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THE ROLE OF INDEPENDENT ASSESSMENT IN THE INTERNATIONAL SPACE STATION PROGRAM

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This paper presents the role of Independent Assessment in the International Space Station (ISS) Program. Independent Assessment is responsible for identifying and specifying technical and programmatic risks that may impact development, launch, and on-orbit assembly and operations of the ISS. The various phases of the assessment process are identified and explained.

This paper also outlines current and future participation by Independent Assessment in Human Exploration and Development of Space projects including the X-38 Space Plane , Mars mission scenarios, and applications of Nanotechnology.

This paper describes how Independent Assessment helps the shuttle, ISS, and other programs to safely achieve mission goals now and into the next century.

INTRODUCTION AND BACKGROUND

This paper presents the role of Independent Assessment (IA) in the International Space Station Program (ISSP). This overview also identifies, describes, and explains future plans for IA involvement in the Human Exploration and Development of Space (HEDS) initiatives.

The International Space Station (ISS) is a multidisciplinary laboratory, testbed, and observatory that will provide unprecedented opportunities in technology and scientific experimentation. The ISS requires that design, hardware, logistics, management, and operations all be integrated. For a mission of this grand scale, some of the ISS assembly elements will be the heaviest cargo items ever sent into space. The ISS assembly requires an unprecedented number of Extra Vehicular Activities (EVA), rendezvous and docking, and robotic remote manipulator system activities. There will be many new challenges inherent in assembling the most complex space structure ever created.

Beginning in 1994, IA activities have been focused on assuring the safety and integrity of the ISS while attaining mission objectives. IA is responsible for identifying and specifying technical and programmatic risks that may impact successful ISS development, launch, and on-orbit assembly and operations. The IA Director reports directly to the Office of Safety and Mission Assurance (S&MA) at NASA Headquarters.

IA assessments provide inputs to the ISSP decision making process by identifying key risks in a timely fashion. IA contributes unbiased evaluations based on analysis and testing. They focus on technical issues rather than Program budget or schedule concerns.
Customers include ISSP managers, the NASA Administrator, and other NASA senior managers.

Our Vision and Mission

The Independent Assessment organization is recognized as a proactive, technically proficient team that provides meaningful, timely, candid assessments that are relevant to the success of the ISSP.

RISK MANAGEMENT

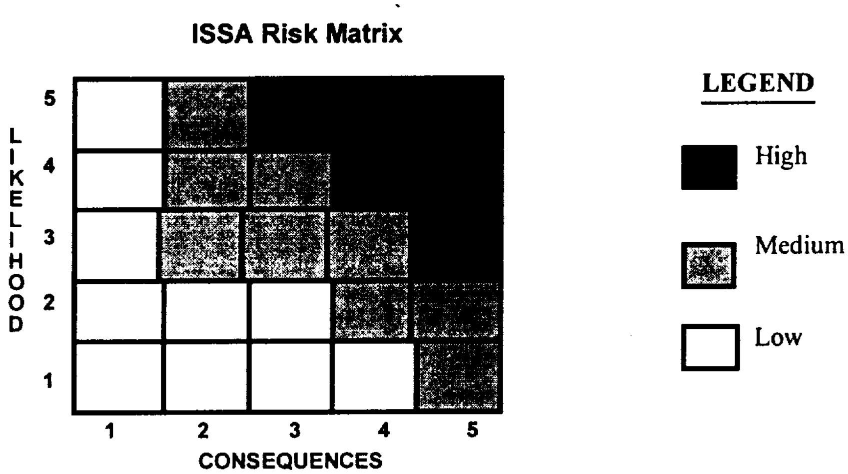
A primary objective of Independent Assessment is to assist the ISSP in risk management and mitigation. Risk management is an organized, systematic decision-making process that effectively identifies risks, assesses or analyzes risks, and effectively reduces or eliminates risks to achieve program goals.

A risk is an undesirable situation or circumstance that has both a probability of occurring and a potential consequence to program success.

Table 1 (see appendix) defines risk factor values for likelihood and consequence. Likelihood is the chance a situation or circumstance will happen. Consequence is the magnitude of the impact if the condition occurs. Figure 1 is a diagram of the ISSP risk matrix display.

Figure 1

ISSP Risk Matrix



This 5-by-5 matrix has three risk zones labeled as high, medium, and low. These zones are defined as follows:

High Risk – Likely to cause significant and/or serious disruption of schedule, increase in cost, or degradation of performance even with special contractor emphasis and close monitoring.

