March 29, 2005

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VICE PRESIDENT, NETWORK OPERATIONS MANAGEMENT

SUBJECT: Management Advisory – Office of Inspector General Assistance to Evolutionary Network Development Independent Verification and Validation Team (Report Number NO-MA-05-001)

In January 2004, the senior vice president, Operations, requested that an Office of Inspector General (OIG) auditor serve as an advisor to the Postal Service's Evolutionary Network Development (END)[1] Independent Verification and Validation (IV&V) team (Project Number 05YC001NO000). This report explains how the OIG assisted the team.

In support of the END initiative, the OIG served on the team in an advisory capacity to help ensure compliance with IV&V guidelines; benchmarked best practices with other agencies; facilitated meetings with subject matter experts; and assisted in providing third-party training opportunities. We are not making recommendations in this report. Management had an opportunity to comment on the report and had no changes.

Background

The OIG issued a report recommending the Postal Service conduct an IV&V of END models and establish policies and procedures for determining IV&V requirements for modeling efforts.[2] The Postal Service subsequently formed an internal team to perform an IV&V of the END models.

In modeling and simulation, the terms "verification" and "validation" have specialized meanings. "Verification" determines that a model's implementation and its data accurately represent the developer's conceptual description and specifications.

[1] Formerly known as Network Integration and Alignment (NIA). We use END throughout this report for consistency.
[2] Network Integration and Alignment Models – Independent Verification and Validation (Report Number NO-AR-04-005, February 24, 2004).

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Verification answers the question, "Did I build the model correctly?" "Validation" determines the degree to which a model and its associated data accurately represent the real world from the perspective of the intended uses of the model. Validation answers the question, "Did I build the correct model?"

Verification and validation help ensure that network changes cause minimal disruptions in service and that results are logical. Validation efforts include a comprehensive audit of the:

- Modeling process.
- Development of the distribution concept.
- Assumptions and criteria for decision making.
- Development and use of all underlying input data.[3]

The goal of an IV&V process is to reduce risk in the use of models and simulations by improving the credibility of results.

Conducting an effective IV&V is important for the successful completion of complex and large-scale simulation applications such as the Postal Service's END initiative. Verification and validation are processes performed primarily by analysts, modelers, and subject matter experts who are knowledgeable about the history of the problem, previous approaches, software development, technical issues in modeling and simulation, and environments. The results of an IV&V give Postal Service management evidence to assess whether a model is sufficient for use in particular situations and under specific conditions. One of the purposes of an IV&V is to provide objective, quantified data on which to base decisions. The Postal Service's IV&V team issued a draft IV&V report in January 2005.

Objectives, Scope, and Methodology

Our objectives were to provide information to the IV&V team on best practices obtained from benchmarking with other agencies that have experience in performing IV&Vs and to work with the team to ensure compliance with IV&V guidelines. We conducted this review from January 2004 through March 2005, in accordance with the President's Council on Integrity and Efficiency, Quality Standards for Inspections. We do not draw conclusions or make recommendations in this report.

We attended monthly IV&V team meetings from February through December 2004, benchmarked best practices with other agencies, facilitated meetings with subject

[3] Postal Service Response to Congress, Infrastructure and Workforce Rationalization: Funding Key Capital Investments, January 2004.

matter experts, served on the team in an advisory capacity, and attended IV&V working group conferences and training events.

Prior Audit Coverage

The OIG issued a report titled Network Integration and Alignment Models – Independent Verification and Validation (Report Number NO-AR-04-005, February 24, 2004). We recommended the Postal Service conduct an IV&V of the END models and establish policies and procedures for determining IV&V requirements for END models. Management concurred with the recommendations and formed an internal team to perform an IV&V and develop Postal Service policy for future IV&Vs.

