NORTHROP GRUMMAN
DEFINING THE FUTURE

Statistically Managing a Critical Logistics Schedule Using CMMI ®

November 2007

Robert Tuthill
Northrop Grumman Integrated Systems

ISER-MLB-PR-07-154

Agenda

- Presentation Overview
- Air Force Technical Order (AFTO) Form 22: Statistical Control of Schedule
- Implementing a Statistically Measurable Improvement
- Benefits
- Questions

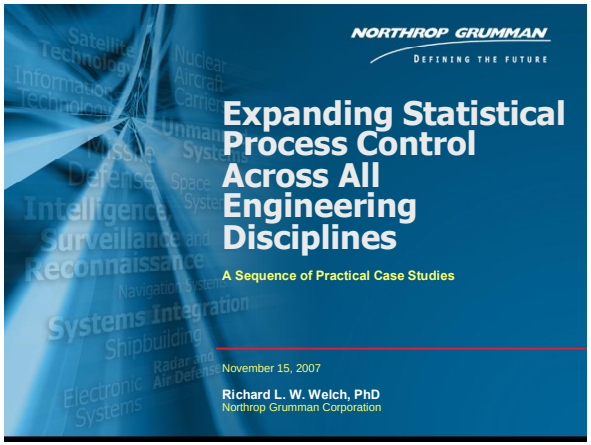
CMMI® is registered in the U.S. Patent and Trademark Office.

Presentation Overview

MMI High Maturity Practices tems/Software

- **The processes and products of Logistics Support are not typically considered prime candidates for statistical management techniques:**
  - In 2005 we achieved CMMI Level 5 in the SE/SW model
  - In 2006 we achieved CMMI Level 5 in the SE/SW/IPPD/SS model by expanding into other disciplines: Test & Evaluation, Avionics, Vehicle Engineering, and Logistics

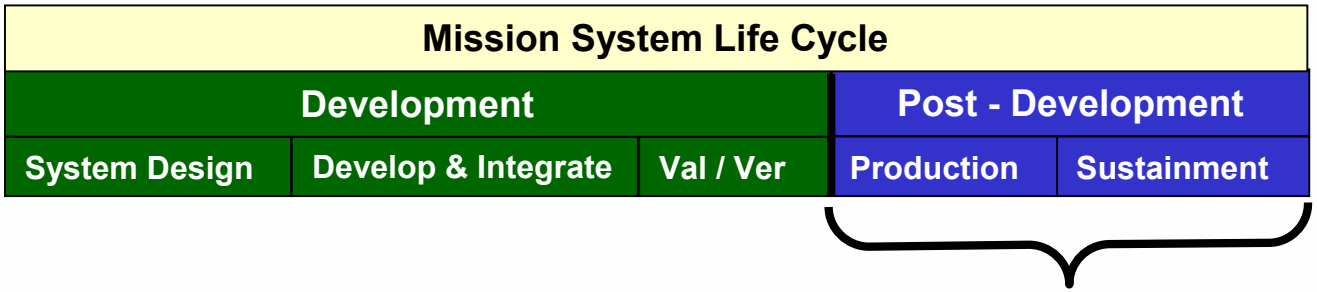
For further discussion on expansion of high maturity practices to other Engineering disciplines see Dr. Welchôs presentation at 11am Thursday, 11/15



  - In support of that expansion, the Logistics Directorate successfully applied Level 4 and 5 practices to manage a challenging scheduling requirement levied by the customer

Air Force Technical Order (AFTO) Form 22: Statistical Control of Schedule

Publications Development sion System Life Cycle Phases



- **During the post-development phases of the Mission System life cycle, Technical Publications delivers and maintains Technical Manuals in support of Mission System deployment:**
  - Changes to Technical Manuals may be driven by:
    - Company proposed Improvements
      - Engineering Change Proposal (ECP)
    - Customer driven comments after delivery ï AFTO 22
      - Air Force Technical Order (AFTO) Form 22 ï issued against fielded manuals owned by customer

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s on AFTO 22 Schedule as a e for Statistical Control

Tightened Schedule Requirements for AFTO 22 Delivery:

- In 2004 (Production Contract) ï Customer levied a schedule requirement to incorporate and deliver Routine AFTOs into Joint Integrated Maintenance Information System (JIMIS)
- In 2005 we transitioned to a Sustainment contract: Total System Support Responsibility (TSSR)
  - Award fees based on meeting various delivery/service milestones
  - As part of TSSR award fee, on-time delivery of incorporated AFTOs became more stringent
  - Delivery schedule of incorporated AFTOs was shortened by 57%

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ve Management Objectives

Team Goals –Technical Publications had two Quantitative Management objectives for incorporation of Routine AFTOs into JIMIS

- **1st Goal: Establish and perform to a statistically stable schedule baseline: days-to-incorporate AFTOs (Voice of the Process)**
- **2nd Goal: Achieve a quantitative improvement to the schedule baseline that could satisfy customer's 2005 award fee criteria (improve Voice of Process to satisfy Voice of the Customer)**
- **Increased efficiency in schedule must not adversely impact customer's expectations of Technical Publications quality (a Blue rating of 0% - 0.5% defects)**

gy for Implementing Statistical Stability – Quantitative Milestones

	IS Sector Phase	Milestone	Description	Suggested Tool	Status Complete/ In Work	If In Work ECD	Comments or Slide Number
Lvl 4	Identify	1	Charter of Process Improvement including the Voice of the Customer (VOC)	VOC Interview			
	Identify	2	Input/Process/Output (IPO) Chart or Supplier/Input/ Process/Output/Customer (SIPOC)	IPO or SIPOC Form			
		3	Value Stream Map- Current State	VSM Presentation- VSM Templates			
	Identify	4	Measurement Analysis	Minitab and Interviewing Subject Matter Experts (SMEs)			
	Identify	5	Stable Baseline Control Chart	Minitab			
Lvl 5	Execute	6	Process Improvement	Causal Analysis & Resolution Form			
		7	Value Stream Map ï Future State	VSM			
	Sustain	8	Stable Control Chart	Minitab			
		9	Verified Savings				

Implemented by a Process Management Team (PMT)

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t Process Output
)

MS1 & 2

Sub process AFTO Incorporation Execution

Process Overview

Process Title AFTO Disposition and Incorporation Process

Process Definition Air Force Technical Order (AFTO) Form 22 is the method by which the government recommends changes/ improvements to Technical Manuals. Northrop Grumman dispositions and incorporates the AFTOs issued by the government into Manuals.

