Statistically Managing Rework Rate of Logistics Support Analysis (LSA) Source Data Using CMMI®

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Eastern Region Melbourne
Agenda

- Identifying Sub-Process Performance Baselines for Statistical Control and Optimization
- Context for LSA Source Data
- Conformance Checklist Database (CC DB)
- Measurement System Analysis (MSA)
- Control Chart Selection
- Causal Analysis & Resolution (CAR)
- Establishing the Improvement
- Performing to the Improved Baseline
- Benefits
- Questions
Identifying Sub-Process Performance Baselines for Statistical Control and Optimization

- Approach employed at Northrop Grumman Integrated System Eastern Region (ISER) in Melbourne:
  - Each Engineering Directorate is seen as critical to successful performance on the project

- Each Engineering Directorate identifies its key processes

- They decompose their key processes to select sub-processes for Statistical Control and Optimization

  - **A Standardized Selection Rationale is Employed:**
    - Scope
    - Organizational Impact
    - Benefits
    - Executability

- Logistics Directorate uses this established methodology to select a critical sub-process performance baseline for Statistical Control and Optimization
Identifying Sub-Process Performance Baselines for Statistical Control and Optimization

Site AOP - Perform on Contracts Within Cost, Schedule, and Quality

Logistics - Disciplines/Processes on the Project

Perform - Sector LRSP

Other Programs

Directorate expanded high maturity practices to other critical Logistics disciplines

Previous high maturity practices were directed at Tech Pubs

Note: Headcounts derived from Melbourne personnel listings in ISER Logistics Organization Chart dated September 2008.
Identifying Sub-Process Performance Baselines for Statistical Control and Optimization

Perform - Sector LRSP

Site AOP - Perform on Contracts Within Cost, Schedule, and Quality

Logistics - Disciplines/Processes on the Project

Supportability (LSA)

1/11 (9.1%) Processes Under Statistical Control, 19.0% of Total Logistics Effort

U2-0801 Joint Cost and Performance System (J-CAPS) Software Configuration Control Process
U2-0301.44 Supportability Analysis
U2-0301.45 Spares Computations
U2-0301.46 Life Cycle Cost Analysis
U2-0301.47 Common Support Equipment (CSE) Procurement Process
U2-0301.48 Aircraft Change Directive Tracking Process

U2-0301.50 Data Review and Approval
U2-0306 Support Requirement Analysis
U2-0307 LSA Source Data Development
U2-0308 Data Validation
U2-0309 Engineering Review of Technical Data

Source data development represents the most significant activity LSA performs.
Identifying Sub-Process Performance Baselines for Statistical Control and Optimization

The quantitative basis for statistical control of LSA source data quality was established with inclusion of Source Data Nonconformance codes in the CC database.

Statistical baseline:
Rate of Compliant Data (NC-Free) per All Data Submitted
LCL yy% < Mean x% < UCL zz%
Context for LSA Source Data: Data Handoffs From Internal to External Customers

Logistics Support Analysis (LSA) is the prime provider of source data to Tech Pubs.

Inputs

Other Engineering Directorates: documentation from Systems, Vehicle, Software, Vendor data, etc.

Rework and revisions from upstream Engineering Directorates must be handled separately.

If LSA reduces the rate of nonconformances it injects in source data, it reduces risk in Tech Pubs effort to catch and correct inherited errors prior to delivery of Manuals.

Logistics

Output: Source Data documentation

Supplemental Data from Engineering

Supplemental Data from Vendor

Tech Pubs

Output: Interactive Electronic Technical Manuals

External Customer (receives NG Technical Manuals)

To sustain customer quality rating, Technical Publication must catch and correct all errors (errors it injects and errors it inherits from upstream in the data process).

Starting at the end of the process

Current Quality of Tech Pubs is rated blue (0.0 - 0.5% defect rate) by the customer.
Context for LSA Source Data: How Quality Impacts Tech Pubs

- Timely delivery of LSA source data is crucial to Tech Pubs:
  - Directly impacts the quality, cost, and schedule

- Source Data: any engineering work product input to Technical Publications
  - Rework of source data after it is delivered to Technical Publications has an adverse impact on cost and schedule
Conformance Checklist (CC): Background

• Technical Publications delivers an Interactive Electronic Technical Manual (IETM) to its customer.
  - The IETM supporting the aircraft system was recently upgraded.

