



***NORTHROP GRUMMAN***

DEFINING THE FUTURE



# Statistically Managing Rework Rate of Logistics Support Analysis (LSA) Source Data Using CMMI<sup>®</sup>

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**Bob Tuthill/Robert Sabatino**

ISER Black Belts

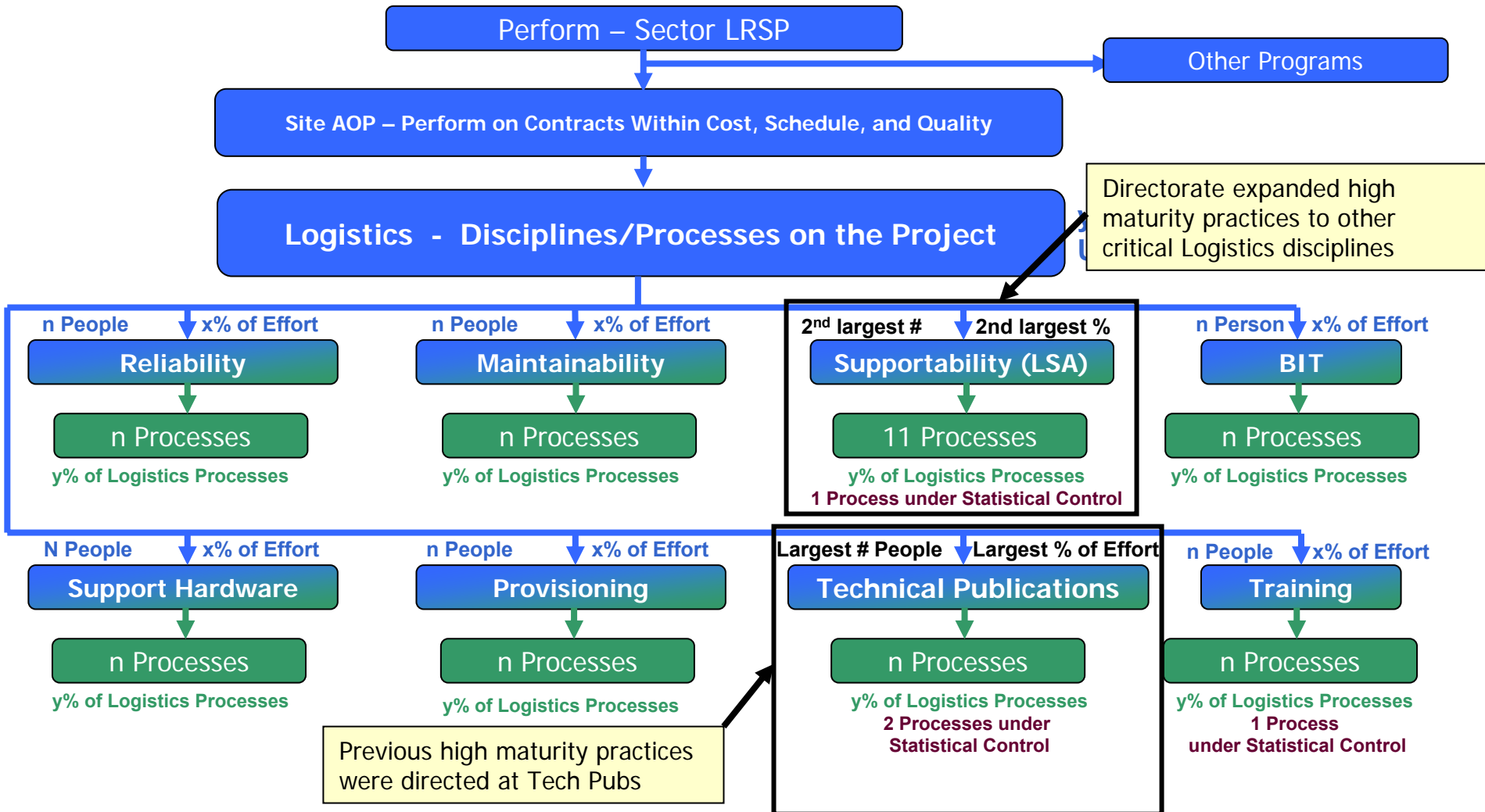
**Northrop Grumman Integrated Systems  
Eastern Region Melbourne**

- 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

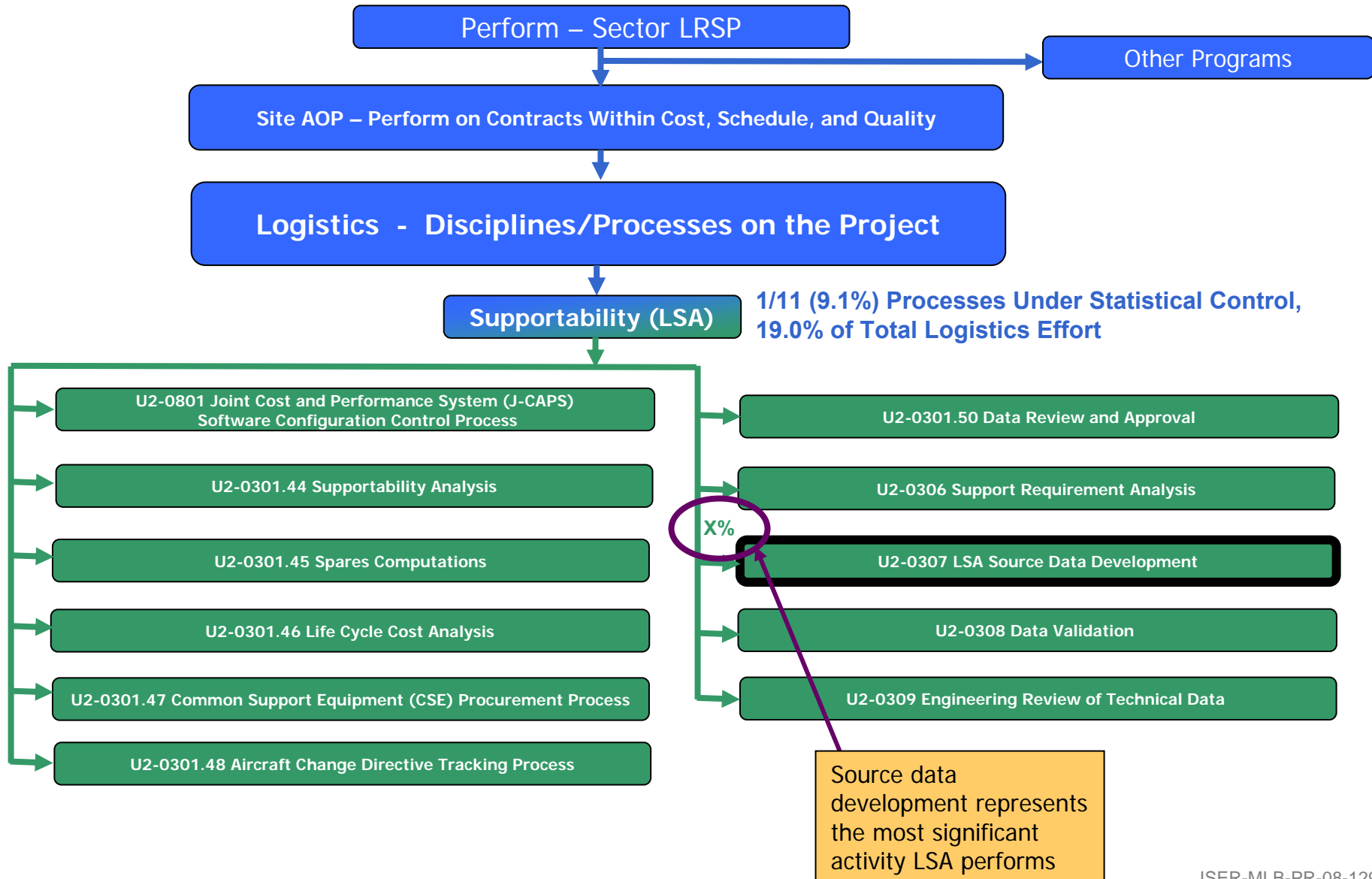
- Approach employed at Northrop Grumman Integrated System Eastern Region (ISER) in Melbourne:
  - Each Engineering Directorate is seen as critical to successful performance on the project
- Each Engineering Directorate identifies its key processes
- They decompose their key processes to select sub-processes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

