Raytheon

Customer Success Is Our Mission

National Defense Industrial Association

3rd Annual

CMMI® Technology Conference

and

User Group

with Technical Co-sponsorship by

Software Engineering Institute,

Carnegie Mellon University

November 17-20, 2003

Estimating Effort for PPQA Using the Raytheon 6σ Process

Raytheon North Texas Software Engineering

Donna Freed

N TX Software Engineering Process Improvement Journey

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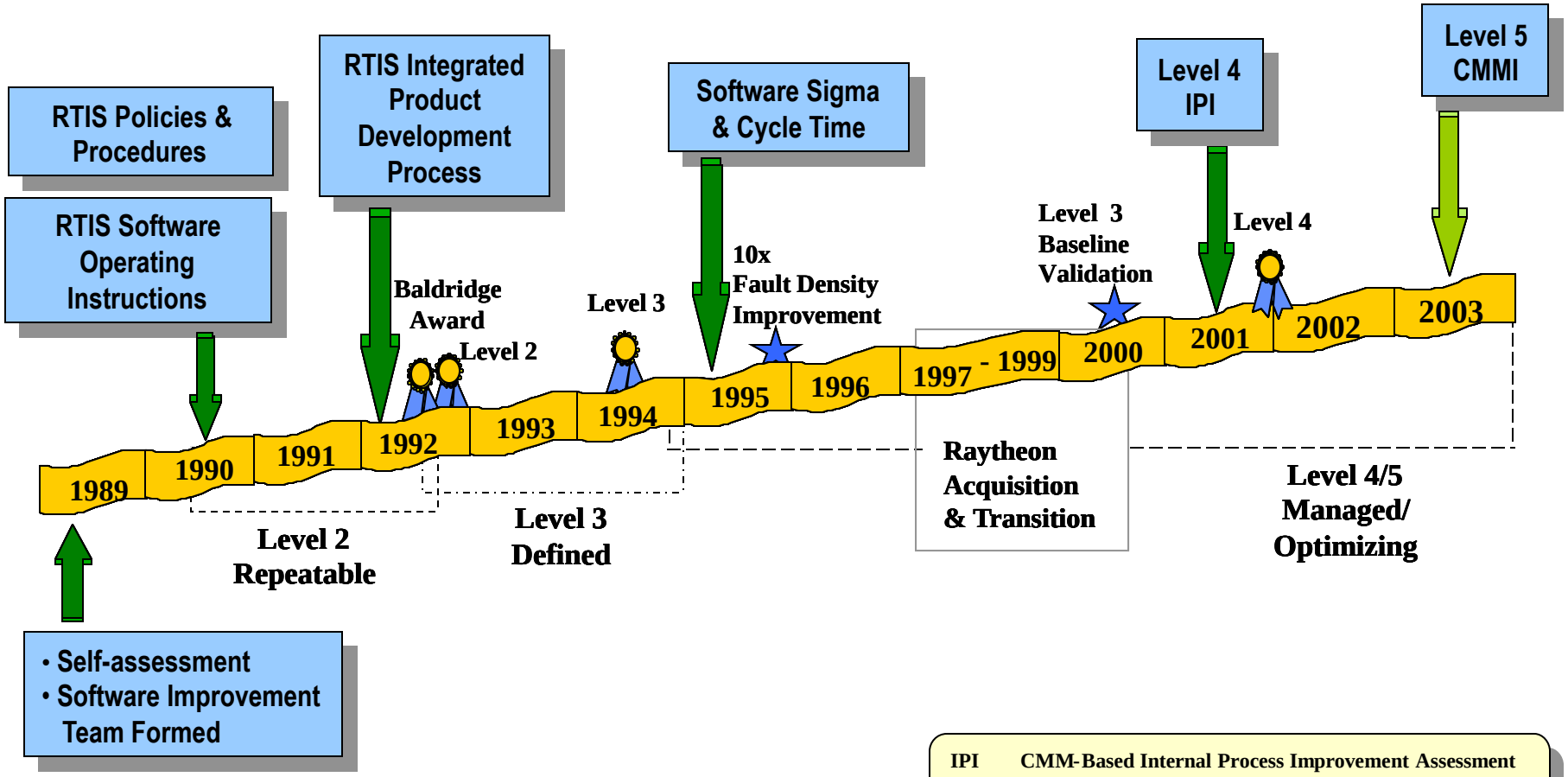

