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**Summit and Joint Meeting Focus on Mission Success in the Wake of Decreased Budgets**

By SUSAN HASTINGS
The Aerospace Corporation

Uncertainty surrounding sequestration and the effects of decreased budgets dominated discussion at Dec. 5’s Joint Space Quality Improvement Council (SQIC) and Space Supplier Council (SSC) and the next day’s U.S. Space Enterprise Mission Assurance Summit (MAS).

At the MAS — with participants from NASA, SMC, NRO, MDA, industry manufacturers, major suppliers, and commercial fleet operators — both NRO Director Betty Sapp and Lt. Gen. Ellen Pawlikowski, Commander of SMC, congratulated the community on the fabulous record of launch successes in the last two years. During her introduction, Sapp noted that the successes the U.S. has experienced in the last two years can result in people taking success for granted. She acknowledged that everyone is very concerned about affordability and appealed to industry to partner with the government to better justify the utility of mission assurance. She emphasized that in this era of cost cutting, it is insufficient to merely cite

**Participants in the MAS senior government executive panel, pictured above, included, from left, Maj. Gen. Susan Mashiko, Deputy Director, National Reconnaissance Office; Maj. Gen. Samuel Greaves, Deputy Director, Missile Defense Agency; Robert Lightfoot, Associate Administrator, NASA; Dr. Wanda Austin, Aerospace President-CEO, who was the facilitator for the senior government executive panel; Lt. Gen. Ellen Pawlikowski, Director, AF Space and Missile Systems Center; and Betty Sapp, Director, NRO.**

**LESSONS LEARNED**

**Unintended Consequences of Changes on Mission Success**

By BARBARA A. SANDE
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One of the basic tenets of complex satellite and launch vehicle programs is that changes will occur. Contracts and missions are revised and requirements are updated. Designs don’t work as intended or design improvements are identified. Manufacturing and test processes evolve. New suppliers are identified or existing suppliers reinvent themselves. Key personnel leave or retire. Materials and parts change or critical materials and parts are no longer available or they may even become disallowed. A properly structured program has the appropriate tools in place to manage risk and change as effectively as possible, but not every circumstance can be foreseen. Some changes, no matter how insignificant in nature, can result in unintended consequences that can devestate the program; those consequences can include mission anomalies and failures. This article defines unintended consequences as adverse outcomes that were not anticipated when a change was made but are unfortunately realized.

Lockheed Martin Space Systems Company (LMSSC) initiated a study to look at the impact of changes, after reviewing information about a supplier who changed the type of floor wax used in a Class 0 clean room to a more environmentally safe “green” product. The new floor wax was not conductive and electrostatic discharge requirements. This seemingly innocuous change resulted in several hardware integrity concerns.

Subsequently, 400 items were identified from a number of sources [1, 2, 3] which span several decades and cover many contractors and agencies. All have the common theme that something was changed, resulting in one or more unintended outcomes. That “something that changed” could be a requirement, a
NDAA-2013 Now Law, Sets Out Steps to Transfer Technologies to Commerce Control List

By REINHOLD BAUER
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The 2013 National Defense Authorization Act (NDAA-2013), signed into law by President Obama on Jan. 2, repeals the 1999 law that controlled satellites and related technologies on the United State Munitions List (USML). Recommendations on what should remain on the USML and what should transfer to the Commerce Control List (CCL) is documented in the 1248 Working Group Report’s Appendix 1. Examples of technologies being recommended for retention on the USML include certain space-qualified large antennas and control moment gyroscopes.

NDAA-2013 now requires that a series of determinations and actions be fulfilled as a condition for an item to be transferred from the USML to the CCL. These requirements are:

- Presidential notification to Congress
- A separate but accompanying report to Congress by the president that includes:
  - A determination that removal of such satellite and items are in the national security interests of the United States
  - An analysis of any differences between the president’s recommendations and the 2010 NDAA Section 1248 report
  - Report to Congress on the efforts of outside entities to illicitly acquire satellite and related items
  - Review of Modifications to Category XV of the USML by the President of the United States, the Secretaries of Defense and Commerce, and as appropriate the DNI.

