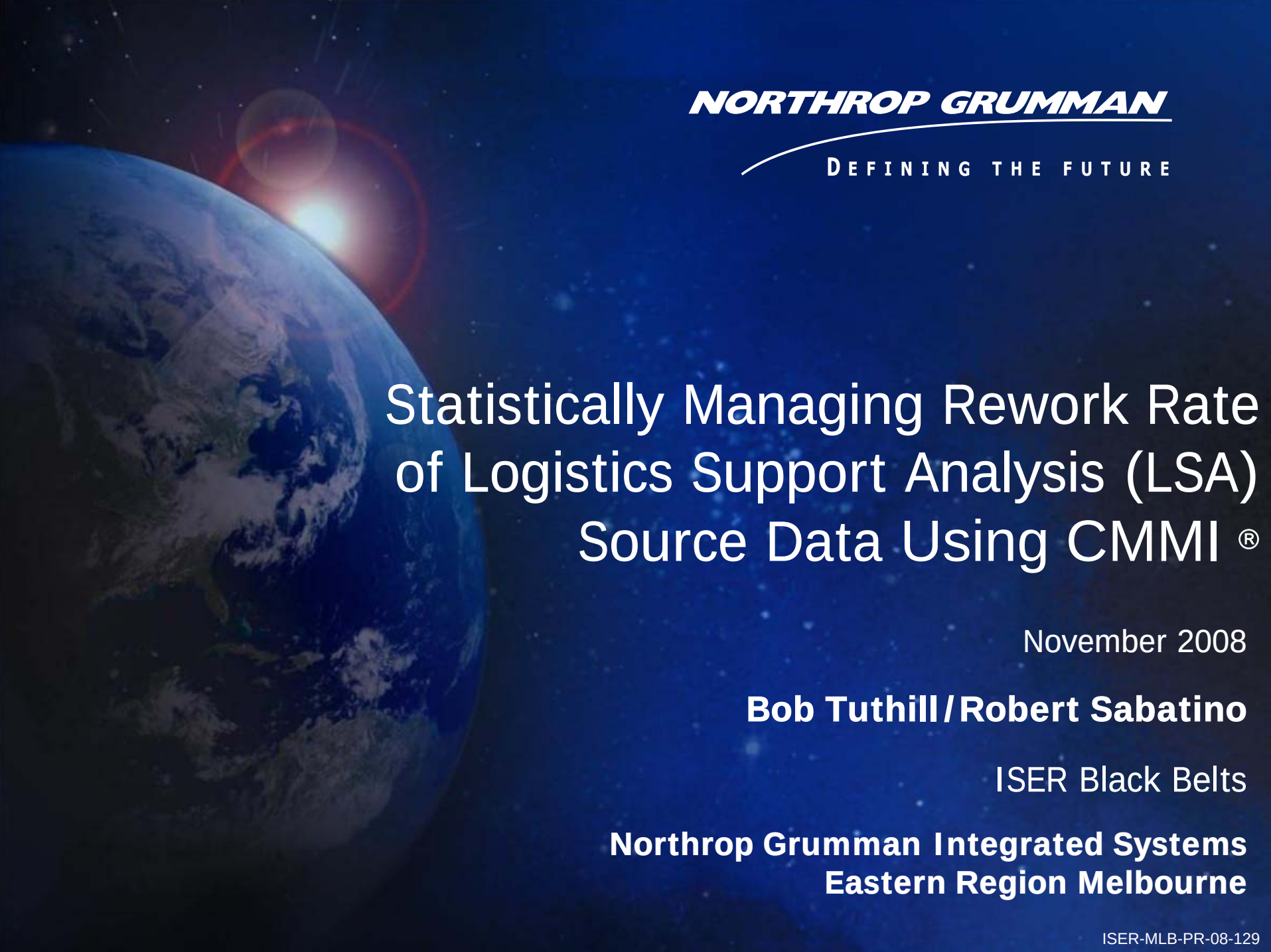

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DEFINING THE FUTURE

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

November 2008

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ISER Black Belts

Northrop Grumman Integrated Systems
Eastern Region Melbourne

ISER-MLB-PR-08-129

Agenda

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- 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