Input
- AFTO 22 submitted by JTF
- AFTO 22 Submitted by 116th ACW

Sub-Processes Steps
- NG at Warner Robins dispositions AFTO
- LKS Review & Approval of AFTO
- Processing Days in LKS
- Develop Data Changes in LSA Melbourne
- Incorporate AFTO into JIMIS
- Review Time in Pubs Tech Support
- Gov't Review in Live Feed
- Released of Data (PDF, JIMIS TMD)
- Data Fielded for use

Output
Tech Orders fielded for usage by the 116th ACW

Applicable Procedures
- I9-TDP-217 – AFTO Disposition and Incorporation Procedure

Applicable Tools
JIMIS Database, AFTO Database (Access) , Management tracking tool (Excel)

Customer = 116th ACW at Robins Air Force Base

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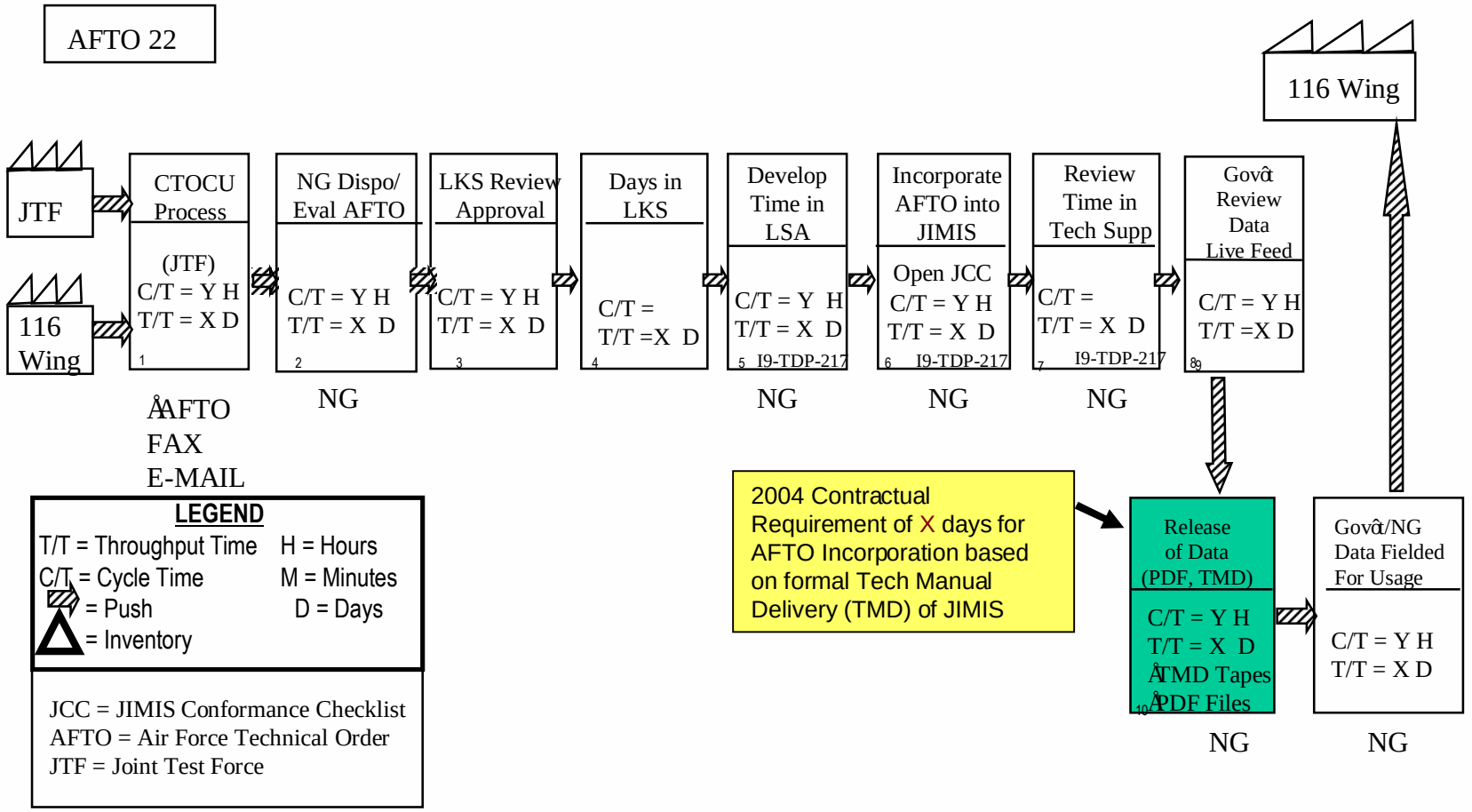
MS3

Value Stream Map – Current State 2004
AGS & BMS Tech Pubs – AFTO 22



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ent Analysis

- **Analysis conducted by the Process Management Team (PMT) reached the following conclusions about the measurement system:**
  - Upon receipt, AFTOs are logged into database by one AFTO administrator exclusively
  - All process milestone dates are logged by one administrator and verified by the Tech Pubs Manager
  - Computations converting dates into days are executed automatically by equations embedded in the AFTO tracking database
- **Conclusion: The metrics for AFTO schedule (days to incorporate in JIMIS) are repeatable, reproducible, and reliable, with negligible sources of variation.**

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Logistics Commodities PMT
1st Goal Accomplishments:

- Developed a statistical control chart from all closed AFTOs in 2004 AFTO database
- Analyzed and justified removal of special causes from data set
- Established Statistically Stable Baseline Schedule (Days-To-Incorporate AFTOs)
- Performed to Stable Baseline in 1st Quarter 2005

