NORTHROP GRUMMAN

Using Moving Average Models to Predict Process Performance

November 19, 2009

Bob Tuthill/Steve Tennant
Six Sigma Black Belts
Northrop Grumman Aerospace Systems

Agenda

- Expectations of High Maturity Behavior in Quantitative Project Management (QPM)
- Scenario 1: Developing a Moving Average Model Based on a Customer Award Fee Criteria
- Scenario 2: Developing a Moving Average Model Based on Software Build Process Performance

Expectations of High Maturity Behavior in Quantitative Project Management (QPM)

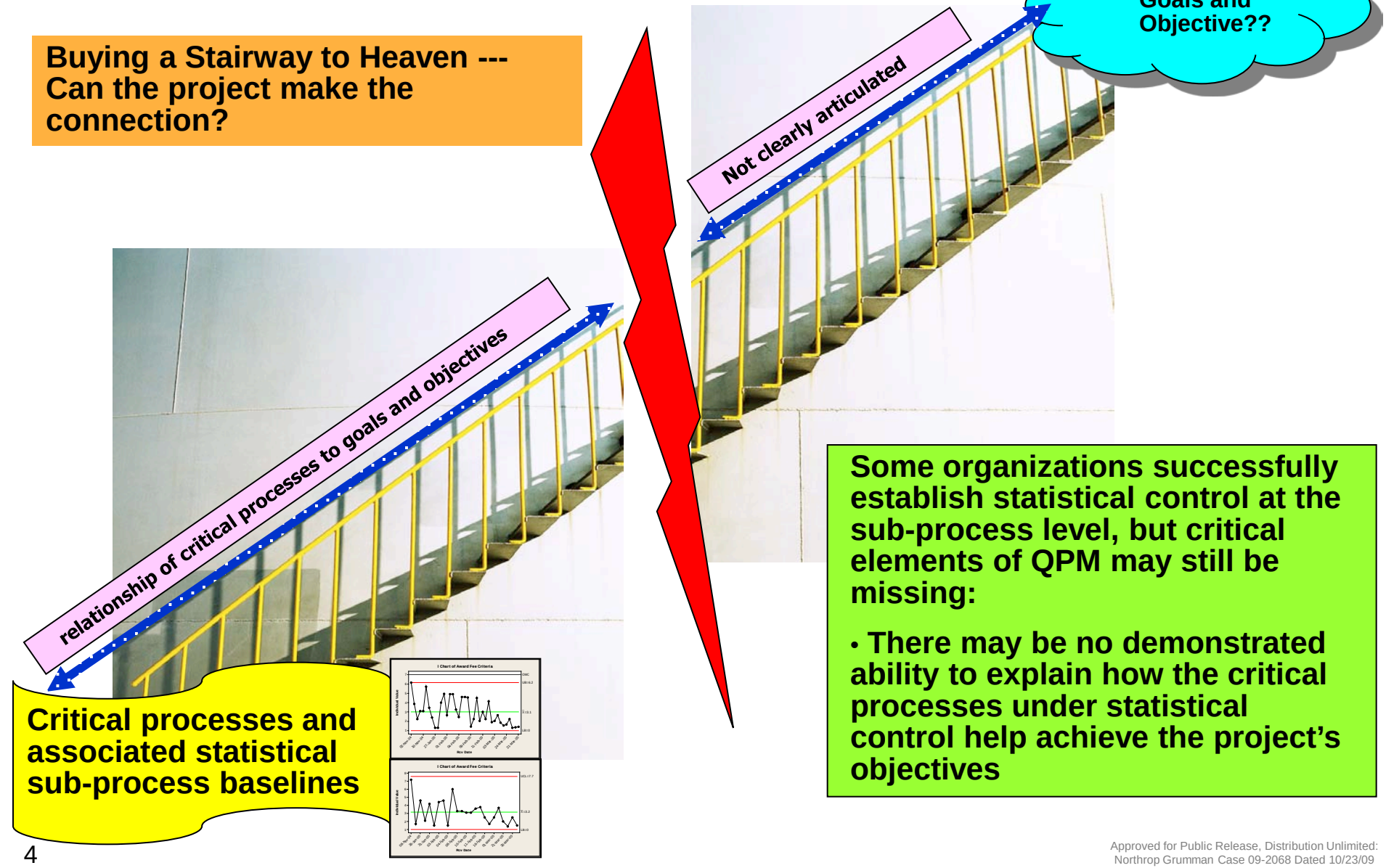
NORTHROP GRUMMAN

- Expectation: Make the connection between statistical sub-process performance and project objectives
  - Clearly define and articulate the ability to *predict* achievement of project *quality and process performance objectives (QPPOs)*, based on performance of *critical processes*
  - Identify the relationship between *critical processes* and *goals and objectives* (QPPOs)
- Use feedback from executing the project's *critical processes* to help manage the project
    - Feedback should indicate whether the project's goals and objectives (QPPOs) will be satisfied

Expectations of High Maturity Behavior in Quantitative Project Management (QPM)

NORTHROP GRUMMAN

Buying a Stairway to Heaven --- Can the project make the connection?



Some organizations successfully establish statistical control at the sub-process level, but critical elements of QPM may still be missing:

- **There may be no demonstrated ability to explain how the critical processes under statistical control help achieve the project's objectives**

Expectations of High Maturity Behavior in Quantitative Project Management (QPM)

NORTHROP GRUMMAN

- Statistical management of sub-processes (using I-charts, C-charts, P-charts, etc) may not provide an effective indicator of whether the larger project objectives will be met
  - Predicting achievement of project objectives may not be apparent when managing process performance baselines (PPBs) that track attributes (cost, quality, schedule) of discrete work products like individual documents, or source code changes, or engineering drawings, etc.

- Other types of control charts might be used as process performance models (PPM) to predict achievement of the project's objectives
  - In some applications, a Moving Average control chart may serve as a PPM

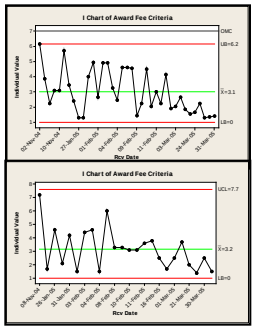
NORTHROP GRUMMAN

Scenario 1: Developing a Moving Average Model Based on Customer Award Fee Criteria