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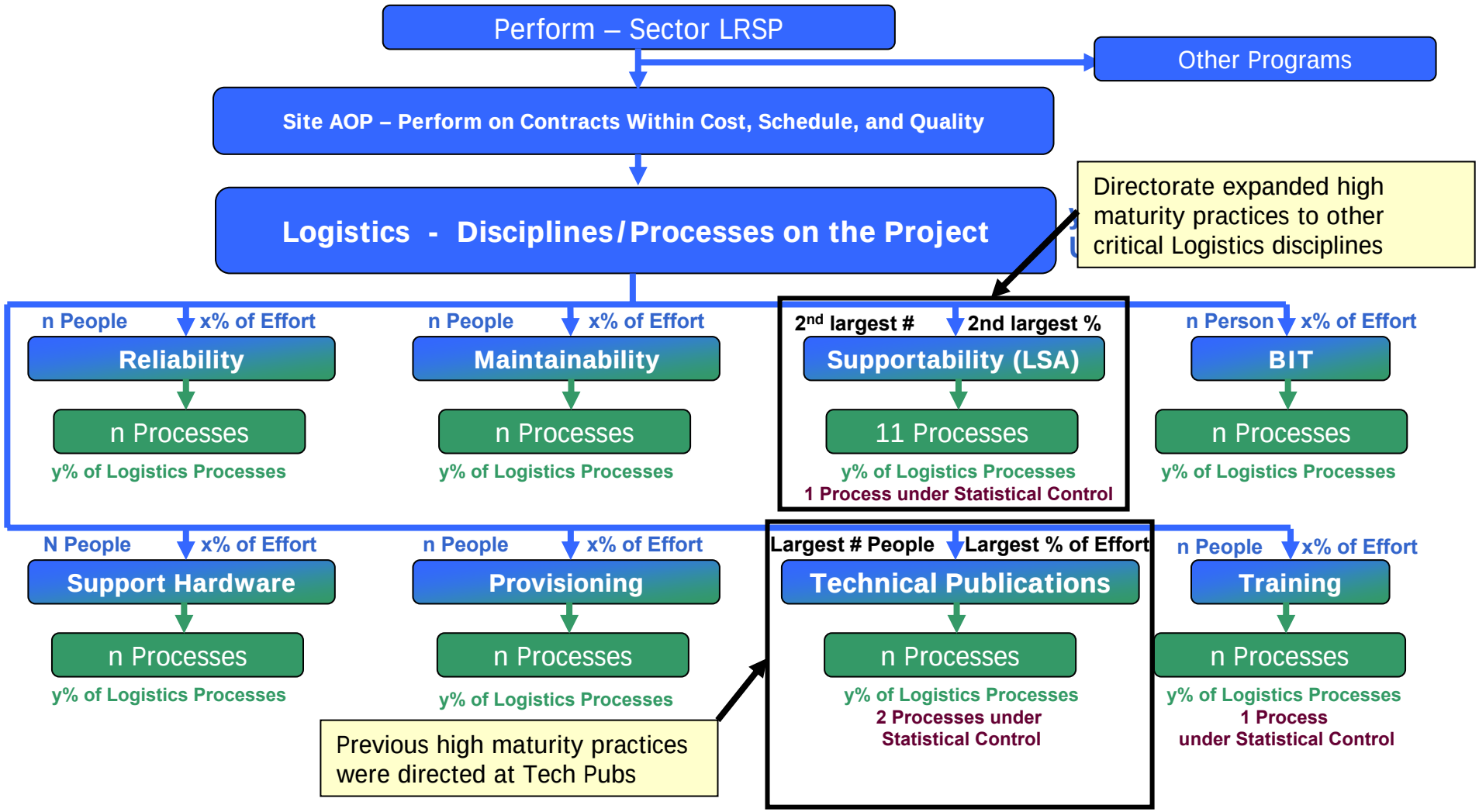
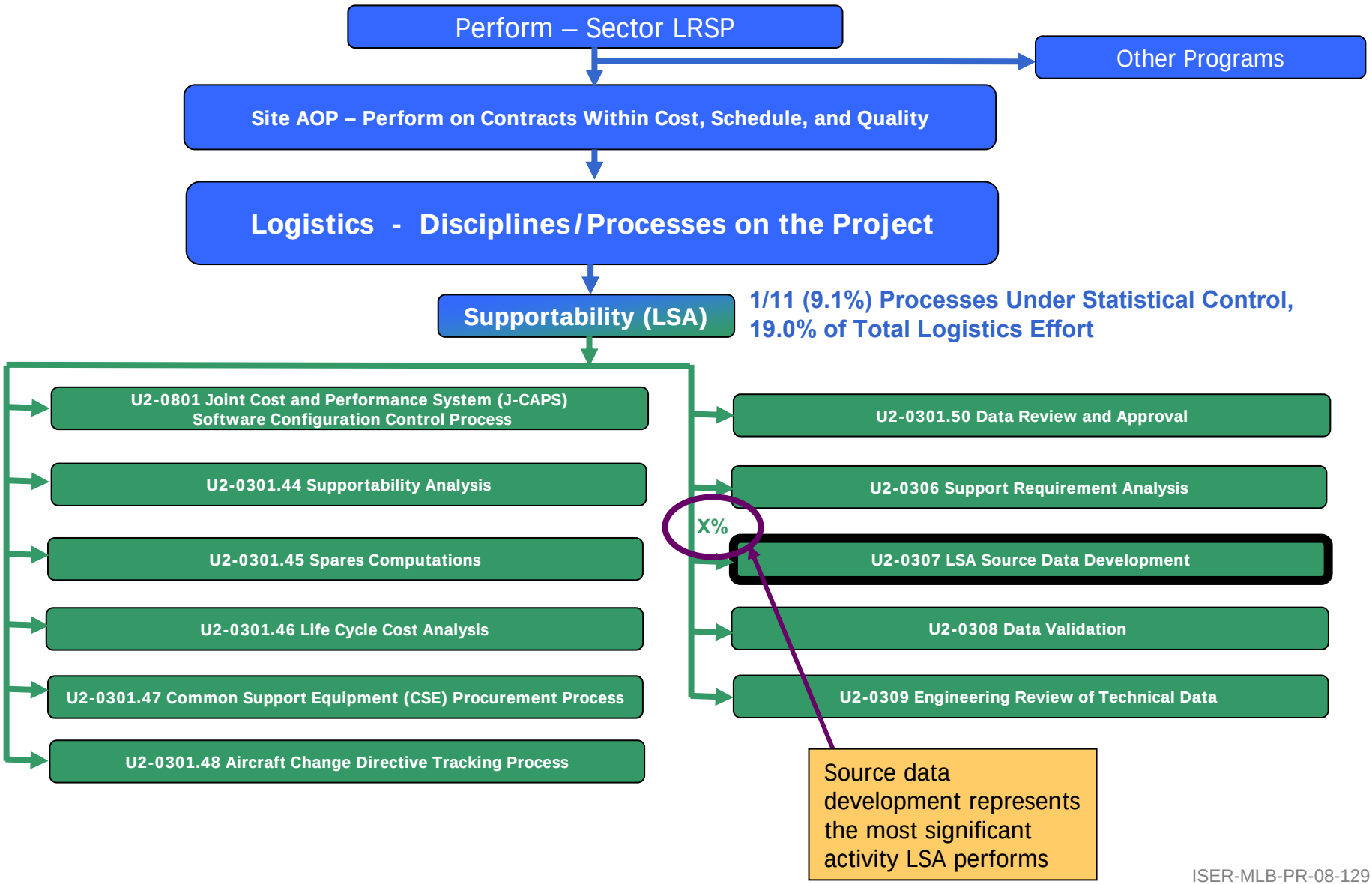
- Approach employed at Northrop Grumman Integrated System Eastern Region (ISER) in Melbourne:
  - Each Engineering Directorate is seen as critical to successful performance on the project
- Each Engineering Directorate identifies its key processes
- They decompose their key processes to select sub-processes 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

