Preparing to Assure Mission Success

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15th International Conference on Space Operations

28 May – 1 June 2018

Marseille, France

Jet Propulsion Laboratory
California Institute of Technology

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Introduction

- Space flight has always been risky.
  - Problems cannot be completely prevented.
  - There are many unknowns.
  - Humans make mistakes.
- Early failures/successes were studied and lessons shared with new missions.
- “Rules of the road” developed.
- Mission Operations Assurance discipline grew out of these rules.

History

- Began as response to operational errors.
  - Focus on operations risk and flight team performance.
- Voyager (1977) mission used paper forms to record in-flight anomalies.
  - Closure required analysis & problem resolution.
- Magellan (1989) added uplink checks and mission assurance staff “independence.”
  - Started keeping command error statistics.

History, cont.

- Mars Climate Orbiter (1998) changed thinking.
  - Lost due to multiple, fixable errors.
  - Lesson: Communication is crucial!
  - Lesson: Ops team test/training can make/break mission.
  - Lesson: “Faster, better, cheaper”? No, pick any two.
- Mission Ops Assurance Manager (MOAM) role expanded to include independent risk assessment, waiver review, problem report management, flight team training assessment, etc.

Role & Background

- Most MOAMs already have 15-20 years day-to-day ops and leadership experience.
  - Very experienced with a solid set of skills.
  - Senior people comfortable working with all levels of management.
  - Difficult to find such people ready and available.
- 14-module program created to develop & train new MOAMs.
  - Builds a pool of system engineers and operators cross-trained for future opportunities.
  - Also helps educate non-candidates on what we do and why.

Module 1: Intro to Mission Ops Assurance

- Discusses history, importance, changes in MOAM role, responsibilities, and vision*.
  - Includes MCO Failure Review Board Findings and a list of required reading.
- Describes 11 categories of tasks in the role.

1. Risk assessment
2. Operational Readiness
3. Problem Reporting
4. Operations Training
5. Operational Requirements
6. Project Planning
7. Flight Rule Assessment
8. Reporting
9. Configuration Management
10. Interfacing with other Quality/Operations Assurance Functions
11. Lessons Learned Assessment

***MOAM vision:**
"To integrate the Mission Operations Assurance function into flight operations, providing value-added support in identifying, mitigating, and communicating the project's risks along with being an essential member of the team during test activities, training exercises, and flight operations."

Module 2: Mission Ops Assurance Manager

- Training moves from MOA discipline to MOAM "mindset" and day-to-day tasks.
  - Mindset:
    - Rigor - all required products are complete, communicated, and correct;
    - Penetration - ask questions until fully satisfied with answers;
    - Follow-through - disciplined & steady attention to successful completion of tasks and thorough resolution of problems.
  - MOAM's role directly supports Project Manager in understanding and assessing mission risk at all levels.

Module 3: Incident/Surprise/Anomaly Reports

- ISAs are core of problem reporting and large part of MOAM's day-to-day work.
  - 3 criticality categories: Major, Significant, Negligible.
  - Initiated on events indicating unexpected performance of ground system, flight system, or flight team.
  - MOAM tracks, distributes, and approves (or disapproves) resolution, closure, and residual risk documentation. Assists team members in analysis and resolution.
  - Module includes examples from flying missions.

Module 4: Command File Errors (CFEs)

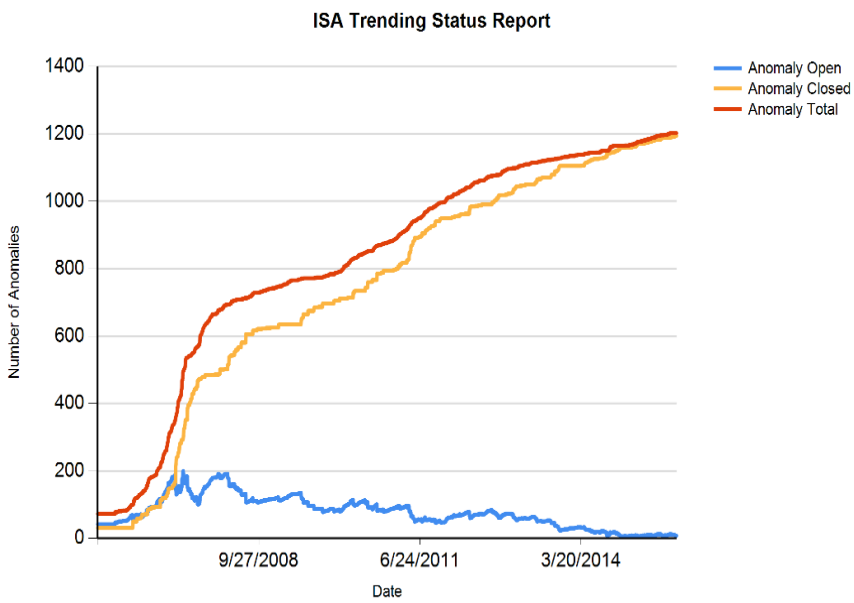
- These errors may be caused by:
  - Erroneous uplink or failed or omitted uplink.
  - Error in processing, approval, or uplink of product to spacecraft.
  - Error in requirements, design or coding in ground or simulation software, or by error in post-launch flight software requirements, design, or coding.
  - Configuration management problem on s/c or ground.
  - Error at tracking facility that prevents uplink.

Command File Errors, cont.

- ISAs still written but receive heightened scrutiny.
  - Additional data required to close.
  - Closure captures residual risk in terms of:
    - Proximate Cause (direct, immediate cause),
    - Root Cause (underlying cause of the problem), and
    - Contributing Causes (other contributing factors.)
  - Often result in changes to procedures or processes and additional team training.
  - Increased rate of CFEs is cause for concern.