Customer Objective Measurement Criteria (OMC) For Change Request Development and Incorporation

NORTHROP GRUMMAN

Existing I-charts monitor schedule performance of individual CCR incorporation, but provided limited use as a predictor of OMC



To more accurately predict achievement of QPPO an intermediate model is required

Notional Data

***n*-day OMC = Project's QPPO For CCRs**

<u>Scenario #1</u>:

- **Schedule performance of Customer Change Requests (CCRs), incorporated into Technical Manuals, is evaluated against the customer's Objective Measurement Criteria (OMC)**
  - **Customer's OMC is based on a schedule criteria of an *n*-day limit for total CCR development and incorporation time into the manuals**
- **Customer computes the *n*-day OMC as the cumulative average of CCR schedule performance over time (at a quarterly rate, and biannually as a roll up)**
  - **The performance of each *individual* CCR is *not* scored against the *n*-day OMC**
  - **Project maintains I-charts of CCR performance, but they provide limited use as a predictor of OMC, since their utility is in understanding *individual* CCR performance**
- **Due to the cumulative average function underlying the OMC, a moving average chart is an effective *predictive model* that can simulate the averaging function of the OMC assessment**
  - **The moving average chart (model) can provide trending data that indicates whether the OMC objective is on track or at risk.**

Customer Objective Measurement Criteria (OMC) For Change Request Development and Incorporation

NORTHROP GRUMMAN

- Averaging the CCRs for a given quarter:
  - Let us assume the cumulative CCR incorporation rate = 43 days per CCR. If the cumulative average for any assessment period remains below the n-day OMC, then the project achieves 100% of the award fee.

$$\frac{n-day\_OMC}{Actual\_Cum\_AV} = \frac{n-days}{43\_days} \geq 100\% \text{ performance against OMC}$$

- Conversely, if the cumulative average for a given assessment period exceeds the n-day OMC, then the project achieves only a partial award fee based on a weighting system provided in the customer Award Plan.
  - For example assume that the Actual_Cum_AV is 150 days.

$$\frac{n-days}{150\_days} = \leq 83.2\% \text{ performance against OMC}$$

Based on the weighting system in the customer's Technical Performance Measurement guidelines, an 83.2% success rate would equate to the project receiving between 70-80% of the award fee.