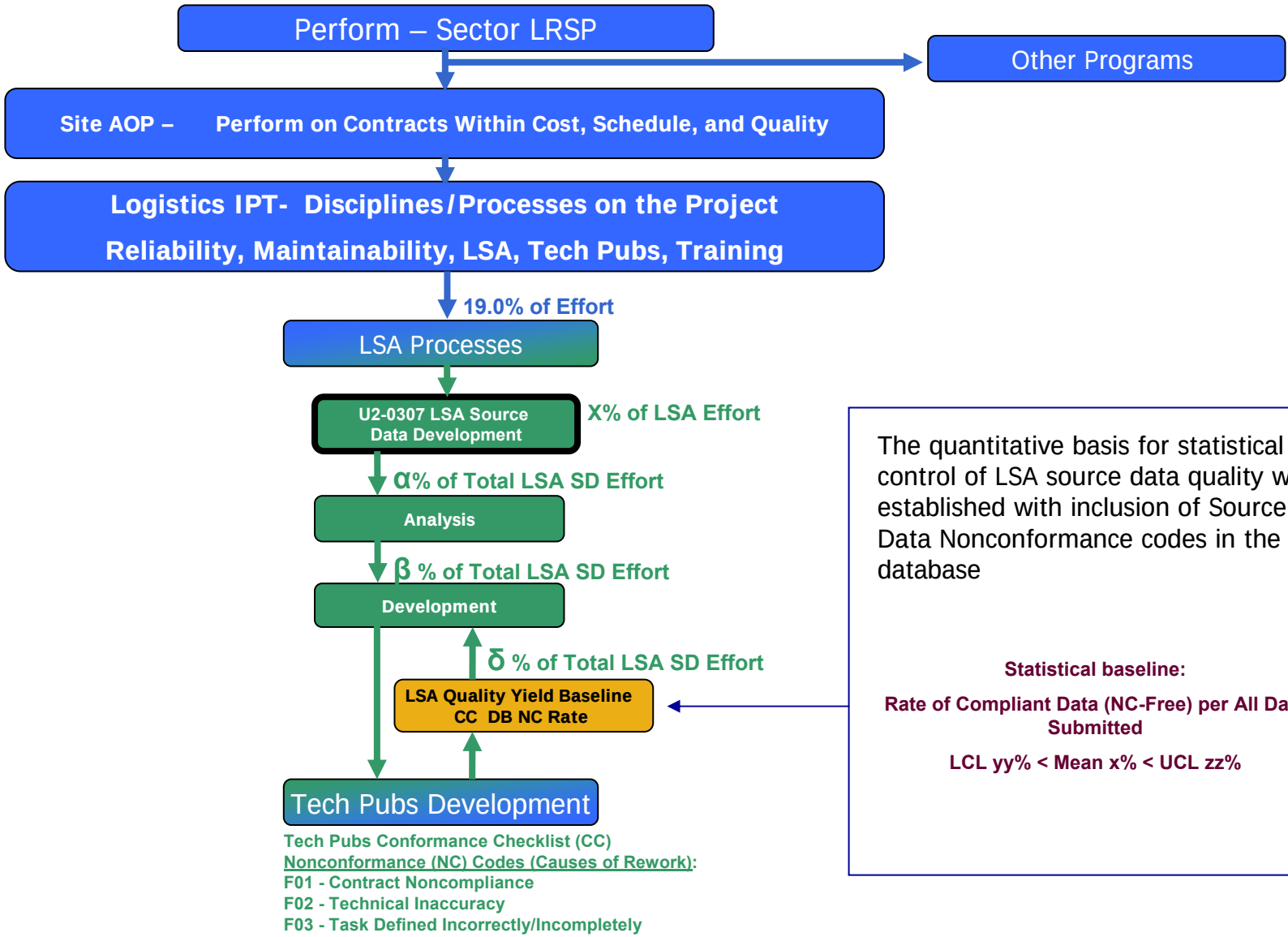


Note: Headcounts derived from Melbourne personnel listings in ISER Logistics Organization Chart dated September 2008.

Identifying Sub-Process Performance Baselines for Statistical Control and Optimization



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

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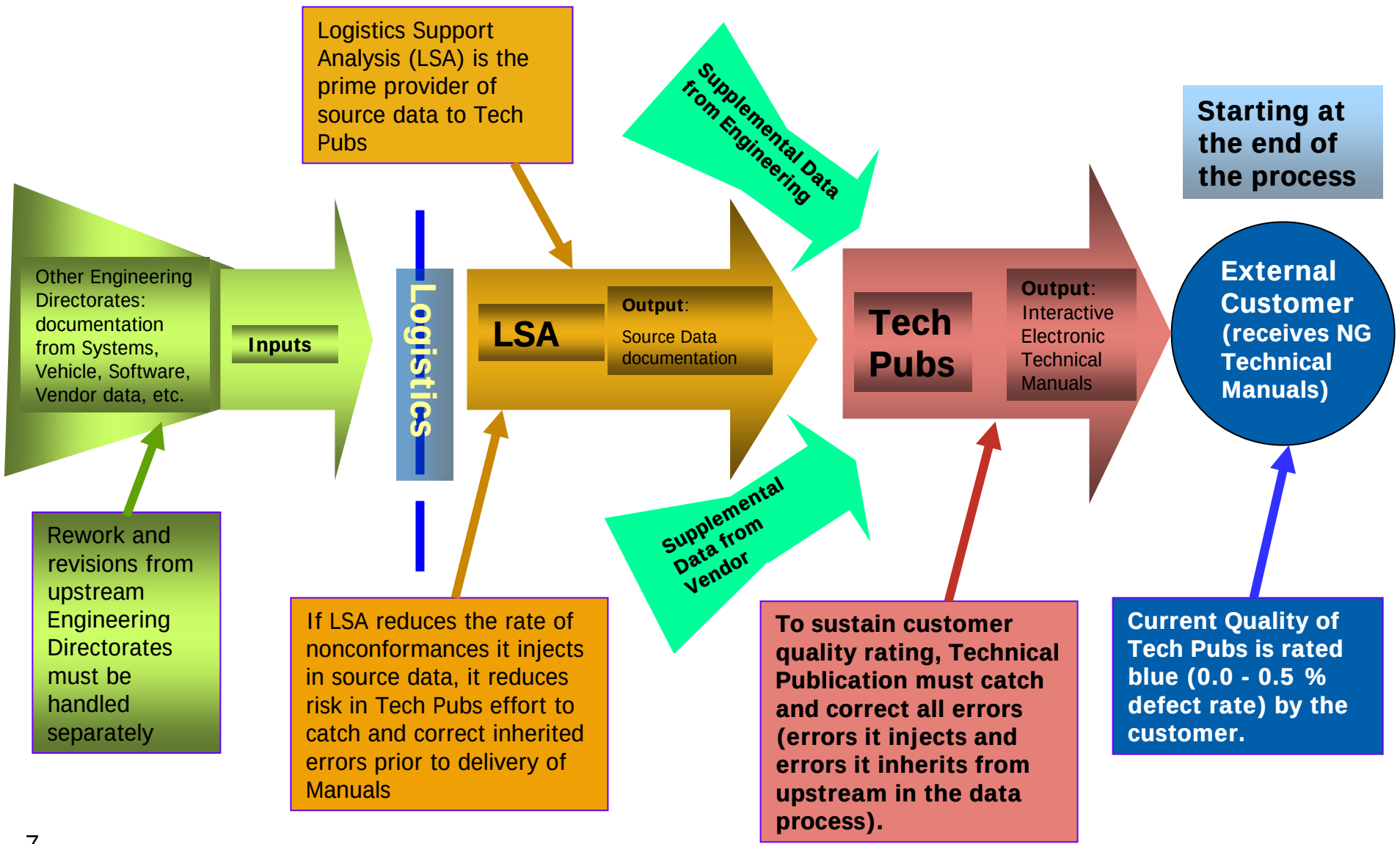

Context for LSA Source Data: How Quality Impacts Tech Pubs

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- 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

Conformance Checklist Database (CC DB) Output Report - Source Data Analysis

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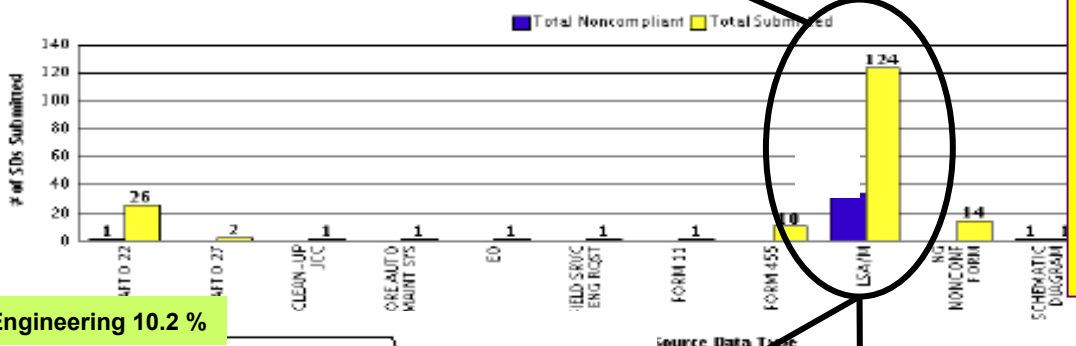
DB Rel no.	Source Data Type Submitted	# of SD IDs Reviewed	# of SD IDs Noncompliant	SD Type Noncompliant	
53	AFTO 22	26	1	2420116ACW519	
	AFTO 27	2			
	CLEAN-UP JCC	1			0 %
	CORE AUTO MAINT SYS	1			0 %
	EO	1			0 %
	FIELD SRVC ENG RQST	1			0 %
	FORM 11	1			0 %
	FORM 455	10			0 %
	LSA/M	124	##	04-116, 05-192, 05-194, 05-276, 05-284, 05-289, 05-290, 05-292, 05-293, 05-296, 05-313, 05-328R1, 05-334R1, 05-367, 05-382, 05-387, 05-390, 05-391R1, 05-393, 05-395, 05-396, 05-397, 05-398, 05-400, 05-407, 05-437, 05-465, 05-471R1, 05-475, 05-483, 05-486R1, 05-493R1, 05-562, 05-566,	X %
	NG NONCONF FORM	14			0 %
	SCHEMATIC DIAGRAM	1	1	C99-3012,	100 %
	TCTO	30			0 %
	TECH DATA DIRECTIVE	1			
	WIRING DIAGRAM	2	1	525-10193,	
	Subtotals:	215	27		

