiency (vagueness, uncertainty, incompleteness, etc.) encountered along the V&V process are considered and quantified, if possible, and (2) the credibility gained by the actually applied V&V activities. This type of goal-driven V&V to achieve the desired V&V level promises to increase efficiency and effectiveness of M&S V&V significantly.

DoD's emphasis on M&S management resulted in the publication of DoD Directive 5000.59 in 1994, which mandated that the military services and defense agencies address the issue of simulation credibility. They were to accomplish this by establishing VV&A policies and procedures for modeling and simulation applications managed by that DoD Service/Component (and by serving as) final authority for validating and accrediting representations of its own forces and capabilities in joint and common use

M&S. The directive also required accreditation for M&S used to support major DoD decision-making organizations (e.g., Defense Acquisition Board) and M&S used for Joint training.

DoD then produced an umbrella VV&A instruction in 1996, DoD Instruction 5000.61, to implement policy, assign responsibilities, and prescribe procedures for VV&A of DoD M&S. They later published the DoD *VV&A Recommended Practices Guide* (RPG) that defines principles, processes, and techniques recommended for use in DoD VV&A efforts. The 1996 version of the RPG provided M&S users, managers, developers, and VV&A agents and personnel with a basic understanding of VV&A terminology, techniques, and processes. (These documents can be accessed through the Defense Modeling and Simulation Office [DMSO] Web site, http://www.dmso.mil.) In response to DoD Directive 5000.59, the Army, Air Force, and Department of the Navy (including the Marine Corps) issued instructions that established VV&A policies and procedures (accessible via http://rac.iitri.org/SIDAC/PRODUCTS/models/modlinks/policy.html). Likewise, VV&A instructions have been developed for other DoD components: the Joint Staff, the Ballistic Missile Defense Organization (BMDO), and the National Security Agency (NSA).

In the 1990s, the increasing demand for high performance simulation systems raised the importance of the study of M&S VV&A. M&S VV&A attracted more attention from the military departments and government. Quite a few policies and guidelines were built up to satisfy the need for the effective M&S VV&A. In 1993, the Department of the Army (U.S.A) published Pamphlet 5-11, Verification, Validation and Accreditation of Army Models and Simulations [1], with the objective to "assist the M&S developer, proponent, and application sponsor in conforming to the VV&A policies in AR 5-11". This pamphlet also provides guidance for the development, execution, and reporting of all VV&A activities. In early 1995, the Defense Modeling and Simulation Office (DMSO) of Department of Defense (DOD) of U.S.A. form a VV&A Technical Support Team to develop and write guide of recommended VV&A practices for the DOD, and the team finished the task which resulted in the most useful VV&A reference book titled DOD: Verification, Validation and Accreditation (VV&A) Recommended Practices Guide (DOD VVARPG) [2].

## VDOT

Capturing the process flow for M&S VV&A is sometimes (mostly) an arduous process. Engineers typically they use poster paper and sticky notes to capture the information, then manually transfer that data to a picture in PDF format, MS PowerPoint or Visio. Unfortunately this is a painstaking effort and errors often occur in the transfer of information. Also it is frequently difficult to arrange for all of the key parties to physically be together in a room to collaborate on the process definition. In addition the diagrams are static, and there is no way to easily deploy them to your teams. Testing of the processes is essentially an academic exercise, and the documentation quickly becomes outdated and unused.

To address these concerns a group of engineers from the Boeing Company developed a software platform called Vdot. The name is derived from the mathematical symbol for the derivative of velocity which is acceleration. Vdot is now a commercial-off-the-shelf (COTS) process management tool from ESI Group that provides the ability to define, deploy, and execute desktop processes for teams in a distributed network environment. Vdot provides the ability to route data, launch tools (IT applications), and it provides automatic real-time project status. Vdot's capabilities have been used on a wide variety of engineering and business processes to enable the key elements of M&S VV&A to be captured, organized, and executable.

Vdot's point and click graphical interface (see **Figure 1**) allows you to quickly and easily define your processes electronically using "Smart Tasks" in "Smart Processes". Smart Tasks are analogous to

kits in the lean factory in which everything an assembly worker needs for the job at hand is gathered into a package and delivered to the point of action. This includes the parts, fasteners, tools, work instructions and timing information to ensure that the task is completed efficiently.