NOTE: All values provided above are notional only, and are not representative of actual contract data.

Calibrating the Moving Average Model

NORTHROP GRUMMAN

Customer Plan Requirement

Measure Start/End: Measured quarterly. Evaluated by using the cumulative result of the two quarters for each semi-annual evaluation period.

Notional Data

	Incorporation		
	Number of CCRs	Incorp into Tech Pubs	Average Days
Nov-07	2	84	42.00
Dec-07	0	0	0.00
Jan-08	10	740	74.00
Feb-08	7	497	71.00
Mar-08	11	440	40.00
Apr-08	18	862	47.89
	9	342	38.00
08-1 Period Cumulative	57	2965	52.02
May-08	3	237	79.00
Jun-08	9	316	35.11
Jul-08	15	485	32.33
Aug-08	7	378	54.00
Sep-08	18	877	48.72
Oct-08	15	816	54.40
08-2 Period Cumulative	67	3109	46.40

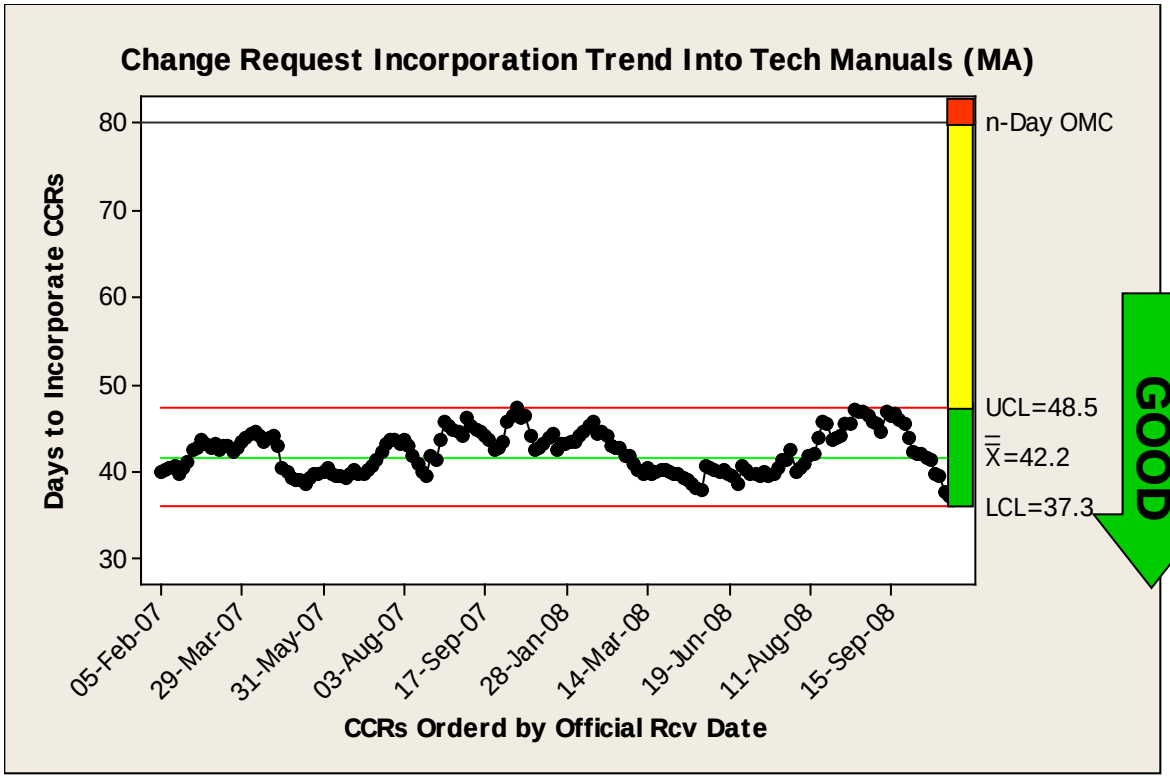
- **Quality and Process Performance Objective (QPPO) = *n*-day OMC**
- **This moving average model provides high predictability for managing achievement of the QPPO**