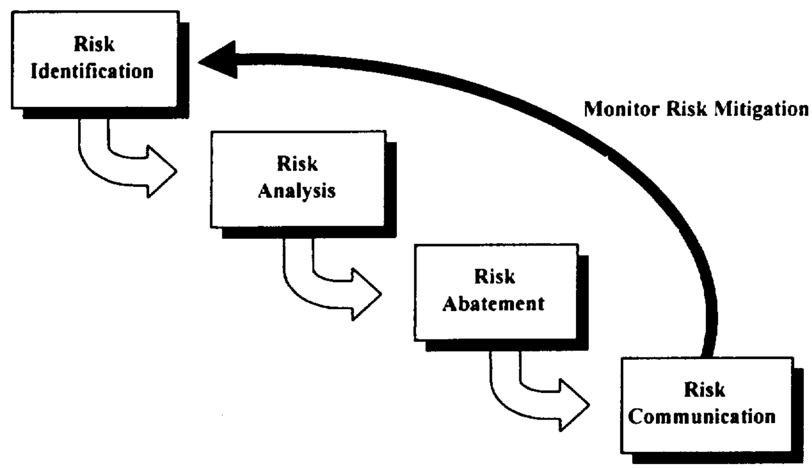
Medium Risk – Potentially can cause some disruption of schedule, increase in cost, or degradation of performance; however, special contractor emphasis and close monitoring will probably be sufficient to overcome difficulties.

Low Risk – Little or no potential for disruption of schedule, increase in cost, or degradation of performance; normal contractor effort and normal monitoring will probably be sufficient to overcome difficulties.

The risk level is determined from the likelihood and consequence values. Table 2 (see appendix) defines IA categories of identified risks.

Figure 2

Risk Management Flow Chart



The flow of ISS Program risk management, as shown in Figure 2, is comprised of 5 steps:

1) Risk Identification – What key technical area or process is at risk?
2) Risk Analysis – Determine the root cause of the risk. Quantify your risks by determining the likelihood of an event and the potential consequence to the ISS.
3) Risk Abatement – What can you do about a risk? Identify possible solutions. Next, develop a mitigation/contingency plan or accept the risk.
4) Risk Communication – Provide status of the risks on a regular basis (done monthly for ISS)
5) Monitor progress of the risk mitigation

FLIGHT LEADS AND SYSTEM SPECIALISTS

A Flight Lead in the IA organization is responsible for all technical aspects associated with a particular flight/mission in the Assembly Sequence. The purpose of the missions vary from delivering ISS hardware elements to orbit, assembly support, or resupply by an International Partner/Participant. A Flight Lead is the IA expert and Point-of-Contact for specific questions about a particular flight. The Flight Leads act in a consulting role to the Independent Assessment Office. They identify and track issues, problems, and risks associated with their flight. Currently, there is a Flight Lead for ISS 2A.1 through 7A.

System Specialists from Operations, Test and Verification (T&V), Thermal and Structures, and Environmental/EVA teams provide information and data to each Flight Lead. They are the expert and Point-of-Contact for specific questions for a particular subsystem or process.

Flight Leads and System Specialists use the Risk Assessment Matrix to define the level of risks associated with a flight. This information is maintained in the IA Risk Database that is located on the IA Web Home Page. Each Flight Lead also maintains a weekly and monthly health summary for their mission. Inputs are provided from each of the Operations and System

Specialist disciplines and integrated by the Flight Lead. An example from Flight 2A.1 is displayed in Figure 3 (see Appendix).

ELEMENTS IN THE TECHNICAL ASSESSMENT PROCESS

The phases of the assessment process include:

a) Planning the Assessment
b) Performing the Assessment
c) Documenting the Assessment
d) Tracking Implementation of Recommendations.

The Assessment Proposal

All technical areas of the Program are reviewed and evaluated for potential assessment. The assessment proposal defines the purpose, approach, and scope of an assessment. It identifies what parameter, question, or measure will be evaluated to meet the objective of the assessment.

Performing an Assessment

Performing an assessment involves gathering data and information on the subject. This research may include reviewing documentation, attending various meetings, panels, or forums, circulating questionnaires, and conducting interviews with a wide variety of personnel. IA personnel may perform their own test or analyses. These facts and calculations are used in determining if defined criteria are met. They provide the basis for developing IA findings and recommendations. These findings lead to conclusions about the adequacy or risk of the subject that evolve into recommendations.