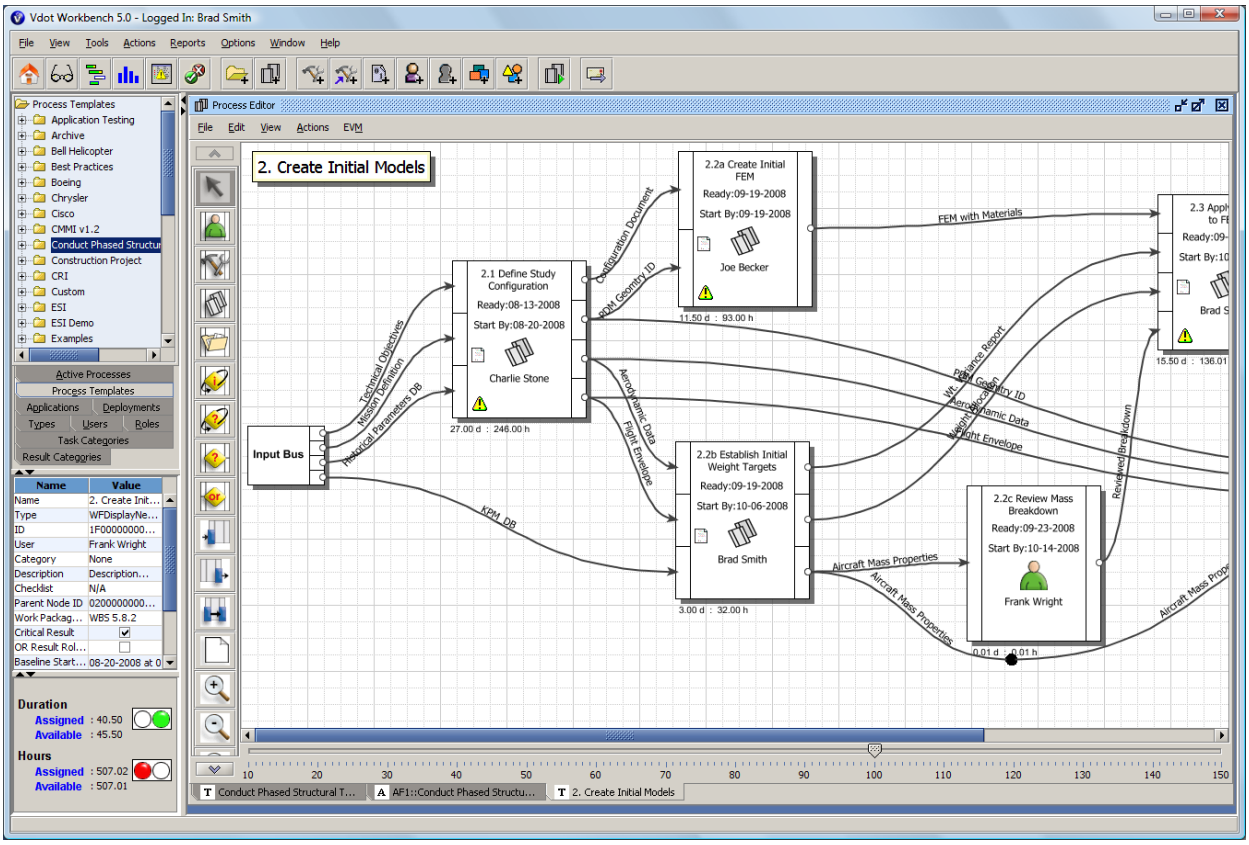


**Figure 1: Defining Work Flow Streams using Vdot's Process Editor**

Similarly in the office or electronic environment Vdot Smart Tasks include a complete description of what needs to be done, when, by whom, and defines the inputs and required outputs for each task. Vdot then makes it easy to define the flow of information between process participants so you have a true awareness of "who needs what from whom". This visual map helps identify undocumented steps in your processes that may be significantly impacting throughput. It also highlights areas where tasks are being worked sequentially that could actually be worked in parallel. This is significantly different from a Gantt chart, yet Vdot can take a Gantt chart from MS Project and use it to make an initial process thread, which accomplishes two things: it shows you "dead ends" or unconnected tasks that is an indication of a MS Project file with low fidelity; and the initial process thread can be expanded and refined upon to capture the true nature of "who needs what from whom". After this expansion and refinement, Vdot can also export to a MS Project file, often with a higher degree of fidelity.

If the M&S VV&A process is depicted in a flow chart, Vdot can be used to map the process. Vdot then makes it easy to define flow of information between process participants so you have a true awareness of "who needs what from whom". This visual map helps identify undocumented steps in your processes that may be significantly impacting throughput. It also highlights areas where tasks are being worked sequentially that could actually be worked in parallel. The visual representation provides a

convenient way to inspect the overall process for the desired Critical To Quality (CTQ) attributes that are important to the success of your efforts. Vdot enables you to define the key measurable characteristics of both the product and the process in order to later quantify the CTQs.

**Figure 2** is an example of a high level process diagram for VV&A. While this level of detail could be used to launch the development of a Vdot process template by assembling the VV&A team together and in real time "drop and drag and connect" the process Smart Tasks together, often the organization has built a process flow chart to define the steps and help educate the workforce on the elements and stakeholders of the verification and validation process, the accreditation process, or the combination of the two in a full VV&A environment. This can be modeled in Vdot to provide a virtual engineering environment in which to run the simulations with a completely traceable process information flow.

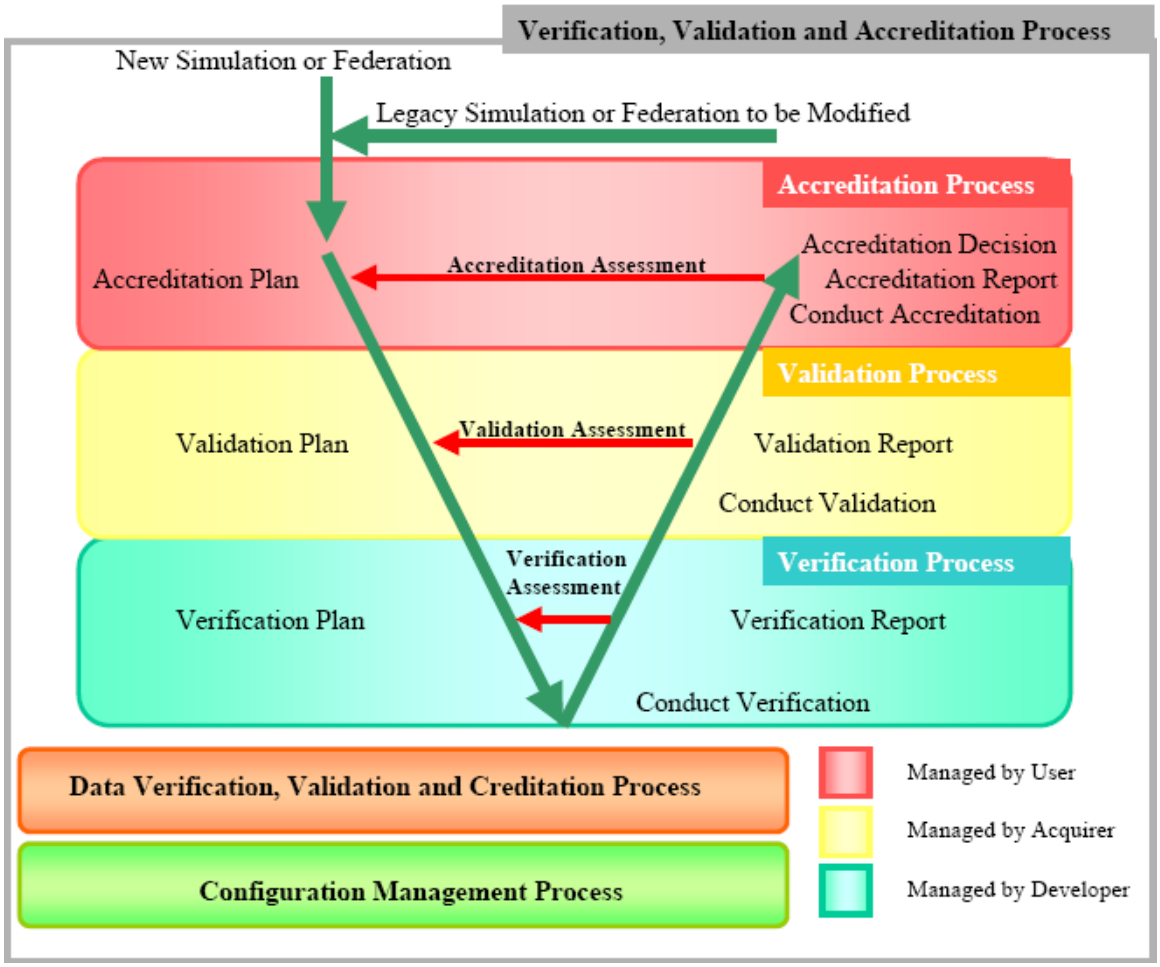


**Figure 2: Verification, Validation and Accreditation Process High Level Overview**

**Figure 3** shows five distinct but interrelated processes to solve problems using simulation. Vdot can be used to model all of these processes together, and a series of nested process diagrams would form a hierarchy of these processes, all interrelated. These are:

a. **Problem Solving Process** – begins with two critical activities, defining the problem and selecting the approach for resolving it. Simulation is but one method for obtaining information needed to solve a problem or support a decision. With Vdot there is no need to have the entire process documented to start using it – processes can be defined at a high level as a starting point and continuously refined along the way using nested processes. By double-clicking on a nested Smart Task you are able to instantly navigate into the sub-process and add the detailed steps necessary to define that level of the process. Processes can be nested to any level of detail you desire. This makes understanding and communicating your processes much simpler and also aids in compartmentalizing the process definition. Process definition may be performed either in a group setting or you can divide up the work and collaboratively diagram and document your processes from distributed locations.