• Quality System for Technical Publications includes a Conformance Checklist (CC) database (DB) in Oracle.
  - CC DB designed to track Technical Publications data development (real time) through each of its critical phases:
    • Nonconformances (NC): CC DB provides coded categories that identify different types of errors/defects for each phase

• Voice of Customer (Tech Pubs) identified concerns with the quality of source data submitted to Publications for data development.
  - Concluded rework was placing constraints on schedule, and increased risk for negative quality levels that might migrate to the external customer.

• Response:
  - Enhanced CC DB to quantify quality of source data inputs to Tech Pubs with specific nonconformance codes.
  - New Source Data Non-Conformance codes were in use by 2005 IETM Release
Management Focus - Identify the most meaningful measure to monitor the process:

- Of the total number of LSA Source Data (Memos) in an IETM release, what Percent of those memos had one or more nonconformances?

- Inversely what percentage had no nonconformances?

- CC DB Analysis indicates LSA is the largest provider of source data and associated rework.

Pie chart indicates % of source data Tech Pubs received from different organizations.

Typical rework rate in a 2005 Release. All LSA source data (memos) incorporated that had one or more NCs.
Measurement System Analysis (MSA)

• Conclusion:
  – The Measurement System is controlled and documented by “Conformance Checklist Processing” procedure
  – Technical publications workforce trained in use of the CC DB system
  – Source Data NC codes (rework metric) offer sufficient basis for trend analysis and statistical management
    • Repeatability
    • Reliability
    • Precision

• Potential Area for Future Improvement:
  – The measurement system is adequate for statistical process control.
  – During improvement phase, enhancement opportunities of source data NC codes can be explored
    • Refinement of operational definitions.
Control Chart Selection

• **Statistical Analysis:**
  - The Moving Average chart was chosen as the primary chart for process owner to monitor process performance
    - Meets requirement to view product quality at an appropriate statistical level
      - (e.g. What percent of LSA data incorporated into Tech Pubs with no errors?)
    - Allows process owner to statistically evaluate changes in process performance
      - (e.g. separate meaningful changes from random noise in the process).
  - A supplemental control chart (C-chart) was also selected:
    • Provides an additional tool to evaluate trends in the moving average chart
    • Provides a basis for future costing of rework
    • Provides capability to perform analysis of discrete nonconformance data per memo
Control Chart Selection:
Moving Average Chart of Compliant Memo Data

IETM Database Release XX was selected as the most representative and most current population of data used to establish first stable baseline.
Control Chart Selection:
C-chart of Defect per Memo

Mean represents number of nonconformance per LSA Memo

UCL=xxx

$\bar{C}=yyy$

LB=zzz

Based on 155 data points
DB Release XX
Causal Analysis & Resolution (CAR): One Solution - Two Applications

- Process Management Team (PMT) comprised of LSA and Tech Pubs personnel performed root cause analysis of statistical data.

- Through data analysis and brainstorming, two intertwined problems/opportunities emerged:
  - Need to institute improvements to reduce nonconformance escapes from LSA source data development process (reduced rework rate).
  - Reevaluate accuracy of operational definitions underlying measurement system embedded in the CC DB (rework rate metric).
    - Ascertain if further improvement over-and-above Level 4 capability can be obtained.

- One Solution - Two Applications:
  - PMT concluded that improved operational definitions for source data defects could be applied to both ends of the process:
    - Improve the source data rework rate by using operational definitions as LSA guidelines (in checklist form) to check source data prior to delivery to Tech Pubs.
    - Ensure accuracy of the measurement system by embedding operational definitions to ensure greater consistency in NC code application by Tech Writers.
## CAR: Developing and Implementing the Action Plan