With the 1248 Report completed and the NDAA-2013 now in place, it is expected that the initial movement of items from the USML to the CCL will begin sometime this year or early next.

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design, a software parameter, a manufacturing or test process, a supplier, a person, or a material or part.

Figure 1 (below) is a graphical example from the analysis and shows, in a stacked bar format, the immediate consequence of a change (showing 12 total categories) and the types of changes driving those consequences (11 categories across the X-axis). Highlights from this chart and other results from the analysis are summarized below:

1. Test failures are the most prominent unintended consequence, with 35% of the 400 items analyzed.
2. Within those test failures, the highest number of test failures occurred at the launch site, which is the last step in processing prior to mission operations. These are "diving catches."
3. 62% of all of the changes that were made could be considered minor (e.g., Class II changes, authorized part/material substitutions, minor manufacturing process or rework changes, routine software parameter updates). For flight failures and flight anomalies, roughly 50% of the changes that resulted in these significant outcomes were minor in nature.
4. Almost 30% of the unintended consequences occurred in the Electrical and Propulsion subsystems. Although Software changes resulted in fewer consequences (5% of the total), all five of the flight failures in the sample set attributed to Software could be considered minor changes (routine parameter changes, routine software uploads, etc.).
5. Characterizing the changes that were made that resulted in an unintended consequence, it was noted that material/part and design/drawing changes were the most dominant, although configuration changes due to improper rework or repair were also significant. System requirements changes had the biggest impact on flight failures and anomalies.
6. A lower-level change category analysis found a common theme among many changes: some aspect of the design change or drawing change or test requirements change (or other change) was in error. A mistake was made in a change that rippled through to an unintended consequence. These are errors of commission. A second theme that was noted is the omission of a key aspect of a change that resulted in a consequence (incomplete requirements, incomplete design change, etc.). Processes need to be robust to avoid errors of commission or omission when changes are made.

Figure 1: Combined view of top-level change and the immediate consequence of that change.
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as justification MA’s small percentage of stacked launch cost.

Pawlikowski delivered the keynote address, in which she provided motivation and a call to action for eliminating unnecessary cost from mission assurance.

Budgets are going down, but the U.S. no longer conducts any national security operation without space, she noted. Every dollar spent on things that do not effectively reduce risk means less capability in the hands of young men and women in harm’s way, she emphasized. She said the U.S. must take a hard look at the existing mission assurance tasks and use good engineering judgment to make decisions about the risk-reducing value of each task.

She relayed an anecdote that, through review of the mission assurance framework for launch, the U.S. was able to remove 20 of 210 recurring tasks for Atlas V and 28 recurring tasks for Delta IV without increasing risk. Through this streamlining, the launch rate was increased while at the same time new entrants could be assisted without increasing the cost of Aerospace support or risk to launch.

The MAS included a senior government executive panel (participants are pictured on page 1) and a senior industry panel, with participation from Robert Strain, Chief Operating Officer of Ball Aerospace; Rick Ambrose, Vice President and Deputy, LMSSC; Jeffrey Grant, Sector Vice President and General Manager, Space Systems, Northrop Grumman Aerospace Systems; David Thompson, Chairman and Chief Executive Officer, Orbital Sciences Corporation; Gwynne Shotwell, President, SpaceX; and Michael Gass, President and Chief Executive Officer, United Launch Alliance. Each senior industry panelist recommended actions the government could take to reduce the cost of programs.

Four small group discussions were also held at the MAS: Design Lessons Learned and Assuring Design Integrity; Risk and Program Success in Cost-Plus Development vs. Fixed Price Production vs. Technology Development; Parts, Materials, and Processes Risk Posture; and Tailoring of Specifications and Standards. The recommendations from the small groups are detailed in the MA Summit minutes and are being considered by government seniors for resourcing and action.