b. **Simulation Use Process** – commences when simulation has been selected as a solution approach. It involves all activities associated with selecting, preparing, and executing (i.e. using) a simulation in support of the problem solving process. One difficulty in applying Simulation Use Process methods to your processes is that there is often no existing data on cycle time and effort to establish a baseline for efficiency comparisons between your as-is and to-be states. Vdot can help you capture this information by providing a simple interface for applying your initial estimates to each task in the process and rolling up the overall duration and hours on the entire process template.

c. **Simulation Development and Preparation Process** – encompasses all the activities needed to develop, modify, and otherwise prepare a simulation for a specific use. Once your process is defined as a Vdot process template it may be activated and deployed instantly to your teams. This creates a dynamic copy (instantiation) of the process template and begins leading the process participants through the activities, ensuring that they get the right information and tools at the right time. Teammates actively work within your processes ensuring proper project execution. Status is automatically gathered in real time as the work is done.

d. **Verification and Validation Process** – encompasses all the activities needed to verify and validate a simulation. The relative importance of each activity and the specific tasks performed depend on the type of simulation and the specifics of the application. With Vdot, a behind the scenes an “as-performed” database captures a complete history of the events that occur during process execution including when tasks are started and completed and by whom. Vdot’s dashboards and task lists are tied directly to the state of your processes and the people working them to provide unprecedented visibility. At any point as shown in **Figure 4** you can see your progress and compare actual schedule and effort results to your original plan. Once you have executed the as-is process through Vdot you will automatically have an actual baseline that may be used for future process improvements.

e. **Accreditation Process** - encompasses all the activities needed to aid an accreditation decision to be made to use a simulation for a specific purpose. A logical next step in the accreditation methodology is to analyze your process to find areas for improvement. The typical metrics that you may analyze to maximize your process velocity or to reduce complexity are inherent to the Vdot process definition. Again Vdot’s visual interface and database enable you to track the actual information flow to see where unwanted rework (defects), process iterations (motion) and bottlenecks (wait times and overproduction) are inhibiting progress. The feature of the built-in dashboards drives directly into the typical sources of non-value added work. Resource loads may be viewed on a team or individual basis (see **Figure 4**). Conflicts are also readily apparent and predicted so that you can proactively make adjustments before there is an impact to your schedule.

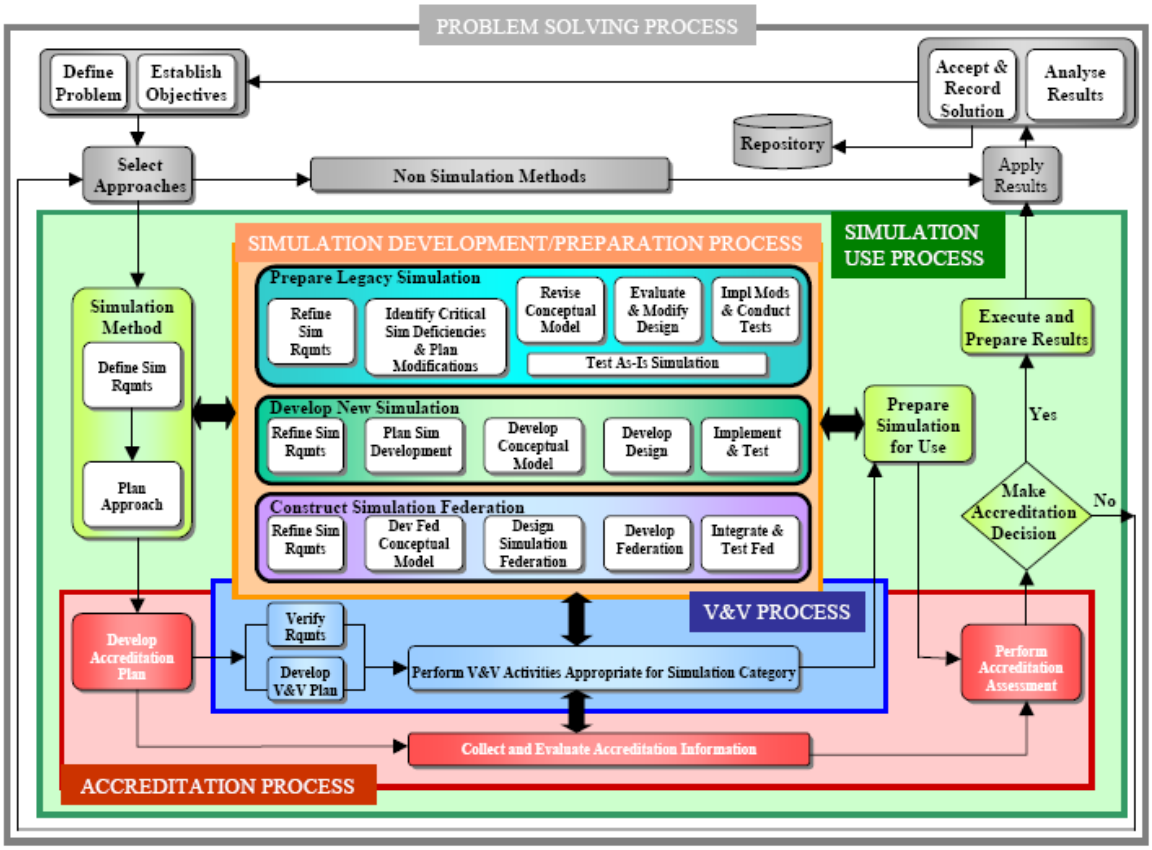


**Figure 3: Problem Solving Process to M&S VV&A**

Once you have established your desired processes another key element of problem solving is control. This means ensuring that your teams execute your best practices repeatability. Vdot's visual process control system immerses your teams into your processes, and helps them perform their assignments in the most effective and efficient sequence. Since all of the information they need for each Smart Task is supplied through the process, data chase is eliminated and rework is minimized. All participants understand the sources of their data and what they need to produce in order for others to successfully complete their assignments. Task priorities are established for individuals based upon dynamic critical path calculations. Deviations or modifications to your processes are captured for future analysis and improvement efforts.