### Data Development Checklist

#### New Data

<table>
<thead>
<tr>
<th>Item</th>
<th>Yes or NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>System and Subsystem Identified</td>
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</tr>
<tr>
<td>Task Title Identified</td>
<td></td>
</tr>
<tr>
<td>Effectivity or Limitation Identified</td>
<td></td>
</tr>
<tr>
<td>Personnel Requirements Identified</td>
<td></td>
</tr>
<tr>
<td>Personnel Instructions Completed</td>
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</tr>
<tr>
<td>Technician A Performs Task</td>
<td></td>
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<tr>
<td>Technician B Assists Technician A</td>
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</tr>
<tr>
<td>Consumable Material Identified</td>
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</tr>
<tr>
<td>Part No.</td>
<td></td>
</tr>
<tr>
<td>NSN</td>
<td></td>
</tr>
<tr>
<td>CAGE Code</td>
<td></td>
</tr>
<tr>
<td>Quantity</td>
<td></td>
</tr>
<tr>
<td>Support Equipment Identified</td>
<td></td>
</tr>
<tr>
<td>Part No.</td>
<td></td>
</tr>
<tr>
<td>NSN</td>
<td></td>
</tr>
<tr>
<td>CAGE Code</td>
<td></td>
</tr>
<tr>
<td>Quantity</td>
<td></td>
</tr>
<tr>
<td>Reference Material Identified</td>
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<tr>
<td>General System Technical Order</td>
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<tr>
<td>Support Equipment Technical Order</td>
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</tr>
<tr>
<td>System Level Warning, Cautions and Notes Identified</td>
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<tr>
<td>Apply to Entire Task</td>
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<tr>
<td>Sequential Task Described</td>
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<tr>
<td>Steps Identified requiring Warning</td>
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<tr>
<td>Warning, Caution or Note</td>
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<tr>
<td>Steps requiring special instructions identified</td>
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<tr>
<td>Step (1)</td>
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</tr>
<tr>
<td>Drawing or Recommended Graphics Provided</td>
<td></td>
</tr>
<tr>
<td>Source Data Attached (as required)</td>
<td></td>
</tr>
</tbody>
</table>

#### Data Update

<table>
<thead>
<tr>
<th>Item</th>
<th>Yes or NA</th>
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<tbody>
<tr>
<td>Assigned SSSN Identified</td>
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<tr>
<td>Task Title Identified</td>
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<tr>
<td>Effectivity or Limitation Identified</td>
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<tr>
<td>Personnel Requirements Changed</td>
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<tr>
<td>Personnel Instructions Changed</td>
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<tr>
<td>Consumable Material Changed</td>
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<tr>
<td>Part No.</td>
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<td>NSN</td>
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<td>Quantity</td>
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<td>Support Equipment Changed</td>
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<td>Part No.</td>
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<tr>
<td>Reference Material Changed</td>
<td></td>
</tr>
<tr>
<td>System Level Warning, Cautions and Notes Changed</td>
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<tr>
<td>Existing Procedure Mark-Up with Change Completed</td>
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<tr>
<td>Graphics Impacts Identified</td>
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<td>Additional Data Impacted (Identify in Remarks)</td>
<td></td>
</tr>
<tr>
<td>Reason for Change or Source Data Attached (as required)</td>
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</tr>
</tbody>
</table>
- **F01 - Administrative Contract Noncompliance:**
  - Direction deviates from current contractual requirements. This includes source data that either does not meet or exceeds MIL-Spec or contract requirements.
  - Direction to violate agreed-to style guide (as a subset of the original TIM agreements), or inconsistent with pre-established system format.
  - Direction does not conform to Technical Manual Contract Requirements (TMCR), Specification Interpretation Documents (SID), or Specification/Standard Application Records (SAR).

- **F02 - Technical Inaccuracy:**
  - Source data is technically incorrect (i.e. values), or is incorrect per LSA Memos, engineering drawings, vendor data, WDs, SDs, etc.
  - Effectivity (UOC) not clearly designated.
  - Any identified content error that may prevent the as-written task from satisfying its intended purpose, including (but not necessarily limited to) content error in:
    - Input task requirements
    - Personnel required
    - Identification of required support equipment/consumables
    - Follow-on task requirements
    - Step-by-step procedures

- **F03 - Task Incomplete:**
  - The as-written task sequence will not accomplish the intended purpose due to missing information, including (but not necessarily limited to) missing:
    - Input tasks
    - Personnel
    - Support equipment/consumables
    - Steps
    - Alerts
    - Redlined graphics, if applicable
    - Follow-on tasks
Other Engineering Directorates: documentation from Systems, Vehicle, Software, Vendor data, etc.

