IG-00-059

AUDIT REPORT

SOFTWARE ASSURANCE

September 28, 2000

NASA

National Aeronautics and
Space Administration

OFFICE OF INSPECTOR GENERAL

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Acronyms

CIO	Chief Information Officer
CMM	Capability Maturity Model
EMC	Engineering Management Council
FY	Fiscal Year
ISO	International Standards Organization
IV&V	Independent Verification and Validation
NPD	NASA Policy Directive
OSMA	Office of Safety and Mission Assurance
PMC	Program Management Council
SOFIA	Stratospheric Observatory for Infrared Astronomy
SWG	Software Working Group

W   September 28, 2000

TO: A/Administrator

FROM: W/Inspector General

SUBJECT: INFORMATION: Audit of Software Assurance
               Report Number IG-00-059

The NASA Office of Inspector General has completed an audit of Software Assurance.
The audit focused on determining whether the Agency had established adequate
guidelines for using independent verification and validation (IV&V) during the software
life cycle and whether program and project managers had implemented NASA's IV&V
Facility recommendations to perform IV&V. We found that NASA lacked adequate
management controls for using IV&V in software development projects. In addition,
NASA lacked adequate controls for collecting, analyzing, and reporting software metrics.
Accordingly, NASA lacks assurance that it can effectively mitigate potential software
failures through the use of IV&V and monitoring of software assurance activities.

NASA recently issued interim guidelines that are intended to improve the software
development process. The guidelines include criteria for using IV&V during software
development.

Background

In 1993, NASA established the IV&V Facility in Fairmont, West Virginia,[1] as part of an
Agencywide strategy to provide the highest achievable levels of safety and cost-
effectiveness for mission-critical software. The IV&V Facility currently supports 21
NASA programs and projects including the International Space Station, Space Shuttle,
Earth Observing System Data and Information System, Checkout and Launch Control
System at the Kennedy Space Center, and Advanced Air Transportation Technology.
The Facility's budget for fiscal year (FY) 2000 is $26 million.

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[1] NASA established the Facility as a result of recommendations made by the National Research Council
and the "Report of the Presidential Commission on the Space Shuttle Challenger Accident."

Recommendations

We recommended that NASA establish procedures for evaluating the adequacy of program and project managers' actions in implementing the interim IV&V criteria and conduct evaluations, as appropriate. Without procedures, NASA lacks assurance that the interim criteria are effectively applied to software development projects. We also recommended that NASA issue guidelines for the IV&V Facility review of programs and projects with significant software applications; for implementing recommendations to perform IV&V; and for collecting, analyzing, and reporting software metrics. Without such guidance, NASA lacks assurance that the risk of potential software failures has been adequately reduced through IV&V. Also, without software metrics guidance, NASA has an unmet requirement for assessing the adequacy of its software policies and procedures.

Management's Response and OIG Evaluation

Management concurred with the recommendations. NASA management issued interim IV&V criteria for use by program and project managers in determining whether new or existing projects should be subject to IV&V. Also, IV&V Facility personnel are assisting the projects in determining the necessary level of IV&V and in developing IV&V implementation plans. NASA management also issued a set of software metrics that it will evaluate over a 12-month period. Upon conclusion of the evaluation period, management will determine whether the metrics gathered satisfy the objectives of the metrics program. The approved metrics will become part of a NASA policy guideline.

The actions planned or taken by management are responsive to the recommendations. Details on the status of the recommendations are in the Recommendations section of the report.

[original signed by]
Roberta L. Gross

Enclosure
  Final Report on Audit of Software Assurance

FINAL REPORT
AUDIT OF SOFTWARE ASSURANCE

W   September 28, 2000

TO: AE/Chief Engineer
             AO/Chief Information Officer
             Q/Associate Administrator for Safety and Mission Assurance

FROM: W/Assistant Inspector General for Auditing

SUBJECT: Final Report on Audit of Software Assurance
             Assignment Number A9906600
             Report Number IG-00-059

The subject final report is provided for your information and use. Our evaluation of your
response is incorporated into the body of the report. The corrective actions planned for
the recommendations are responsive. The recommendations will remain open for
reporting purposes until agreed to corrective actions are completed. Please notify us
when action has been completed on the recommendations, including the extent of testing
performed to ensure corrective actions are effective.

If you have questions concerning the report, pleas contact Mr. David Gandrud, Program
Director, Information Technology Program Audits, at (650) 604-2672, or Mr. Roger
Flann, Program Manager, at (818) 354-9755. We appreciate the courtesies extended to
the audit staff. The final report distribution is in Appendix D.