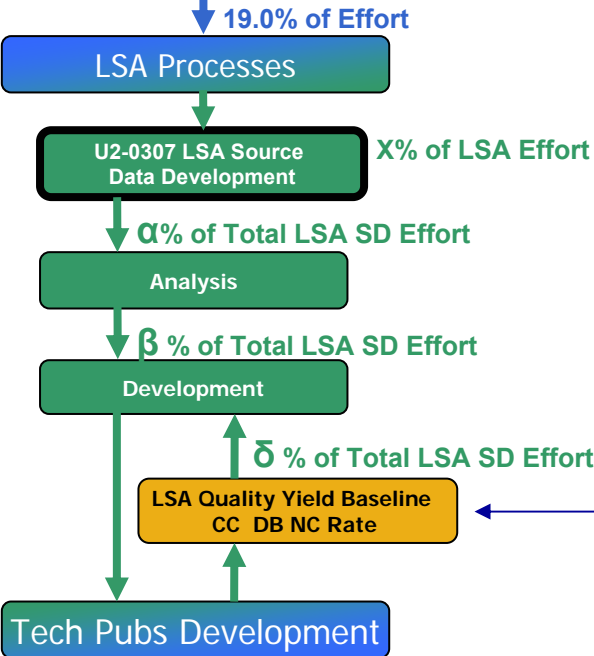
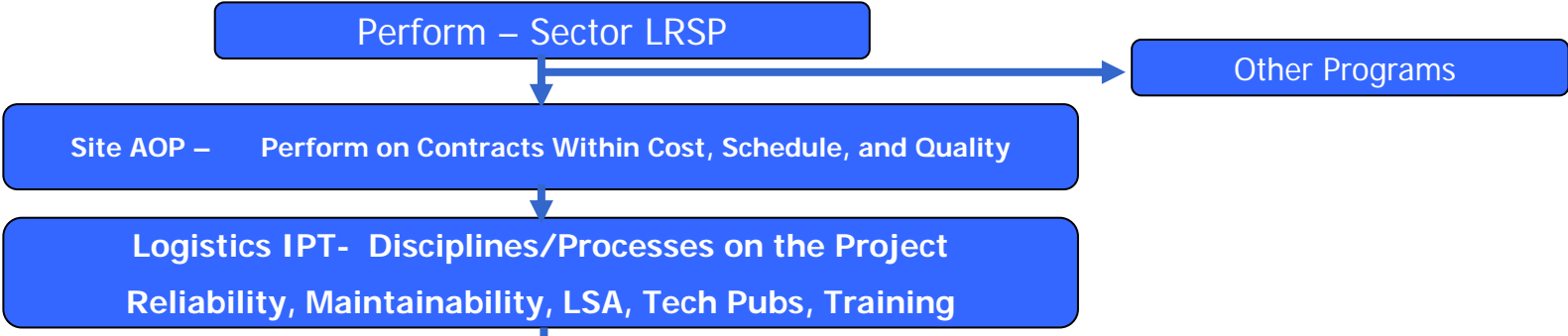


Note: Headcounts derived from Melbourne personnel listings in ISER Logistics Organization Chart dated September 2008.