Results

The OIG assisted the Postal Service with the IV&V of the END models as follows:

- Served on the IV&V team in an advisory capacity and attended monthly team meetings from February through December 2004.
    - The Postal Service IV&V team consisted of two groups: field managers with operational expertise and headquarters staff with experience in Postal Service databases and cost analysis. The operations group focused on the feasibility of outputs from the simulation models, while the headquarters group focused on verifying inputs and the model itself. During the meetings, the OIG representative helped the IV&V team formulate its process for conducting the IV&V. For example, the OIG representative provided examples of completed IV&V reports from other agencies, discussed sampling methodologies, and helped the team focus on risk and coverage.
- Identified best practices through benchmarking efforts.[4]
    - Identified best practices included understanding risk, developing an IV&V plan, selecting an IV&V team, and becoming familiar with IV&V techniques. In April 2004, the OIG representative provided the IV&V team with detailed documentation that included a discussion of best practice elements. (See the appendix for more information on IV&V best practices.) The team used the information for reference in developing its approach to conducting the IV&V.

[4] Agencies benchmarked included the Defense Modeling and Simulation Office, the National Institute of Standards and Technology, the National Aeronautics and Space Administration, and other sources. Best practices were offered as guidelines, not absolutes. The Postal Service considered them as the IV&V process was developed and used the applicable ones.

- Identified subject matter experts and facilitated meetings with the experts.

    - As part of our benchmarking effort, the OIG representative met several times with the technical director of verification, validation and accreditation for the Defense Modeling and Simulation Office (DMSO). Based on those meetings, the OIG representative recommended the technical director as a subject matter expert and arranged to have the technical director meet with the IV&V team. The technical director provided expert guidance on IV&V methodology and made suggestions that the IV&V team welcomed and considered.

    - The OIG representative also consulted with an OIG statistician and suggested that a Postal Service statistician be added to the IV&V team. The Postal Service subsequently added a statistician to the team.

- Attended IV&V working group conferences and training events to gain knowledge of the IV&V process.

    - In March 2004, the OIG representative attended a meeting of the Verification, Validation, and Accreditation Technical Working Group hosted by the DMSO. These periodic meetings featured presentations from various IV&V experts in government and the private sector. The OIG representative also arranged for several members of the Postal Service's IV&V team to attend the meeting.

    - In December 2004, the OIG representative attended a two-day IV&V training workshop, along with two members of the IV&V team. This training focused on the IV&V process and included case studies. The training also allowed members of the Postal Service's IV&V team to network with other IV&V practitioners. Information provided in the training will be helpful to the Postal Service in developing policy for future IV&V efforts.

We appreciate the cooperation and courtesies provided by your staff. If you have any questions or need additional information, please contact Robert J. Batta, Director, Network Operations – Processing, or me at (703) 248-2300.

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Attachment

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APPENDIX. BEST PRACTICES

Risk

"Risk" is defined as the potential realization of undesirable consequences from hazards arising for a possible event.[5] The primary risk in modeling and simulation is that the simulation will produce an incorrect result or will fail. An Independent Verification and Validation (IV&V) collects the evidence that illuminates the risk.

The following two types of risk can be associated with making a decision: rejecting correct evidence and accepting incorrect evidence as correct. In modeling and simulation, accepting incorrect evidence as correct is usually considered the bigger risk.

Operational risks arise from using the incorrect outputs of a simulation that are believed to be correct. Operational risk is concerned with credibility. While modeling and simulation requirements establish what the simulation must do and how well it must be done, the desired level of credibility determines how much information is needed about the simulation to draw a reasonable and acceptable conclusion. The amount of confidence that the user needs in the simulation's results depends on how much risk the user is willing to tolerate. Often, an operational risk assessment or analysis is performed.

Risk analysis provides a specific, objective, and frequently quantitative method for identifying potential problems with developing and applying a simulation.[6] Model credibility refers to the decision maker's confidence in the model. One goal of the IV&V process is to ensure that the user gains this credibility.[7]

Typical IV&V Plan[8]

A typical IV&V plan includes some or all of these elements:

- Purpose and description of the IV&V.
- Scope of the IV&V effort and responsibilities.
- Identification and responsibilities of each participant.
- Intended use(s)/application(s) of the simulation.