Presentation of IA Results, Findings and Recommendations

Findings and recommended actions based on results of an assessment are coordinated with the Program through an assigned Point-of-Contact. A response to these findings and recommendations is provided by Program personnel from the area associated with the assessment topic. The assessment author then tracks implementation of the recommendations. In some cases the recommendations and proposed resolution may also be presented to a Program board or panel overseeing the subject of the assessment.

Certificate of Flight Readiness Input

IA participates in the ISSP Certificate of Flight Readiness (CoFR) Review. CoFR is the culmination of a continuous process of Program review and evaluation of the ISS requirements, design implementation, mission planning, and processes. CoFR is conducted to determine if the hardware, software, procedures, training, and technical support is ready for flight. It certifies the on-orbit stage and operations readiness for each flight. The IA participation in CoFR is iterative including assessments of specific topics to participation in ISSP forums with real time decisions. It includes flight-related assessments, tracking Program risks, and participation in various Program meetings. Risks identified as a result of IA activity are worked both formally and informally with the Program. Flight Leads track risks for each flight to support the CoFR decision. Status of flight risks are updated by interim reports, presentations, and status briefings at specific times to support earlier CoFR reviews. Signature by the IA Manager who represents the IA Director to the ISS Program signifies concurrence that IA activity has revealed nothing that will preclude safe and successful launch and on-orbit operations.

RECENT CONTRIBUTIONS

Topics of recent assessments include:

a) Lessons Learned from ISS Phase 1
b) Space Vision System
c) Electrical Power System ORUs and System Performance Concerns
d) ISS Truss Segment P6 Thermal Dissipation
e) Structural Analysis of the X-38 Spaceplane Parafoil
f) ISS and Joint ISS/Shuttle Flight Rules
g) Shuttle Readiness to Support ISS Assembly Flights 2A through 7A
h) Problem Reporting and Corrective Action System for the ISSP
i) ISS Government Furnished Equipment
j) Reliability and Maintainability of ISS Critical Items

INDEPENDENT VERIFICATION AND VALIDATION

The Software Independent Verification and Validation (IV&V) group within the IAO is responsible for assessment of mission critical software to ensure adequate performance and reliability. This includes a variety of activities from requirements development phase through formal qualification testing and follow-on integration testing.

IV&V is a process whereby the products of the software development life cycle phases are independently reviewed, verified, and validated by an organization independent of the developers and acquirers of the software. These activities are accomplished on the U.S. segments for designated catastrophic, critical, or high risk software systems. IV&V employs a Criticality Analysis and Risk Assessment (CARA) to identify which components of the function in question require IV&V and to what extent. Criticality is a measure of the potential impact to the program of an error in the specification or implementation of a function. Risk is a measure of the likelihood of occurrence of such an error. The CARA then serves as a quantitative aid to the effective allocation of IV&V resources.

The ISS will be developed and assembled in stages. Each stage is a complete, self-contained operating vehicle. For this reason, the stage aspects of development are an important concept in the ISS IV&V plan. IV&V activities are repeated for each stage or group of stages.

Contributions from NASA Centers

Analysts are resident at the Johnson Space Center, Kennedy Space Center, and Marshall Space Flight Center to support assessments at these sites. Lewis Research Center personnel perform parallel activities for Boeing in Huntington Beach and Canoga Park. Other IA members are located at NASA Headquarters in Washington, D.C. and the IV&V facility at Fairmont, W.V.

Safety Review Panel and ISO 9000

A representative from the Independent Assessment Team is a voting member of the ISS Safety Review Panel (SRP). This group evaluates potential safety hazards associated with the assembly or operation of the ISS. The IA representative discusses potential hazards with the Flight Leads and addresses their issues and concerns to the panel.

Since NASA/JSC is ISO 9000 certified, IA follows the process in place for documentation and performance of its activities.

Integration of OnOrbit Assembly and Operations

Effective October, 1998, the Independent Assessment Office became responsible for independent assessments of the Space Shuttle Program. One of the greatest challenges is to overcome the non-integrated problems between shuttle and station especially with on-orbit assembly and operations. Towards this goal, IA is performing an assessment that examines the processes for S&MA early involvement on late Shuttle and Space Station changes. This evaluation was an outcome of the STS-96/ISS2A.1 flight. On that mission, the biggest challenge was keeping abreast of the late manifest revisions and an unsettled timeline.