- The moving average model approximates the quarterly assessment rate specified in the customer Award Fee Plan
- The moving average range is based on Technical manual deliveries released every 75 days @ # CCRs per release
- The moving average of # CCRs conservatively models the quarterly averaging of CCR performance conducted on the project.

Practical Application of Statistical Management

NORTHROP GRUMMAN

Notional Data



Red Status: The process has violated the *n*-day Objective Measurement Criteria (OMC) by 1 or more data points. Model prediction is that rating to compute award fee will be adversely impacted (refer to project Award Plan for projected impacts)

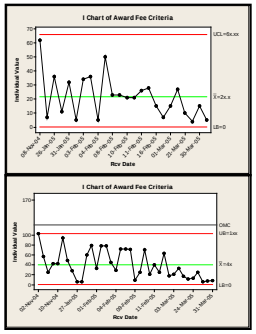
Yellow Status: The process has violated the UCL by 1 or more data points. Model prediction is that there is only a 0.14 % chance that the average duration (days) of CCR Incorporation for the reporting period will exceed 48.5 days

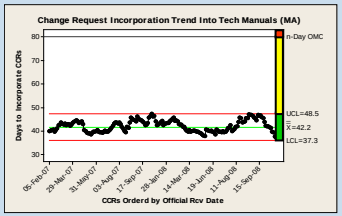
Green Status: The process operates within the boundaries of the Moving Average chart. Model prediction is that there is a 99.86% probability the average duration (days) of CCR Incorporation for the reporting period will be less than 48.5 days

Seeing the Relationship of Sub-process Performance to Project Objectives (QPPO)

NORTHROP GRUMMAN

Trends in moving average model predict impacts to achievement of the QPPO (OMC)





Project QPPO For CCRs=*n*-day OMC

I-Charts provides identification of instantaneous changes in process performance that predict trends in moving average model

Notional Data

Demonstrates how a statistically controlled sub-process baseline for CCR incorporation schedule predicts achievement of the Project's QPPO

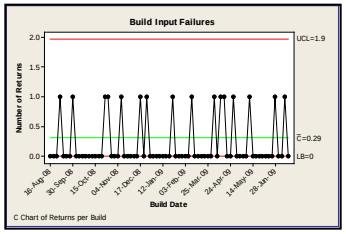
NORTHROP GRUMMAN

Scenario 2: Developing a Moving Average Model Based on Software Build Process Performance

Customer Objective Measurement Criteria (OMC) For Change Request Development and Incorporation

NORTHROP GRUMMAN

Sub-process control (C-Chart) provides identification of instantaneous changes in number of returns per SW Build



To more directly predict achievement of QPPO (SPI) an intermediate model is needed

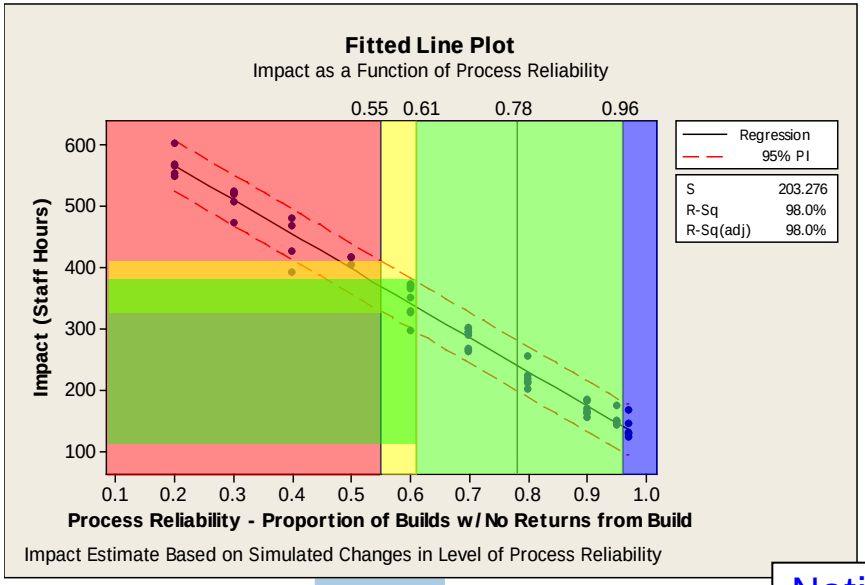
SPI	Project Color Rating
1.00	
0.99	
0.98	
0.97	
0.96	
0.95	
0.94	
0.93	
0.92	
0.91	
0.90	