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

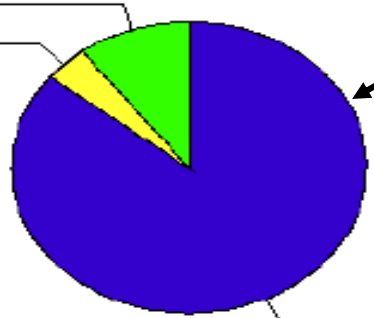


Management Focus - Identify the most meaningful measure to monitor the process:

- **Of the total number of LSA Source Data (Memos) in a IETM release, what Percent of those memos had one or more nonconformance**
- **Inversely what percentage had no nonconformances?**

Vehicle Engineering 10.2 %

Tech Pubs (Parts) 4.0 %



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

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

LSA 85.7%

Measurement System Analysis (MSA)

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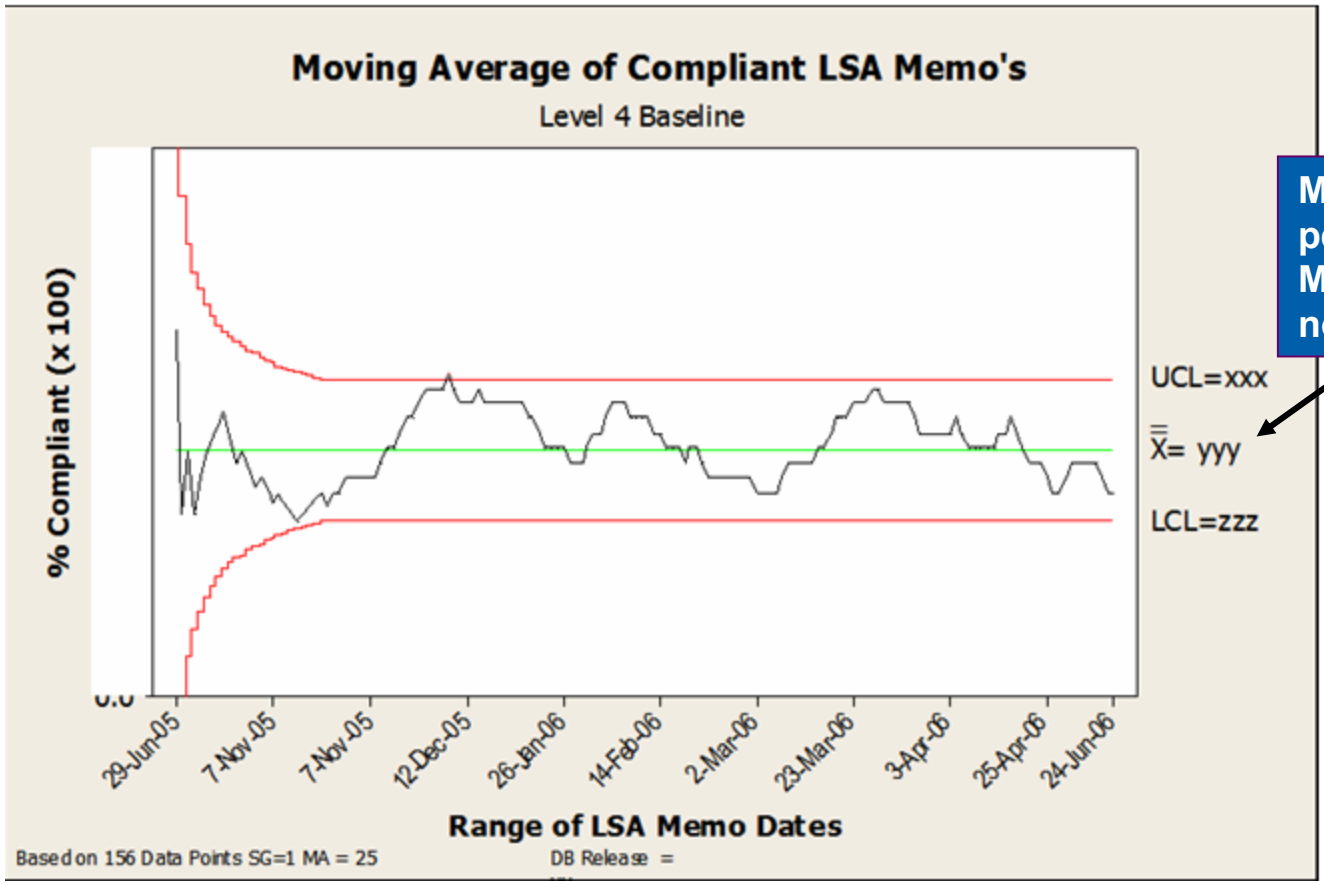
- Conclusion:
  - The Measurement System is controlled and documented by “Conformance Checklist Processing” procedure
  - Technical publications workforce trained in use of the CC DB system
  - Source Data NC codes (rework metric) offer sufficient basis for trend analysis and statistical management
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

