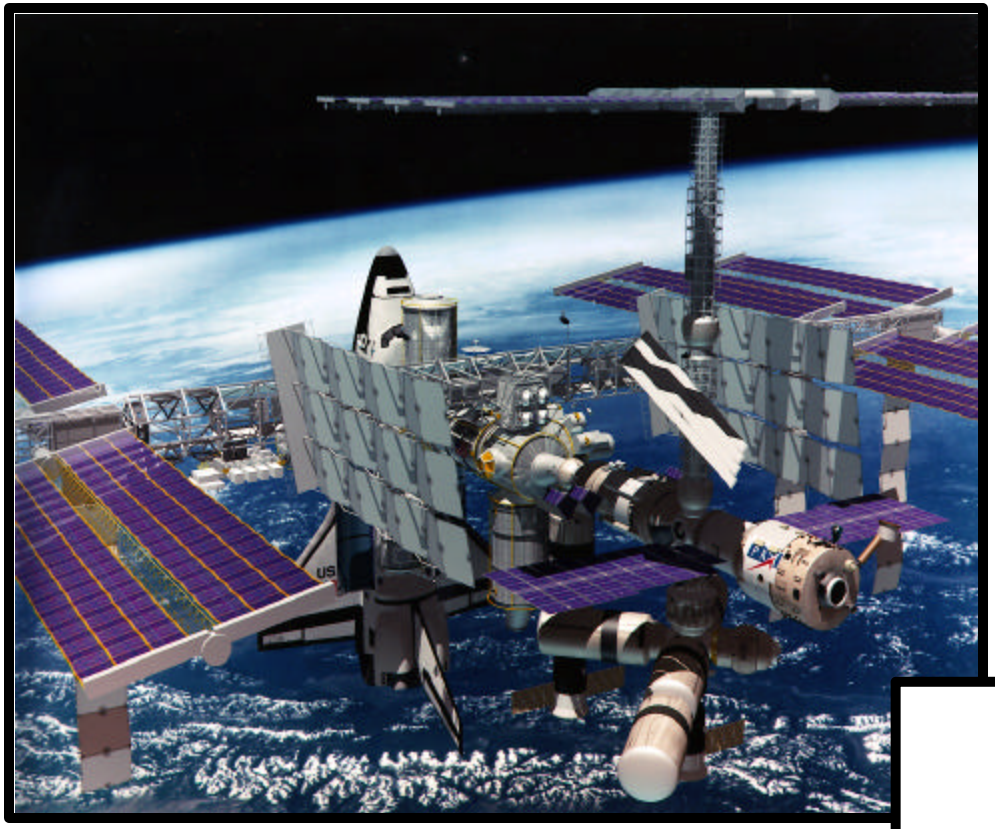

ISS Payload Integration Process Improvement

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Outline

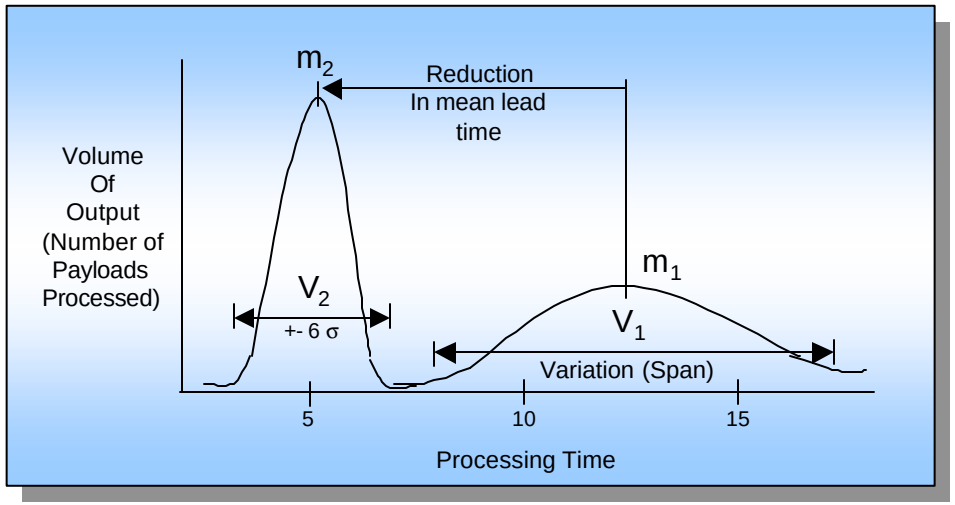
- Background
- Improvement Approach
- Approach Implementation
- Results
- Recent Victories
- Forward Work
- Conclusion