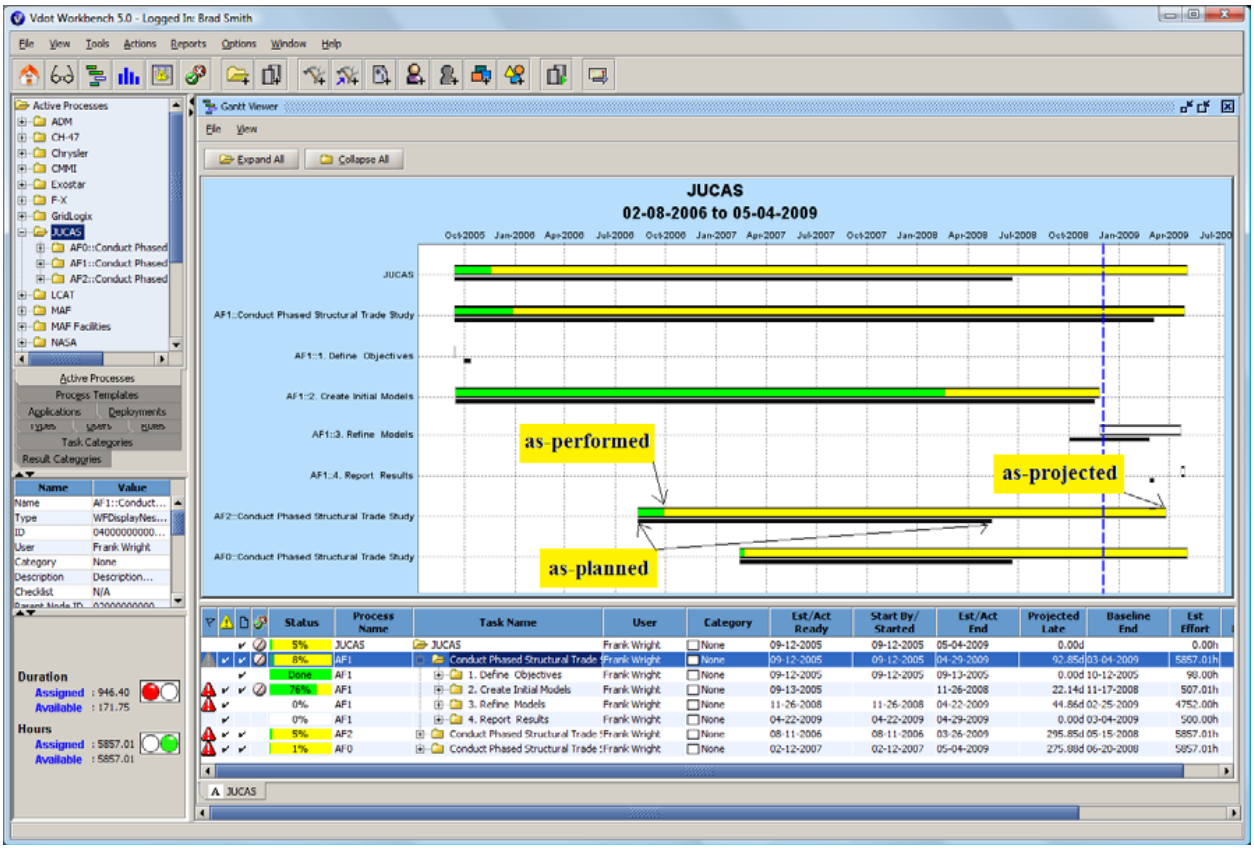


**Figure 4: Vdot Dashboard Showing Assignments, Metrics, Status**

**Figure 5** shows the high level process for simulation development and preparation. Easily applied to this process, Vdot helps you improve your processes in a number of ways. As mentioned previously, it allows you to quickly capture all of the details of your processes in an accessible format that can be continuously refined and reused. It also helps you capture a baseline of your current state and see the problem areas through actual execution of the processes by your teams. One extremely valuable advantage of using Vdot is that you can adapt your active processes on-the-fly to fix bottlenecks and problems immediately without stopping progress. Tasks may be added or removed and changes to the information flow may be incorporated as necessary for improvement. Any changes you make may be saved as a new process template for the next project so that you can gain from your actual experiences and capture the knowledge of what works and what doesn't work. **Figure 6** is the process diagram from the AFOTEC Operational Test and Evaluation Guide (6th Edition) for the Accreditation process. **Figure 7** is the overview of the VV&A process. **Figure 8** is the detailed process diagram for the VV&A process of a legacy simulation showing agent activities [2]. Both **Figure 6** and **Figure 8** have been mapped into the Vdot tool for subsequent presentation and discussion. **Figure 9** is the AFOTEC Accreditation process mapped in Vdot.

**Note:** the DoD VV&A process and the AFOTEC Accreditation process were selected arbitrarily, and used for demonstration purposes and the Vdot templates are notional.