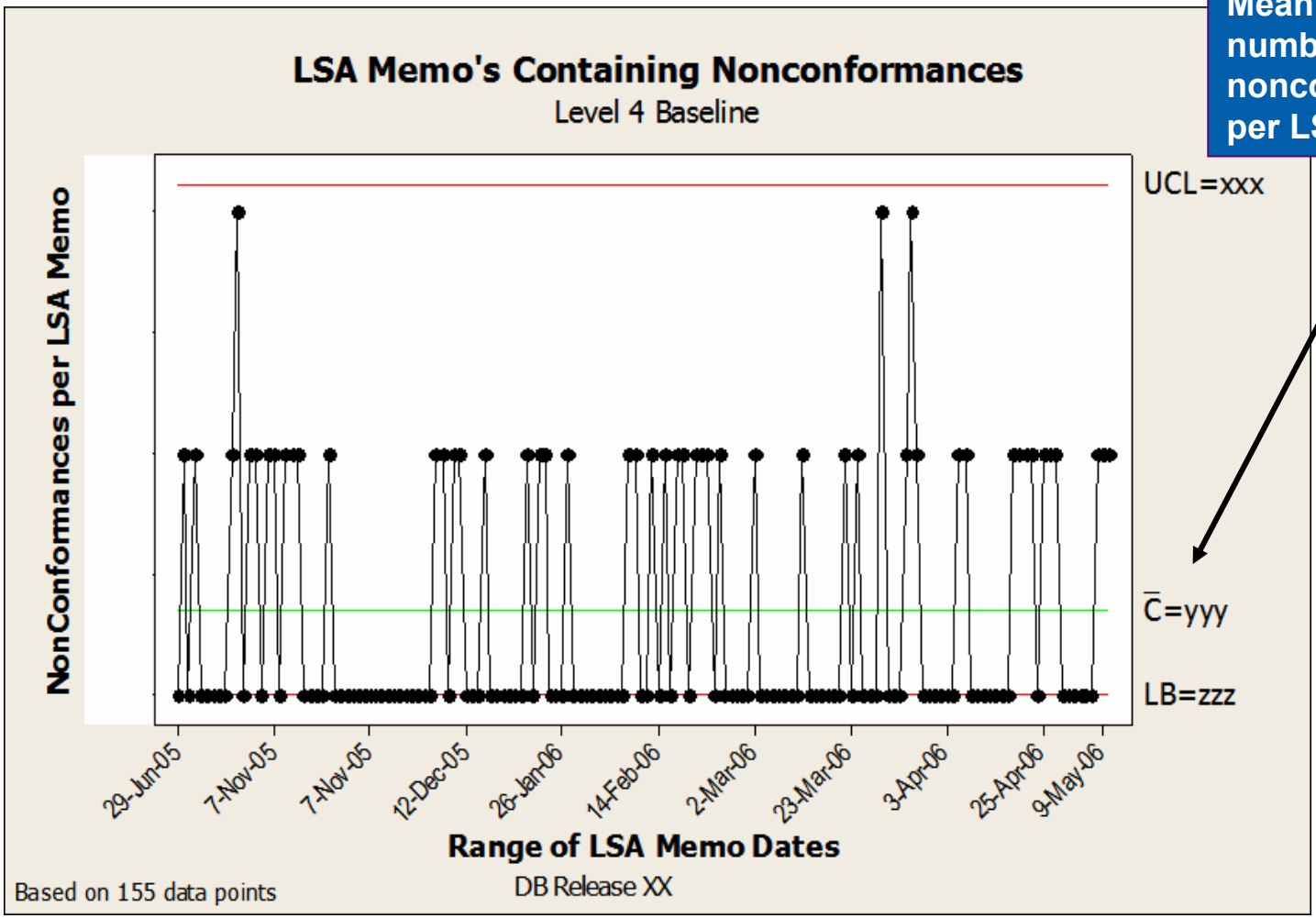


Mean represents percent of LSA Memos with no nonconformances

Good

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

Good

Causal Analysis & Resolution (CAR): One Solution - Two Applications

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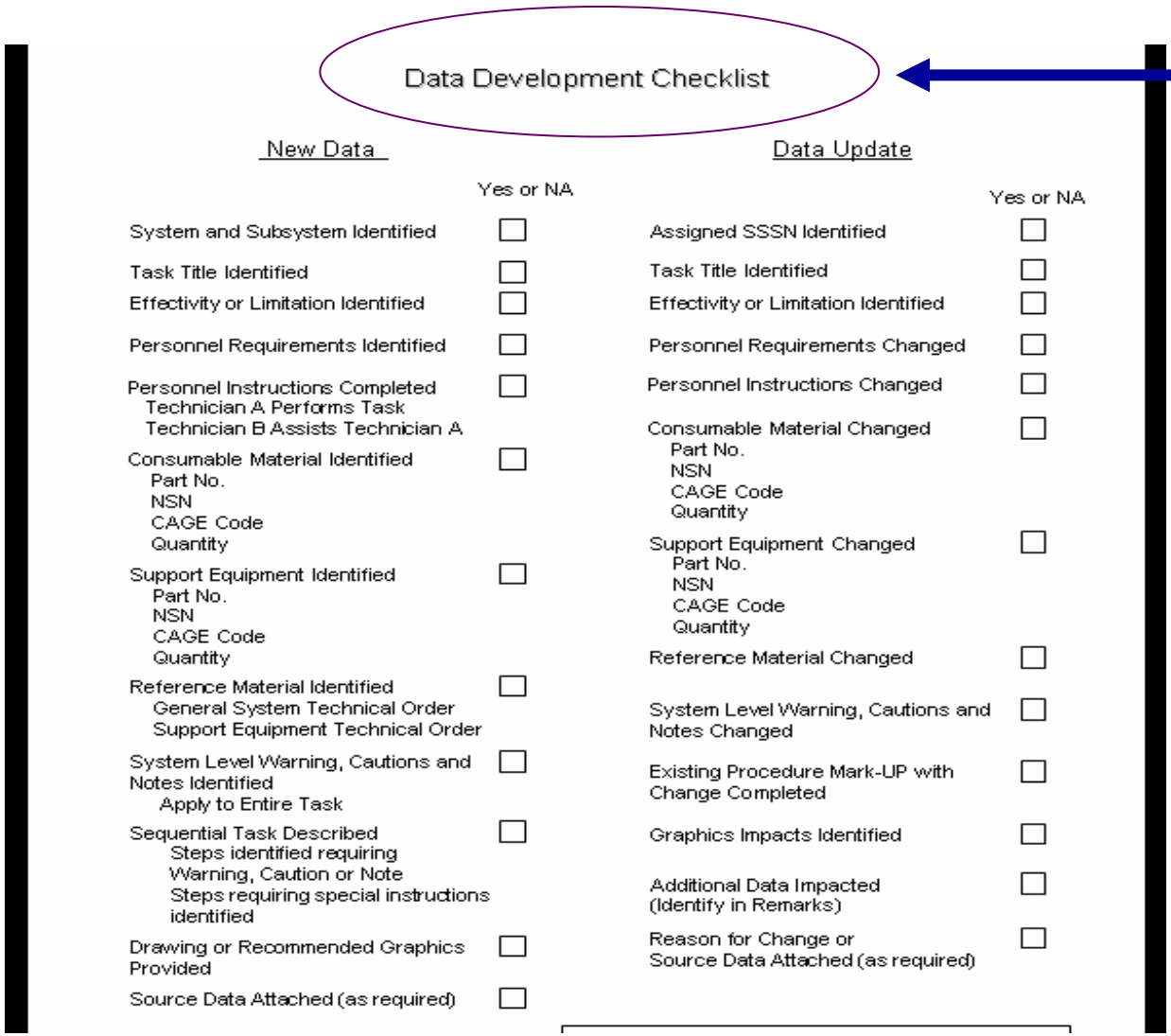
- Process Management Team (PMT) comprised of LSA and Tech Pubs personnel performed root cause analysis of statistical data.
- Through data analysis and brainstorming, two intertwined problems/opportunities emerged:
  - Need to institute improvements to reduce nonconformance escapes from LSA source data development process (reduced rework rate).
  - Revaluate 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	Yes or NA	Data Update	Yes or NA
System and Subsystem Identified	☐	Assigned SSSN Identified	☐
Task Title Identified	☐	Task Title Identified	☐
Effectivity or Limitation Identified	☐	Effectivity or Limitation Identified	☐
Personnel Requirements Identified	☐	Personnel Requirements Changed	☐
Personnel Instructions Completed Technician A Performs Task Technician B Assists Technician A	☐	Personnel Instructions Changed	☐
Consumable Material Identified Part No. NSN CAGE Code Quantity	☐	Consumable Material Changed Part No. NSN CAGE Code Quantity	☐
Support Equipment Identified Part No. NSN CAGE Code Quantity	☐	Support Equipment Changed Part No. NSN CAGE Code Quantity	☐
Reference Material Identified General System Technical Order Support Equipment Technical Order	☐	Reference Material Changed	☐
System Level Warning, Cautions and Notes Identified Apply to Entire Task	☐	System Level Warning, Cautions and Notes Changed	☐
Sequential Task Described Steps identified requiring Warning, Caution or Note Steps requiring special instructions identified	☐	Existing Procedure Mark-UP with Change Completed	☐
Drawing or Recommended Graphics Provided	☐	Graphics Impacts Identified	☐
Source Data Attached (as required)	☐	Additional Data Impacted (Identify in Remarks)	☐
		Reason for Change or Source Data Attached (as required)	☐

LSA Deployed Checklist by Linking it to LSA Source Data Procedure

CAR: Developing and Implementing the Action Plan

- **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

Technical Publications Embedded Refined Operational Definitions Directly into CC Database