Background

- The Payload Community perceived that the NASA ISS Payload Integration Process needed improvement in several key areas.
  - Overall cycle time and general process streamlining.
  - Quantity of documentation required.
  - Communication between the ISS Program and the Payload community.
  - Quantity of resources needed to support the process.
- As a result, the ISS Payloads Office chartered an effort to address these and other concerns.
  - OZ asked Boeing, the ISS Payload Integration Contractor (IPIC), to direct an effort to address the issues.
  - Boeing acquired the services of ARES Corporation to facilitate a Lean Six-Sigma process improvement technique to improve the payload integration process.

Improvement Approach

- Lean Six Sigma is a dual approach utilized to reduce cycle time (Lean) and reduce process variation (Six Sigma) to increase process execution speed and quality and reduce costs.



- Lean Six Sigma uses a “Breakthrough Strategy” to effect improvement.
- This strategy is described on the next page.

Improvement Approach

Define

1. Identify what's important to the customer. Define project scope.

- Cost of Poor Quality (COPQ)
- Pareto Chart
- Product, Process Performance Metrics
- Process Flowchart (high level)
- Customer "Voices"
- Critical To (CT) Matrix

Measure

2. Determine what to measure (Y) and validate the measurement system.
3. Quantify current performance and estimate improvement target.

- Input-Process-Output (IPO) Diagram
- Process Mapping
- Check Sheets
- Pareto Diagram
- Measurement Systems Analysis (MSA)
- Process Capability Analysis

Analyze

4. Identify causes (Xs) of variation and defects
5. Provide statistical evidence that causes are real. Commit to improvement target for Y.

- Cause and Effect Diagram
- Cause and Effect Matrix
- Failure Mode & Effects Analysis (FMEA)
- Multi-Vari Charts
- Correlation and Regression
- Hypothesis Testing
- Design of Experiment (DOE) Screening

Improve

6. Determine solutions (ways to counteract causes) including operating levels and tolerances.
7. Install solutions and provide statistical evidence that the solutions work.

- Design of Experiment (DOE)
- Error Proofing
- Statistical Tolerancing
- Failure Mode & Effects Analysis (FMEA)
- Hypothesis Testing

Control

8. Put controls in place to maintain improvement over time.
9. Provide statistical evidence that the improvement is sustained (3 months of data)

- Control Plans
- Control Charts
- Visual Management
- Procedures / Work Instructions
- Process Capability
- Total Productive Maintenance

Source: Six Sigma Academy

Approach Implementation

- To date, eight sessions have been held with key stakeholders in the payload integration process.
  - ISS Program Office
  - MSFC Payload Operations
  - Payload Safety
  - Payload Engineering and Integration
  - KSC Ground Processing
  - Representative Payload Developers
  - Et al.

Approach Implementation

- The sessions were aligned in conjunction with the beginning of the IPIC.
  - Session one was conducted September 23 – 27, 2002.
  - IPIC contract began October 1, 2002.
  - Session two was conducted October 28 – November 1, 2002.
  - Session three was conducted December 2 – 6, 2002.
  - Session four was conducted February 25 – 27, 2003.
  - Session five was conducted April 29 – May 1, 2003.
  - Session six was conducted May 29 – 30, 2003.
  - Session seven was conducted August 1, 2003.
  - Session eight was conducted November 20 – 21, 2003.
- The goal of the sessions was to identify areas where improvements to the process could be achieved and plan implementation of those improvements.