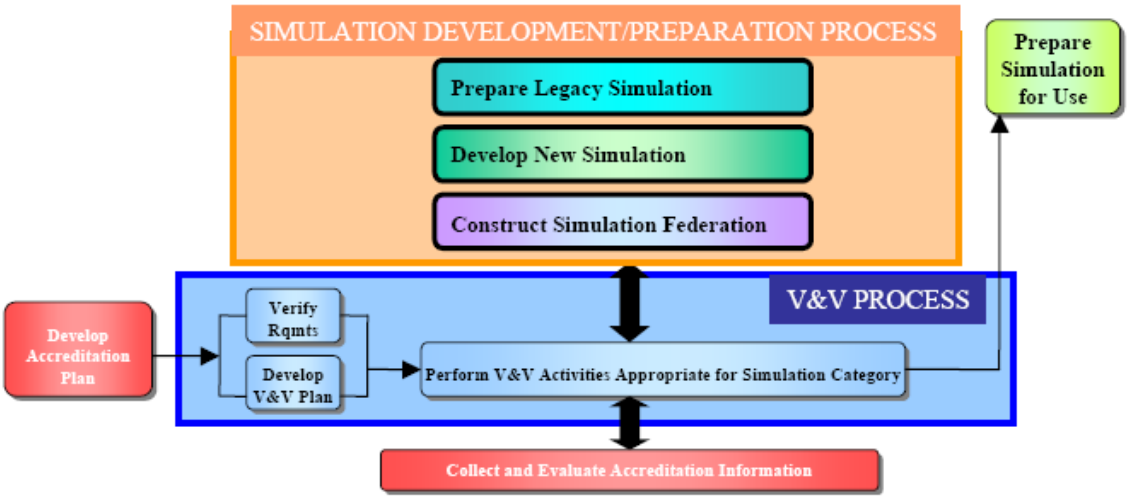


**Figure 5: Simulation Development and Preparation Process Overview**

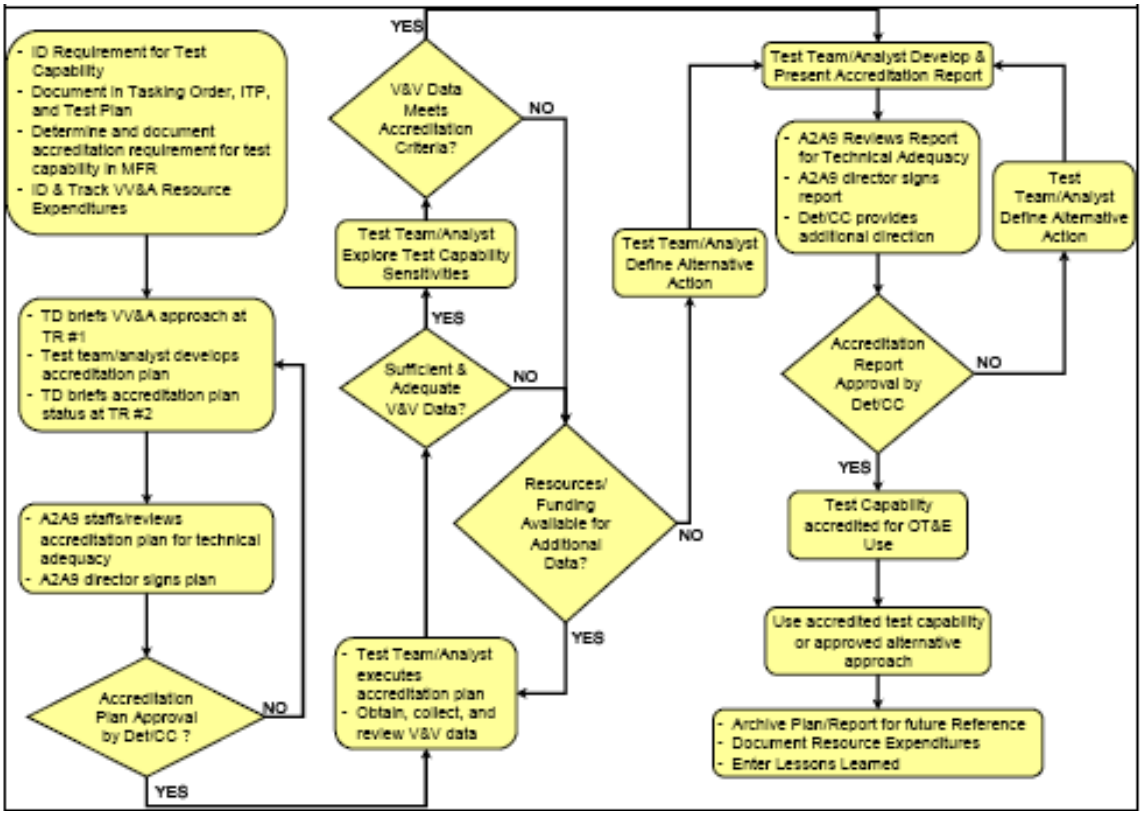


**Figure 6: AFOTEC Accreditation Process Top Level (ref. DOT&E Guide, 6th Edition)**

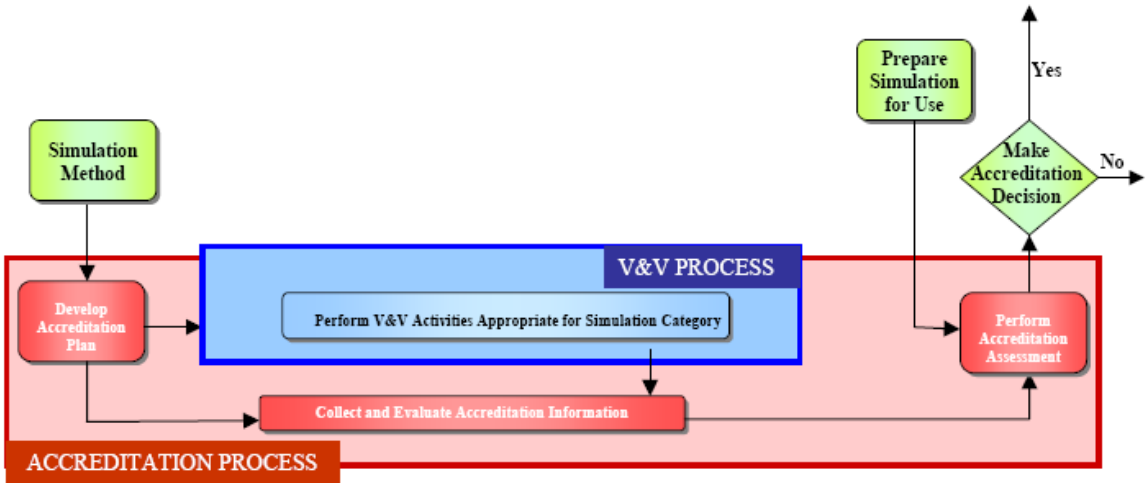


**Figure 7: Overview of the VV&A Process**

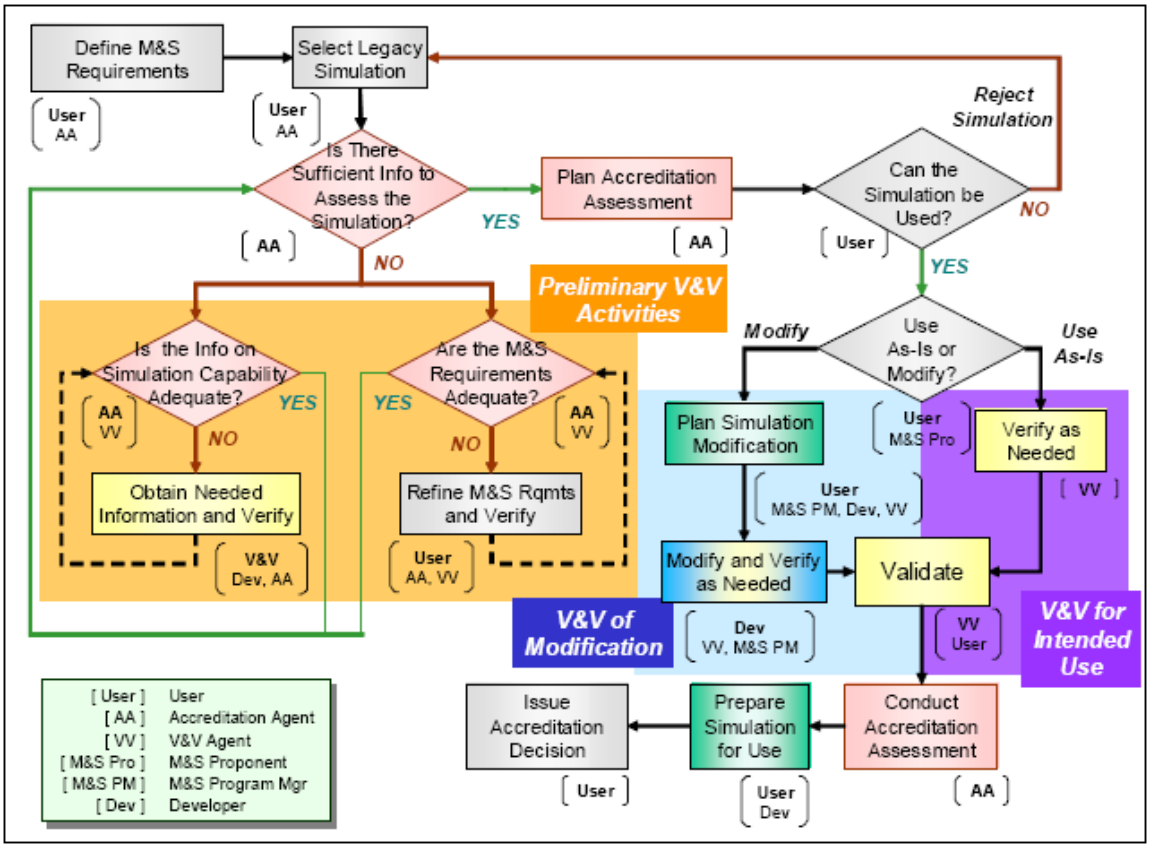


**Figure 8: V&V Agent Activities in the VV&A of a Legacy Simulation**

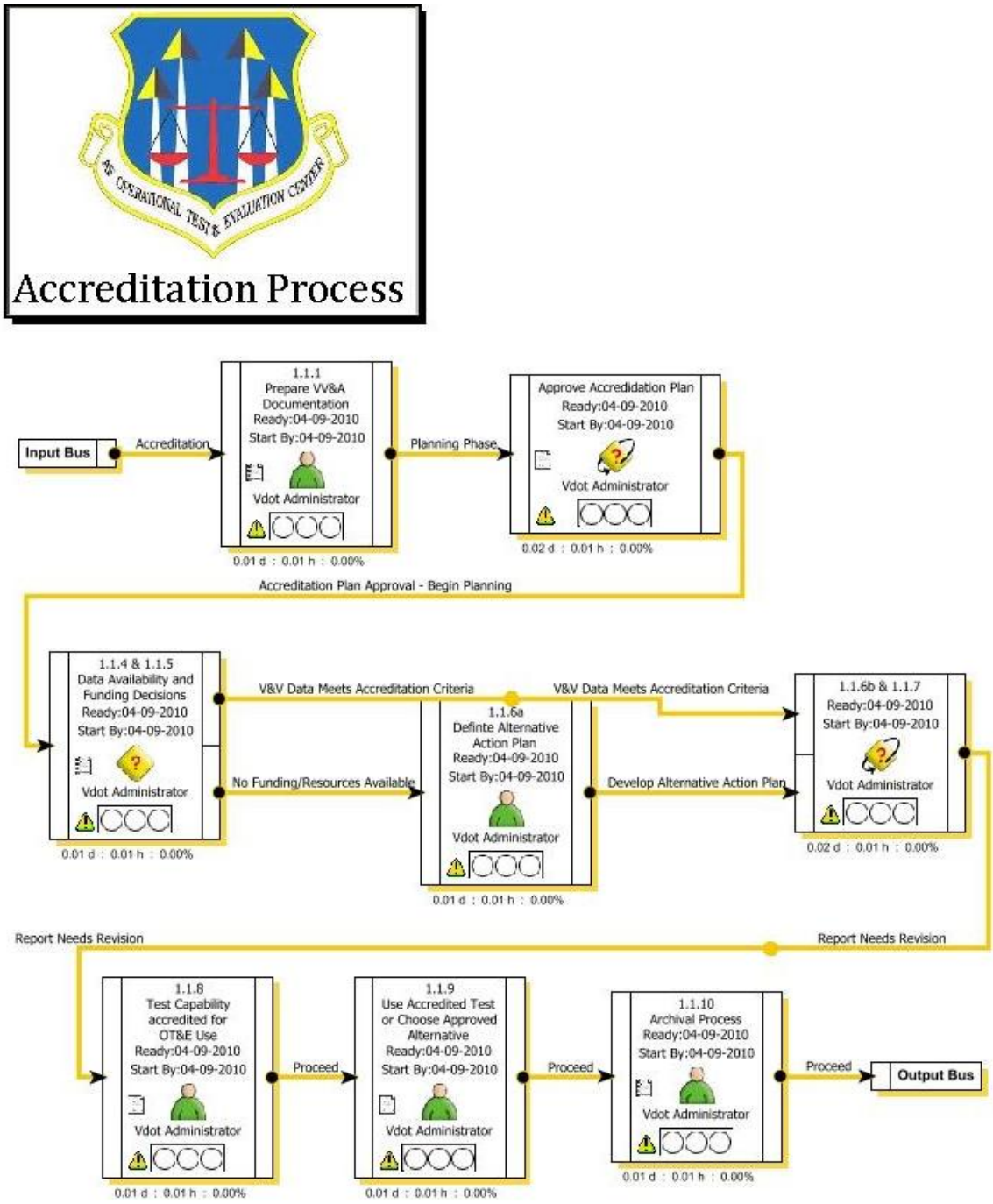


**Figure 9: AFOTEC Accreditation Process Top Level Modeled in Vdot**

It should be noted that the AFOTEC Accreditation process contains decision loops, which one would expect. Vdot has provisions for this logic, and provides two ways to create loops in a process: the Iterator Loop Sub-process and the Decision Loop Sub-process. They work the same except in how they exit. An Iterator Loop will exit after the planned number of iterations. A decision Loop will execute until a manual decision is made to exit rather than continue the loop. Either kind