Notional Data

Scenario #2:

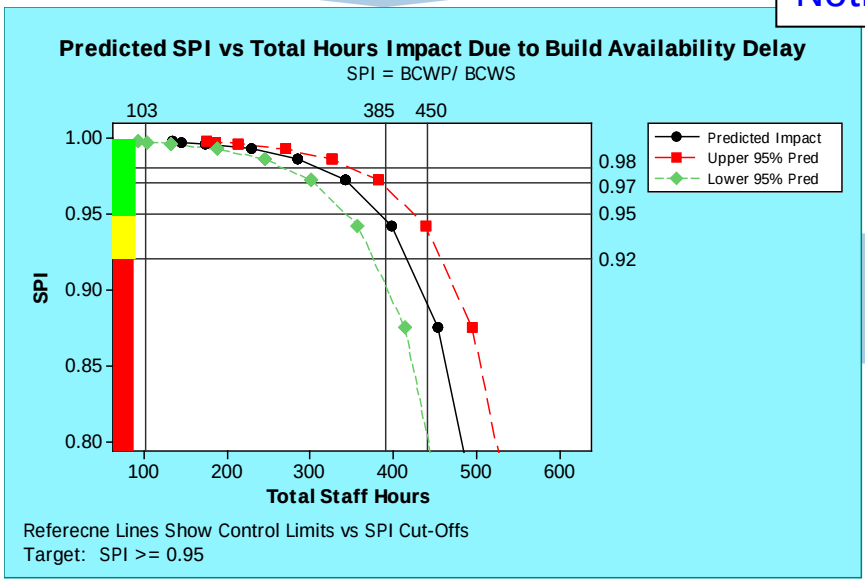
- **Schedule performance is managed across the project life-cycle to ensure that the schedule performance index (SPI) remains green**
  - **Circumstances that cause yellow or red conditions are costly, and management seeks to avoid or mitigate these through predictive measures**
- **Project maintains a C-chart of returns from software build, but this provides limited use as a predictor of SPI impact, since the chart's utility is in understanding the "by-build" return rate**
- **Cumulative delays in build processing, caused by excessive return rate, can adversely impact project SPI performance**
  - **A moving average chart can provide an effective predictive model that forecasts when delays in build processing, caused by excessive return rate, will noticeably effect SPI**

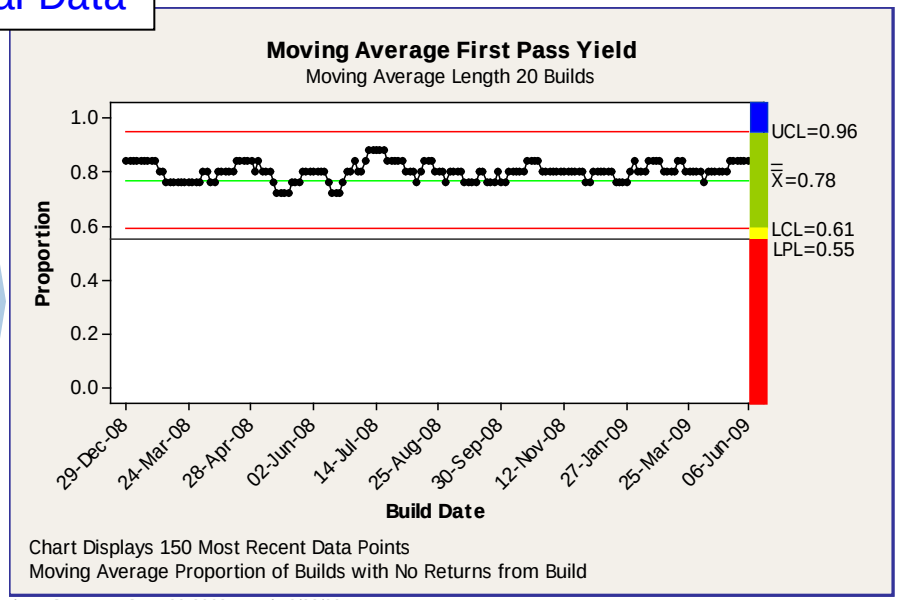
Relation of Control Chart Indications to Project Objectives