During the Joint SQIC-SSC outbrief the day before, Richard McKinney, Deputy Under Secretary of the Air Force for Space Programs, expressed a similar sentiment to Sapp and Pawlikowski by stating that the budget will be getting smaller and therefore quality, mission assurance, and getting it right the first time are more important than ever because the U.S. doesn’t have the time or money for redos.

The Joint SQIC-SSC explored improving acquisition synchronization and efficiency through asking each attendee: “What can we do to incentivize increased accountability on the part of producers and overseers to achieve higher first-pass product quality?” Creating a sense of pride and ownership at the employee level reverberated with most companies. Customer visibility has a significant effect on quality, so members encouraged the government to visit the factory floor and let workers know how their product is important to the mission. Often attention is focused on heroics to fix an issue, but people who did the right thing all along also need to be recognized, they indicated.

The minutes for both the Joint SQIC-SSC and the Mission Assurance Summit are listed in Recent Guidance and Related Media and include additional details of these events.

Did You Know…

Gold embrittlement can lead to solder joint failure and cause gold plated components to fall off the board

Gold plating provides several advantages in electronic manufacturing. Gold resists oxidation and tarnishing and has a long shelf life, so device leads or terminations for assemblies are often gold plated to improve future solderability. A nickel underplate is used to prevent diffusion of the gold into underlying metal layers, typically copper. The gold layer must be removed prior to soldering using a process known as “pretinning.” If gold removal is inadequate or not done, an intermetallic compound (IMC) layer will form between the gold and the solder. The most common IMC phases are AuSn4 and AuSn2, but others do occur. Gold embrittlement is generally not observed when Au concentration is ~3 wt% or less.

This lesson is four decades old, but may experience a resurgence with the use of lead-free solders because many of the replacement solders contain gold.

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GETTING IT RIGHT ACRONYM DEFINITIONS

MAIW Mission Assurance Improvement Workshop  
MDA Missile Defense Agency  
NASA National Aeronautics and Space Administration  
NRO National Reconnaissance Office  
PMP Parts, materials, and processes  
SMC Space and Missile Systems Center  
SQIC Space Quality Improvement Council  
SSC Space Supplier Council

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7. Nearly 10% of the lower-level changes were due to unauthorized parts/materials substitutions or unauthorized rework/repair. Changes that are outside the normal approved processes are much more difficult to control.

8. Recovery from the unintended consequence required wide-ranging actions, from communication of the issue to other programs to extensive design and process changes and hardware rejections. These actions often require additional resources that are not planned by the program. These secondary actions had some likelihood (not measured) of inducing further unintended consequences.

PROCESS IMPROVEMENTS AND RECOMMENDATIONS

Getting from these observations to actual robust processes that are immune to unintended consequences requires a top-down approach that eliminates both errors of commission and omission.

The study concluded that there are a few basic process requirements that, if rigorously followed, alleviate unintended consequences from changes. Although these requirements are broadly stated and might be viewed as common sense for any program, the complexity of space industry programs and missions sometimes leads to situations where such basics are overlooked. Discipline is the key.

1. Ensure proper maintenance of design configuration.

2. Ensure design handoffs are error free and closed loop.

3. Ensure adequate design margins for worst case conditions and end of life.

4. Design for producibility, testability and maintainability.

5. Mistake-proof designs to the highest level of proofing.

Optimizing these requirements necessitates improved collaborative processes that involve all of the stakeholders in determining product and process outcomes that minimize the need for changes.