of loop may be set to exit automatically if its critical result value becomes “Pass”. **Figure 10** and **Figure 11** depict the first and second decisions loops for the AFOTEC process.

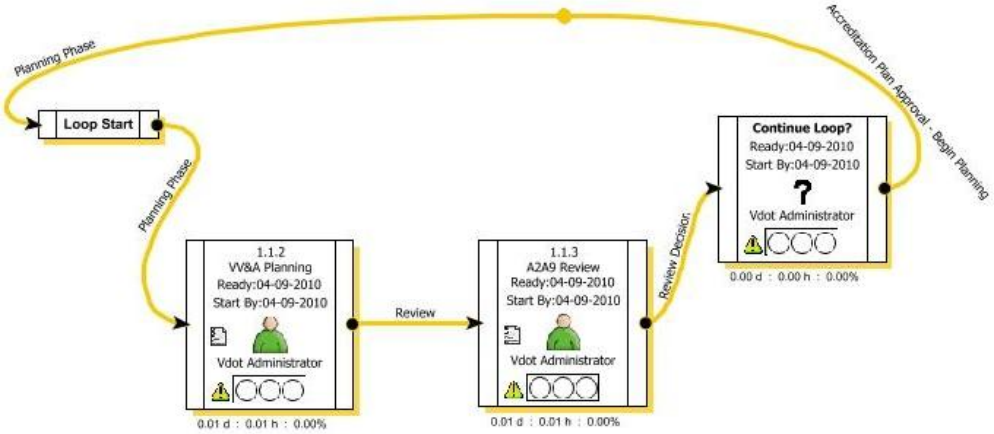


**Figure 10: AFOTEC Accreditation Process First Inner Loop**

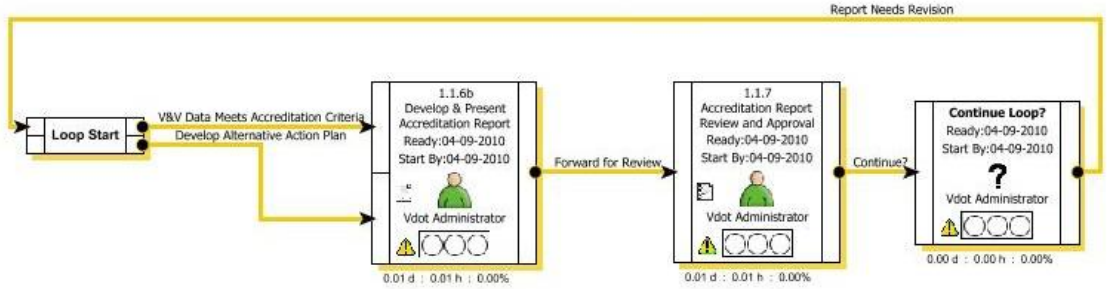


**Figure 11: AFOTEC Accreditation Process Second Inner Loop**

Note that properly functioning loops cannot be created by making backwards connections. If an output item is connected back to a preceding task there is no way for that task to become ready (all input data present), unless it is an OR Task which executes upon the first input data item arriving. Creating a backward link thru an OR Task will at least execute once. If a looping item is then sent back to secondary input on the OR Task it might seem that recalling that Or would allow the rest of the tasks to be re-executed with the iterated data rather than the initial starting data, but that iterated data would itself have been recalled.