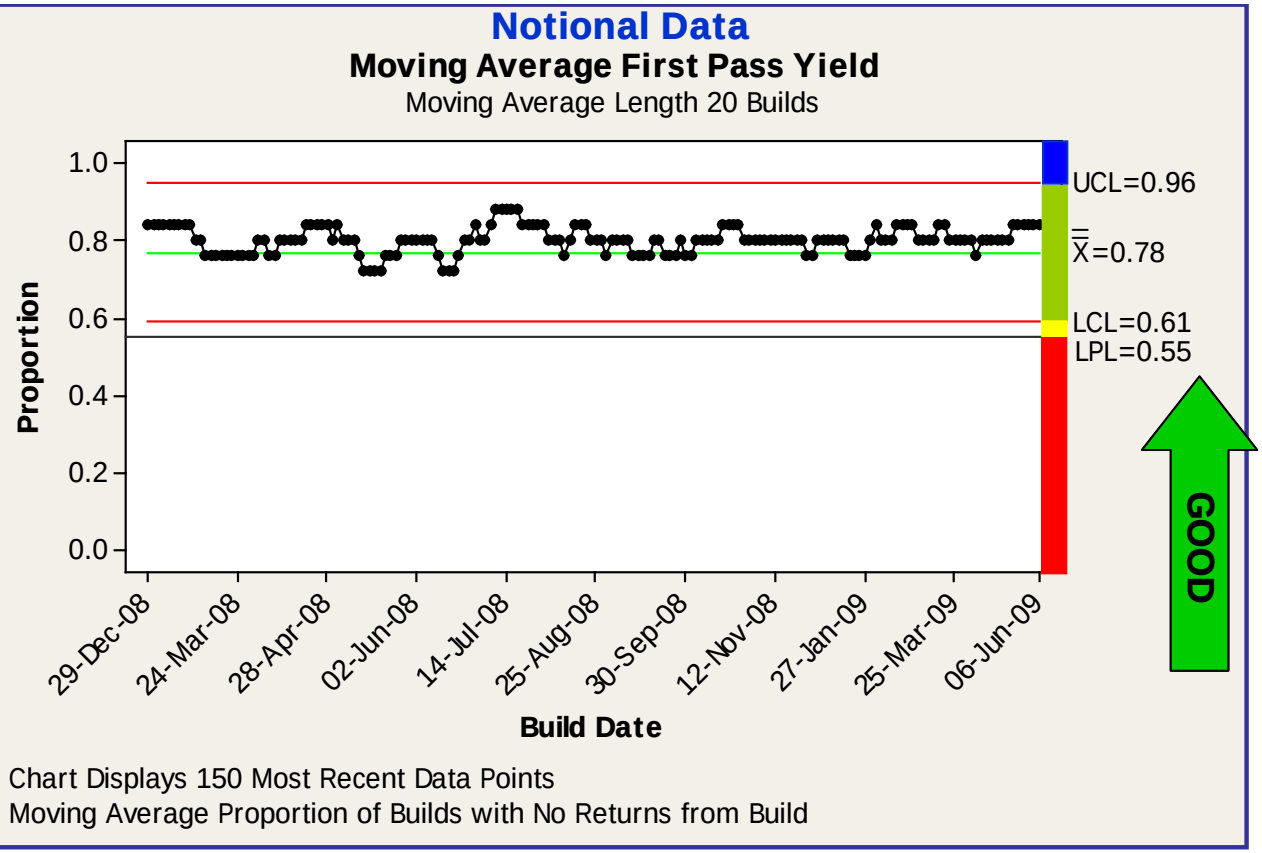
- Estimated impact of the cumulative delay in build availability per release vs process reliability is used as a model to identify the resulting impact on the project's SPI performance
- The zones identified on the moving average control chart reflect the project's ability to achieve SPI objectives