[original signed by]
Russell A. Rau

Enclosure

cc:
B/Chief Financial Officer
B/Comptroller
BF/Director, Financial Management Division
G/General Counsel
JM/Acting Director, Management Assessment Division
200-1/Director, Ames Research Center
100/Director, Goddard Space Flight Center
307/Acting Director, NASA Independent Verification and Validation Facility,
     Goddard Space Flight Center

NASA Office of Inspector General

IG-00-059
A9906600

September 28, 2000

Software Assurance

Introduction

Software assurance is the planned and systematic set of activities for ensuring that software processes and products conform to established requirements, standards, and procedures. Verification and validation of the software processes and products are part of software assurance. IV&V is a process used to ensure that software products of the software development life-cycle phases are independently reviewed, verified, and validated by an organization that is neither the developer nor the acquirer of the software. IV&V is a vital part of a sound management process because it ensures that program advocacy is balanced by substantive evidence. NASA's planned information technology investment for FY 2000 is $2.2 billion.[2]

NASA Policy Directive (NPD) 2820.1, "NASA Software Policies," May 29, 1998, defines NASA policies regarding management, engineering, and assurance of software created or purchased by the Agency. The NPD requires program and project managers to employ verification and validation techniques for risk mitigation and requires the Agency to collect, analyze, and report on software metrics.

The overall audit objective was to determine whether NASA has exercised effective software assurance. Due to the importance of IV&V in the software assurance process, we limited our review to determining whether the Agency had established adequate guidelines for using IV&V during the software life cycle and whether program and project managers had implemented recommendations to perform IV&V. Details on our audit objectives, scope, and methodology are in Appendix A.

Results in Brief

NASA lacked adequate management controls for using IV&V in software development projects. Additionally, management had not established metrics for evaluating software policies and procedures and for reporting to the NASA Engineering Management Council[3] (EMC) as required by NPD 2820.1. As a result, NASA is not assured that it can

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[2] Information technology investments include computers, ancillary equipment, software, firmware, networks, services and support services, personnel, funds, and related information resources. Because software costs are not separately tracked, that portion of the information technology investment cost is not known.

[3] The Engineering Management Council is a forum for assessing and improving Agency engineering practices, policies, training and certification standards, procedures, and capabilities. The Engineering Management Council conducts or supports independent technical reviews of NASA programs and informs the Chief Engineer about NASA-wide engineering activities.

effectively mitigate potential software failures through robust use of IV&V and effective monitoring of software assurance activities. NASA recently issued interim guidelines that are intended to improve the software development process.

Background

The IV&V Facility in Fairmont, West Virginia, is intended to be the NASA center of excellence for applying software verification and validation technology. It manages independent assessments,[4] software and system engineering tasks, and IV&V for NASA programs and projects.[5]

The NASA Office of Safety and Mission Assurance (OSMA) had initial management responsibility for the Facility. In 1995, management responsibility transferred to Ames. In July 2000, NASA transferred management responsibility to Goddard.[6] The transfer was intended to better integrate the IV&V Facility into the software development life cycle of NASA's programs and projects.

Management Controls

Finding. NASA lacked adequate management controls for determining whether to use IV&V in its software development projects and for collecting, analyzing, and reporting software metrics designed to monitor these projects. This condition occurred because NASA had not issued guidelines to implement the controls. As a result, NASA has less assurance that the risk of potential software failures has been adequately reduced through IV&V and implementation of sound software assurance policies and procedures.

NASA Software Policies and Procedures

NPD 2820.1 requires program and project managers to employ verification and validation techniques for risk mitigation, including IV&V as appropriate, based on project cost, size, complexity, life span, risk, and consequences of failure.[7] The NPD does not include specific criteria for determining whether IV&V is appropriate for a software development project.

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[4] An independent assessment identifies the risks to the critical software elements that could jeopardize mission safety and success. Program and project managers can use the results of an independent assessment to determine whether a software development project should undergo IV&V. Software and system engineering tasks identify potential issues based on software design analyses, software code reviews, and peer reviews. These tasks do not constitute IV&V, which involves evaluating the software development project throughout its life cycle. The IV&V Facility and the project managers determine which tasks will be performed based on the status of the project.

[5] The IV&V Facility uses contractors to perform work supporting NASA programs and projects.

[6] OSMA has management responsibilities for the Agency's software assurance and IV&V of critical flight systems and conducts these responsibilities through Goddard.

[7] Consequences of failure include loss of life, serious injury, catastrophic mission failure, partial mission failure, loss of equipment, waste of resource investment, adverse visibility, and impact on routine operations.

NPD 2820.1 also requires the IV&V Facility to collect, analyze, and report on software metrics. Software metrics include:

- Evidence of project compliance with the NPD.

- Agency trends on software cost and schedule baseline deviations and the degree to which delivered software satisfies Agency requirements, including safety, quality, and reliability measures.