Next, **Figure 12** is the process of the V&V Agent Role in the VV&A of Legacy Simulations modeled in Vdot. Each role can be performed by a different individual, group, or organization; or multiple roles can be performed by the same individual, group or organization. The number of performers required for a given application is predicated on the needs of the application, the amount of work required in each role, the availability of resources, and the risks involved. When a Legacy Simulation is well documented, has been used for similar applications in the past, the Vdot tool can dramatically increase the throughput of process efficiency. Vdot helps you improve your processes in a number of ways. It allows you to quickly capture all of the details of your processes in an accessible format that can be continuously refined and reused. **Figures 13 through 17** show the details of the process mapping, and while this is preliminary it offers a view into how the Vdot tool can support M&S VV&A efficiently and effectively.

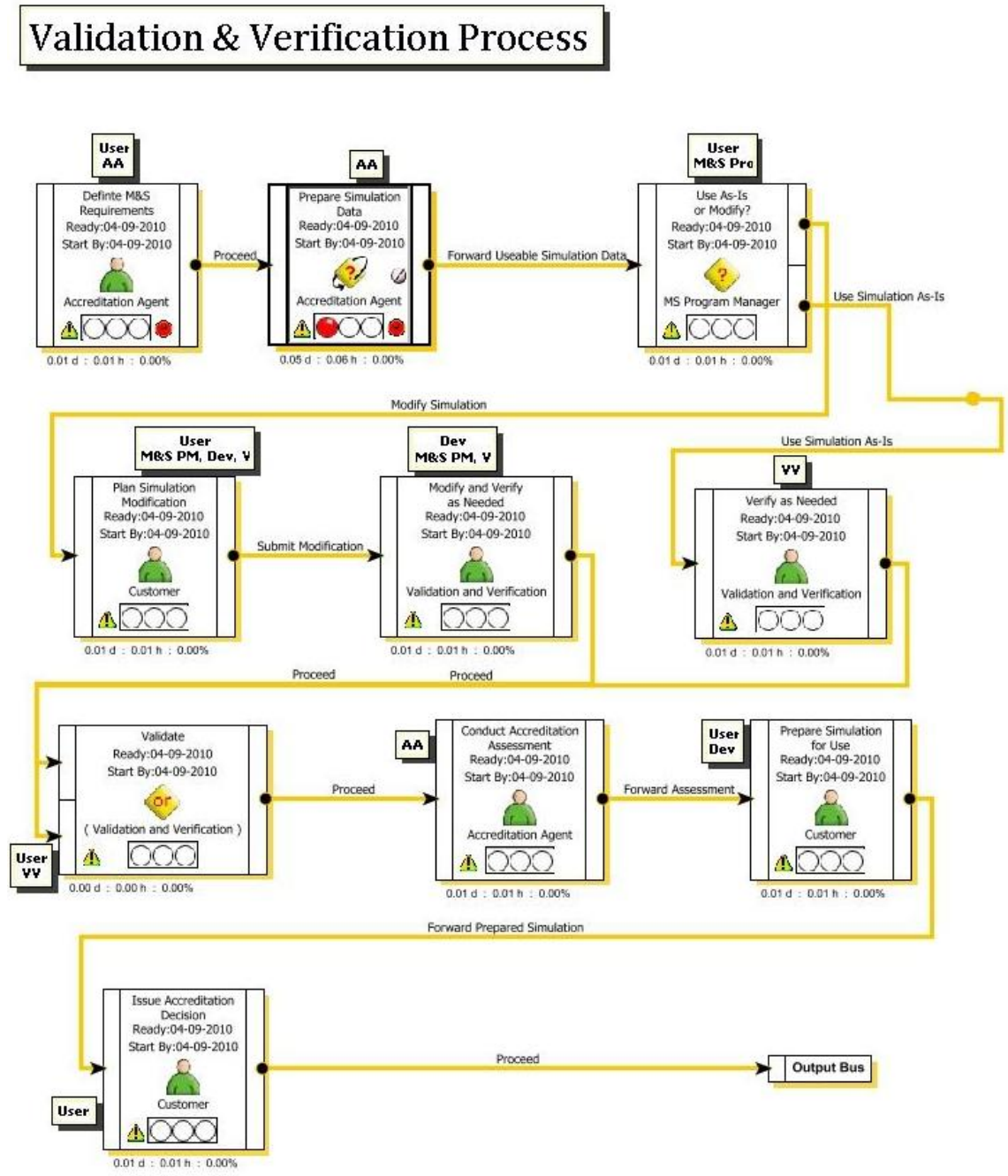


**Figure 12: DoD Verification and Validation Process for Legacy System mapped in Vdot**

Once you have established your desired processes another key element of Vdot is control. This means ensuring that your teams execute your best practices repeatability. Vdot's visual process control system immerses your teams into your processes, and helps them perform their assignments in the most effective and efficient sequence. Since all of the information they need for each Smart Task is supplied through the process, data chase is eliminated and rework is minimized. All participants understand the sources of their data and what they need to produce in order for others to successfully complete their assignments. Task priorities are established for individuals based upon dynamic critical path calculations. Deviations or modifications to your processes are captured for future analysis and improvement efforts.