IPI CMM-Based Internal Process Improvement Assessment
RTIS Raytheon/TI Systems
CMMI CMM Integrated

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CMMI at Levels 4 & 5

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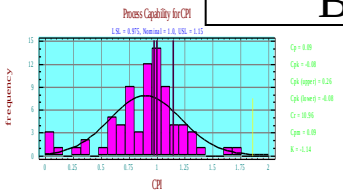
Measure Improvements & Re-baseline

Set Objective Performance & Quality Goals

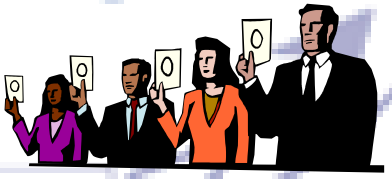
Stabilize process & Establish Process capability Baseline

CPI



Deploy Improvements

Select & Prioritize Improvements



Pilot Improvements

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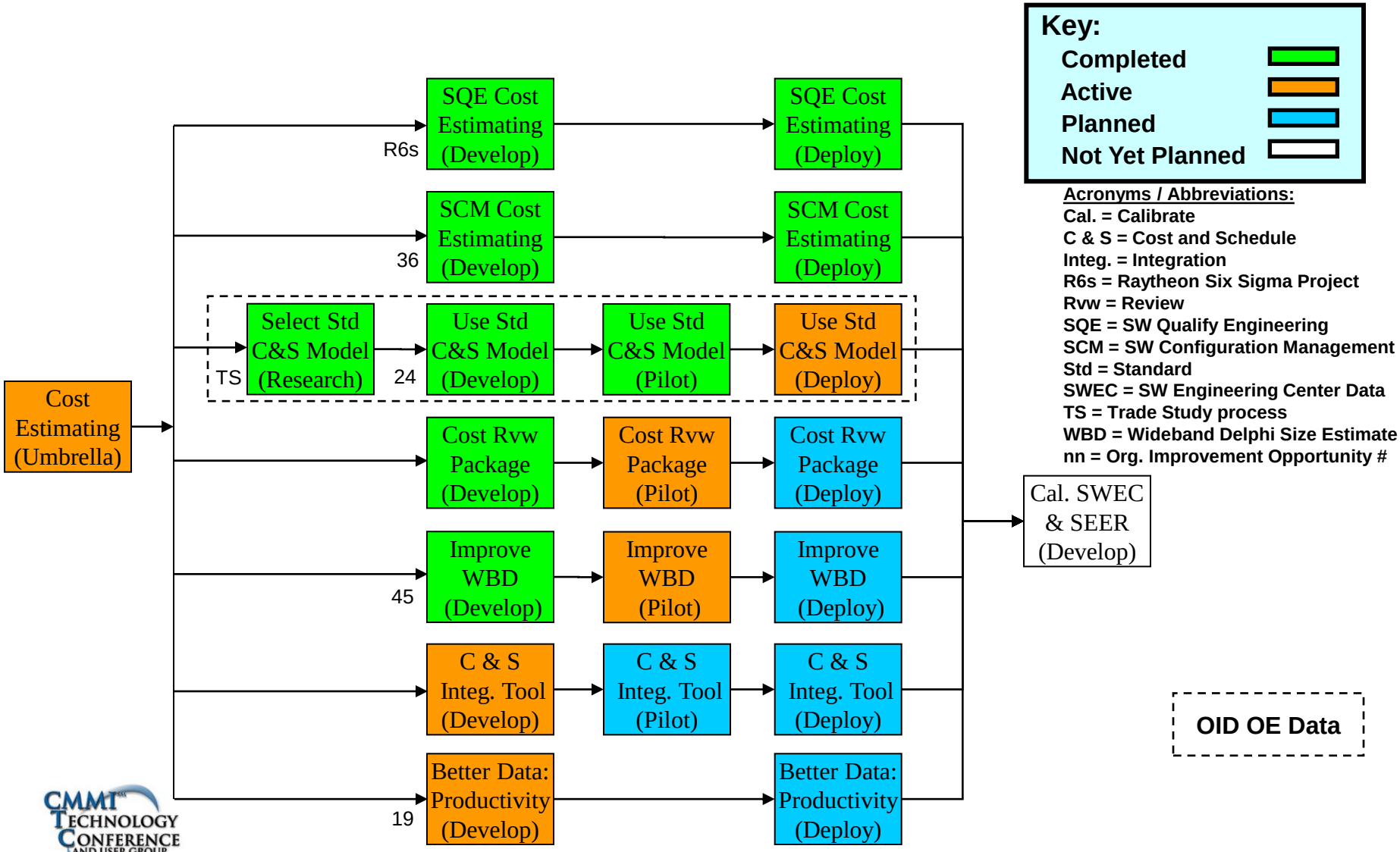
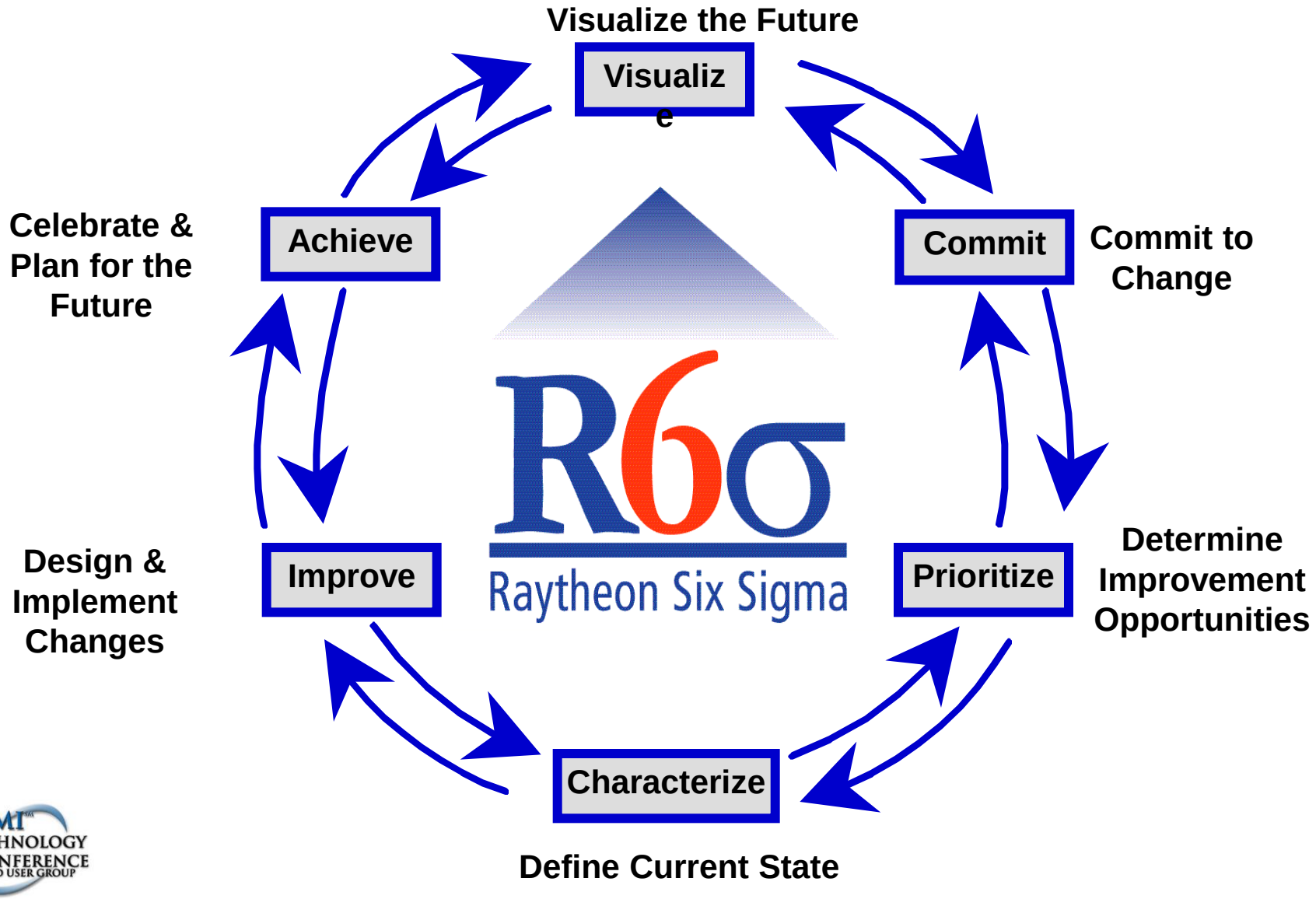
Cost Estimating Improvement Roadmap