Notional Data





Process Proportion First Pass Yield



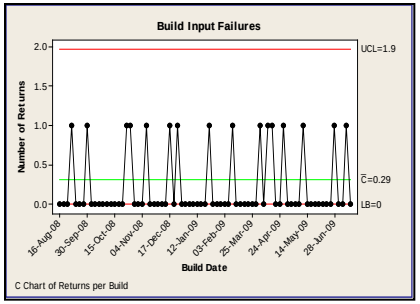
Green Status: The process is operating with a first pass yield greater than 61%. This means that > 61% of SW builds are error free over the 20-build moving average window. Model prediction is that there is a 99.86% probability the process will continue to operate within these boundaries with no adverse impact to SPI due to build delays.

Yellow Status: The process is operating with a first pass yield between 55% - 61%. Model prediction is that the project is in jeopardy of achieving its SPI objective due to cumulative impact of build delays.

Red Status: The process is operating with a first pass yield less than 55%, or has remained in yellow status for more than 5 builds. Model prediction is that the project is in serious jeopardy of achieving its SPI objective due to cumulative impact of build delays.

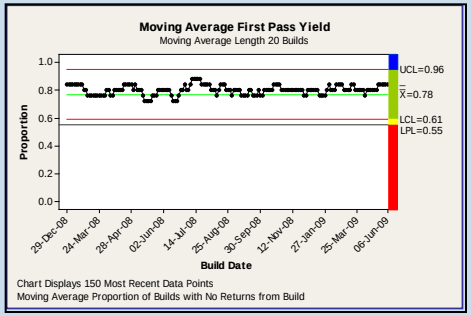
Operation of the process in the green zone enables prediction that the project is enabled to achieve its objective for schedule performance (SPI) based on historical performance with build processing time delays

Seeing the Relationship of Sub-process Performance to Project Objectives (QPPO)



Sub-process control (C-Chart) provides identification of instantaneous changes in process performance that predict trends in moving average model

Trends in moving average model predict impacts to achievement of the QPPO (SPI)



SPI	Project Color Rating
1.00	
0.99	
0.98	
0.97	
0.96	
0.95	
0.94	
0.93	
0.92	
0.91	
0.90	

Notional Data

Demonstrates how a statistically controlled sub-process baseline for software build process performance predicts achievement of the Project's QPPO!

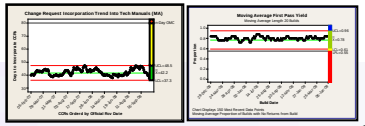
Summary: Demonstrating Relationship of Process Performance to Project Objectives

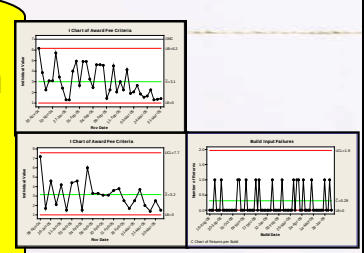
NORTHROP GRUMMAN

The Stairway to Heaven Completed

Project QPPOs:
- ***n*-day OMC for CCRs**
- **SPI**

Relationship of critical processes to goals and objectives now established via moving average charts





Critical process: CCR Incorporation and Software Build processes, and their associated statistical sub-process baseline

Linkage now established through use of moving average models:

- **Visible relationship of statistically managed sub-processes to project objectives now in place**
- **Process performance used to predict achievement of project objectives**

NORTHROP GRUMMAN

QUESTIONS ?


NORTHROP GRUMMAN