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REFERENCES

[1] Example of legacy data: Titan Corrective Action Problem Summary (CAPS) reports, submitted under contract to SMC


Recent Guidance & Related Media

MAIW PRODUCTS

Electrical Design Worst-Case Circuit Analysis: Guidelines and Draft Standard by B. Lenertz; TOR-2012(8960)-4; OK’d for USGC

Electrical Design Worst-Case Circuit Analysis: Guidelines and Draft Standard (Abridged) by B. Lenertz; TOR-2012(8960)-4 Rev A; OK’d for public release

Guidance for Efficient Resolution of Post-Contract Award – MA Requirements Issues by W. Bjorndahl; TOR-2012(8960)-5; OK’d for public release

Mission Assurance Approach within a Mission Class Development vs. Production Programs by C. Stevens; TOR-2012(8960)-6; OK’d for public release

Space Mission Resilience to Cyber Attacks by F. Belz; TOR-2012(8960)-7; OK’d for USGC

BEST PRACTICES

Specification and Standards Tailoring Lessons Learned and Pitfalls by S. Hastings; TOR-2013(8506)-59; OK’d for USGC

Mission Class A-D Tailoring Spreadsheet by B. Shaw; TOR-2013(8506)-12175e; OK’d for USGC

General Software Assurance Statement of Work Tasks by P. de Naray; TOR-2012(8506)-11933e; OK’d for USGC

MEETING PROCEEDINGS

Mission Assurance Approach within a Mission Class Development vs. Production Programs by C. Stevens; TOR-2012(8506)-78; OK’d for USGC

2012 Mission Assurance Summit Overview by S. Hastings; TOR-2013(8506)-77; OK’d for USDoDDC

Joint Space Quality Improvement Council/Space Supplier Council Meeting 5 December 2012 by C. Spohnholtz; TOR-2013(8506)-78; OK’d for USDoDDC

Best Practices for Supplier Conferences by C. Spohnholtz; TOR-2013(1518)-1; OK’d for USGC

Evaluation Mechanism for Spacecraft Pre-Launch Debris-Generation Explosion Risk Assessment by B. Brady; TOR-2013(8506)-56; OK’d for USGC

Test and Evaluation Guidelines for Liquid Rocket Engines, JANNAF-GL-2012-01-R0; OK’d for public release

SPECIAL REPORTS

Star Tracker Anomaly Survey Report by D. Ennich; TOR-2012(8546)-14; OK’d for USGC

MEETING PROCEEDINGS

Space Mission Resilience to Cyber Attacks by L. Austin; ATR-2012(5389)-2; OK’d for public release

Space Mission Resilience to Cyber Attacks by B. Brady; TOR-2012(5389)-3; OK’d for USDoDDC

Tube Contamination – Generation, Testing, and Identification of Contaminant by S. Hastings; TOR-2012(1103)-4; OK’d for USGC

Managing the “Parallel Jungle” with Parallel Libraries and Frameworks by J. Kozlowski; TOR-2012(8546)-14; OK’d for USGC

MEETING PROCEEDINGS

Space Quality Improvement Council Meeting 5 December 2012 by C. Spohnholtz; TOR-2013(8506)-78; OK’d for USDoDDC

2012 Mission Assurance Summit Overview by S. Hastings; TOR-2013(8506)-77; OK’d for USDoDDC

Joint Space Quality Improvement Council/Space Supplier Council Meeting 5 December 2012 by C. Spohnholtz; TOR-2013(8506)-78; OK’d for USDoDDC

Best Practices for Supplier Conferences by C. Spohnholtz; TOR-2013(1518)-1; OK’d for USGC

енные процессов.

7. Реконструкция несмотря на несогласованность с программами других пяти областей привела к изменению продукта и процессов, что уменьшает необходимость в изменениях.

8. Исправление этих требований требует улучшения совместных процессов, вовлекающих всех участников в определение продуктов и процессов исходя из их потребностей.

Оптимизация этих требований способствует улучшению процессов, вовлекающих всех участников в определение продуктов и процессов исходя из их потребностей.


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СИСТЕМЫ ИНФОРМАЦИИ

[1] Пример данных пострадок: Методика коррекции проблем (CAPS) отчеты, сданнные под контракт SMC


[3] Харланд, Дэвид М. и Ральф Д. Лоренц, Космические системы: катастрофы и спасательные операции. Космические объекты и пространственные объекты, Copyright 2005 Praxia Publishing Company (использован в качестве дополнительного исследования)