R6σ Process


Visualize the Future
Visualize
Commit
Commit to Change
Prioritize
Determine Improvement Opportunities
Characterize
Define Current State
Improve
Design & Implement Changes
Achieve
Celebrate & Plan for the Future
R6σ
Raytheon Six Sigma

Visualize

- "Imagine the Future"
  - Create a vision of the future with a clear and pressing need for change. Align sponsorship throughout the value stream to maximize our benefits.
  - In late 1999, Raytheon introduced a new methodology for software cost estimating that included the use of "adders" or percentages for support engineering.

PPQA Support	Minimum	Selected
Defined Process	x	x
North Texas		?

Example is too low!

This Sigma project determines North Texas Guidance for PPQA based on actuals for labor hours

Visualize

- **Confidence in the cost estimation process for PPQA support is low:**
  - **Proposals need to be more task based so managers can understand and explain PPQA functions on their programs when presenting proposals.**
    - **Johnny Barrett, SWEC Director, challenge for PPQA as input to December 1999 SQE Planning Session**

- **PPQA took the challenge:**
  - **to verify and justify the PPQA cost percent estimate used in proposals.**
  - **to provide a process for PPQA cost estimation based on historical actuals and tasks required to support the project.**

Commit

- "Commit to Change"
  - Develop a committed sponsor and team aligned with the vision, accountable and energized to make change.
    - ☐ Commitment from sponsors (SWEC Director)
    - ☐ Commitment from subject matter expert (Software Cost Estimation)
    - ☐ Commitment from specialist (SQE Manager)

- To establish commitment, PPQA prepared a detailed break out of the actual labor cost data from 2 historical sources:
  - SMCRS and the "old" SMDB
- Two pareto charts were prepared and presented to the SWECLT, characterizing the actuals.

The wide spread of percentages called into question whether there is a valid percentage.