Approach Implementation

- Session One:
  - Introduced the Lean Six Sigma process.
  - Defined the problem statement.
  - Identified specific, key problems to solve.
  - Identified key measures of effectiveness.
  - Identified input data streams (e.g., verification data, safety data packages, etc.).
  - Identified twenty-four separate data vehicles (EIAs/PIAs, OPMS, PDL, etc.).
  - Identified thirty-three separate process outputs (e.g., Ops documentation, Integrated Complement Analysis, Station CoFR requirements, etc.).
  - Mapped the data streams to the data vehicles.
  - Mapped the outputs to the owners.
  - Defined Lessons learned from other similar programs (e.g., Spacehab, Spacelab, etc.).
  - Identified possible improvements for each key issue.

Approach Implementation

- Session Two:
  - Developed an end-to-end level one process flow for payload integration.
  - Identified and honed improvement options for key issues.
  - Developed detailed level two process flows for processes on level one flows.
- Session Three:
  - Reviewed and evaluated level one, two and three process flows.
  - Reviewed process improvement initiatives developed prior to session three.
  - Identified and reviewed additional improvement initiatives.
  - Developed improvement initiative action items.
  - Developed improvement initiative implementation schedule.

Approach Implementation

- Session Four:
  - Status of improvement initiative action items.
  - Presented initial results of newly implemented Human Factors Integration Team (HFIT).
- Session Five:
  - Status of improvement initiative action items.
- Session Six:
  - Status of improvement initiative action items.
- Session Seven:
  - Status of improvement initiative action items.