- Assessments and audits of conformance to International Standards Organization (ISO)[8] 9001 and the Capability Maturity Model (CMM)[9] for Software in NASA software creation and acquisition organizations.

- Other surveys relating to the implementation of the Directive.

- Improvements in software acquisition and creation of software projects, resulting from the use of the CMM.

- Improvements in management of software creation and acquisition, resulting from case studies and shared experiences.

The NASA Chief Information Officer (CIO), Chief Engineer, and Associate Administrator for OSMA are responsible for jointly promoting software policies, standards, best practices, and guidelines. The CIO has primary responsibility for developing the Agency's software policies. During a Senior Management Council[10] meeting in June 1999, the NASA Administrator stated that only the IV&V Facility should conduct IV&V for NASA projects. The Associate Administrator for OSMA reiterated the Administrator's decision in a November 10, 1999, memorandum.[11]

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[8] ISO 9000 is a series of standards and guidelines that define the minimum requirements for an effective Quality System that is accepted internationally. The ISO 9001 standard requires NASA Headquarters to document what it does, do what it documents, and provide objective evidence of accomplishment. The standard also requires that NASA review its processes for improvement when necessary.

[9] The CMM for Software describes the principles and practices underlying software process maturity and is intended to help software organizations improve the maturity of their software processes in terms of an evolutionary path from informal, chaotic processes to mature, disciplined software processes.

[10] NASA's Senior Management Council is chaired by the Administrator and consists of Associate Administrators, Officials-in-Charge of Headquarters offices, and installation Directors. This council advises the Administrator on the status of Agency programs and plans and serves as a forum for discussing issues affecting Agency management.

[11] The Associate Administrator for OSMA issued the November 10, 1999, memorandum on "Software Assurance for Safety and Mission Assurance," to Enterprise Associate Administrators, Center Directors, and Center Safety and Mission Assurance Directors. (The Agency established four Strategic Enterprises to function in primary business areas for implementing NASA's mission and serving customers. The four Enterprises are (1) Aerospace Technology, (2) Earth Science, (3) Human Exploration and Development of Space, and (4) Space Science.

On May 10, 2000, NASA established an initiative to improve software quality and safety.[12] As part of this initiative, the CIO, Chief Engineer, and Associate Administrator for OSMA assigned the Software Working Group [13] (SWG) the responsibility for developing criteria for use in determining whether to use IV&V. The initiative also included the requirement to collect meaningful software metrics.

On July 21, 2000, the Chief Engineer issued a memorandum that included the SWG-developed interim criteria for IV&V.[14] The interim criteria provide quantifiable standards for determining whether IV&V should be applied to a software development project. Program and project managers are to use the criteria to evaluate specific aspects of a project for consequences of failure and probability of failure. The criteria also identify factors for evaluating the projects and for rating the risks to software development. The Deputy Associate Administrator for OSMA stated that, as an interim measure, program and project managers must apply the criteria to selected existing and all new software development projects.

Use of IV&V

NASA has not established guidelines to help users determine whether to use IV&V based on a software project's cost, size, complexity, life span, risk, and consequences of failure as required by NPD 2820.1.

The benefits of performing IV&V have been well demonstrated. For example, through the application of IV&V for the Space Shuttle Program, the IV&V Facility identified 15 software errors that could have resulted in loss of the Shuttle or crew. With the correction of the software errors, the Space Shuttle Program increased mission safety and reliability and reduced program cost. Notwithstanding such efforts, the IV&V Facility had performed IV&V on only 9[15] of about 170 programs and projects, as of December 22, 1999 managed by Program Management Councils (PMC's).[16]

With issuance of the interim criteria, NASA has taken substantial steps toward improving its software assurance program. For example, managers must now evaluate their programs and projects during project formulation to determine whether software IV&V

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[12] The CIO, Chief Engineer, and Associate Administrator for OSMA issued the May 10, 2000, memorandum on "NASA's Initiative to Improve Quality and Safety of Software," to Officials-in-Charge of Headquarters Offices, Center Directors, and the Director of the Jet Propulsion Laboratory.

[13] The SWG is the responsibility of the Chief Engineer. The SWG advises the Agency on software-related matters and recommends software management, engineering, and assurance polices, standards, best practices, and guidance.

[14] The Chief Engineer issued the July 21, 2000, memorandum on "Interim NASA Software Independent Verification and Validation (IV&V) Policy and IV&V Facility Planning Action to Project Managers," to Officials-in-Charge of Headquarters Offices, Center Directors, and the Director of the Jet Propulsion Laboratory.

[15] Appendix B identifies the NASA programs and projects for which the IV&V Facility performed an independent assessment, software and system engineering tasks, or IV&V.