IA was instrumental in devising a test plan for OSVS operations from the ground while the crew slept. This approach minimized the amount of crew time and involvement in the DTO on a flight that was already heavily "booked" in terms of crew timeline and workload.

Threats and concerns that IA are tracking for STS-101/ISS 2A.2 include:

a) Crew concern about number, priority, procedures, and training for EVA and IVA installation tasks and hardware
b) On-orbit stowage shortfall
c) Definition of Orbiter Space Vision System test requirements
d) Noncompliance of Service Module acoustics including the Treadmill with Vibration Isolation and Stabilization (TVIS)
e) Service Module Outfitting
    - Enough time for installation tasks and logistics stowage?
    - Enough crew participation in developing procedures and training actual tasks in a flight rated vehicle
    - Lack of high fidelity mockup
    - Installation tasks : list of tasks complete? Timely?
    - Tools – integration and management of SS, ISS, and Russian tools for installation tasks
f) Stowage and Installation Integration – highly dependent on each other
g) EVA – Lack of integration between various US and Russian groups for training plans, hardware testing, procedures, and timelining further hindered by a lack of perspective and authority to implement action
h) EVA – tasks are performed in priority order but not necessarily the most efficient method and may increase overall risk
i) EVA – a very compressed schedule for EVA task development, testing, and training with much of it performed in Russia
j) the risk of having to unman the station after crew arrival for the first system failure, or a failure to get critical systems activated within the consumables reserves, or depleting your contingency reserves before you have even started the increment

In general, many late changes to 2A.1 and 2A.2 manifests and tasks, plus late receipt of hardware and certification data raise concerns for adequate review, training and overall mission planning requiring oversight by NASA and Boeing

A summary of the major concerns are listed below for each of the follow-on flights:

3A – determine operational and attitude constraints for Launch-to-Activation operations
4A – Full impact of thermal environment on ORUs not known
5A – Software issues, berthing operations concerns, and numerous hardware problems must be surmounted.
5A.1 – Free drift constraints are undefined.
6A – Incomplete definition of tasks to be performed on ISS 5A.1 and 6A
7A – GFE : various problems with the Battery Charge Assembly, Power Supply Assembly, and Collapsible Water Reservior.
Interim Control Module – Will it fly? RF antenna and Star Tracker thermal failures

Human Exploration and Development of Space and the Future

Early in the next Century, NASA plans to return to the Moon and explore Mars and beyond. Current and future plans for IA's involvement in HEDS include the X-38 Crew Return Vehicle, X-34 Reusable Launch Vehicle, various Lunar and Mars mission scenarios, and applications of Nanotechnology. IA will support the HEDS requirements for developing new technologies while mitigating risks. HEDS provides a valuable springboard to design, develop, test, and evaluate the technologies that will make these missions possible. The next generation of planetary explorers has begun to fly aboard the Shuttle today.

Unique Contributions and Value to Customer

IA provides the following contributions to their customers through its assessments:

a) Provides management with an objective review and unbiased perspective of Program activities
b) Provides a means for checks and balances of decisions
c) Provides a technical expertise to assist with special problems
d) Ensures the Program is operating safely and competently by challenging designs, requirements, processes, and products
e) Insulated from most budget, schedule, or political influences

Added value to the Program from these contributions comes in the form of improved processes, training, maintenance, mockups or simulations, data or information flow, or flight systems. Thus, greater confidence is established in mission safety and integrity .

World Wide Web Site

For more information on IA, see this web site: wwwsrqa.jsc.nasa.gov/ia/HEDS.htm. Note this site is not accessible to the public. Access may be granted on an individual need basis.

SUMMARY AND CONCLUSION

IA establishes confidence in the safety and mission integrity of NASA programs and projects. It identifies problems or issues that might otherwise go unnoticed until they result in a mishap or failure. These services help prepare the Program to safely operate the shuttle and develop, assemble, and operate the ISS to achieve mission goals and success now and into the next century.