# Identifying Sub-Process Performance Baselines for Statistical Control and Optimization



# Identifying Sub-Process Performance Baselines for Statistical Control and Optimization

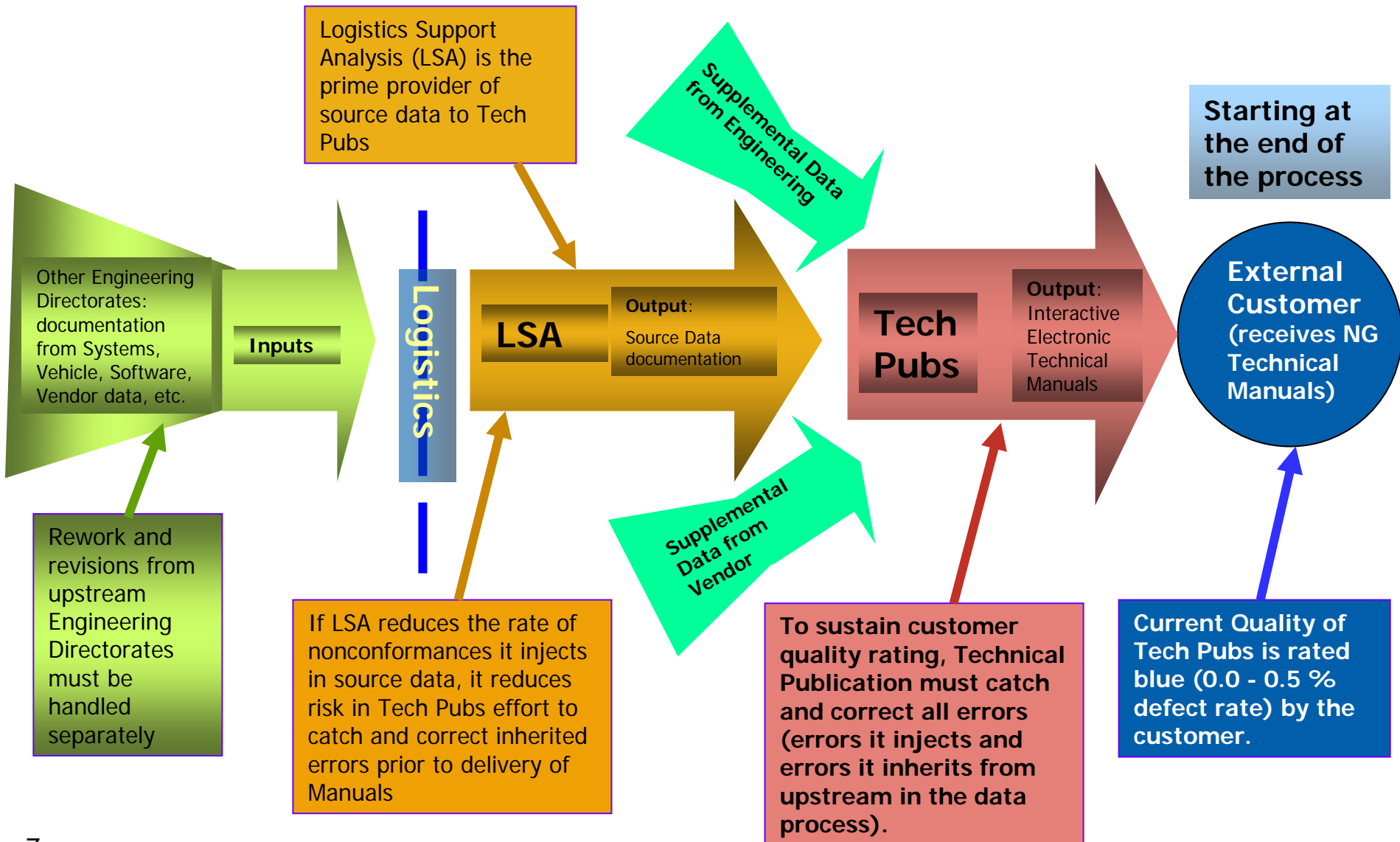


The quantitative basis for statistical control of LSA source data quality was established with inclusion of Source Data Nonconformance codes in the CC database

**Statistical baseline:**  
**Rate of Compliant Data (NC-Free) per All Data Submitted**  
**LCL yy% < Mean x% < UCL zz%**

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

# Context for LSA Source Data: Data Handoffs From Internal to External Customers



# 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

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

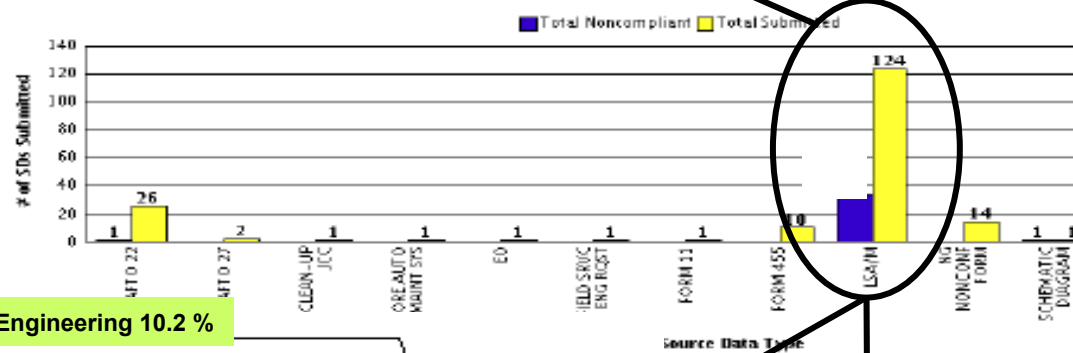
DB Rel no.	Source Data Type Submitted	# of SD IDs Reviewed	# of SD IDs Noncompliant	SD Type Noncompliant
53	AFTO 22	26	1	2420116ACW519
	AFTO 27	2		
	CLEAN-UP JCC	1		
	CORE AUTO MAINT SYS	1		
	EO	1		
	FIELD SRVC ENG ROST	1		
	FORM 11	1		
	FORM 455	1		
	LSAIM	124	##	04-116, 05-192, 05-194, 05-276, 05-284, 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,
	NG NONCONF FORM	14		
	SCHEMATIC DIAGRAM	1	1	C99-3012,
	TCTO	30		
	TECH DATA DIRECTIVE	1		
	WIRING DIAGRAM	2	1	525-10193,
	Subtotals:	215	7	

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%

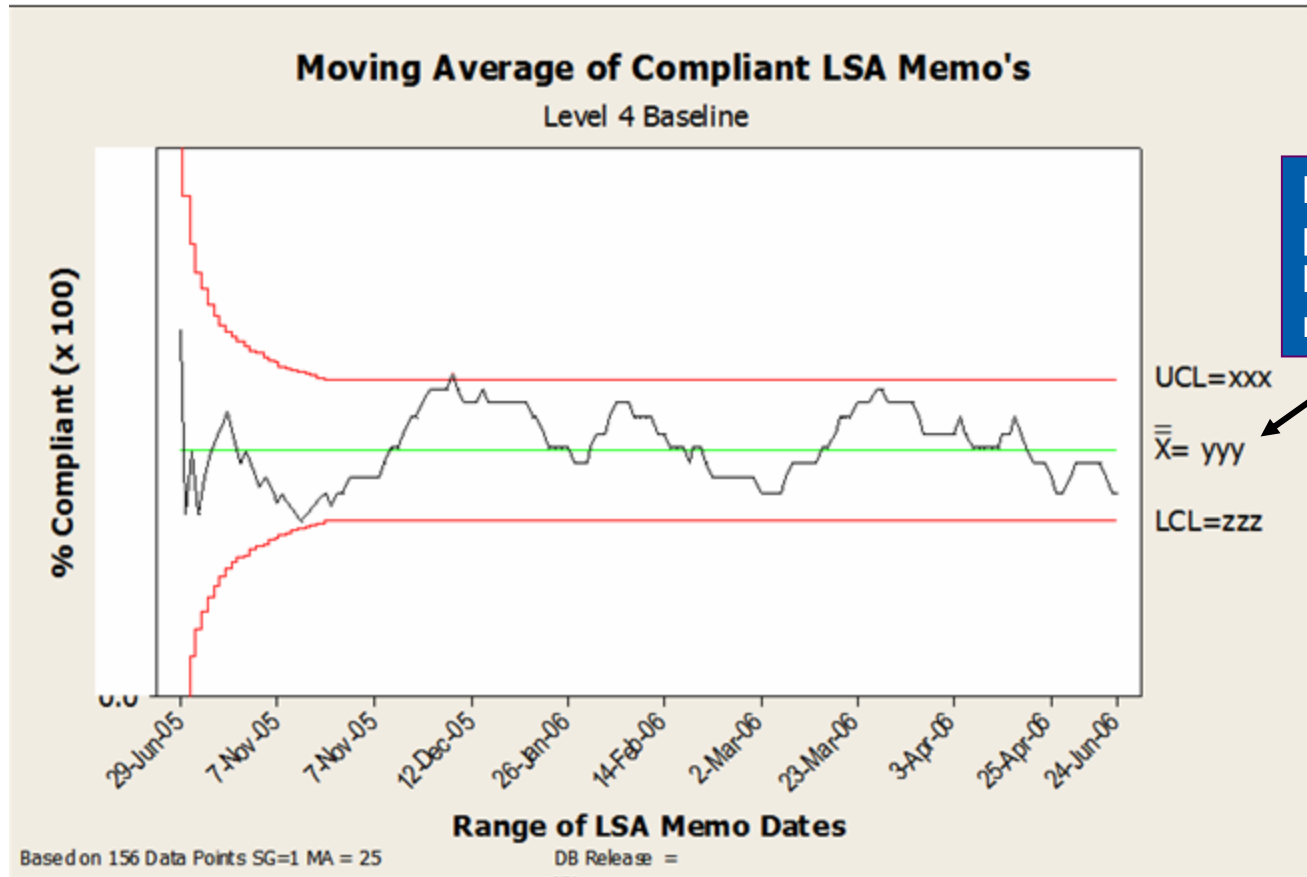
# Measurement System Analysis (MSA)