[16] NASA has established a hierarchy of PMC's that are responsible for assessing program and project formulation and implementation and for providing oversight and direction. PMC's exist at the Agency, Lead Center, and Center levels.

or an independent assessment is required. Further, managers must coordinate their evaluation results with the governing PMC's and the Center Directors. To ensure that the interim criteria are effectively applied to software development projects, responsible NASA officials should evaluate the adequacy of program and project managers' actions in implementing the criteria.

Recommendations to Perform IV&V

The IV&V Facility performs independent assessments that may result in a recommendation to perform IV&V on software development projects. However, NASA had not established guidelines to help ensure that program and project managers adequately address the recommendations.

As of August 1, 2000, the IV&V Facility performed independent assessments for 12 NASA programs and projects (see Appendix B) and recommended IV&V for 4 of them: the Checkout and Launch Control System, [17] Mars Surveyor Program, [18] Stratospheric Observatory for Infrared Astronomy (SOFIA), [19] and Boeing 757 New Generation Display Simulation. [20] Managers for three of the four programs and projects chose to not implement IV&V. Specifically:

- The project manager for the Mars Surveyor Program did not follow the Facility's recommendations to perform IV&V due to insufficient funding for IV&V. The Mars Surveyor Program later failed, in part, due to reported software problems or failures.

- The project manager for SOFIA initially determined that the recommendation to perform IV&V would not be implemented because "an additional review effort would be deleterious to the program's already seriously challenged schedule and cost status." The IV&V Facility and program management have since begun negotiations to perform IV&V.

- Project management for the Boeing 757 project determined that the verification and validation processes for the project sufficiently mitigated project risks and considered IV&V to be unnecessary.

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[17] The Checkout and Launch Control System processes Space Shuttle data at the Kennedy Space Center. This includes providing multi-orbiter support from one control room; multi-system monitoring capability from one console; and local monitoring, command, and control.
[18] The Mars Surveyor Program included the Mars Climate Orbiter and Mars Polar Lander.
[19] SOFIA will be the largest airborne telescope in the world, making observations that are impossible for even the largest, highest ground-based infrared telescopes. NASA, the German Aerospace Center, and an international contractor team are working together to create SOFIA—a 2.5-meter (98.5-inch)-diameter reflecting telescope mounted in a modified Boeing 747SP. Ames manages the project.
[20] The Boeing 757 is a flying laboratory for aeronautical research. NASA has modified the aircraft for a broad range of flight research programs and uses the aircraft to conduct research to increase aircraft safety, operating efficiency, and compatibility with future air traffic control systems. The Langley Research Center maintains and flies the Boeing 757.

Improved management controls for addressing recommendations to perform IV&V, based on independent assessments, are needed to ensure that program and project managers adequately address software development risks through IV&V. Without such controls, the value added by the independent assessment process may not be realized.

Use of Software Metrics

The Agency has not collected, analyzed, or reported software metrics as required by NPD 2820.1. The NPD requires the IV&V Facility to collect and analyze metrics and to submit an annual report on Agency software policies and practices to the NASA EMC. The Directive further requires the governing PMC's to review software processes and products and to provide the results to the IV&V Facility. The Directive references unpublished NASA Policy Guidelines 2820[21] for specific responsibilities related to collecting, analyzing, and reporting software metrics. Further, the Directive does not identify the types of information that should be included in the annual report and does not address how the IV&V Facility or NASA management should use the information. Guidelines for collecting, analyzing, and reporting software metrics are needed to help the Agency meet NPD 2820.1 software metric requirements.

In the May 10, 2000, memorandum on NASA's initiative to improve the quality and safety of software, the CIO, Chief Engineer, and Associate Administrator for OSMA addressed software metrics as an important part of the initiative. The metrics currently required are presented on page 3 of this report. Beginning with the second half of FY 2001, program and project managers will be required to collect and report software metrics. The memorandum states the SWG will analyze the metrics. Subsequently, the Deputy Chief Engineer stated that the IV&V Facility will collect and analyze the metrics and provide the results to the SWG. The NASA official further stated that the SWG has begun reevaluating the metrics to ensure that NASA has identified the appropriate software metrics to be collected.

While NASA's recent actions represent important steps to improving software policies and procedures, NASA should ensure that it develops and issues policy guidelines for collecting, analyzing, and reporting appropriate software metrics. Without the guidelines, the requirement for collecting, analyzing, and reporting software metrics may remain unmet and Agencywide software policies and procedures will lack adequate visibility.

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[21] Until recently, the CIO, Chief Engineer, and Associate Administrator for OSMA had not determined whether NASA would issue NPG 2820 (title not known). As part of NASA's actions to improve software policies and procedures, the NASA managers have determined that the NPG will be issued.