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edule Activities 2004

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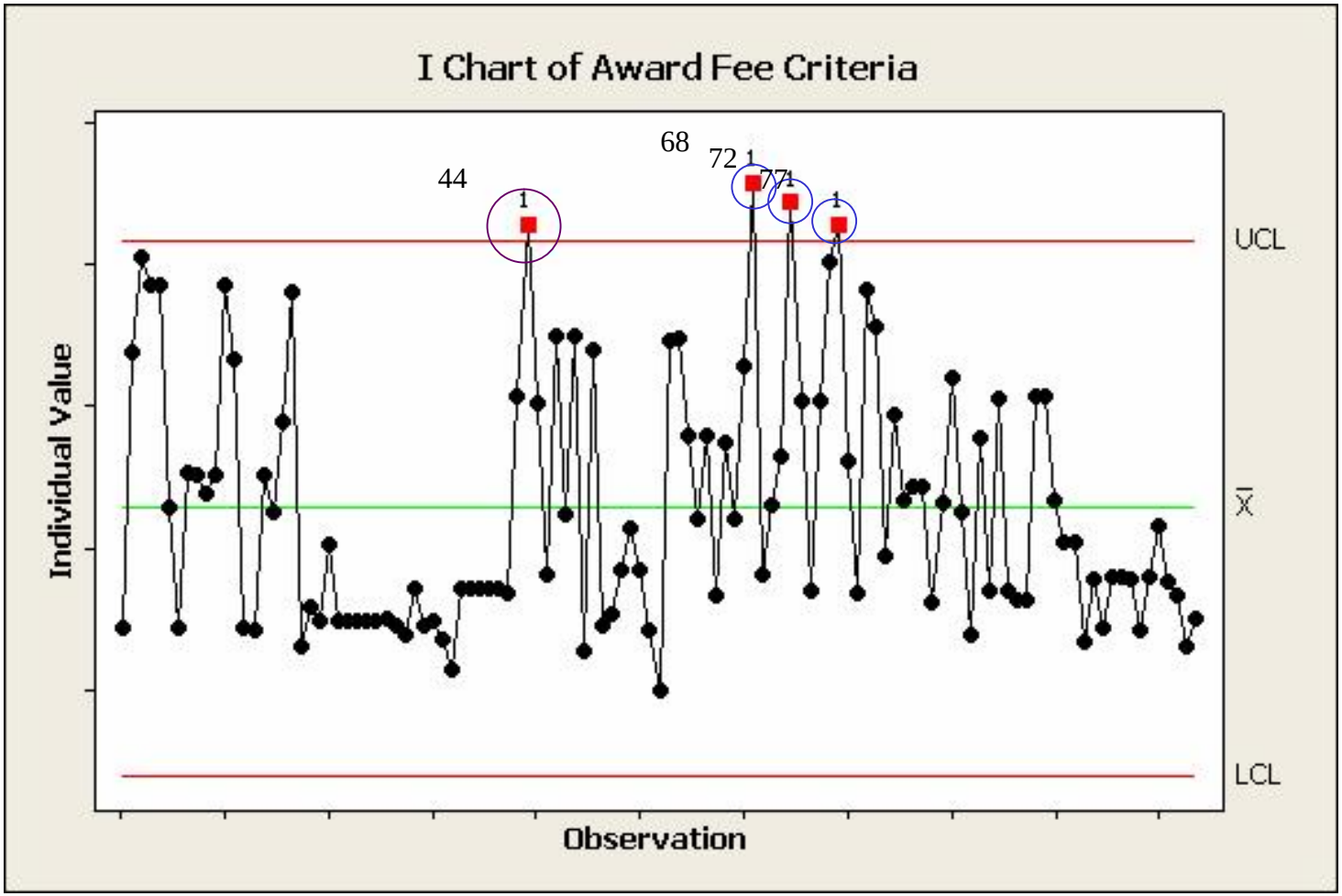

All Incorporated Routine AFTO's All Complexities – 115 Data Points

- Contractually Excluded Categories

- Special Causes

Stable Baseline Established

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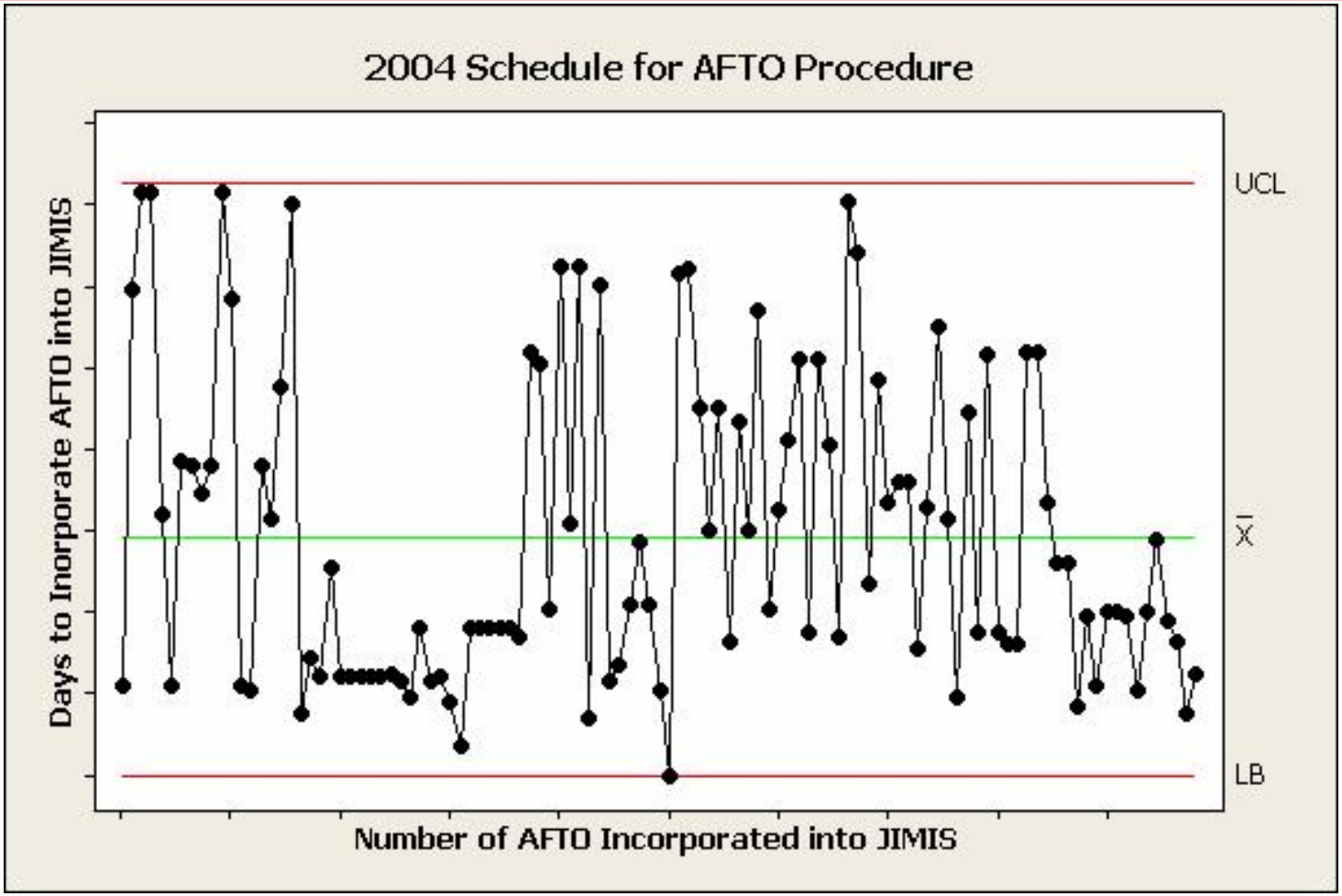