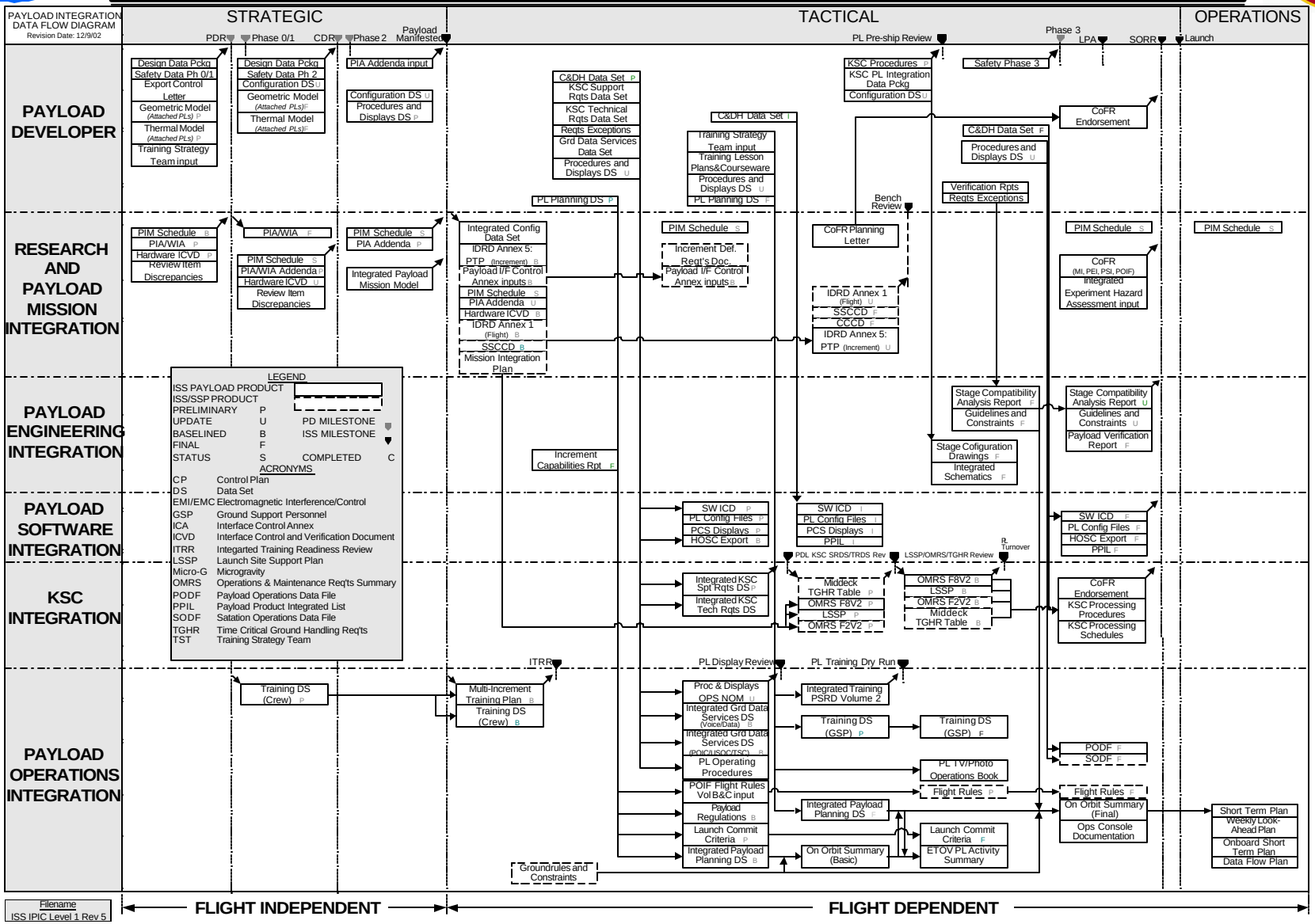
Approach Implementation

- Session Eight:
  - Status of improvement initiative action items.
  - Initiated discussion of potential new actions for the following payload types:
    - » New EXPRESS subrack payloads (as defined by SSP 57066)
    - » New Small Payloads (as defined by SSP 57063)
    - » Reflight payloads
    - » Payloads that stay on orbit and continue to operate
    - » Payloads with simple resupply/stowage flights for their existing on-orbit hardware
    - » Payloads for which the Principal Investigator and Payload Developer (PD) teams are one in the same
  - Initiated discussion of transition from initial process improvement activity to integration of continual improvement in ISS Payloads Integration processes.

Results

- A PD-centric philosophy to improve the payload integration process was defined.
- A revised, updated, multi-level payload integration process flow was developed (shown on the next page).