Recommendations, Management's Response and Evaluation of Response

1. The NASA CIO, in collaboration with the NASA Chief Engineer and Associate Administrator for OSMA, should establish procedures for evaluating the adequacy of program and project managers' actions in implementing the interim IV&V criteria and conduct evaluations, as appropriate.

Management's Response. Concur. The Goddard Office of System and Mission Assurance issued an IV&V Interim Policy. The policy states that all projects meeting defined criteria will document and implement a plan that addresses the performance of IV&V during software development. The Goddard Office of Systems Safety and Mission Assurance is leading the development of a NASA policy document for IV&V. The document is sponsored by the NASA OSMA and will be in the initial stage of the NASA Directives Management review cycle by October 31, 2000. The complete text of management's response is in Appendix C.

Evaluation of Management's Response. Management's ongoing and planned actions are partially responsive to Recommendation 1. However, management's actions discussed regarding Recommendation 2 below describe additional actions that effectively meet the intent of Recommendation 1. Recommendation 1 is resolved but will remain undispositioned and open pending the final issuance and implementation of an NPD relating to the use of IV&V in NASA's software development projects.

2. The NASA CIO, in collaboration with the NASA Chief Engineer and Associate Administrator for OSMA, should issue guidelines for IV&V Facility review of programs and projects with significant software applications; for implementing recommendations to perform IV&V; and for collecting, analyzing, and reporting software metrics.

Management's Response. Concur. On June 28, 2000, NASA's SWG released the criteria for assessing project software risk and for determining the necessity for IV&V. About 100 NASA projects under development and not currently implementing IV&V applied the criteria during August 2000. The projects sent the results to the IV&V Facility for it to determine the necessity to implement IV&V. The IV&V Facility used the results to develop an initial list of projects that should have IV&V. Personnel from the IV&V Facility are in the process of meeting with the projects identified for application of IV&V in order to determine the necessary level of IV&V and to develop implementation plans. These initial meetings will be completed by December 31, 2000. IV&V activities on identified projects will be initiated during FY 2001 and fully under way on all projects by the end of FY 2001.

The draft NPD for IV&V specifies that, in their planning stages, all new software projects shall determine the need for IV&V. The issuance of the NPD will formalize this requirement.

Regarding the need for software metrics guidelines, in July 2000, the SWG released a set of metrics applicable to all NASA software development programs. The IV&V Facility will analyze the metrics over a 12-month period. When this period concludes in October 2001, the

Facility will use these analyses to determine whether the metrics collected satisfy the objectives of the metrics program. If the results indicate changes are needed in the metrics set, the SWG will reevaluate the metrics and make necessary changes to the set of metrics to be collected. Metrics collection will begin on all projects as specified in NPD 2820.1 starting October 2001.

Evaluation of Management's Response. The actions ongoing and planned are responsive to the recommendation. The recommendation is resolved but will remain undispositioned and open pending final issuance and implementation of the NPD for IV&V and implementation of software metrics for all projects.

Appendix A. Objectives, Scope, and Methodology

Objectives

The overall audit objective was to determine whether NASA has exercised effective software quality assurance. Specifically, we were to determine whether selected software development projects had complied with applicable software quality assurance standards and procedures related to project planning, acceptance-level testing, and reporting. Due to the importance of independent verification and validation (IV&V) in the software assurance process, we limited our review to determining whether:

- the Agency established adequate guidelines for using IV&V during the software life cycle;

- program and project managers had implemented recommendations to perform IV&V; and

- software metrics were being collected, analyzed, and reported in accordance with NPD 2820.1.

A future audit will include the review of software quality assurance standards and procedures.

Scope and Methodology

We limited our review to NASA's use of IV&V when developing software for NASA programs and projects. We performed the following:

- Reviewed applicable policy directives, guidelines, guidebooks, standards; reports and presentations; and other documentation to gain an understanding of NASA processes and procedures for software assurance.

- Identified NASA programs and projects for which IV&V and independent assessments had been performed (by the IV&V Facility and Goddard) to determine the extent of IV&V performed.

- Interviewed NASA officials at Headquarters, Ames Research Center (Ames), Goddard Space Flight Center (Goddard), the Jet Propulsion Laboratory, Johnson Space Center (Johnson), Langley Research Center (Langley), and the IV&V Facility to determine their roles and responsibilities in the software assurance area.

Management Controls Reviewed

We reviewed management controls for determining whether program and project managers should incorporate IV&V into their software development projects. NASA had not established the management controls for determining whether to use IV&V; for implementing independent assessment recommendations; and for collecting, analyzing, and reporting software metrics.

Audit Field Work

We performed audit field work from October 1999 through August 2000 at NASA Headquarters, the IV&V Facility, Ames, Goddard, Johnson, the Jet Propulsion Laboratory, and Langley. We conducted the audit in accordance with generally accepted government auditing standards.