Special Causes Analyzed & Removal Justified:
All Incorporated Routine AFTO's All Complexities – 109 Data Points

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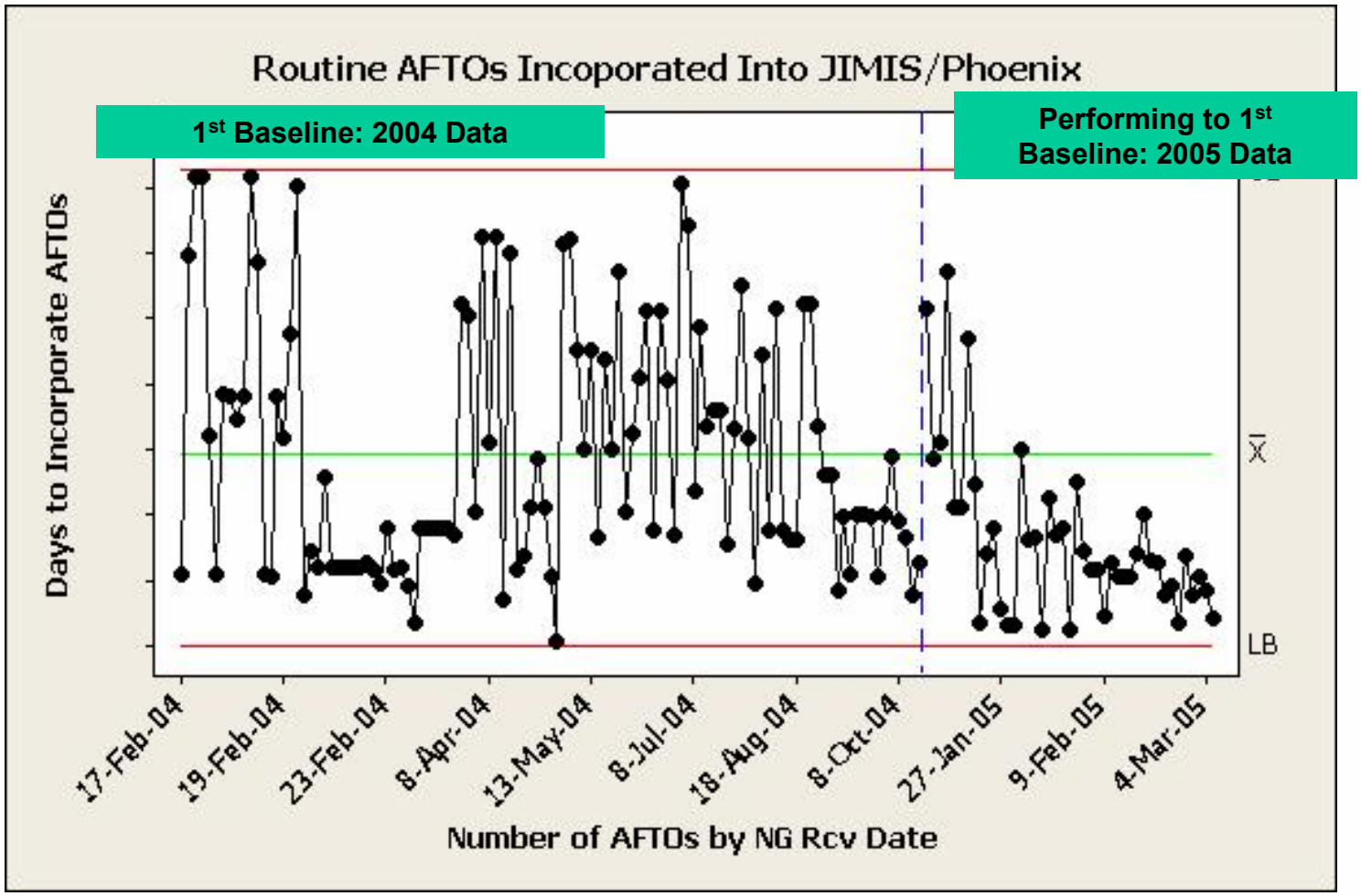
g to 1st Stable Baseline



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IMPLEMENTING A STATISTICALLY MEASURABLE IMPROVEMENT

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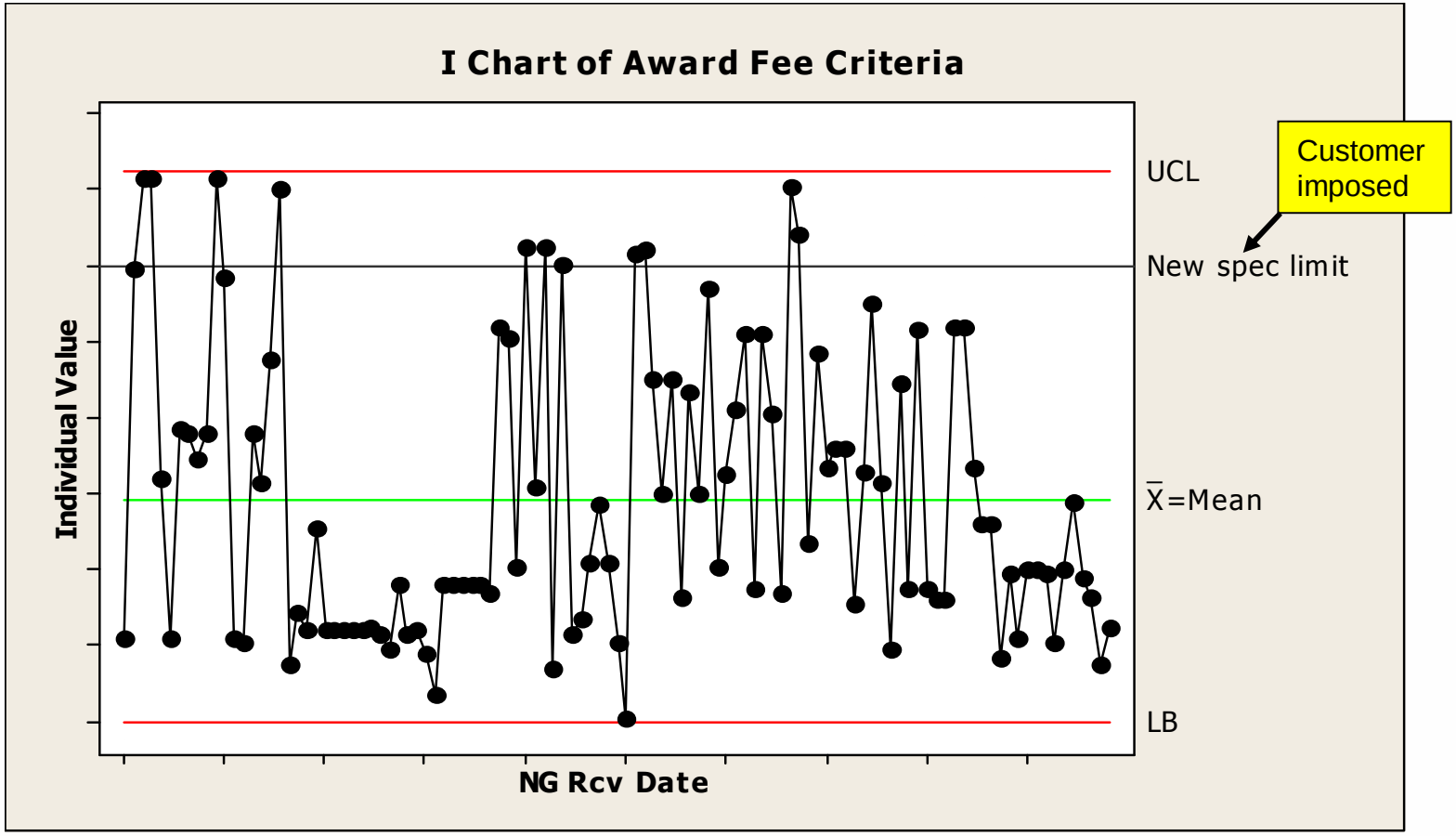
: Reduce Upper Control Limit Below New Spec Limit