- 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.

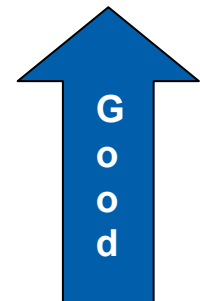
# Control Chart Selection

- 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

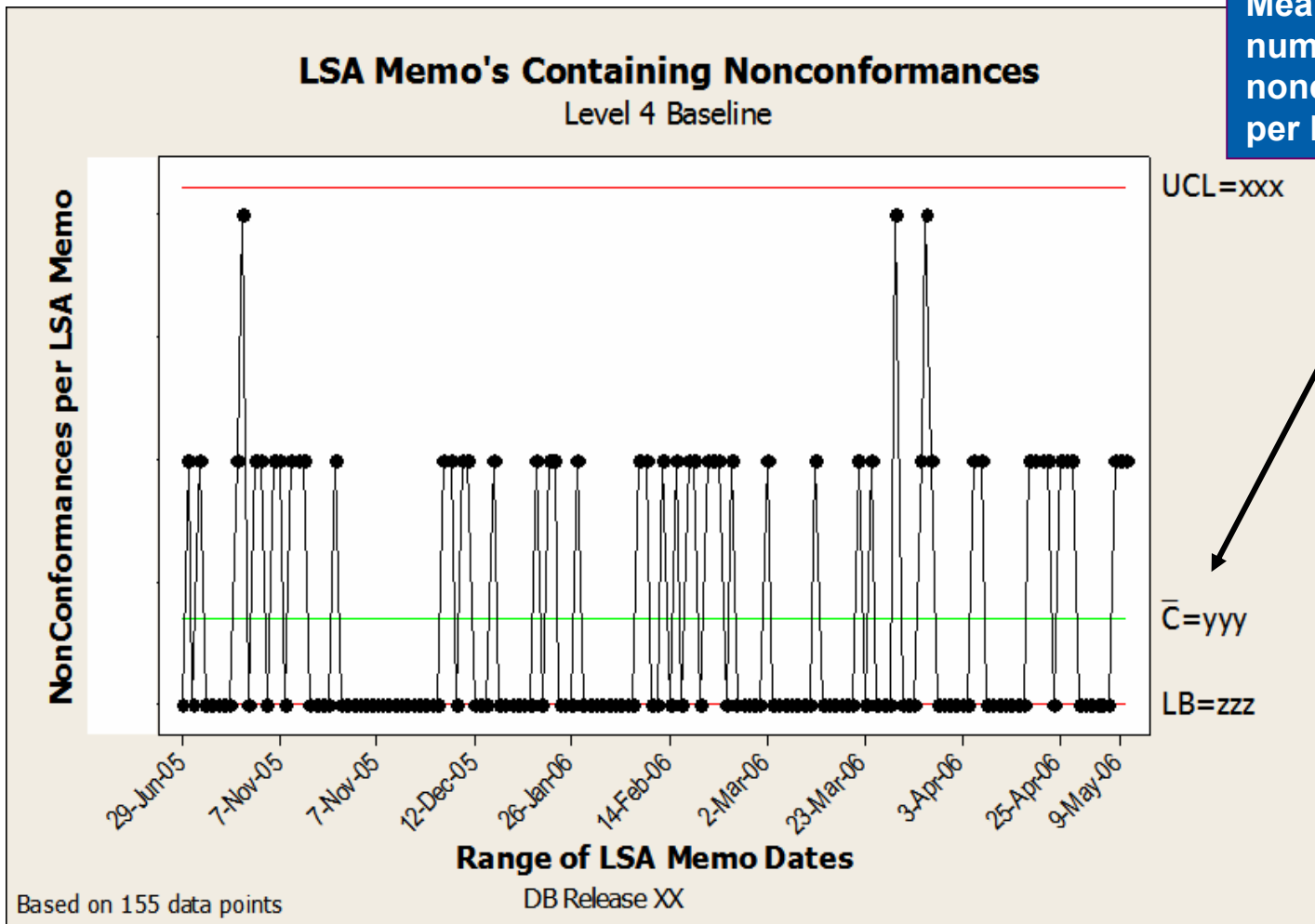


Mean represents percent of LSA Memos with no nonconformances



**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



# 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

**LSA Deployed Checklist by Linking it to LSA Source Data Procedure**

<u>New Data</u>		<u>Data Update</u>	
	Yes or NA		Yes or NA
System and Subsystem Identified	<input type="checkbox"/>	Assigned SSSN Identified	<input type="checkbox"/>
Task Title Identified	<input type="checkbox"/>	Task Title Identified	<input type="checkbox"/>
Effectivity or Limitation Identified	<input type="checkbox"/>	Effectivity or Limitation Identified	<input type="checkbox"/>
Personnel Requirements Identified	<input type="checkbox"/>	Personnel Requirements Changed	<input type="checkbox"/>
Personnel Instructions Completed Technician A Performs Task Technician B Assists Technician A	<input type="checkbox"/>	Personnel Instructions Changed	<input type="checkbox"/>
Consumable Material Identified Part No. NSN CAGE Code Quantity	<input type="checkbox"/>	Consumable Material Changed Part No. NSN CAGE Code Quantity	<input type="checkbox"/>
Support Equipment Identified Part No. NSN CAGE Code Quantity	<input type="checkbox"/>	Support Equipment Changed Part No. NSN CAGE Code Quantity	<input type="checkbox"/>