Appendix B. NASA Programs and Projects
Supported by the IV&V Facility
June 1994 – July 2000

Program/Project	Status of Work by Independent Verification & Validation (IV&V) Facility		
	Independent Assessment	Software & System Engineering Tasks (SET)	IV&V
Advanced Air Transportation Technology	Not performed	Work ongoing	Not applicable
Blended Wing Body Low Speed Vehicle	Independent assessment completed	Agreement for SET being negotiated	Not applicable
Boeing 757 New Display Simulation	System software assessment completed	Not performed	Recommendations for IV&V not implemented [1]
Cassini	Not performed	Life-cycle process assessment completed	Not performed
Checkout Launch and Control System	Criticality assessment completed—lead to IV&V	Not performed	IV&V ongoing
Earth Observing System Data Information System	Not performed	SET completed—leading to IV&V	IV&V ongoing
Gravity Probe-B	Not performed	SET ongoing with negotiations to expand tasks	Not applicable
Hyper-X	Completed independent assessment—lead to SET	SET ongoing	Not applicable
Integrated Asset Management	Not performed	Not performed	IV&V ongoing
Integrated Financial Management Program	Not performed	Not performed	IV&V ongoing

[1] The project manager determined that IV&V activities were not needed and that verification and validation activities adequately mitigated project risks.

Appendix B

Program/Project	Status of Work by Independent Verification & Validation (IV&V) Facility		
	Independent Assessment	Software & System Engineering Tasks (SET)	IV&V
International Space Station	Not performed	Not performed	IV&V ongoing
Mars Surveyor Program 1998	Criticality risk assessment completed	SET completed	Recommendations for IV&V not implemented[2]
Mars 2001/Genesis	Not performed	Agreement to perform SET being negotiated	Not applicable
Mission Control Center	Independent assessment completed	Not performed	Not performed
National Polar-orbiting Operational Environmental Satellite System	Not performed	SET ongoing, and recommendations for IV&V anticipated	Agreement for IV&V to be negotiated, as appropriate
Picasso-Cena	Independent assessment completed	Not performed	Project identified as a candidate for future IV&V
Production Support Flight Control Computers	Not performed	SET completed	Not performed
Small Spacecraft Technology Initiative/Clark	Independent assessment completed	Not performed	Not performed— launch delayed, and project later cancelled
Space Shuttle	Not performed	Not performed	IV&V ongoing
Space Shuttle Upgrade	Not performed	Not performed	IV&V ongoing
Space InfraRed Telescope Facility	Independent assessment is ongoing	Not applicable	Not applicable

[2] The project manager determined that IV&V activities were not needed and that verification and validation activities adequately mitigated project risks.

Program/Project	Status of Work by Independent Verification & Validation (IV&V) Facility		
	Independent Assessment	**Software & System Engineering Tasks (SET)**	**IV&V**
Stratospheric Aerosol and Gas Experiment III	Independent assessment is ongoing	Not applicable	Not applicable
Stratospheric Observatory for Infrared Astronomy	Independent assessment completed	Not performed	Agreement for IV&V being negotiated [3]
X-33	Not performed	Not performed	IV&V ongoing
X-34	Independent assessment completed—SET recommended	SET ongoing	Not applicable
X-37	Not performed	Not performed	Negotiating agreement for IV&V
X-38	Not performed	Not performed	Negotiating agreement for IV&V

[3] The project initially determined that IV&V was not needed. Subsequently, the project determined that the IV&V Facility would perform IV&V. The Facility and project are negotiating an agreement for the IV&V.

Appendix C. Management's Response

National Aeronautics and
Space Administration
Headquarters
Washington, DC 20546-0001

NASA

Reply to Attn of   QS

SEP 2 5 2000

TO: W/Assistant Inspector General for Auditing

FROM: Q/Associate Administrator for Safety and Mission Assurance

SUBJECT: Draft Report on Audit of Software Assurance
             Assignment Number A9906600

As you requested in your August 23 letter to the Chief Engineer, the Chief Information
Officer, and me, enclosed is our consolidated response to subject report.

NASA concurs with the findings in the OIG report and is pleased that these OIG findings
parallel and validate potential improvements independently identified by NASA Headquarters
during the early part of CY 2000. The Agency is taking aggressive action to correct
shortcomings and improve the implementation of independent verification and validation
throughout NASA.

Thank you for the opportunity to include our comments in the final report.

Frederick D. Gregory

Enclosure

cc:
AE/Mr. Keegan
AO/Mr. Holcomb
JM/Mr. Werner
GSFC/100/Mr. Diaz

NASA Response to NASA Office of Inspector General (OIG) Draft Audit Report on
"Software Assurance" dated August 23, 2000 (A9906600)

We appreciate the opportunity to provide our written response to the draft report on "Software Assurance" (A9906600).