Although Stable, the process was not capable of achieving new customer requirement

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Statistically Measured Improvement

2nd Goal Accomplishments:

- Completed Causal Analysis and Resolution activity to determine common cause of excessive variation in upper control limit
- Developed an Action Proposal Plan for Improvement
- Implemented Action Plan
- Gauged Improvements by Tracking New Data Points Against Baseline
- Refined Analysis: Improvement vs. Correction AFTO
- Deployed Two 2005 AFTO Baselines (Improvement & Correction)
- Performed to New Baselines
- Updated Value Stream Map to Reflect TSSR Award Fee Criteria and Stable Baseline Performance

ted ACTION PROPOSAL

ments Instituted by Feb 2005)

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- **TRAINING:**

- Provided awareness training of the new schedule requirements - Series of email instructions and repeated face-to-face discussions to train/brief personnel in TSSR award fee criteria vs. Production Contractual requirements

- **TOOLS:**

- Improved AFTO tracking database to ñRed-lightò AFTOs that exceeded planned days in critical phases of development

- **PROCESS:**

- Inter-Directorate coordination to expedite revisions of wiring diagrams/schematic diagrams (WD/SD) impacted by AFTOs
  - Coordinated with Vehicle Engineering so updates of WD/SD associated with AFTOs would not adversely affect AFTO schedule

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nprovements seline

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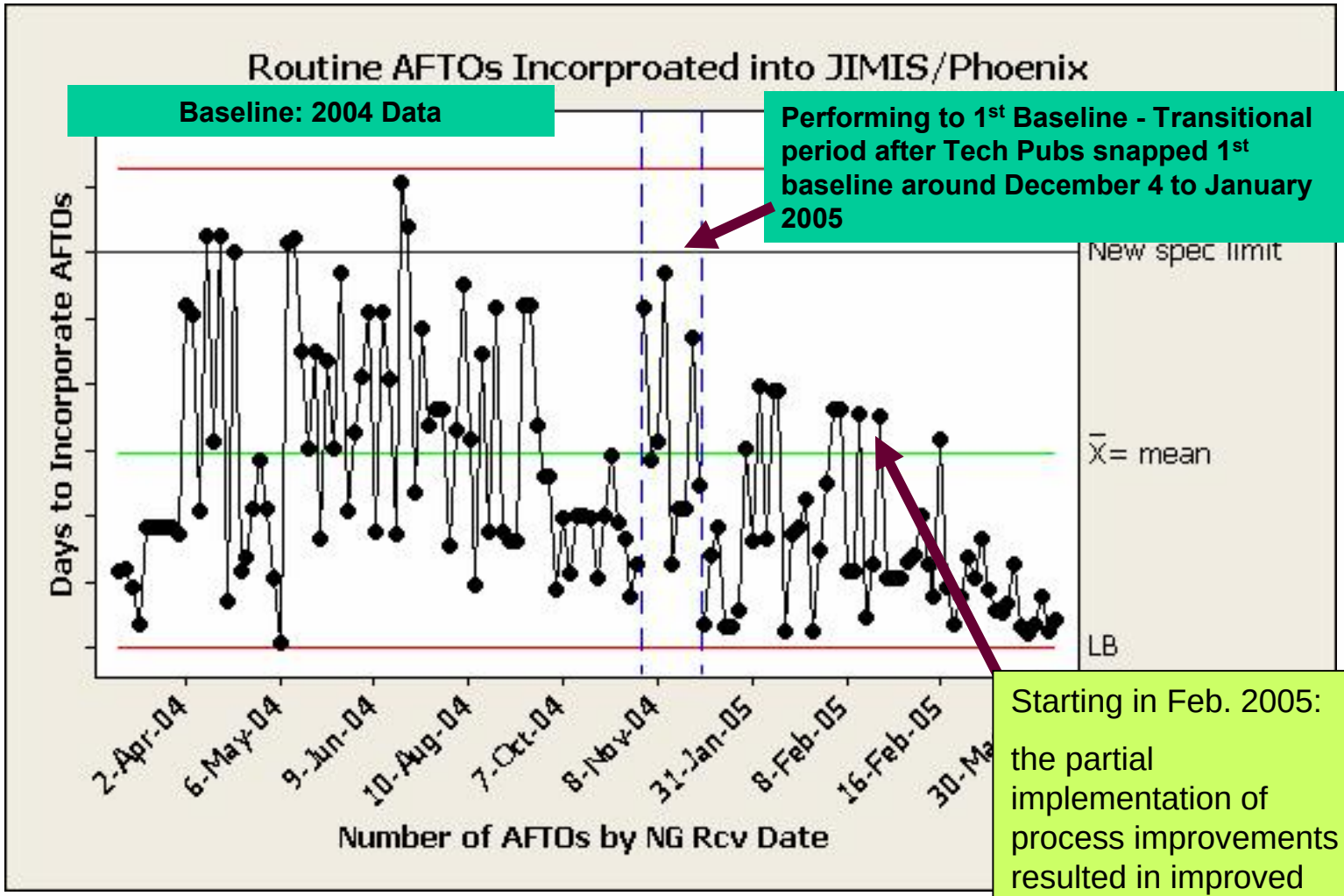