CAR: Developing and Implementing the Action Plan

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

Inputs

Logistics

LSA

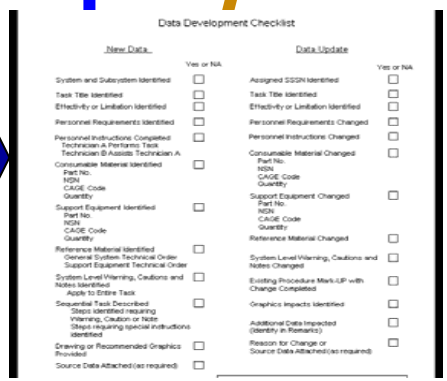
Output: Source Data documentation

Tech Pubs

Output: Interactive Electronic Technical Manuals

External Customer (receives NG Technical Manuals)

LSA Checklist Deployed in this phase of the process


Data Development Checklist

New Data

Yes or NA

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

Data Update

Yes or NA

Assigned SSSN Identified
Task Title Identified
Effectivity or Limitation Identified
Personnel Requirements Changed
Personnel Instructions Changed
Consumable Material Changed
Part No.
NSN
CAGE Code
Quantity
Support Equipment Changed
Part No.
NSN
CAGE Code
Quantity
Reference Material Changed
System Level Warning, Cautions and Notes Changed
Existing Procedure Mark-UP with Change Completed
Graphics Impacts Identified
Additional Data Impacted (Identify in Remarks)
Reason for Change or Source Data Attached (as required)

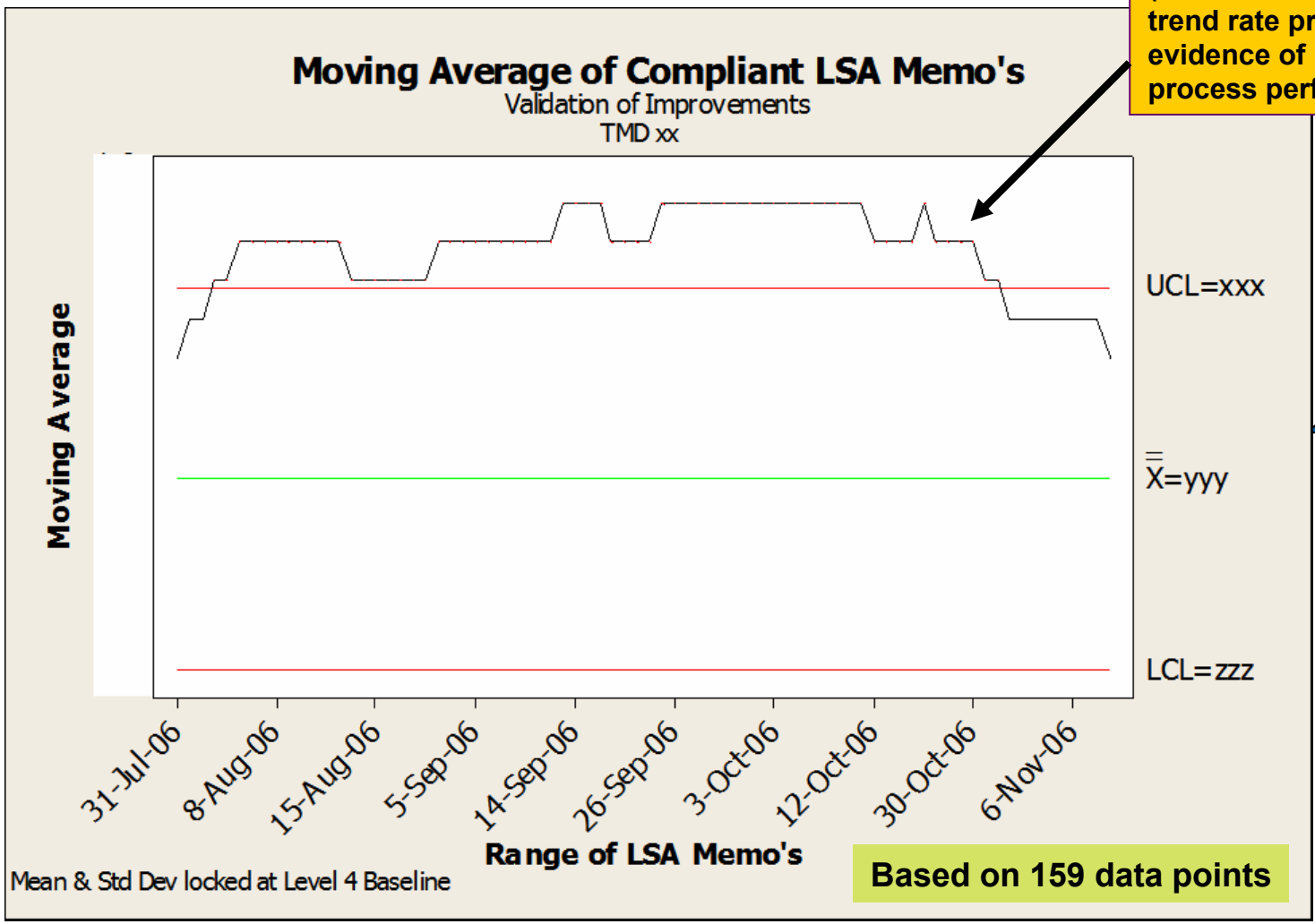
Operational Definitions Embedded in JCC

- **F01 – Administrative Contract Noncompliance:**
- **F02 – Technical Inaccuracy**:
- **F03 – Task Incomplete**