The implementation of Independent Verification and Validation (IV&V) is critical to the safety, productivity, and success of NASA missions. NASA recognizes the importance of the appropriate use of IV&V by Agency programs. To strengthen this function within the Agency, NASA transferred the management of its West Virginia IV&V Facility to the Goddard Space Flight Center in July. This action will enable the IV&V Facility to better capitalize on the synergy that comes from affiliation with a field center that is intimately involved in mission development activities that are very dependant on software for success. In conjunction with this management transfer, NASA undertook many other activities to strengthen IV&V.

NASA concurs with the findings in the OIG report and is pleased that these OIG findings parallel and validate potential improvements independently identified by NASA Headquarters during the early part of CY 2000. The Agency has already taken aggressive action to correct shortcomings and improve the implementation of IV&V throughout NASA. The Agency is well on its way to accomplishing the objectives of the OIG report.

OIG Recommendation:
1. **The NASA CIO, in collaboration with the NASA Chief Engineer and Associate Administrator for OSMA, should establish procedures for evaluating the adequacy of program and project managers' actions in implementing the interim IV&V criteria and conduct evaluations as appropriate.**

Response: CONCUR

Actions Completed
- The Agency, through the GSFC Office of System Safety and Mission Assurance (OSSMA), wrote and released an IV&V Interim Policy Interpretation. This Policy Interpretation was released in the IV&V Facility Business Plan, June 2000. The policy states that all projects meeting defined criteria will document and implement a plan that addresses the performance of IV&V.
- In a July 20, 2000, letter to all NASA software projects, NASA's Chief Engineer provided the authority to strengthen the interpretation and application of NASA's IV&V Policy.

Actions in Process
- The Director of GSFC Code 300, Office of Systems Safety and Mission Assurance, Charles Vanek, is leading the development of the NASA Policy Document (NPD) for IV&V. We expect this Code Q sponsored document to be in the initial stage of the NASA Directives Management review cycle by October 31, 2000.

Actions Planned
- NASA Headquarters will coordinate, approve, and issue an NPD on IV&V through the Directives Management System.

OIG Recommendation:
2. **The NASA CIO, in collaboration with the NASA Chief Engineer and Associate Administer for OSMA, should issue guidelines for IV&V Facility review of programs and projects with significant software applications; for implementing recommendations to perform IV&V; and for collecting, analyzing and reporting software metrics.**

Response: CONCUR

A. The following addresses creating guidelines for IV&V Facility review of programs and when to perform IV&V:

Actions Completed
- On June 28, 2000, NASA's Software Working Group (SWG), under the authority of the Office of the Chief Engineer, released the criteria for assessing project software risk and determining the necessity for IV&V. The criteria facilitate the evaluation of the project's risk based on: the probability of failure (determined using software development factors) and the consequence of software failure (derived from the purpose of the software). The combination of probability and consequence yields a risk assessment that is used to identify the need for IV&V and the necessary level of IV&V.
- NASA projects under development and not currently implementing IV&V (approximately 100) applied the criteria during August 2000. The projects sent their results to the IV&V Facility for the Facility to determine the necessity to implement IV&V.
- IV&V Facility personnel used the above information to develop an initial list of projects that should have IV&V. They included the list in the draft NASA IV&V Facility Program Plan. This draft is currently under HQ review and will be published within 30 days.
- Review of the remaining projects will be conducted during the course of the following year.

Actions in Process
- Personnel from the NASA IV&V Facility are meeting with the projects identified for application of IV&V in order to determine the necessary level of IV&V and to develop implementation plans. These initial meetings will be completed by December 31, 2000.
- IV&V activities on identified projects will be initiated during FY01 and fully underway on all projects by the end of FY01.

Actions Planned
- The draft NPD for IV&V specifies that, in their planning stages, all new software projects shall determine the need for IV&V. The issuance of the NPD will formalize this requirement.

2   Enclosure

B. The following addresses guidelines for collecting, analyzing, and reporting software metrics:

Actions Completed
- In July 2000, the SWG released a set of metrics applicable to all NASA software development programs. This set of metrics is posted on the NASA IV&V Facility website.
- Per NPD 2820, "NASA Software Policies," the NASA IV&V Facility is responsible for the management of the metrics collection. Working in conjunction with the SWG, the NASA IV&V Facility developed a website and database for metrics collection.

Actions in Process
- In August 2000, NASA initiated through the SWG a 12-month pilot program. In this pilot, two projects from each NASA Center are to collect and report metrics to the IV&V Facility. Metrics will be entered for three consecutive quarters, starting October 1, 2000 (which will report the metrics for July, August, and September 2000). The last three months of the pilot program will be used to evaluate the metrics and write a formal assessment report.