Starting in Feb. 2005:

the partial implementation of process improvements resulted in improved performance

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ation of Improvements

- Data confirmed that the process was performing within stable baseline limits
- Data indicated that process was not only below the UCL, but was under new spec limit (due to early improvement implementations)
- Since much of the improvement plan had been incorporated by February 2005, a new control chart based exclusively on 2005 data was run to analyze a tentative new baseline

# of 2005
ine Data

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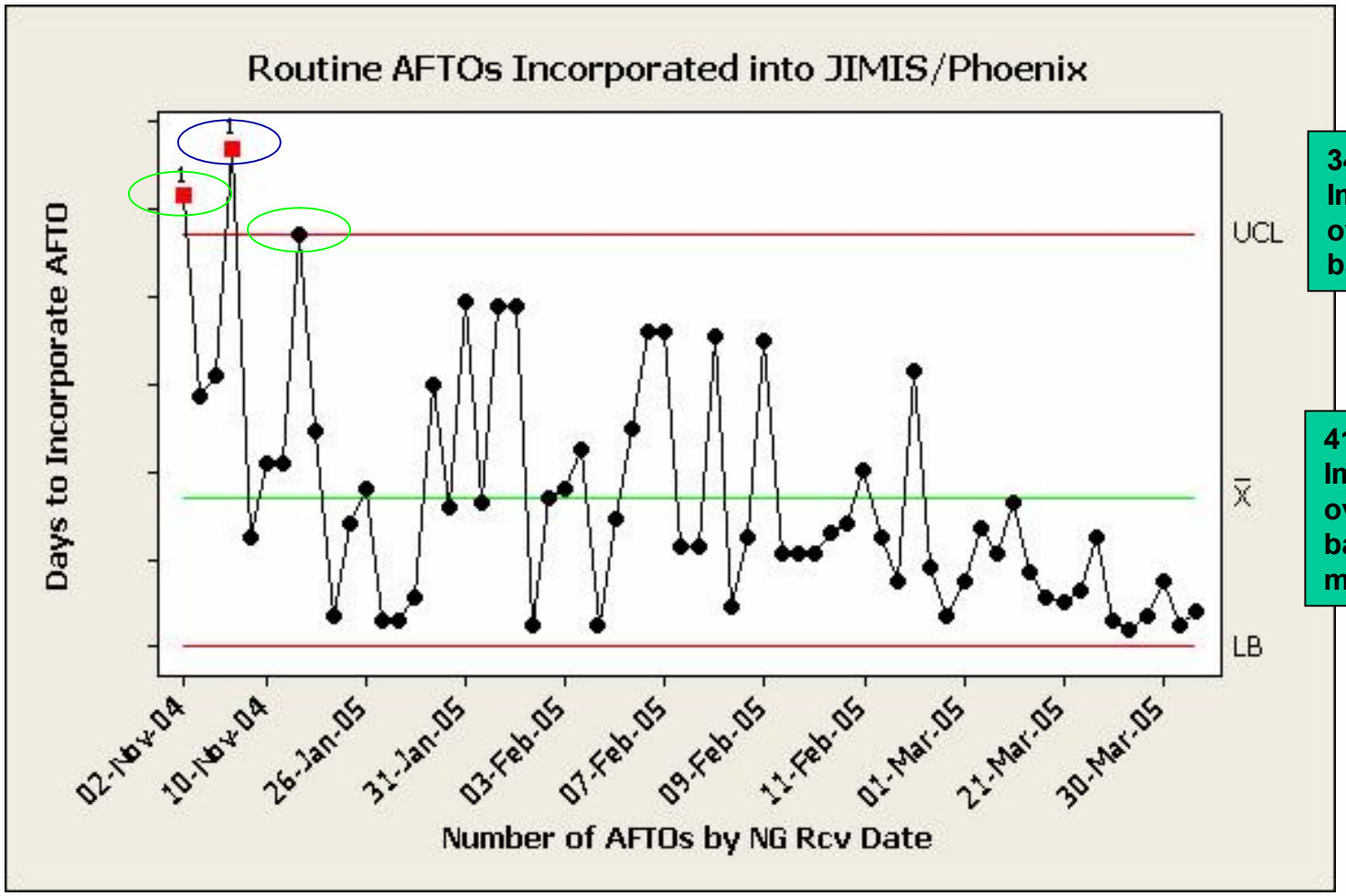

34% Improvement over original baseline UCL

41.8% Improvement over original baseline mean

- SD/WD

- Improvement AFTO

alysis: nt vs. Correction AFTO

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- Due to wide range of the upper and lower limits in the 2004 process (1st baseline), differences in distribution between Correction and Improvement AFTOs were not a factor
- In 2005, with tightened performance limits, the differences between the two types of AFTOs became more evident
- Further statistical analysis of the data would confirm that Improvement AFTOs and Correction AFTOs should be charted separately (i.e. there were two populations of data)

mprovement ve AFTO

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- **Using Minitab, 62 new data points from 2005 data were separated into two Subgroups:**
  - Improvement Subgroup (38)
  - Correction Subgroup (24)
- **Each of the two Subgroups were then divided (binned) into a Contingency table**
- **With data in a Contingency table, a Chi Square test could be conducted in Minitab**

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CHI SQUARE Test

Chi-Square Test:

Expected counts are printed below observed counts
Chi-Square contributions are printed below expected counts

	A	B	C	Total
1.	21	14	3	38
	26.35	9.81	1.84	
	1.088	1.793	0.733	
2.	22	2	0	24
	16.65	6.19	1.16	
	1.723	2.839	1.161	
Total	43	16	3	62

Observed Counts

Computed Expected Counts

Chi-Square Contribution

Chi-Sq = 9.338, DF = 2, P-Value = 0.009
two cells with expected counts less than five.