Operational Definitions Deployed in this phase of the process

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



Good

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

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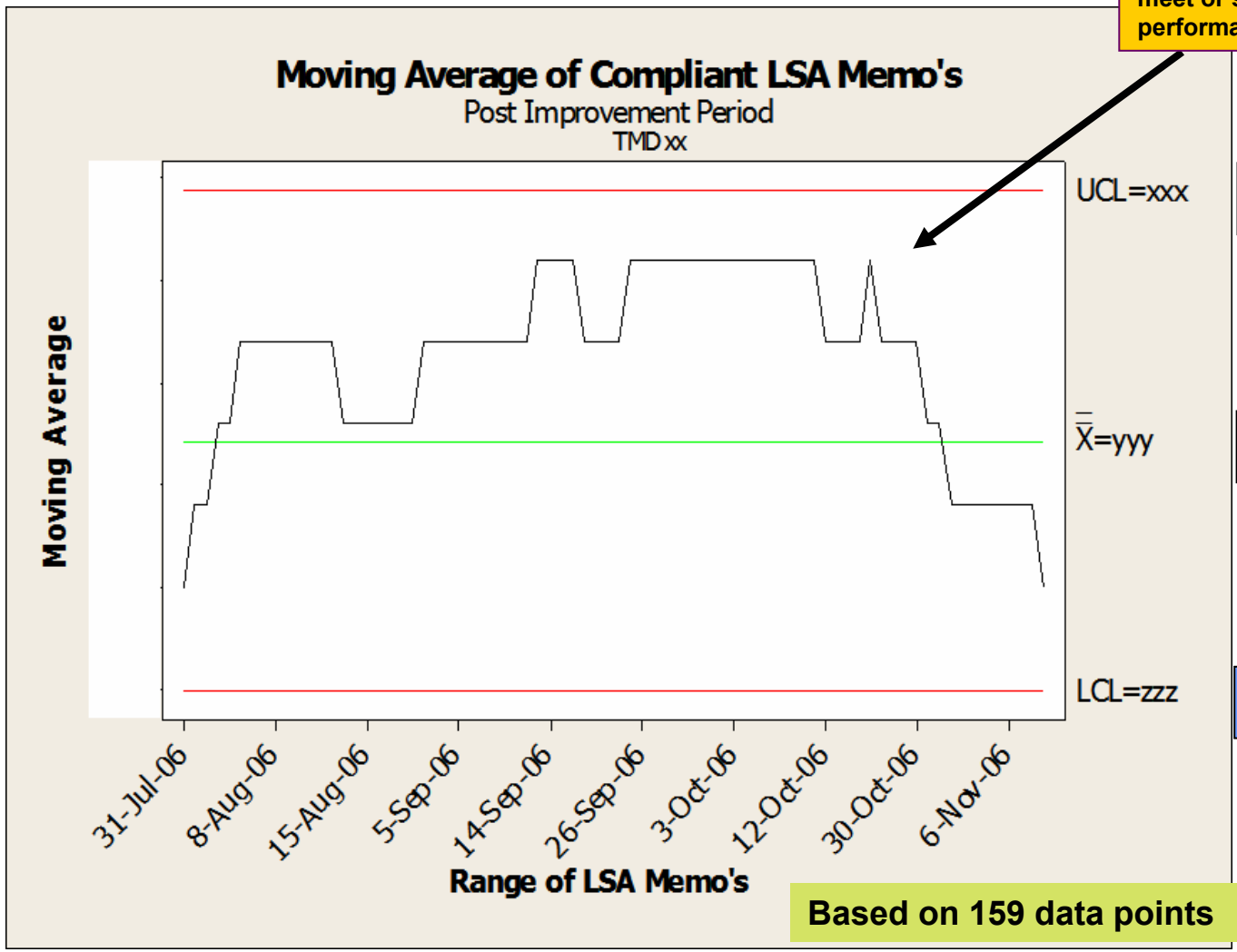
Sustained trending above the mean. Process demonstrates capability to meet or surpass this new performance mean