[5] Definition from McGraw-Hill Dictionary of Engineering.
[6] From Defense Modeling and Simulation Office (DMSO) Recommended Practices Guide, Risk Assessment and Its Impact on VV&A.
[7] From article ""Model Verification and Validation" by John S. Carson, II, Brooks-PRI Automation, Marietta, Georgia.
[8] From DMSO Recommended Practices Guide, The V&V Agent's Role in the VV&A of New Simulations, Appendix B: An Adequate V&V Plan.

- IV&V schedule.

- Information needed:
  - Development products and processes.
  - Data sources.
  - Information about the user and problem domains.

- Description of developer's configuration management system and how it will be used for IV&V.

- Description of the IV&V process model used.

- IV&V techniques and methods matched to development paradigm:
  - Verification processes in the context of planned simulation development.
  - Definitions of activities to be completed in each development phase.
  - Descriptions of verification tasks to be performed.
  - Validation processes in the context of planned simulation development.
  - Definitions of activities to be completed in each development phase.
  - Descriptions of validation tasks to be performed.

- Validation data to be used during validation of results, data sources, and plans for obtaining and reducing this data.

- IV&V tools, products, and deliverables.

- IV&V reporting procedures, reports, and formats.

- IV&V baseline (approved) budget.

- Description and locations of IV&V archives.

- Appendices (as required).

Skills Needed for IV&V Team

- Knowledge of/experience with similar types of models and simulations.

- Knowledge of/previous experience with the systems being modeled.

- Extensive knowledge of the domains involved (e.g., problem, user, simulation).

- Familiarity with selecting and using appropriate automated tools.
- Familiarity with the software languages and hardware platforms being used.
- Experience with modeling and simulation development.
- Solid analytical skills.
- Willingness to accept challenge.
- Technical curiosity.

IV&V Techniques

Numerous IV&V and statistical techniques can be used to validate models. The term "testing" is frequently used when referring to the implementation of these techniques because IV&V involves testing the model or simulation to assess its credibility. The Defense Modeling and Simulation Office (DMSO) separates techniques into four categories:

- Informal techniques are the most commonly used. These tools and approaches rely heavily on human reasoning and subjectivity.
- Static techniques reveal a variety of information about the structure of the model and the modeling techniques used.
- Dynamic techniques evaluate the model based on its execution behavior. These techniques involve inserting additional code into the model to collect information about model behavior during execution.
- Formal techniques are based on formal mathematical proofs or correctness and are the most thorough means of verifying and validating models. You should apply formal methods early in the model development process to achieve maximum benefit.

The IV&V process involves a series of activities and tasks that are selected to address the particular needs of the application. Selecting the best techniques to apply to a given IV&V task in a given situation is not always straightforward. The tasks that are selected and the techniques chosen to accomplish them depend upon a number of factors, such as:

- The type of simulation (legacy, new modeling and simulation).
- The problem that needs to be solved.
- Objectives and requirements and their acceptability criteria.
- The user's risks and priorities.
- Constraints of time, money, personnel, and equipment.[9]

A common technique is to conduct a software traceability analysis. In such an analysis, software requirements and implementation would be traced to system requirements (and vice versa) to check the relationships for accuracy, completeness, consistency, and correctness.[10]

All techniques selected for IV&V should be carefully documented. The documentation of each IV&V technique should include the objectives, assumptions, constraints, methods employed, data, tools, artifacts produced, and the results of the assessment and review.[11]

[9] Excerpted from DMSO Recommended Practices Guide, V&V Techniques.
[10] National Institute of Standards and Technology Special Publication 500-234, Reference Information for the Software Verification and Validation Process, March 29, 1996.
[11] DMSO Recommended Practices Guide, The V&V Agent's Role in the VV&A of New Simulations.