Results


PAYLOAD INTEGRATION DATA FLOW DIAGRAM
Revision Date: 12/9/02
STRATEGIC
TACTICAL
OPERATIONS
PDR
Phase 0/1
CDR
Phase 2
Payload Manifested
PL Pre-ship Review
Phase 3
LPA
SORR
Launch
PAYLOAD DEVELOPER
RESEARCH AND PAYLOAD MISSION INTEGRATION
PAYLOAD ENGINEERING INTEGRATION
PAYLOAD SOFTWARE INTEGRATION
KSC INTEGRATION
PAYLOAD OPERATIONS INTEGRATION
Design Data Pckg
Safety Data Ph 0/1
Export Control Letter
Geometric Model (Attached PLs) P
Thermal Model (Attached PLs) P
Training Strategy Team input
Design Data Pckg
Safety Data Ph 2
Configuration DS U
Geometric Model (Attached PLs) F
Thermal Model (Attached PLs) F
PIA Addenda input
Configuration DS U
Procedures and Displays DS P
C&DH Data Set P
KSC Support Rqts Data Set
KSC Technical Rqts Data Set
Reqts Exceptions
Grd Data Services Data Set
Procedures and Displays DS U
C&DH Data Set I
Training Strategy Team input
Training Lesson Plans&Courseware
Procedures and Displays DS U
PL Planning DS P
PL Planning DS F
KSC Procedures P
KSC PL Integration Data Pckg
Configuration DS U
Safety Phase 3
CoFR Endorsement
C&DH Data Set F
Procedures and Displays DS U
Verification Rpts
Reqts Exceptions
Bench Review
PIM Schedule B
PIA/WIA P
Hardware ICVD P
Review Item Discrepancies
PIA/WIA F
PIM Schedule S
PIA/WIA Addenda P
Hardware ICVD U
Review Item Discrepancies
PIM Schedule S
PIA Addenda P
Integrated Payload Mission Model
Integrated Config Data Set
IDRD Annex 5: PTP (Increment) B
Payload I/F Control Annex inputs B
PIM Schedule S
PIA Addenda U
Hardware ICVD B
IDRD Annex 1 (Flight) B
SSCCD B
Mission Integration Plan
PIM Schedule S
Increment Del. Reqt's Doc.
Payload I/F Control Annex inputs B
CoFR Planning Letter
IDRD Annex 1 (Flight) U
SSCCD F
CCCD F
IDRD Annex 5: PTP (Increment) U
PIM Schedule S
CoFR (MI, PEI, PSI, POIF) Integrated Experiment Hazard Assessment input
PIM Schedule S
LEGEND
ISS PAYLOAD PRODUCT
ISS/SSP PRODUCT
PRELIMINARY P
UPDATE U
BASELINED B
FINAL F
STATUS S
PD MILESTONE
ISS MILESTONE
COMPLETED C
ACRONYMS
CP Control Plan
DS Data Set
EMI/EMC Electromagnetic Interference/Control
GSP Ground Support Personnel
ICA Interface Control Annex
ICVD Interface Control and Verification Document
ITRR Integarted Training Readiness Review
LSSP Launch Site Support Plan
Micro-G Microgravity
OMRS Operations & Maintenance Req'ts Summary
PODF Payload Operations Data File
PPIL Payload Product Integrated List
SODF Satation Operations Data File
TGHR Time Critical Ground Handling Req'ts
TST Training Strategy Team
Stage Compatibility Analysis Report F
Guidelines and Constraints F
Stage Cofiguration Drawings F
Integrated Schematics F
Stage Compatibility Analysis Report U
Guidelines and Constraints U
Payload Verification Report F
Increment Capabilities Rpt F
SW ICD P
PL Config Files P
PCS Displays P
HOSC Export B
SW ICD I
PL Config Files I
PCS Displays I
PPIL I
SW ICD F
PL Config Files F
HOSC Export F
PPIL F
PDL KSC SRDS/TRDS Rev
LSSP/OMRS/TGHR Review
PL Turnover
Integrated KSC Spt Rqts DS P
Integrated KSC Tech Rqts DS
Middeck TGHR Table P
OMRS F8V2 P
LSSP P
OMRS F2V2 P
OMRS F8V2 B
LSSP B
OMRS F2V2 B
Middeck TGHR Table B
CoFR Endorsement
KSC Processing Procedures
KSC Processing Schedules
ITRR
PL Display Review
PL Training Dry Run
Training DS (Crew) P
Multi-Increment Training Plan B
Training DS (Crew) B
Proc & Displays OPS NOM U
Integrated Grd Data Services DS (VoiceData) B
Integrated Grd Data Services DS (POIC/USOC/TSC) B
PL Operating Procedures
POIF Flight Rules Vol B&C input
Payload Regulations B
Launch Commit Criteria P
Integrated Payload Planning DS B
Integrated Training PSRD Volume 2
Training DS (GSP) P
Training DS (GSP) F
PL TV/Photo Operations Book
Flight Rules P
Integrated Payload Planning DS U
On Orbit Summary (Basic)
Launch Commit Criteria F
ETOV PL Activity Summary
Groundrules and Constraints
PODF F
SODF F
Flight Rules F
On Orbit Summary (Final)
Ops Console Documentation
Short Term Plan
Weekly Look-Ahead Plan
Onboard Short Term Plan
Data Flow Plan
Filename
ISS IPIC Level 1 Rev 5
FLIGHT INDEPENDENT
FLIGHT DEPENDENT

Results

- 92 action items have developed to improve the payload integration process.
  - 78 actions have been closed.
  - 6 actions closed to plans in the process of being implemented.
  - 8 actions remain open.