Good

12% improvement over former UCL

23% improvement over former mean

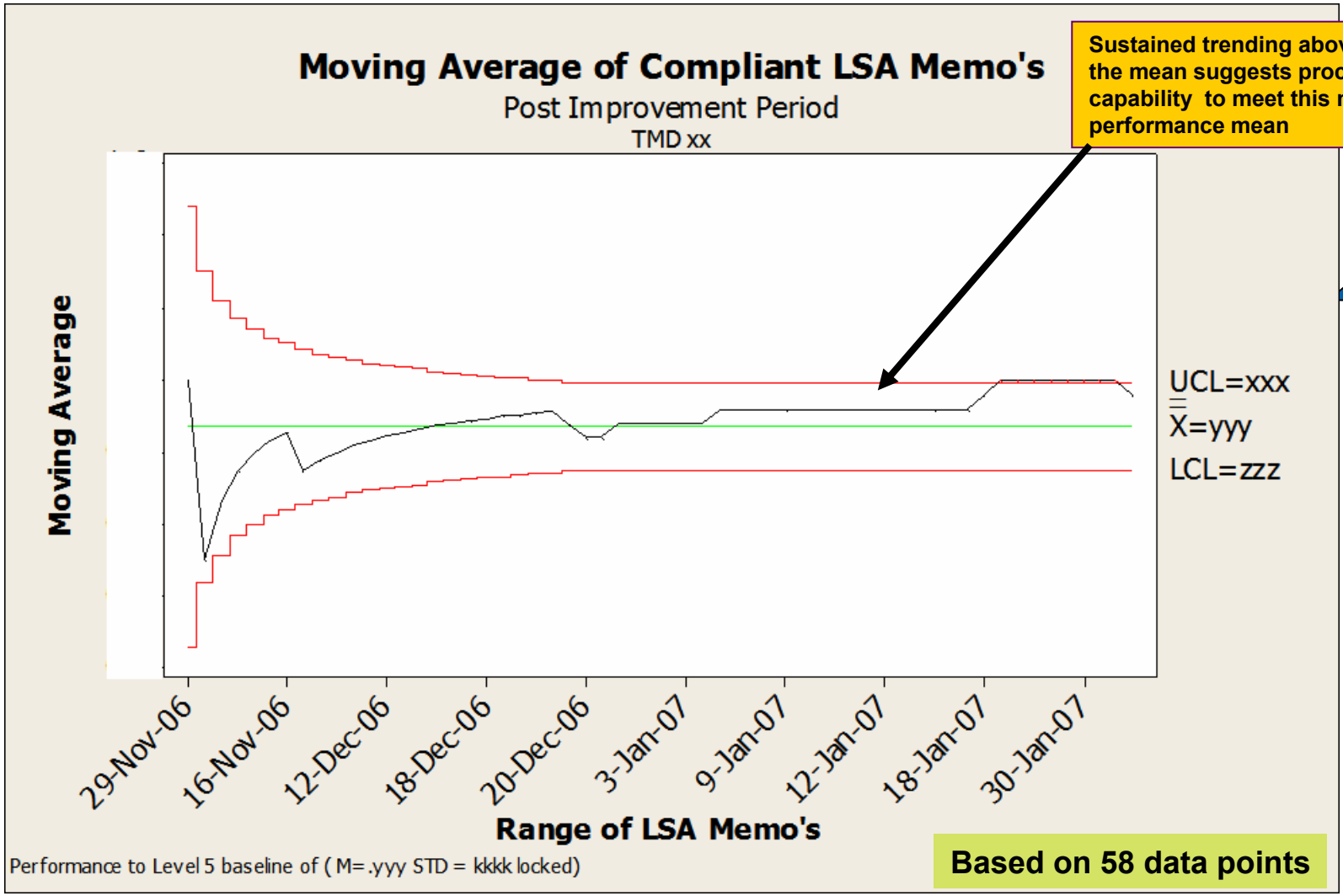
37% improvement over former LCL

Performing to the Improved Baseline

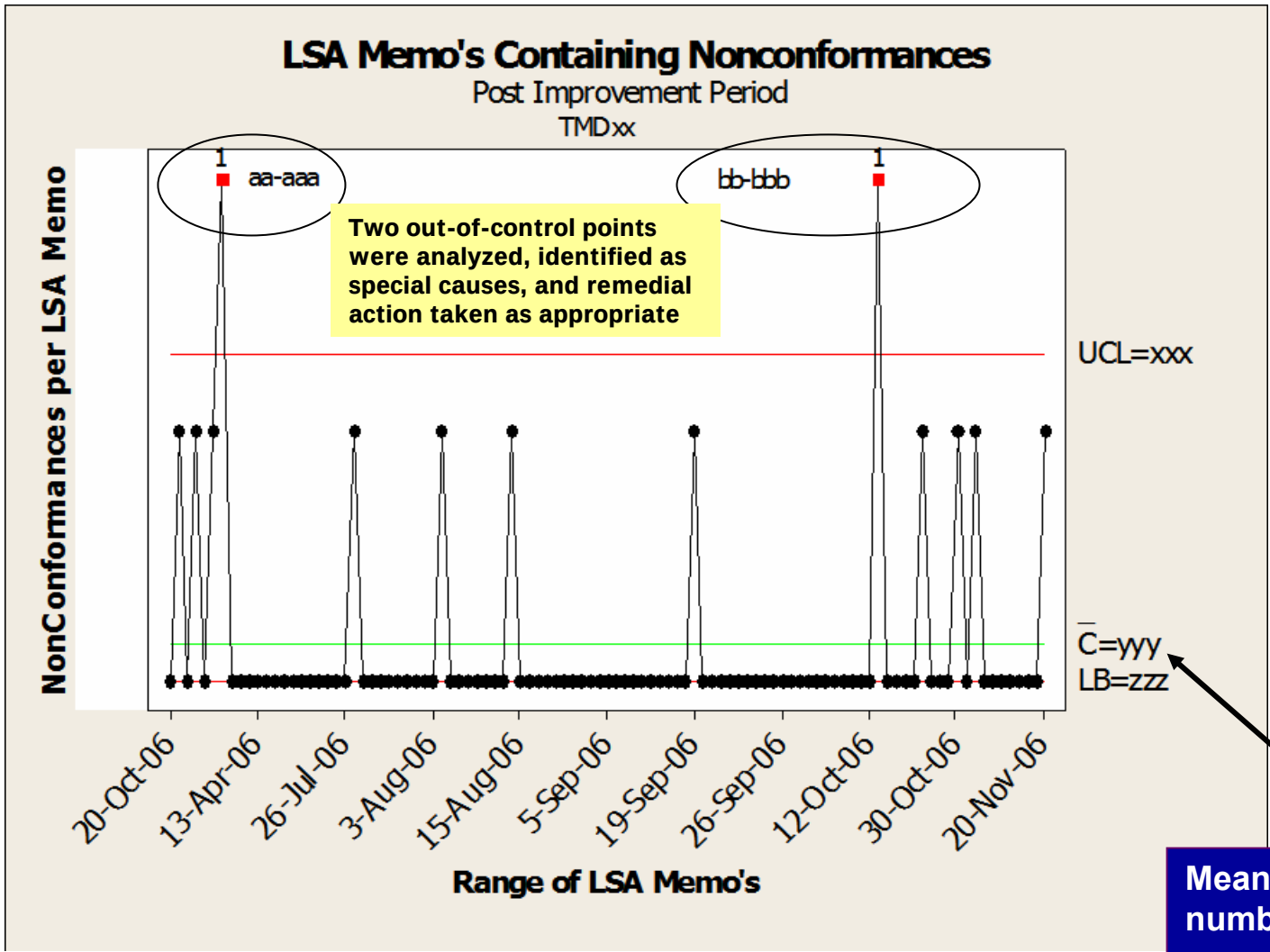
- To confirm the improved stable baseline, the next IETM Release after the “post-improvement” baseline was monitored against new control chart limits

- Process performance improvements were confirmed as established within improved limits

Performing to the Improved Baseline



Performing to the Improved Baseline: Using Supplemental C-Chart for Drill Down Analysis



Good

38% improvement over former UCL

57% improvement over former mean

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** x **Y** x **Z** = **T** NC per year
- **T** x ***N*** = **cost** NC rework hrs per year

Benefits

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Post Improvement

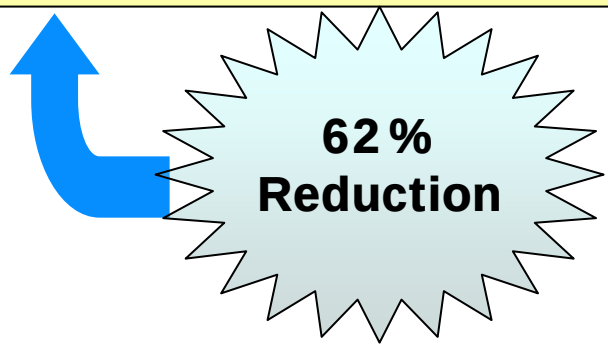
Z = NC rate per Memo **(Z is established from mean of the C-Chart)**

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

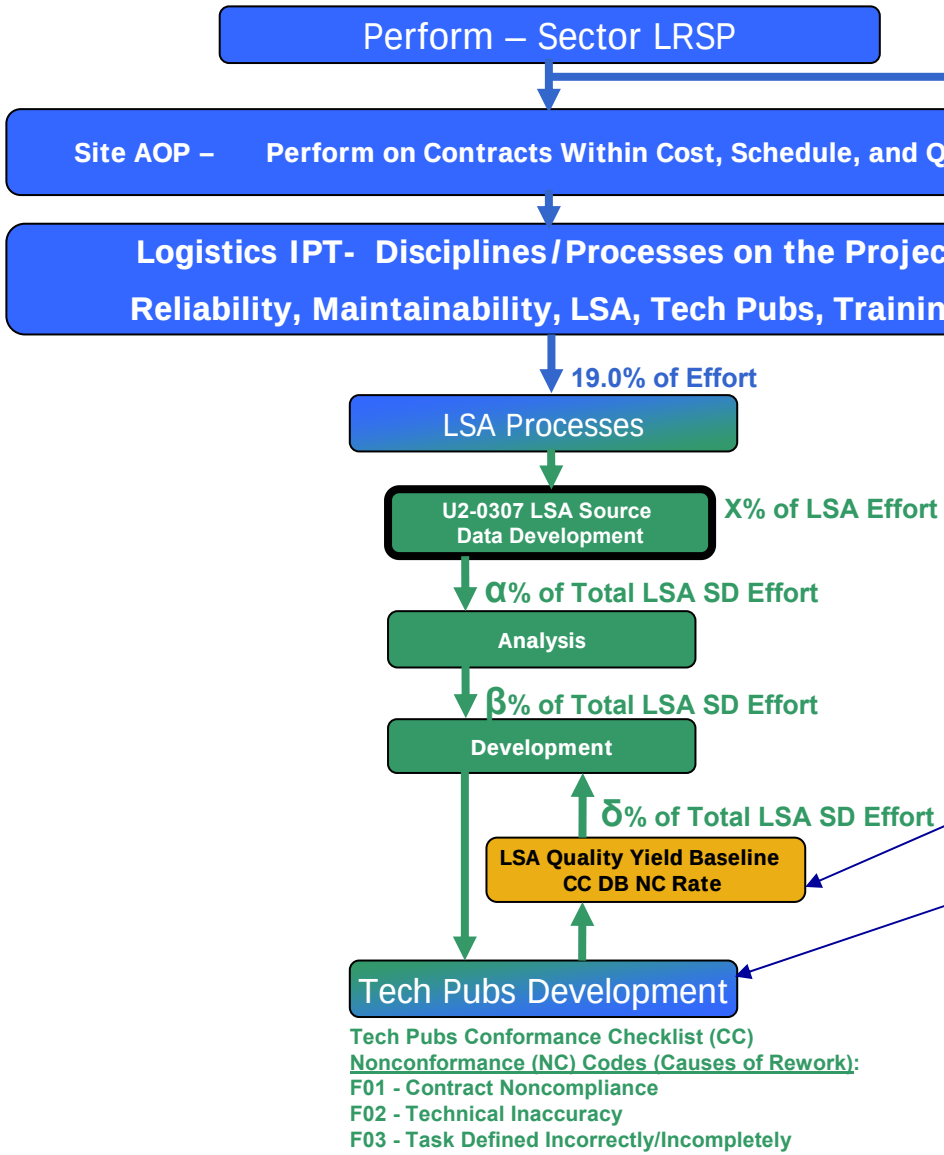
Improved NC rate per Memo **= Z(new)**

- **X** x **Y** x **Z(new)** = **T(NEW)** NC per year

- **T(NEW)** x ***N*** = **NC rework hrs per year New cost**



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**

Questions

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