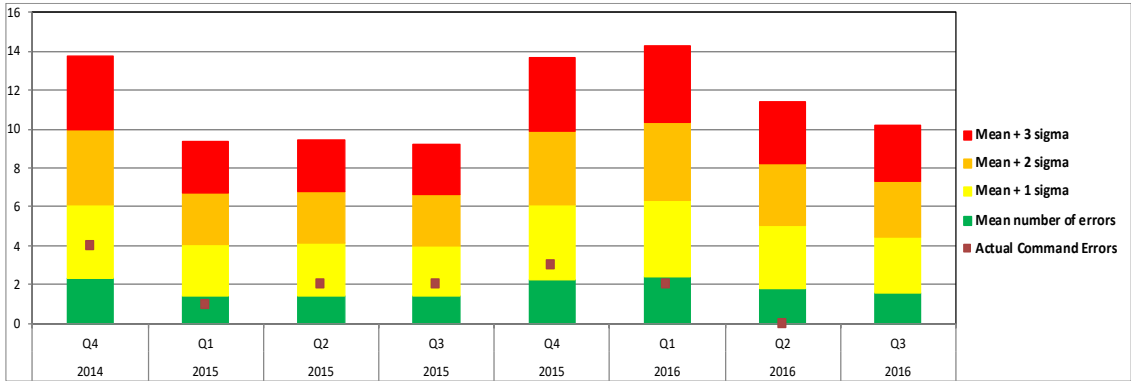
ISA Statistical Analyses

- ISA statistics are tracked and reported monthly.
  - Analysis of 20-year database has shown that # of ISAs can be predicted for each “phase” of ops (checkout, cal/val, nominal, anomalous, transitioning, etc.)
  - Mission’s open/close rate can be compared to predicts for performance assessment.



Error Significance Model (ESM)

- Statistical analyses show two factors drive CFE rates:
  - number of files radiated,
  - level of “novelty” in building uplink (usually changed processes.)
- ESM developed to model the expected CFE rate.
  - Allows MOAM to understand if error rate was expected.
  - Helps identify upcoming higher CFE periods to better prepare.
  - Can also use to predict performance of future missions.



Module 4: CFEs, cont.

- Presentations:
  - Managing command file errors,
  - Error Significance Model and several current mission model examples,
  - Discussion of command error that caused loss of 1975 Viking 1 lander,
  - Example “flight school” refresher training given to Dawn mission as proactive step to avoid errors during transition from Vesta-Ceres cruise to Ceres ops.

Additional Modules 5-9

- In addition, MOAMs perform other more common functions that are covered in modules 5 through 9:
  - Module 5: Configuration Management Overview,
  - Module 6: Independent Risk Assessments,
  - Module 7: Office of Safety & Mission Success Reporting,
  - Module 8: Project Review Support,
  - Module 9: Institutional Waivers.

Module 10: Anomaly Resolution

- MOAM responsible for making certain that flight team is on a safe path to resolving anomaly.
- Special duties the MOAM may perform include:
  - Helping to document the anomaly in ISA,
  - Managing upward communication concerning anomaly,
  - Contacting off-project personnel that may be useful in analyzing and resolving anomaly.
    - Includes discussion of types of support available from the other disciplines in Office of Safety and Mission Success.

Modules 11-12: Less common duties

- These responsibilities apply to only a few missions.
  - MOAMs support 1-3 missions at a time, and fill in for other MOAMs as necessary, so all MOAMs are trained for these activities.
- Module 11: Space Weather Reporting
  - Includes data sources, examples, & a GRAIL anomaly.
- Module 12: MOAM for Rover Operations
  - Includes daily process for the Curiosity mission and observation of an 8-hour tactical shift.

Modules 13-14: Pulling it all together

- Module 13: War Stories
  - Senior personnel present lessons learned in complex situations, e.g., major anomalies and mission losses.
  - Variety of stories prepared, specific stories covered chosen depending on composition of class, current priorities, and availability of storyteller.
  - Most provide lessons applicable outside mission assurance discipline.

Modules 13-14: Pulling it all together, cont.

- Module 14: Case Study
  - Trainees act as MOAM for critical ops decision.
    - Risk trade is made for decision to swap hardware.
    - Trainees get risk drivers and stakeholder concerns.
    - Trainees perform risk balance and make recommendation.
    - “Project Manager” (trainer) acknowledges recommendation but makes conflicting decision.
    - Trainees then create Independent Tech Assessment to SMA management for the second, independent reporting path.
    - To conclude, trainer presents actual events on which study is based, discusses decision and its outcome.

Results and Looking Forward

- First class held 17 July – 15 August 2017.
  - Included all MOAMs (2 new) plus 6 systems engineers.
  - Next offering planned for Fall 2018.
  - Also discussing sharing training materials with another NASA center and possibly offering JPL class there.
- Module 15, “Mission Ending Events” in development.
  - Will examine how missions come to conclusion, whether via planned or unexpected events.
  - Currently 16 mission conclusions in the materials.

Backup information

Supplemental reading

- “Mars Climate Orbiter Mishap Investigation Board Phase I Report”, NASA Public Lessons Learned System, November 30, 1999. https://llis.nasa.gov/lesson/641
- “Mission Assurance During Mars Climate Orbiter Operations (1999)”, NASA Public Lessons Learned System, April 27, 2000. https://llis.nasa.gov/lesson/886
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- “Mars Global Surveyor (MGS) Spacecraft Loss of Contact”, NASA Public Lessons Learned System, September 3, 2007. https://llis.nasa.gov/lesson/1805, https://www.nasa.gov/sites/default/files/174244main_mgs_white_paper_20070413.pdf
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- Space Weather Prediction Center, National Oceanic and Atmospheric Administration, URL: https://www.swpc.noaa.gov

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