Inputs

Logistics

Output: LSA
Source Data documentation

Tech Pubs
Output: Interactive Electronic Technical Manuals

External Customer (receives NG Technical Manuals)

Operational Definitions Deployed in this phase of the process

LSA Checklist Deployed in this phase of the process

Operational Definitions Embedded in JCC
- F01 - Administrative Contract Noncompliance:
- F02 - Technical Inaccuracy:
- F03 - Task Incomplete
Establishing the Improvement

With control chart ranges locked at first stable baseline limits (CMMI Level 4) higher trend rate provides clear evidence of improved process performance.

Validation of Improvements
TMD xx

Mean & Std Dev locked at Level 4 Baseline

Based on 159 data points
Establishing the Improvement

- To establish an improved stable baseline, a post-improvement IETM Release was re-run in Minitab with the control chart limits unlocked so new performance limits could be computed.

- Improved performance limits were confirmed.
Establishing the Improvement

Moving Average of Compliant LSA Memo's
Post Improvement Period
TMD xx

Sustained trending above the mean. Process demonstrates capability to meet or surpass this new performance mean.

Based on 159 data points

Good

12% improvement over former UCL

23% improvement over former mean

37% improvement over former LCL

UCL=xxx

= \bar{x}=yyy

LCL=zzz

Based on 159 data points
Performing to the Improved Baseline

- To confirm the improved stable baseline, the next IETM Release after the “post-improvement” baseline was monitored against new control chart limits

- Process performance improvements were confirmed as established within improved limits
Performing to the Improved Baseline

Moving Average of Compliant LSA Memo's
Post Improvement Period
TMD xx

Sustained trending above the mean suggests process capability to meet this new performance mean

UCL=xxx
X=yyy
LCL=zzz

Based on 58 data points

Performance to Level 5 baseline of (M=yyy STD = kkkk locked)
Performing to the Improved Baseline: Using Supplemental C-Chart for Drill Down Analysis

Good Mean represents number of nonconformance per LSA Memo

57% improvement over former mean

38% improvement over former UCL

Two out-of-control points were analyzed, identified as special causes, and remedial action taken as appropriate

Mean represents number of nonconformance per LSA Memo
Benefits

Based on Engineering estimates

When a CC DB Non-Conformance is issued:

1. Assigner of CC NC reviews with LSA Cog for concurrence on NC legitimacy = hrs avg
   1a. If required, (on larger issue) LSA Cog does additional research to verify NC = hrs avg
2. QC and Pubs Manager assess CC NC for accuracy = hr avg
3. Real-time review of NCs occurs with LSA Lead & Tech Pubs manager for concurrence = hr avg
4. If required by scope of change (see steps 1 & 1a) the accepted NC is reworked by LSA Cog = hrs avg.
5. Author makes Tech Pubs inputs based on revised memo or concurrence = hrs avg

- \( N \) = Sum of effort (hours) in the above steps (hours per CC NC using average of ranges)

- \( X \) = Average number of Tech Pubs IETM Releases per year,
  \( Y \) = Average number of memos per release,
  \( Z \) = NC rate per Memo

  (\( Z \) is established from mean of the C-Chart = # of NC per LSA memo)

- \( X \times Y \times Z = T \) NC per year

- \( T \times N \) = cost NC rework hrs per year
Benefits

Post Improvement

\[ Z = \text{NC rate per Memo (}Z\text{ is established from mean of the C-Chart)} \]

- Improvement reduces the mean of the C-Chart by 57%  

Improved NC rate per Memo = \( Z(\text{new}) \)

- \( X \times Y \times Z(\text{new}) = T(\text{NEW}) \) \( \text{NC per year} \)

- \( T(\text{NEW}) \times N = \text{NC rework hrs per year New cost} \)

62% Reduction
Benefits

- The 62% Cost Reduction is in Rework Effort.
- Based on Preliminary Engineering Estimates, Rework Effort Represents δ % of the Overall LSA Source Data Development Process
- Reduction of LSA Rework also has Positive Downstream Impact, Reducing Risk to Cost, Schedule, & Quality.
- Tech Pubs is Currently Conducting Estimates on Cost Impact of Rework to Tech Pubs Authoring

Tech Pubs Conformance Checklist (CC)
Nonconformance (NC) Codes (Causes of Rework):
F01 - Contract Noncompliance
F02 - Technical Inaccuracy
F03 - Task Defined Incorrectly/Incompletely
Questions