- Key actions included:
  - Develop options for how mission integration will be performed.
    - » Incorporated in options will be ease of reflight and payload integration (vs increment integration).
    - » Incorporated in options will be simplified documentation (i.e. combined integration agreements).
  - The development of a cross-functional payload data management function chartered to identify duplicative data and recommend and implement changes.
  - The development of a single, World-class Payload Developer website to ease access to payload integration processes, requirements, data,etc.
  - Develop payload data management plan and improvements to PDL.
  - Review end-to-end processes for labeling, ops nom, IMS and determine ways to simplify and streamline processes.

Results

- Significant improvements in implementation:
  - The development of Payload Integration Manager Service Standards to improve the services provided to the PDs.
  - Baseline the Payload Tactical Plan (manifest) at I-16.
  - Human Factors Integration Team (HFIT) established to help payload developers verify and close Human Factors requirements at the payload site.
  - Verification data reduction in CR Process.
    - » Goal established: 25% reduction.
    - » Changes currently in process will result in an average 29% reduction.
  - The deletion of the required delivery of acoustic, EMI/EMC and Micro-g Control Plans.
  - Streamline Training Strategy Team/ Establish Ops TIM.
  - Combine PODF and PDRT Teams.
  - Team established to identify and implement improvements to the Payload Data Library driven by inputs from Payload Developers.
    - » Normal PDL update process regularly includes important improvements.
    - » Enhanced PDL prototype in development and has received favorable reviews by Payload Developers.
  - A detailed customer satisfaction survey has been implemented that provides useful feedback to the ISS Payloads Office.
    - » Post-increment surveys for Increments 5 and 6 have been completed.
    - » The post-increment for Increment 7 survey is in progress.
    - » For future increments, the survey will be split into a post-delivery/pre-launch survey and a post-flight-operations survey to improve the feedback to the ISS Payloads Office.
    - » The ISS Payloads Office and Boeing have initiated a process to flow improvement ideas from the survey and the Increment lessons learned to the ISS Payloads Office process improvement team.

Recent Victories

- ISS Program Manager approved 20 middecks per flight for Research starting on ULF-2 (1100 W for powered middecks).
- No waivers required for thermal exceptions of up to nominal 1500 W on ISS (US Lab).
- Payload Developer Web Portal on line and operational.
- Process Improvement information now available on the ISS Payloads Office website and will be updated monthly.
- HFIT has been very successful and very well-received by the Payload Developers.

Forward Work

- Close remaining open action items.
  - The process improvement effort is being transitioned to an implementation phase with processes in place to identify and implement new improvement actions as they develop.
  - No new dedicated Lean 6 Sigma sessions are currently planned. Action item status is presented monthly at Program Management Reviews and the ISS Payloads Office website.
- Complete integration of labeling, operations nomenclature, and Inventory Management System processes.
- Complete implementation of Payload Data Library enhancements.
- Complete verification data reduction improvements.
- Implement enhanced payload developer questionnaire.
- Assess and address CAIB findings applicable to ISS Payload Program.
- Review and evaluate the ISS Payloads Program strategic vision to ensure the program will continue to provide efficient service to existing and future payload customers.

Conclusion

- The ISS Payloads Office made a substantial investment and commitment to improve the Payload Integration Process.
  - All affected parties (including PDs) were involved.
- Significant results were achieved in the meetings and plans for further changes were developed.
- Implementation of these plans will occur during the next year.
- Transition to an continual integration of Lean Six Sigma strategies in ISS Payloads Integration processes is in progress to be completed this year.