Result: Only a 0.9 % chance these differences occurred by natural variation. There is 99.1% probability that there is a difference between Improvement and Correction distributions

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wo Baselines in 2005: nt & Correction AFTOs

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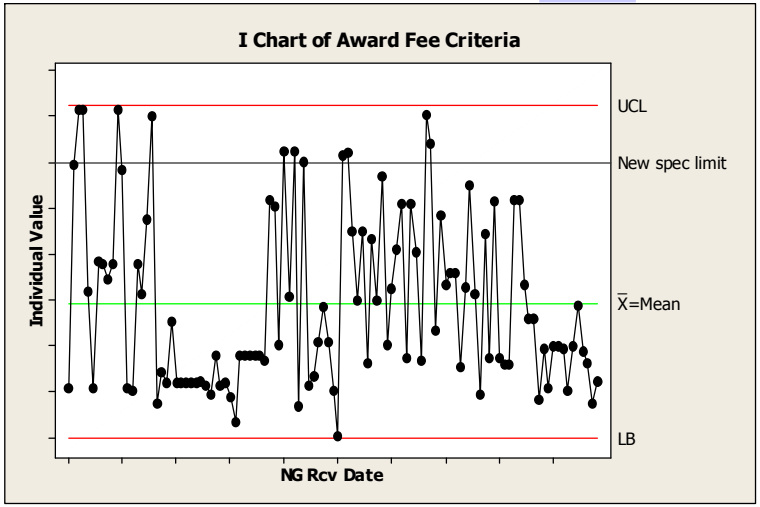
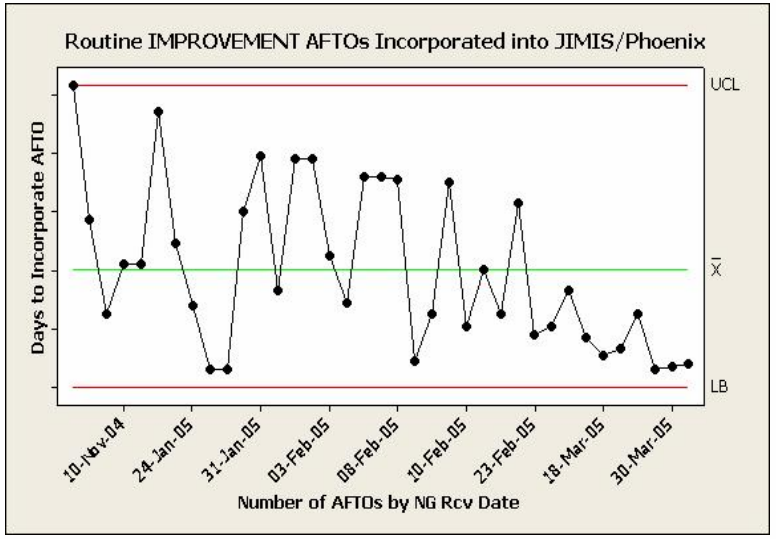
UCL = 29% improvement

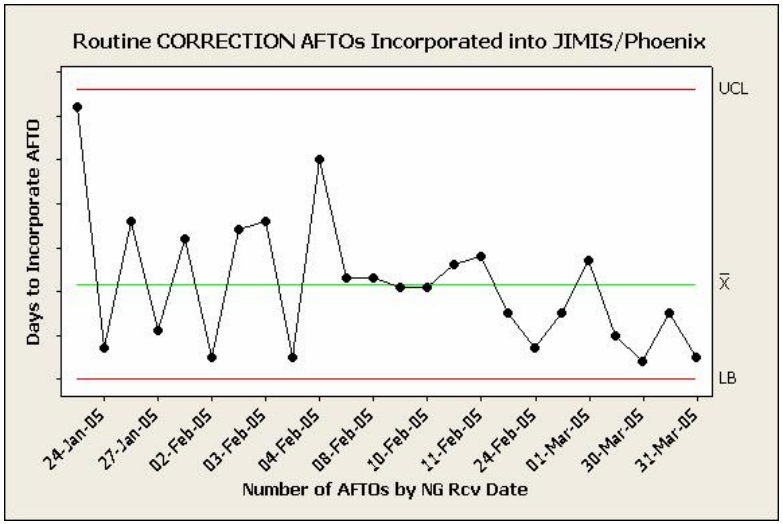
Mean = 31.7% improvement



UCL = 54% improvement

Mean = 62% improvement





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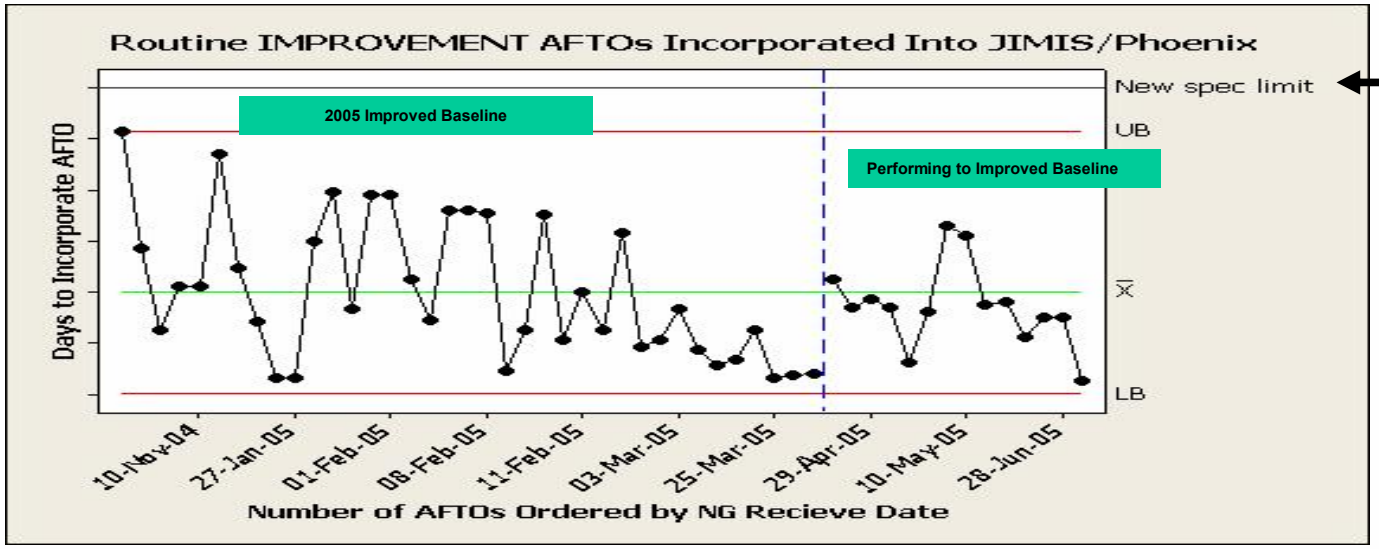
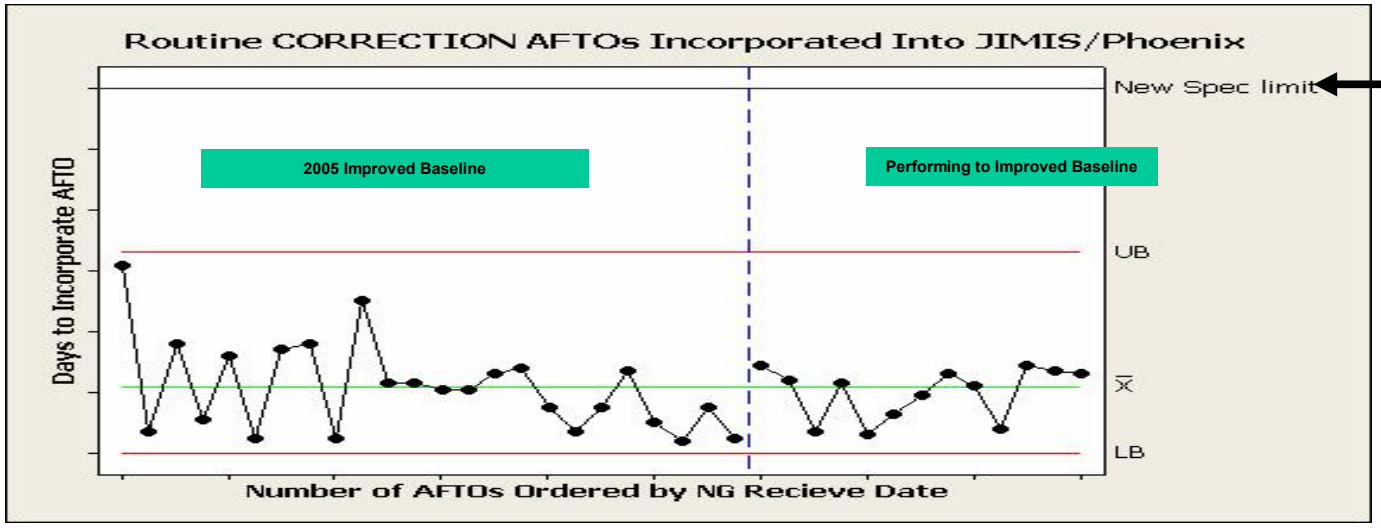
ent & Correction AFTOs: g to Improved Baseline