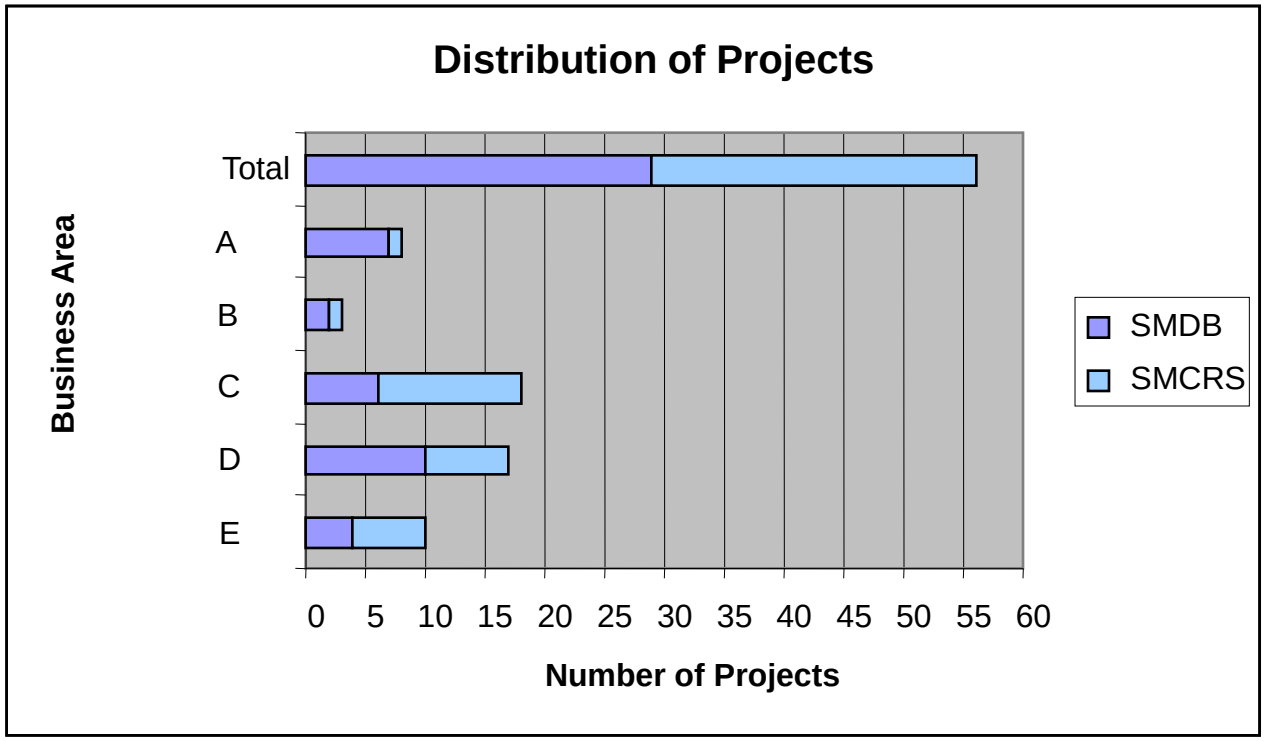
Prioritize

- "Determine Improvement Priorities"
  - Define goals and action plans. Commit resources to focused improvement project(s) in order to realize significant results

- Goal/Scope: Is there a valid PPQA "adder" percentage?
  - Analyze actual labor hour ranges for PPQA for software engineering in North Texas
  - Limited to SQE costs, but approach can apply to other support.
    - ☐ Johnny Barrett, SWEC Director, sponsored this analysis as a R6σ project

Characterize--Analyze Actuals

- **Combined SMCRS and SMDB into one file for analysis.**
- **Further refined data by removing all projects without core labor hours.**



Characterize

- "Define Existing Process and Plan Improvements"
  - Understand and document current state performance (metrics, process flow, and critical factors); translate the current state opportunities into a plan for improvement.

- Validate current data
  - Break down cost actuals
    - ☐ Omitted projects with data collection in "bid" or "contract"
    - ☐ Selected projects with data collection: Final
    - ☐ Omitted projects with no data or inadequate data in development stages
  - Other factors to consider
    - ☐ Omitted any project with no SQE actuals

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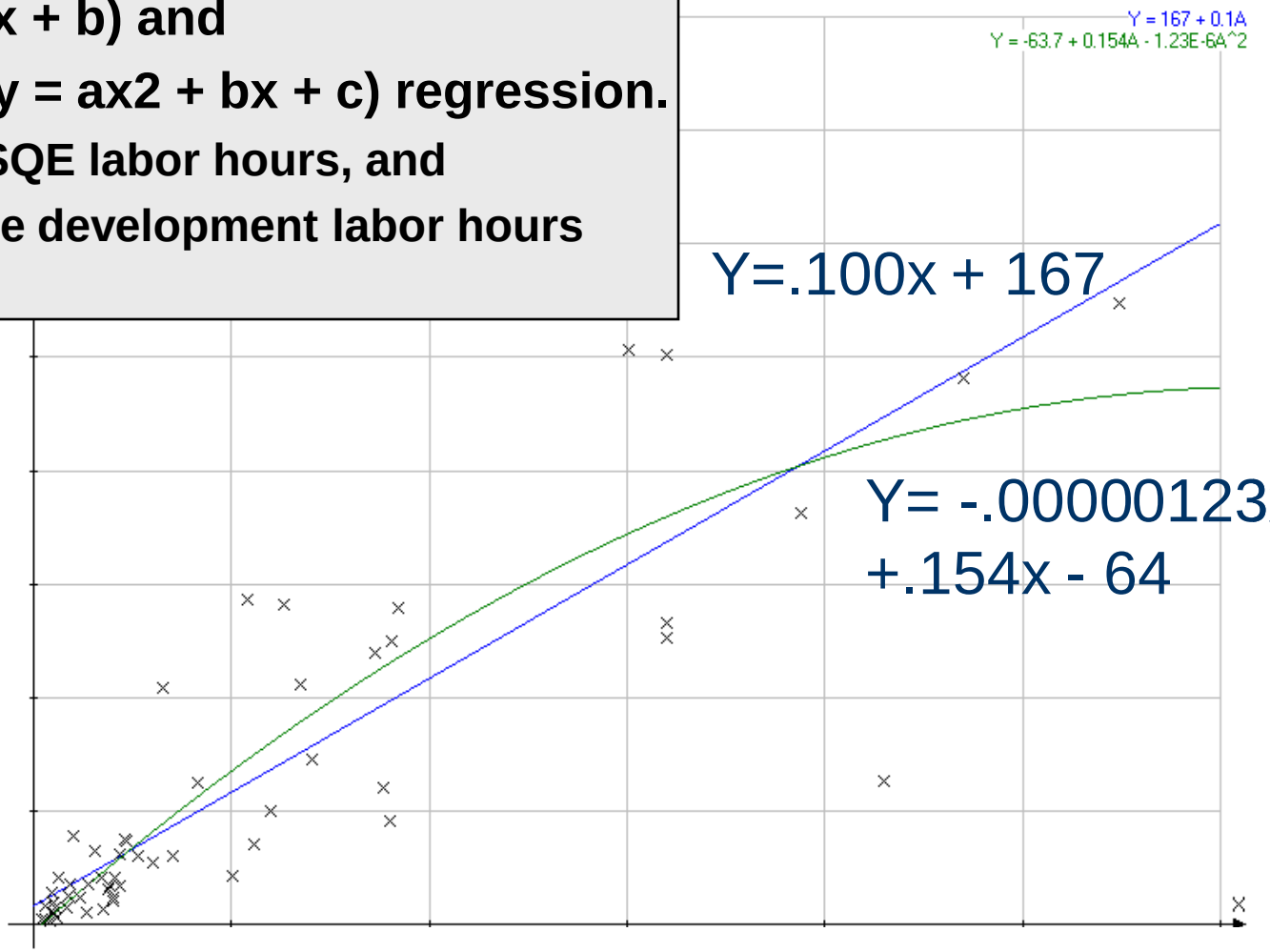
Approach: validate then analyze actuals