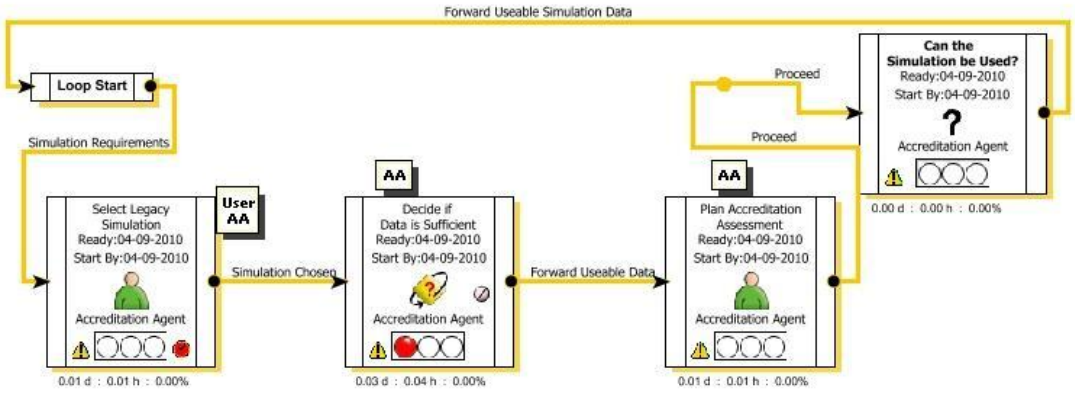


**Figure 13: DoD Verification and Validation Process First Inner Loop**

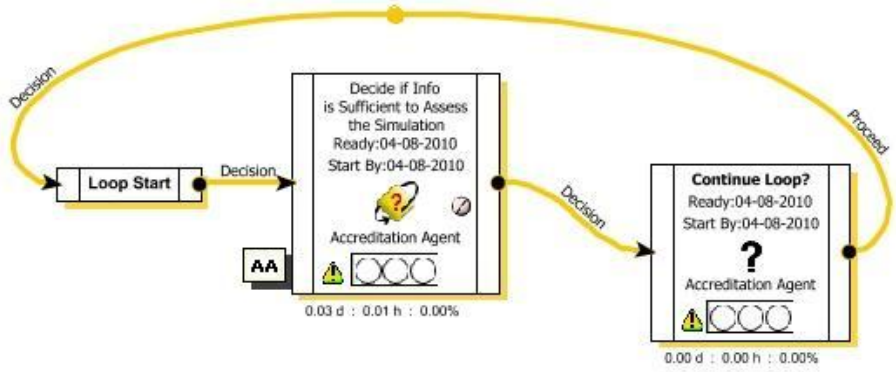


**Figure 14: DoD Verification and Validation Process Second Inner Loop**

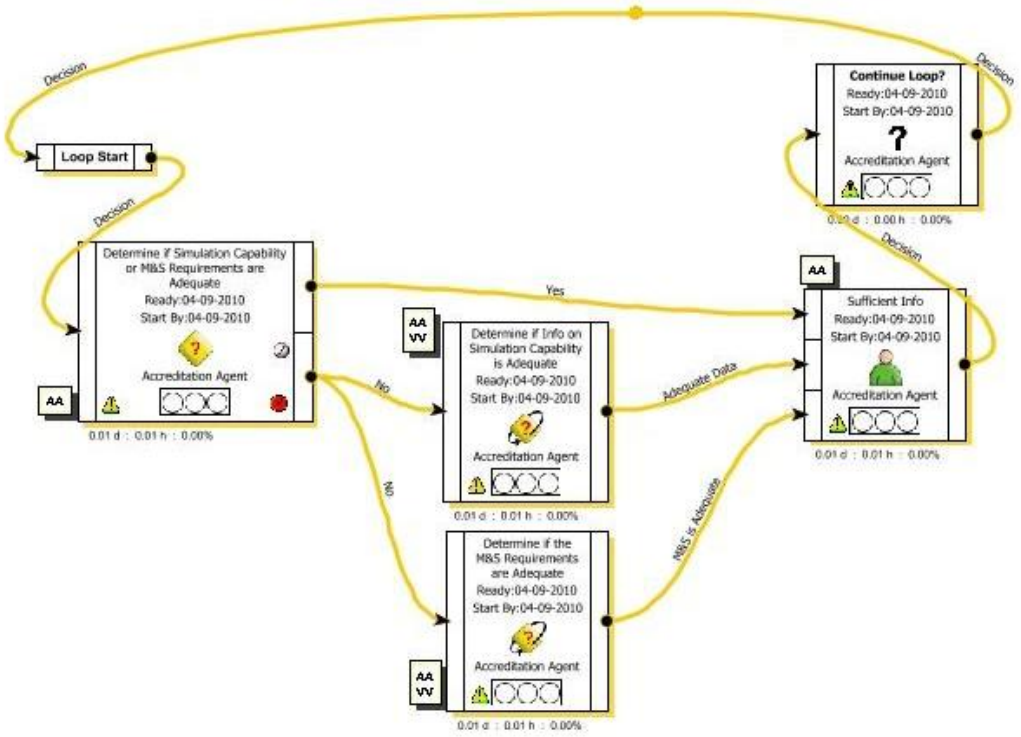


**Figure 15: DoD Verification and Validation Process Third Inner Loop**

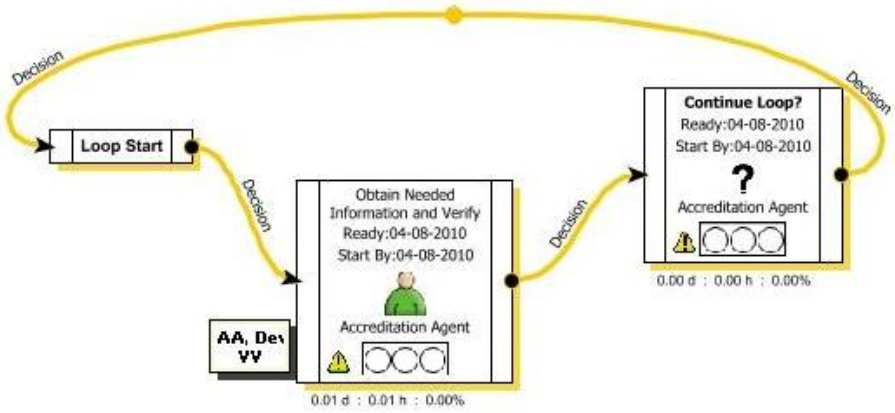


**Figure 16: DoD Verification and Validation Process Third Inner Loop 1st Critical Decision**

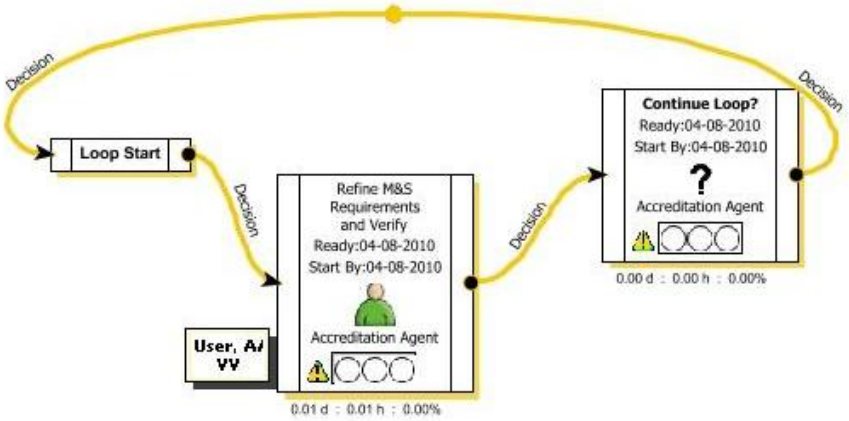


**Figure 17: DoD Verification and Validation Process Third Inner Loop 2nd Critical Decision**

## CONCLUSION

Verification, Validation and Accreditation in the life cycle of Modeling and Simulation is the main trend in evaluation and improving of models and simulations credibility. This paper gives the reader a very comprehensive introduction to the approach the Vdot process automation tool would map VV&A processes. The increasing of scale and degree of complexity of simulation system add to the difficulty and cost of VV&A process in life cycle of M&S and Vdot can effectively and efficiently reduce these costs and simplify the efforts. Research and a pilot study on how the powerful Vdot process automation of VV&A techniques is important to improve VV&A effectiveness and accuracy. VV&A automation tools are of great need in VV&A practices and deserved to study more intensively in future work. The authors welcome inquiries or requests for a demonstration of Vdot to support a M&S V&V or VV&A environment.

## REFERENCES

[1] Department of the Army. 1993. Pamphlet 5-11: Verification, Validation, and Accreditation of Army Models and Simulation.

[2] DMSO. 1996. Department of Defense Verification, Validation and Accreditation (VV&A) Recommended Practices Guide

## ACKNOWEDGEMENTS

The authors would like to acknowledge Mr. Stephen McArthur of Qualis Corporation for his mapping of the AFOTEC and VV&A for Legacy Systems processes into Vdot.