Reference Material Identified General System Technical Order Support Equipment Technical Order	<input type="checkbox"/>	Reference Material Changed	<input type="checkbox"/>
System Level Warning, Cautions and Notes Identified Apply to Entire Task	<input type="checkbox"/>	System Level Warning, Cautions and Notes Changed	<input type="checkbox"/>
Sequential Task Described Steps identified requiring Warning, Caution or Note Steps requiring special instructions identified	<input type="checkbox"/>	Existing Procedure Mark-UP with Change Completed	<input type="checkbox"/>
Drawing or Recommended Graphics Provided	<input type="checkbox"/>	Graphics Impacts Identified	<input type="checkbox"/>
Source Data Attached (as required)	<input type="checkbox"/>	Additional Data Impacted (Identify in Remarks)	<input type="checkbox"/>
		Reason for Change or Source Data Attached (as required)	<input type="checkbox"/>



# CAR: Developing and Implementing the Action Plan

## – F01 – Administrative Contract Noncompliance:

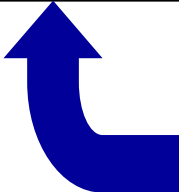
- Direction deviates from current contractual requirements. This includes source data that either does not meet or exceeds MIL-Spec or contract requirements
- Direction to violate agreed-to style guide (as a subset of the original TIM agreements), or inconsistent with pre-established system format
- 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

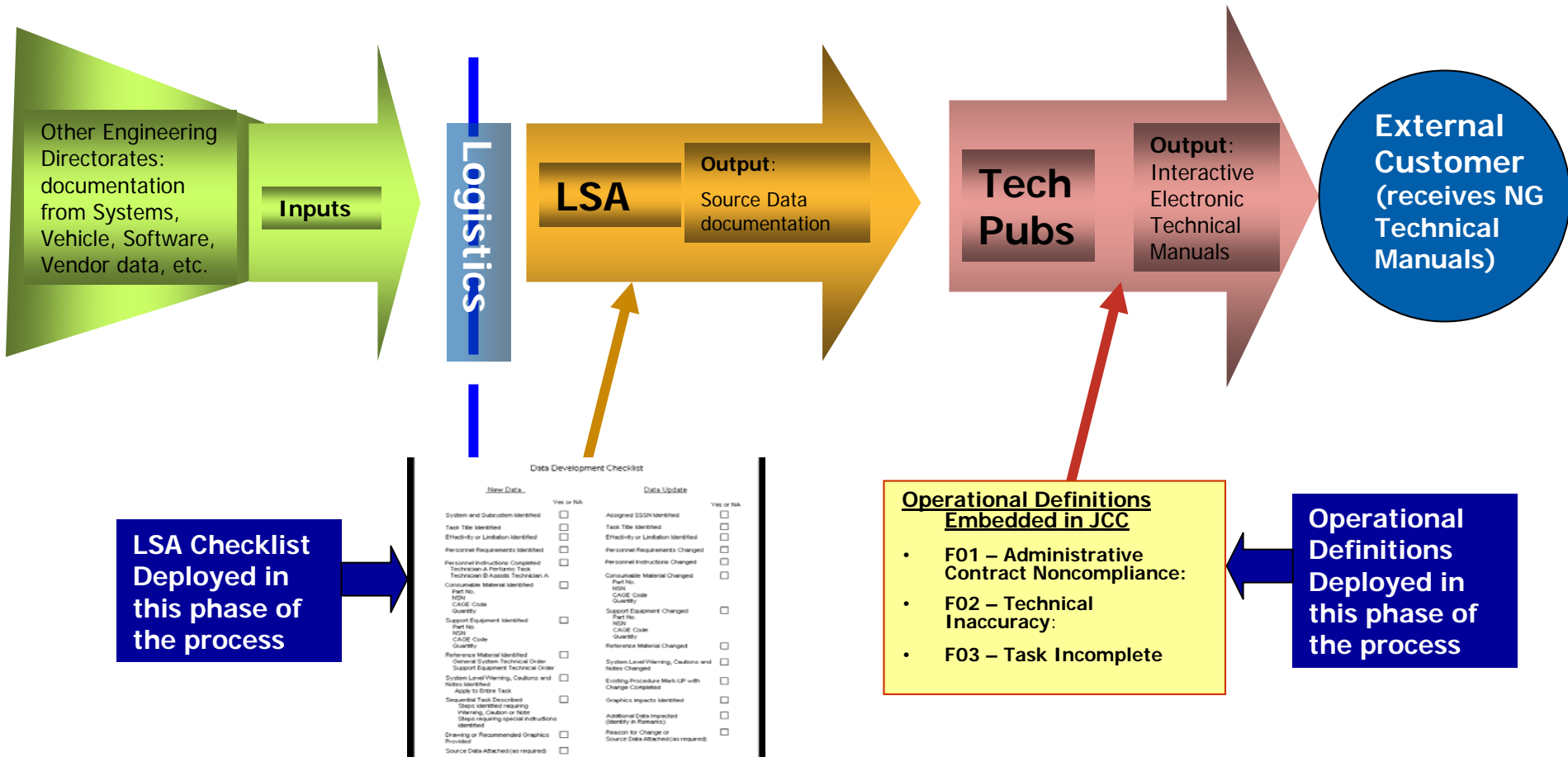
## – F03 – Task Incomplete:

- 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



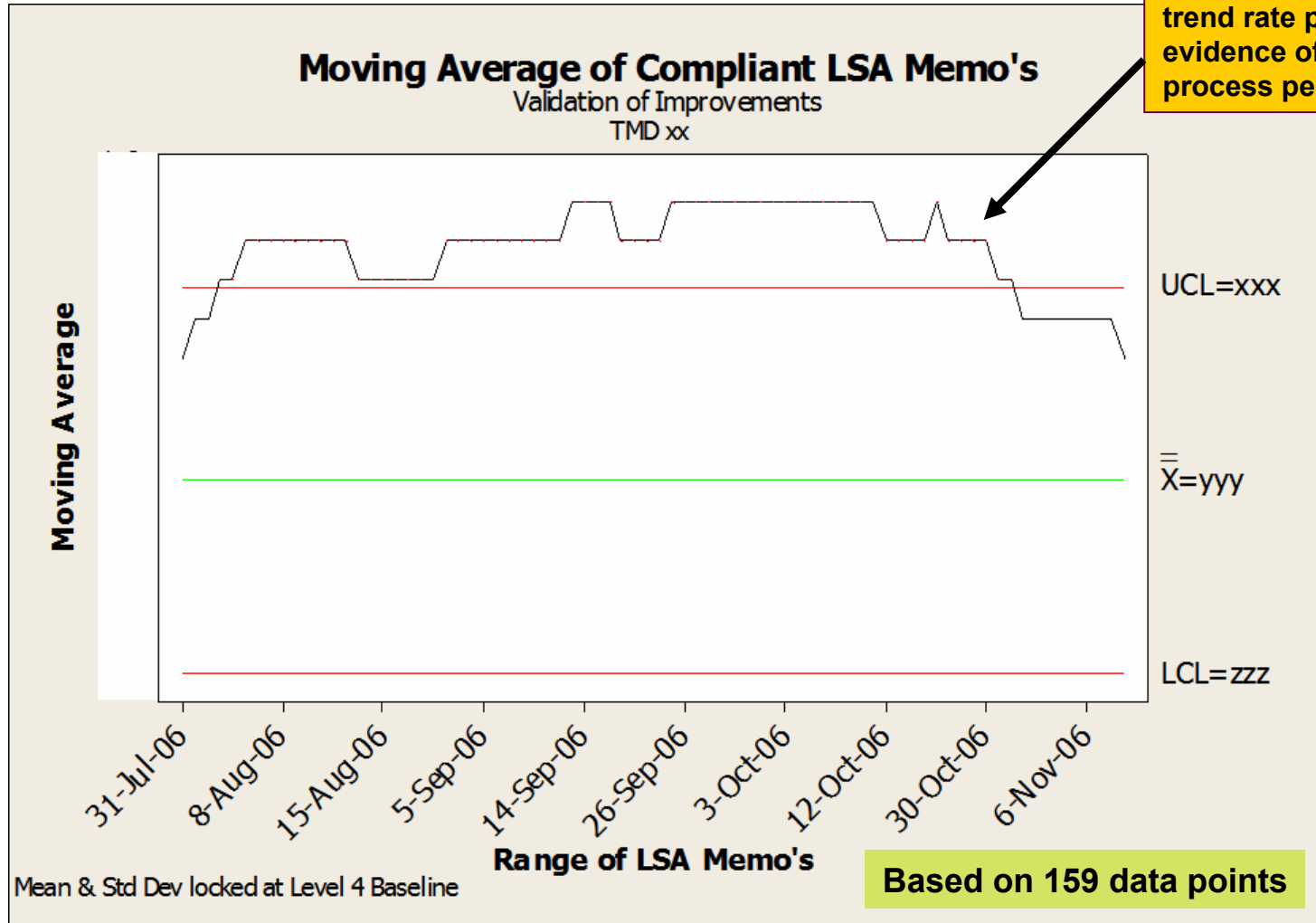
**Technical Publications Embedded  
Refined Operational Definitions  
Directly into CC Database**

# CAR: Developing and Implementing the Action Plan



# 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

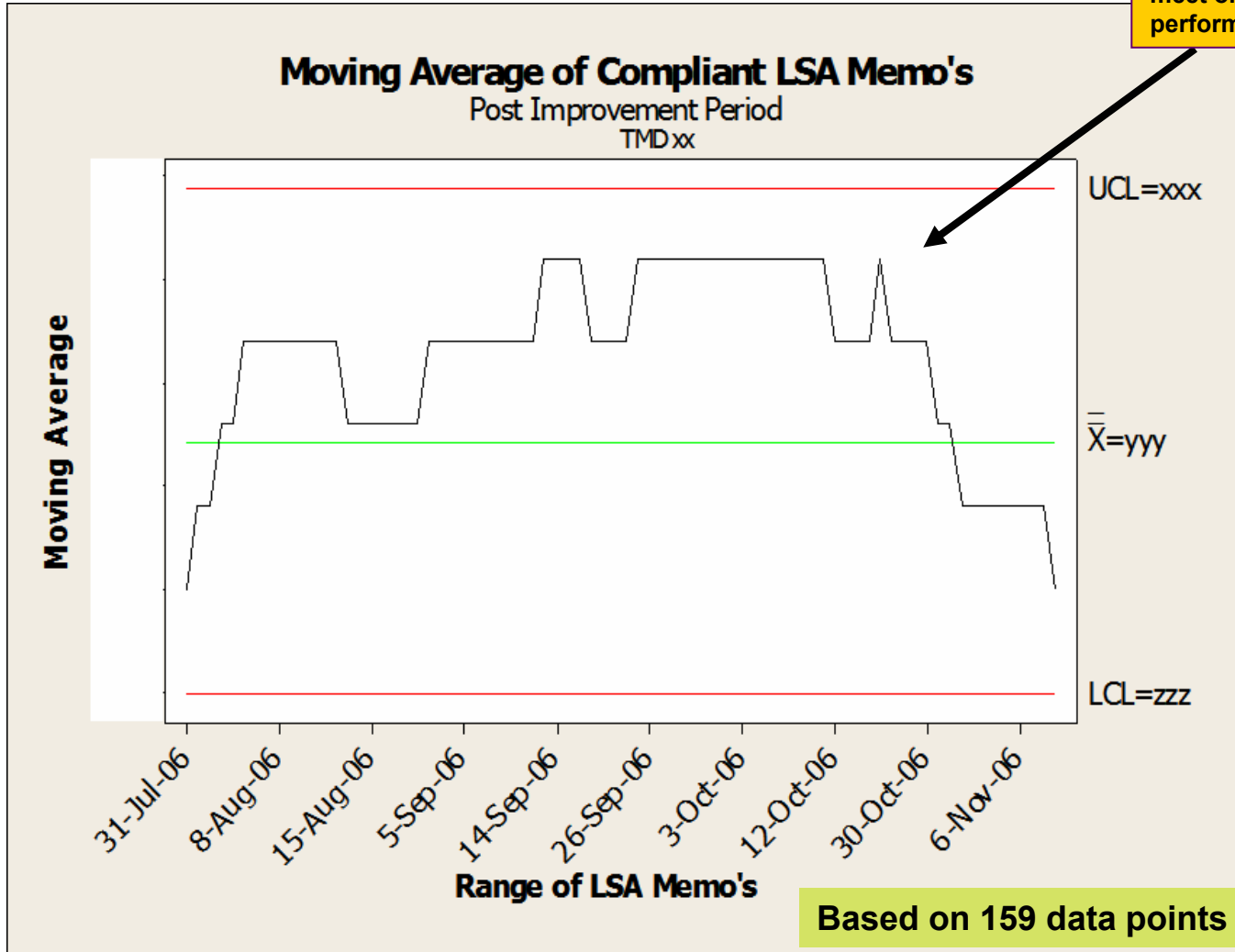
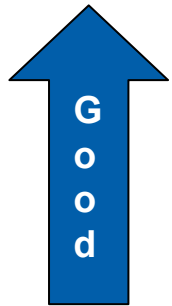