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JSC 27771	ISS IA CoFR Implementation Process Plan (July 1997)
NQ1-ASM-001	Planning and Proposal Development for an Assessment (3/98)
NQ1-ASM-002	Performing an Assessment and Generating the Report (3/98)
SAIC Class Notes	The Technical Assessment Process and Measures of Merit (1998)

Table 1

Likelihood vs. Consequence

Likelihood	**Consequence**
0 - Not Credible	0 - None
1 - Extremely Unlikely	1 - 1st Aid Injury; Loss of ORU (small number, recoverable); may require alternative procedure
2 - Unlikely	2 - Injury (can function in most tasks); some short term loss of mission capability; requires extra EVA, IVA, etc.
3 - 50/50 Chance	3 - Injury (treatable on-orbit but not fully capable); <50% loss mission capability (recoverable); cannot complete assembly tasks (deferred completion)
4 - Probable	4 - Severe Injury / minor permanent disability (requires evacuation); Loss of element / Loss of > 50% Mission capability (recoverable); Inability to assemble a given element (return to earth for repair)
5 - Will Occur	5 - Death/Permanent Severe Disability; Loss of ISS/Capability (non-recoverable); Inability to continue assembly

Table 2

IAO Categories of Identified Risks

Unacceptable Risk. A safety / mission success risk designated by the IA Manager to be an exception to the ISS Certification of Flight Readiness (CoFR). The ISS Program mitigation plan will not likely resolve the risk by the launch date.

Potentially Unacceptable Risk. A safety / mission success risk that may be elevated to an unacceptable status in the future. This risk will be classified as either an issue or a concern. An issue is a risk that IA believes is either not being addressed by the Program or has a defined mitigation plan that is inadequate or is not being implemented adequately. A concern is a risk that the Program acknowledges and IA believes has an adequate mitigation plan which is being implemented (if enough time has elapsed since the risk was identified).

Watch Item. A safety / mission success risk which IA does not expect to raise to an unacceptable status because the Program has a credible mitigation plan in place which is reasonably on schedule and results are good. This risk is serious enough to warrant tracking to completion.

Acceptable Risk. A safety / mission success risk which IA does not expect to raise to an unacceptable status because either it has low likelihood and consequence scores or it has a high score but IA agrees with the Program's risk acceptance rationale.

Closed Risk. A safety / mission success risk which IA believes has been resolved. Only the risks closed since the previous review are identified within this presentation package.

Figure 3

Flight 2A.1 Status

Team	Status	Remarks
Electrical Power Systems		• No Known Issues
Engineering	Y	• Removal & reinstallation of Common Berthing Mechanism (CBM) controllers in PMA-2 is a concern based on past experience and performance • Sequential Shunt Unit in rework
International Partner/Participant		• 98% of drawings of Russian H/W delivered for Stowage planning
Launch Processing Integration		• 1 week slip in launch date to May 20 due to STS-93/AXAF but no technical impact
Operations	Y ↑	• Late manifest revisions and unsettled manifest • Procedure for controlling the FGB (without Service Module) during docking operations with an APAS lacks detail (software patch in work) • Stowage Layout presented at Jan. 26 SDOM showed positive (10 – 15 Middeck Locker Equivalent) margin
Payloads	Not App	
Safety		• No Known Issues
Shuttle Integration		• No Known Issues
Software	Y	• Orbiter Space Vision System (version 4.2) : late delivery may adversely affect quality of training
Systems	Y ↑	• Questionable reliability of CBM controllers after reinstallation
Test and Verification		• No Known Issues (100% of T&V requirements submitted to NASA)
Thermal/Structures		• No Known Issues
Mission Integration	Y ↑	• Late manifest revisions and unsettled manifest continue but no technical impact

G Acceptable - Credible mitigation plans are in place, or low likelihood and consequences scores, or agreement to accept risks.

Y Potentially Unacceptable - Inadequate/incomplete resolution.

R Unacceptable - Not likely to be resolved, an exception to the ISS CoFR.

↑ Improving ↓ Worsening

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Acronyms

CARA	Criticality Analysis and Risk Assessment
CoFR	Certificate of Flight Readiness
EVA	Extra Vehicular Activity
HEDS	Human Exploration and Development of Space
IA	Independent Assessment
ISO	International Standards Organization
ISSP	International Space Station Program
IV&V	Independent Verification and Validation
NASA	National Aeronautics and Space Administration
S&MA	Safety and Mission Assurance
SRP	Safety Review Panel
SVS	Space Vision System
T & V	Test and Verification
Y2K	Year 2000