MS8



TSSR Award Fee Criteria



TSSR Award Fee Criteria

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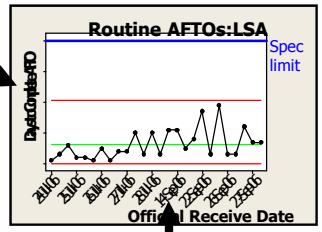
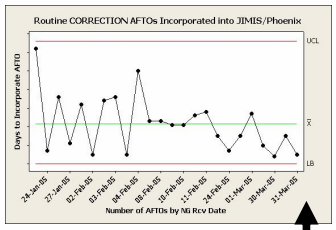
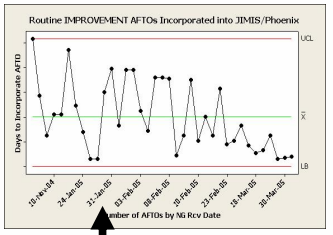
MS7

Draft Value Stream Map – Future State 2006
AGS & BMS Tech Pubs – AFTO 22

In 2006 a second goal to control & optimize LSA sub-process within AFTO 22 process was achieved







AFTO 22

	O (F-E)	P (G-F)	Q (H-G)	R (I-H)	S (K-J)	T (L-K)	U (L-H)
JTF / 116th Wing	CTOCU Process	NG Dispo/ Eval AFTO	LKS Review Approval	Days in LKS	Develop Time in LSA	Incorporate AFTO into JIMIS	Review Time in Tech Supp	Award Fee Criteria
	(JTF) C/T = Y H T/T = x D	C/T = YH T/T = x D	C/T = Y H T/T = x D	C/T = T/T = x D	C/T = Y H T/T = x D	Open JCC C/T = Y H T/T =x D	C/T = T/T = x D	**Inform Customer** C/T = Y H T/T = x D
	1	2	3	4	5 I9-TDP-217	6 I9-TDP-217	7 I9-TDP-217	8 I9-TDP-217
	ÅAFTO FAX E-MAIL	NG			NG	NG	NG	NG

2005 TSSR Award Fee Criteria of X days for AFTO Incorporation based on availability of data in Live Feed

Govt Review Data Live Feed	Release of Data (PDF, TMD)	Govt/NG Data Fielded For Usage
C/T = Y H T/T = x D	C/T = Y H T/T = x D ÅTMD Tapes ÅPDF Files	C/T = Y H T/T = x D
9	10	
	NG	NG

LEGEND

T/T = Throughput Time — H = Hours
C/T = Cycle Time — M = Minutes
= Push — D = Days
= Inventory

JCC = JIMIS Conformance Checklist
AFTO = Air Force Technical Order
JTF = Join Test Force

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BENEFITS

Significant Accomplishments

- **1st Goal Accomplishment:**
  - Technical Publications Established a Statistically Stable Baseline for AFTO Incorporation Schedule
  - Demonstrated Performance to the Stable Baseline
- **2nd Goal Accomplishment:**
  - Significantly Reduced the Process Performance Mean
  - Significantly Reduced Excessive Variation in UCL of the Process
  - Determined Need For Two Baselines:
    - Improvement AFTO Incorporation Schedule
    - Correction AFTO Incorporation Schedule
- **Customer Expectations of "Blue Rated" Quality Have Been Maintained With Improved Schedule Efficiency:**
  - From Sept 05 Night Eyes ï ñDCMA is pleased to report that for JIMIS-JIMIS quality, Phoenix has maintained exceptional quality levels, currently 0.0 percent defect rate, through three consecutive revisions.ò

- **The improved process assures continued success in meeting and exceeding the customer's defined schedule days for Routine AFTO Incorporation**
- **The improved Disposition & Incorporation of AFTOs process has a substantial impact on award fees**
  - The total AFTO Disposition & Incorporation activity in TSSR represents 2% of the annual award fee
- **The improved and statistically stable AFTO process ensures that Northrop Grumman will continue to meet the requirements of the customer and realize 100% of the Routine AFTO Award Fee activity**

QUESTIONS?

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DEFINING THE FUTURE

Statistically Managing a Critical Logistics Schedule Using CMMI ®

November 2007

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