# Establishing the Improvement

- 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

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



12% improvement over former UCL

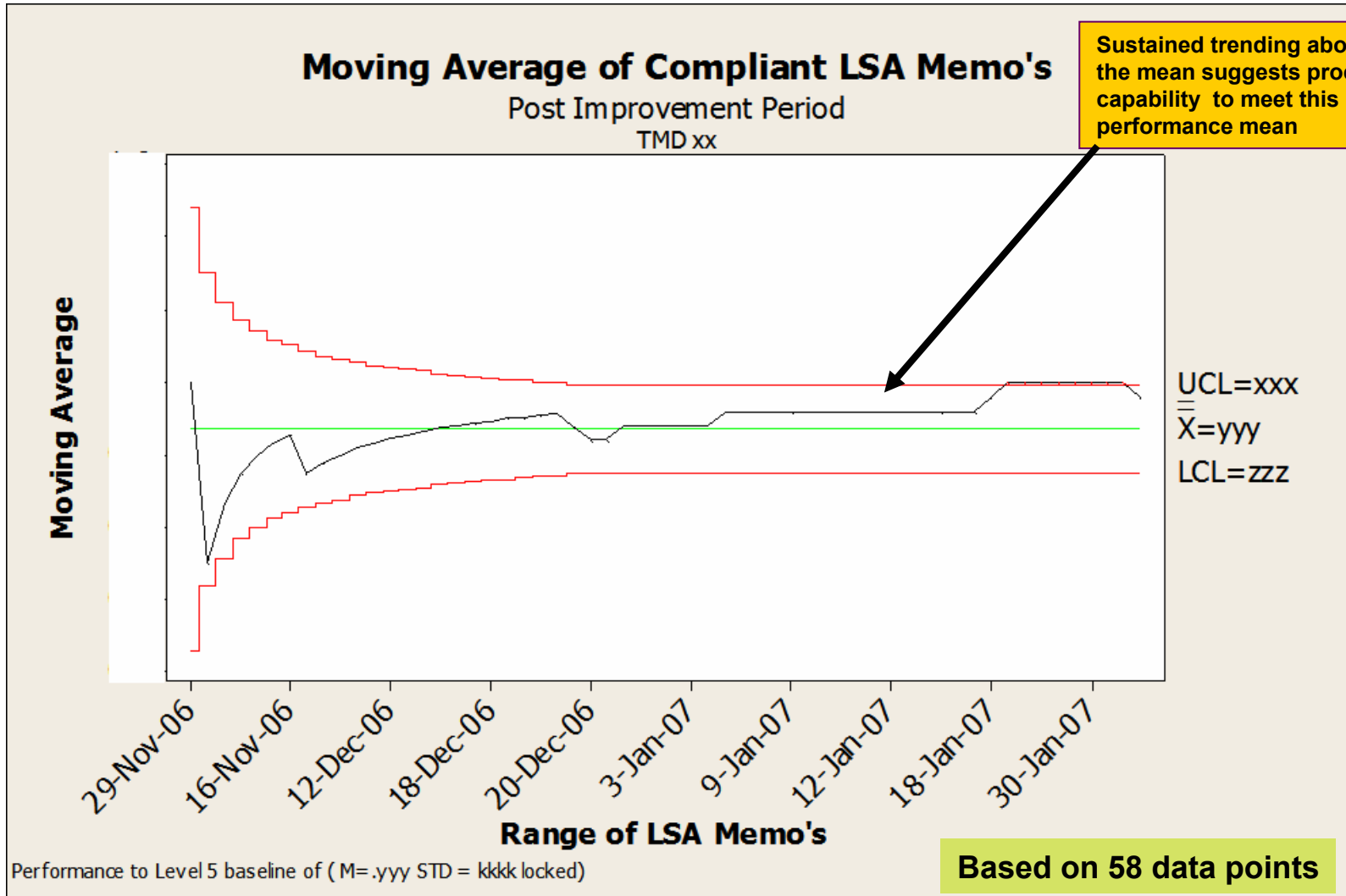
23% improvement over former mean

37% improvement over former LCL

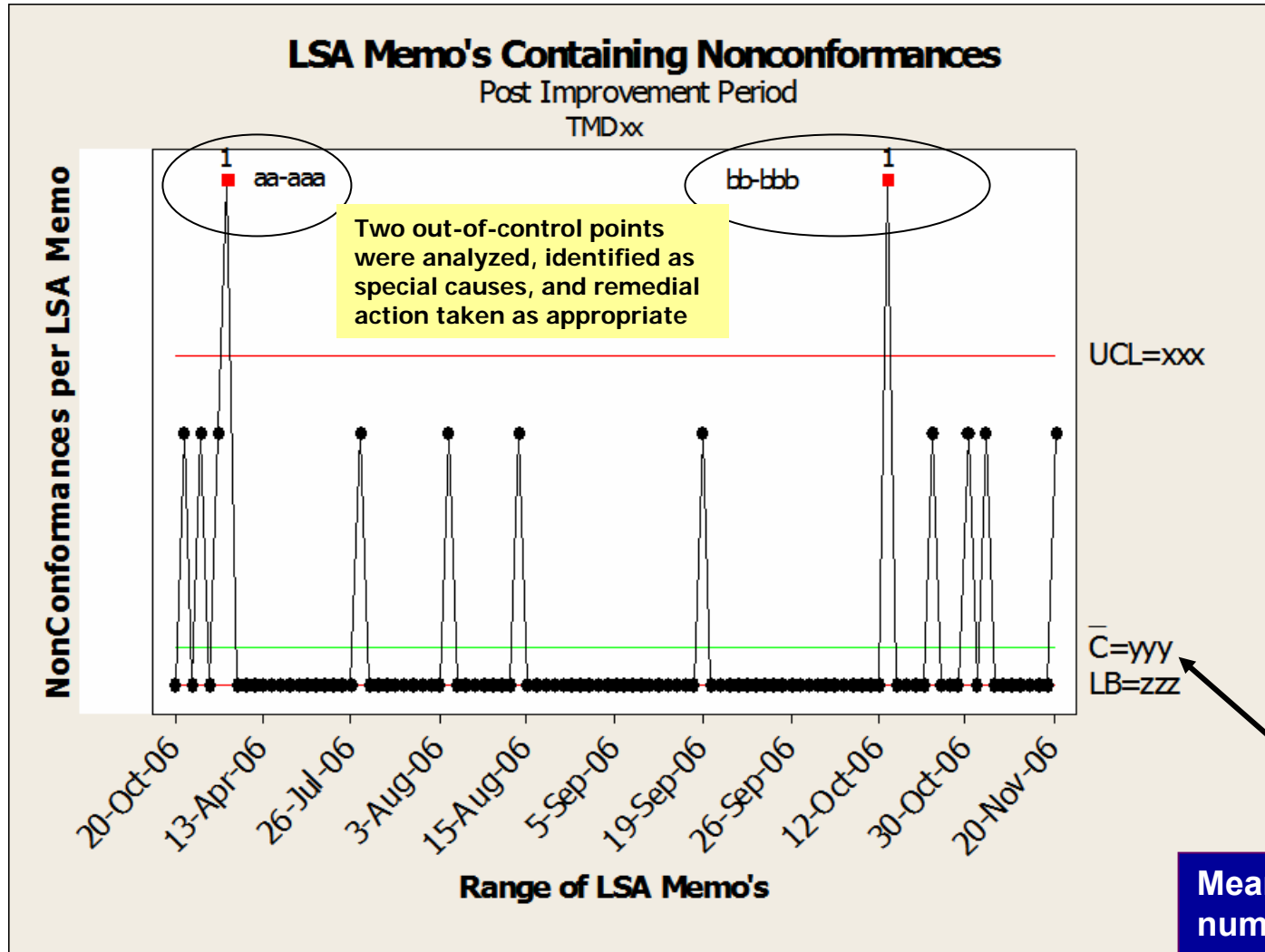
# Performing to the Improved Baseline

- 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



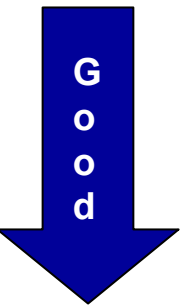
