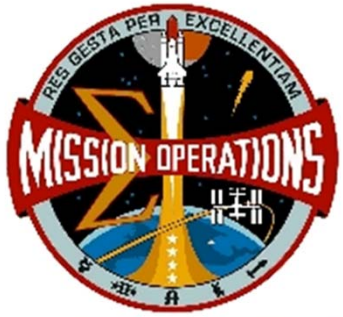
Space Shuttle Lessons Learned Knowledge Sharing Forum

JSC – Mission Operations Directorate Incorporation of Lessons Learned



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A little background

- MOD known for their flight controllers in the Mission Control Center
  - Most visible part of the organization
- Mission planning and training (crew and flight controller) are also key elements
  - As well as the operational and training facilities
- MOD is typically described as a “Plan-Train-Fly” organization with Facilities support and utilization encompassing all of those aspects.

A little background

- Mission planning
  - Development of the mission/crew timeline
  - Flight Design / Trajectory Analysis
  - Consumables management
- Training
  - Simulations
    - MCC
    - SMS
    - NBL
  - Flight specific and generic

MOD Culture

- MOD is committed to “bullet proof” technical support and “ruthless” continuous improvement
- We are relentless in pursuing answers to the unexpected or unknowns in mission prep, training, and flight.
- “What could we have done better? What could we now do better?
- Self-imposed continuous improvement

Preparing for the Unexpected

- Apollo 13 demonstrated the need to be able to respond to the unexpected.
- MOD continually analyzes the onboard systems and the operational environments to identify the potential failure modes and off-nominal situations.
- As these potential failures and situations are identified, the required responses are also developed and incorporated into the flight rules and the operational procedures.
  - Line-by-line review of all procedures and rules after Challenger accident

Types of Lessons Learned

- For MOD, “Lessons Learned” are in two forms:
  - Incorporation of flight data and experiences
    - New, additional flight data or insights
    - Operational efficiencies
    - Programmatic changes and vehicle modifications
  - Unexpected, off-nominal events and situations
    - Errors (procedures, references, timeline)
    - Systems/hardware failures (anomalies)
    - Previously unknown conditions or activities
      - Never seen that before
      - Didn’t work like we expected it to

Incorporation of Lessons Learned

- Real-time adjustments
  - When problems occur during the mission
  - Mods to procedures, rules, crew timelines
- Post flight discussions / technical reviews
  - Post mission "Quick Looks"
    - Discipline specific mission overviews
  - Flight Technique panels
  - Lessons Learned JOPs
  - Post mission reports
- Modifications to procedures, flight rules, console tools, operational philosophies, crew training, simulations, etc. prior to next flight

Shuttle Knowledge Capture

- MOD-wide effort in progress to capture Shuttle unique operational information and lessons learned
- Hundreds of examples across all aspects of MOD
- Using IRD's JSC Lessons Learned Database as the repository for that information
- Valuable information to be used for future operational programs
  - Utilize Shuttle experience to influence vehicle and operational design
  - Already applying those experiences and lessons learned to current Orion (MPCV) vehicle design activities and ops concepts developments

Lessons Learned

- **STS-88 Prelaunch scrub**
  - Unexpected Master Alarm at APU start (~L-6 min)
    - Caused by accidental switch "tease" (pumps taken from Low press to Norm press) (isn't this the opposite, the pumps were in norm and teased back to low then to norm again. We want them in norm for launch.)
    - Held launch count (small launch window)
  - MOD flight controllers determined the cause and attempted to contact KSC to restart count before launch window closed
  - KSC started count where T-0 would be after close of launch window
  - Additional challenge to get count stopped
  - Count stopped – scrubbed for the day

Lessons Learned

- Emphasis for better communication and coordination between JSC and KSC during prelaunch activities
  - Developed protocol procedures for communication
- Improved LCC procedures
  - Pre-planned contingency actions
- S0044 Simulations
  - Integrated prelaunch simulations with JSC/KSC
- Incorporated into Space Flight Resource Management (SFRM) instruction at JSC
  - For crew and flight controller training

Lessons Learned

- **STS-27 Post Landing Undertemp**
  - Post landing connection of ground cooling caused undertemp condition on Shuttle cooling loops
    - Risk of freezing cooling loops (Freon/H20 heat exchangers)
    - Possible vehicle and/or equipment damage
  - MOD flight controllers made time critical calls to deactivate Freon Loop pumps and NH3 system
  - Coordination with convoy crew to correct cooling cart settings and established good ground cooling
  - JSC calls to reconfigure onboard systems back to a nominal config

Lessons Learned

- Other factors
  - ASP onboard (crew already egressed)
    - Procedures not available onboard at that time (DoD mission)
  - JSC handover at crew egress (per Flight Rule agreements)
  - Flight control team already started post mission plaque hanging ceremony (MCC full of people; very noisy)

Lessons Learned

- Flight Rules changed to reflect JSC handover at crew egress or establishment of good ground cooling (whichever comes later)
- Improved communication/coordination with ground crew and JSC flight control team
- Better insight to lack of FDF onboard for DoD missions
- Implementation of post landing simulations (JSC)
- Better management of cooling systems during entry and post landing

Lessons Learned

- **Incorporation of flight data for cryo tank usage**
  - Cryogenic O2 and H2 used for fuel cell electrical production
    - O2 also used for crew atmosphere (with N2)
  - Initial cryo baseline data built from theoretical data and small set of test data
  - Greater demand for longer missions (more cryo usage)
  - Observed inefficiencies in usage rates

Lessons Learned

- Flight data used to update loading, usage, and pressure profile information (50+ flights worth of data)
- Better insight to usage calculations
  - Improved capability for premission planning and real-time consumables management
    - Maximize mission duration capability
    - Maximize power consumption (payload capability)
  - Improved insight to leak monitoring
- Improved insight to prelaunch loading and boiloff
  - Maximize margin

Lessons Learned – Facilities

- What works and doesn't work in a control center
  - Process, technologies
- Offline training environments
  - Reduce dependencies on "big rig" simulators
- Transition of operations from one control room to another
  - Old FCR to new FCR
- Technology advancements
  - Transition from Mainframe/dedicated consoles to workstation environment
  - Communication and data delivery improvements
- Remote access
  - Ability to view real-time mission data (and simulation data) from remote locations
  - Emergency Control Center Ops (EMCC)
    - In response to contingency situations where primary MCC would be unavailable (i.e Hurricane)
    - Ability to do operations (command and control) to Shuttle and ISS from location other than Mission Control Center in Houston (i.e. MSFC, Round Rock, Texas)

Summary

- MOD culture based on continuous improvement
- Lessons Learned have always been a vital part of improved operational efficiencies
  - MOD has incorporated these lessons on regular basis throughout the Shuttle program
- Lessons Learned and operational experiences serve as foundation for other programs and future missions (i.e. ISS, Orion/MPCV)