Actions Planned
- The IV&V Facility is responsible for the analyses of the metrics collection process and the value of the data collected. The IV&V Facility will report the progress of the analyses to the SWG on a quarterly basis and to AA/OSMA during its bi-monthly General Management Review.
- When the 12-month metrics pilot program concludes in October 2001, the IV&V Facility will use these analyses to determine if the metrics collected satisfy the objectives of the metrics program. If the results indicate changes are needed in the metrics set, the SWG will re-evaluate the metrics and make necessary changes to the set of metrics to be collected. Metrics collection will begin on all projects as specified in NPD 2820 starting October 2001.
- The initial set of metrics will be listed in Section 4 of the interim NASA Policy Guideline (NPG) for NPD 2820. Goddard Space Flight Center will suggest a draft NPG to the NASA Headquarters in November 2000 for review and approval using NODIS.

3   Enclosure

Appendix D. Report Distribution

National Aeronautics and Space Administration (NASA) Headquarters

A/Administrator
AE/Chief Engineer
AI/Associate Deputy Administrator
AO/Chief Information Officer
B/Chief Financial Officer
B/Comptroller
BF/Director, Financial Management Division
C/Associate Administrator for Headquarters Operations
G/General Counsel
H/Associate Administrator for Procurement
HK/Director, Contract Management Division
HS/Director, Program Operations Division
J/Associate Administrator for Management Systems
JM/Acting Director, Management Assessment Division
L/Associate Administrator for Legislative Affairs
M/Associate Administrator for Space Flight
Q/Associate Administrator for Safety and Mission Assurance
R/Associate Administrator for Aerospace Technology
S/Associate Administrator for Space Science
U/Associate Administrator for Life and Microgravity Sciences and Applications
Y/Associate Administrator for Earth Science
Z/Associate Administrator for Policy and Plans

NASA Centers

Director, Goddard Space Flight Center
  Acting Director, NASA Independent Verification and Validation Facility
Chief Counsel, John F. Kennedy Space Center
Director, Jet Propulsion Laboratory
Director, Lyndon B. Johnson Space Center
Director, Langley Research Center

Non-NASA Federal Organizations and Individuals

Assistant to the President for Science and Technology Policy
Director, Office of Management and Budget

Non-NASA Federal Organizations and Individuals (Cont.)

Deputy Director of Management, Office of Management and Budget
Deputy Associate Director, Energy and Science Division, Office of Management and
  Budget
Branch Chief, Science and Space Programs Branch, Energy and Science Division, Office
  of Management and Budget
Professional Assistant, Senate Subcommittee on Science, Technology, and Space

**Chairman and Ranking Minority Member – Congressional Committees and
Subcommittees**

Senate Committee on Appropriations
Senate Subcommittee on VA, HUD, and Independent Agencies
Senate Committee on Commerce, Science, and Transportation
Senate Subcommittee on Science, Technology, and Space
Senate Committee on Governmental Affairs
House Committee on Appropriations
House Subcommittee on VA, HUD, and Independent Agencies
House Committee on Government Reform
House Subcommittee on Government Management, Information, and Technology
House Subcommittee on National Security, Veterans Affairs, and International Relations
House Committee on Science
House Subcommittee on Space and Aeronautics, Committee on Science

Congressional Member

Honorable Pete Sessions, U.S. House of Representatives

NASA Assistant Inspector General for Auditing
Reader Survey

The NASA Office of Inspector General has a continuing interest in improving the usefulness of our reports. We wish to make our reports responsive to our customers' interests, consistent with our statutory responsibility. Could you help us by completing our reader survey? For your convenience, the questionnaire can be completed electronically through our homepage at http://www.hq.nasa.gov/office/oig/hq/audits.html or can be mailed to the Assistant Inspector General for Auditing; NASA Headquarters, Code W, Washington, DC 20546-0001.

Report Title: _____

Report Number: _____   Report Date: _____

Circle the appropriate rating for the following statements.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	N/A
1. The report was clear, readable, and logically organized.	5	4	3	2	1	N/A
2. The report was concise and to the point.	5	4	3	2	1	N/A
3. We effectively communicated the audit objectives, scope, and methodology.	5	4	3	2	1	N/A
4. The report contained sufficient information to support the finding(s) in a balanced and objective manner.	5	4	3	2	1	N/A

Overall, how would you rate the report?

Excellent   Fair
Very Good   Poor
Good

If you have any additional comments or wish to elaborate on any of the above responses, please write them here. Use additional paper if necessary. _____

_____

_____

_____

How did you use the report? _____

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How could we improve our report? _____

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How would you identify yourself? (Select one)

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May we contact you about your comments?

Yes: _____   **No:** _____

Name: _____

Telephone: _____

Thank you for your cooperation in completing this survey.

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