# Performing to the Improved Baseline: Using Supplemental C-Chart for Drill Down Analysis



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

## Post Improvement

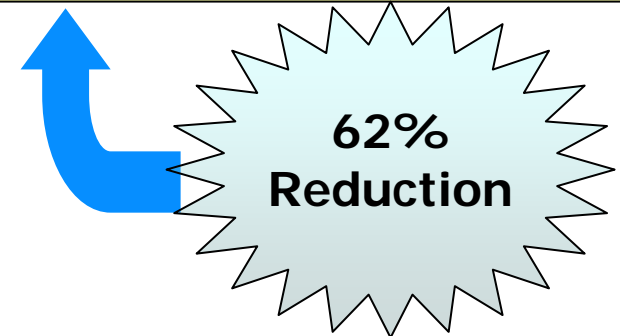
$Z =$  NC rate per Memo (**Z is established from mean of the C-Chart**)

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

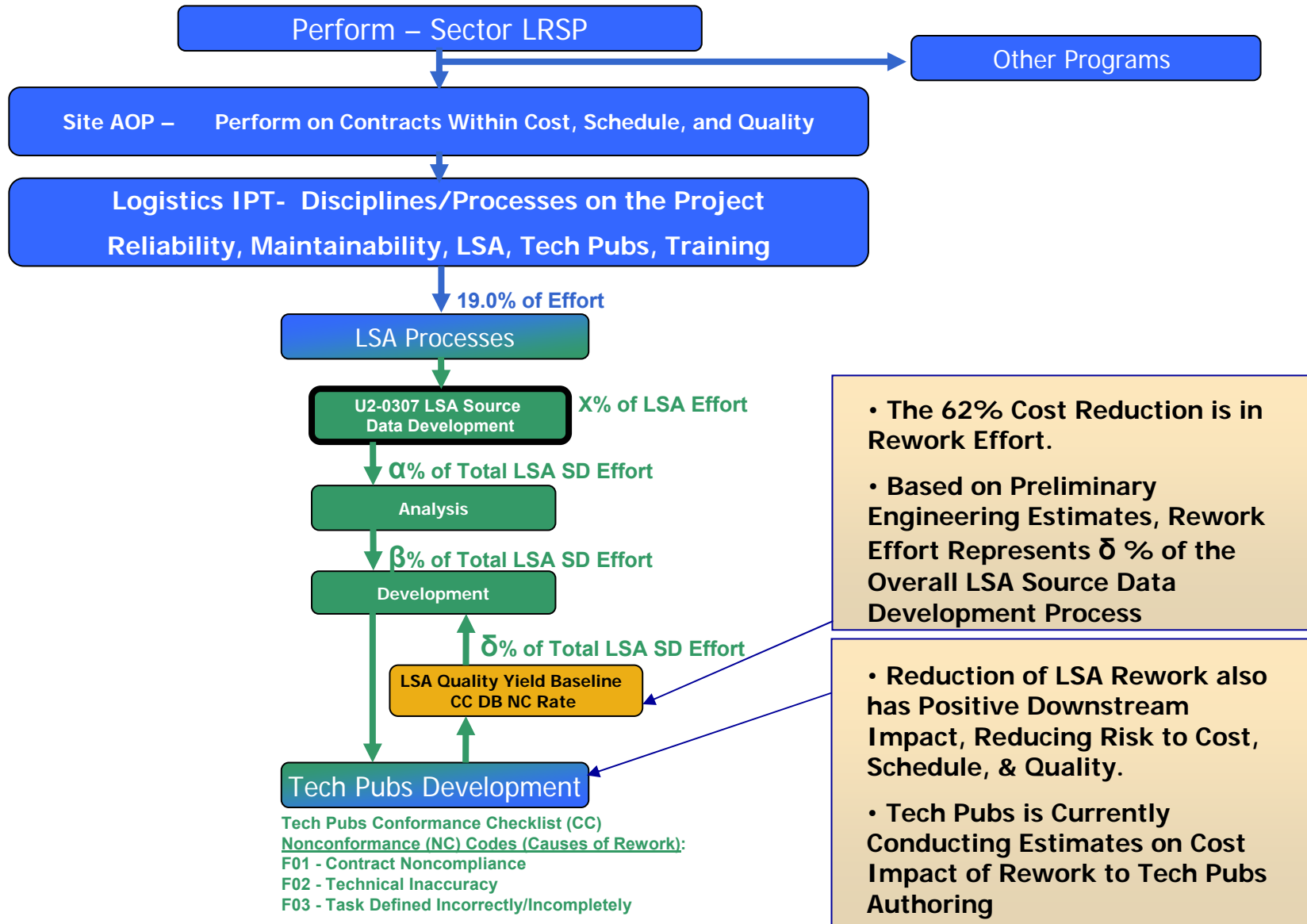
Improved NC rate per Memo = **Z(new)**

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

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



# Benefits





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