Characterize--Analyze Actuals

- **Actuals were analyzed using both**
  - **linear (y = mx + b) and**
  - **polynomial (y = ax2 + bx + c) regression.**
    - ☐ **Note: y = SQE labor hours, and x = software development labor hours**



PPQA

Core

Characterize-- Detailed Results

- **Coefficient of correlation:**
  - **Core: Linear = .85, Polynomial = .86**
  - **Total: Linear = .83, Polynomial = .84**
    - **Virtually no differences between core and total results--either can be used with the same confidence in the cost model**

- **Residual (remaining base constant for x=0)**
  - **Core: Linear = 167, Polynomial = -64**
  - **Total: Linear = 180, Polynomial = 6**
    - **Polynomial correlation shows significant advantage over linear especially in model based on total hours (because residual is closer to 0)**

Our intuition was incorrect!

Characterize-- Predictions from the model

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- Model predicts declining percentage of SQE effort as size of project increases
- Model works best with medium size projects
- Smaller projects may be inaccurate due to fixed cost in core model
- Not enough data points for larger projects

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Improve – Design and Implement Improvements

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- "Design and Implement Improvements"
  - Design and implement integrated improvements and control systems to maximize value.
- Improvement Plan
  - Publish guidance for PPQA cost estimating
  - Review and approve Cost SMR content for PPQA estimates (Heisenberg principle--the act of observing influences the object being observed)
  - Verify metrics data input for PPQA actuals
  - Enforce requirement to collect PPQA costs separately.

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How do we compare?

Northeast SQE Bidding Guidelines vs. N. TX model

SQE Support Adders	NE Guidance	NTX Guidance
Project Size		
Micro	x+ 5.5% (+ / -1.5)	x+ 1.1% (+ / - .9)
Small	x+ 2.55% (+ / - 1.5)	x+ .7% (+ / - .7)
Medium	x% (+ / - 1.0)	x+ .2% (+ / - .9)
Large	x- 1.75% (+ / - .75)	x- .6% (+ / - 1.1)
Very Large	x- 3% (+ / - .5)	x- 2.1% (+ / - 1)

As a percent of Total Software Development effort, including requirements, design, code and test activities.

Achieve – Celebrate Achievements, Build for Tomorrow

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- "Celebrate Achievements, Build for Tomorrow"
  - Deliver measurable results that change the way people think and act, create knowledge, build momentum for continuous improvement, celebrate success, and get people excited about doing Raytheon Six Sigma repeatedly.

- SQE Cost estimating procedure provides consistency for SQE proposal preparation.
- Cost Management review includes the SQE Manager to verify that:
  - Costs fall within guidelines
  - Tasks fall within guidelines for software quality process
- Tasks outside the standard Raytheon software quality process are estimated separately

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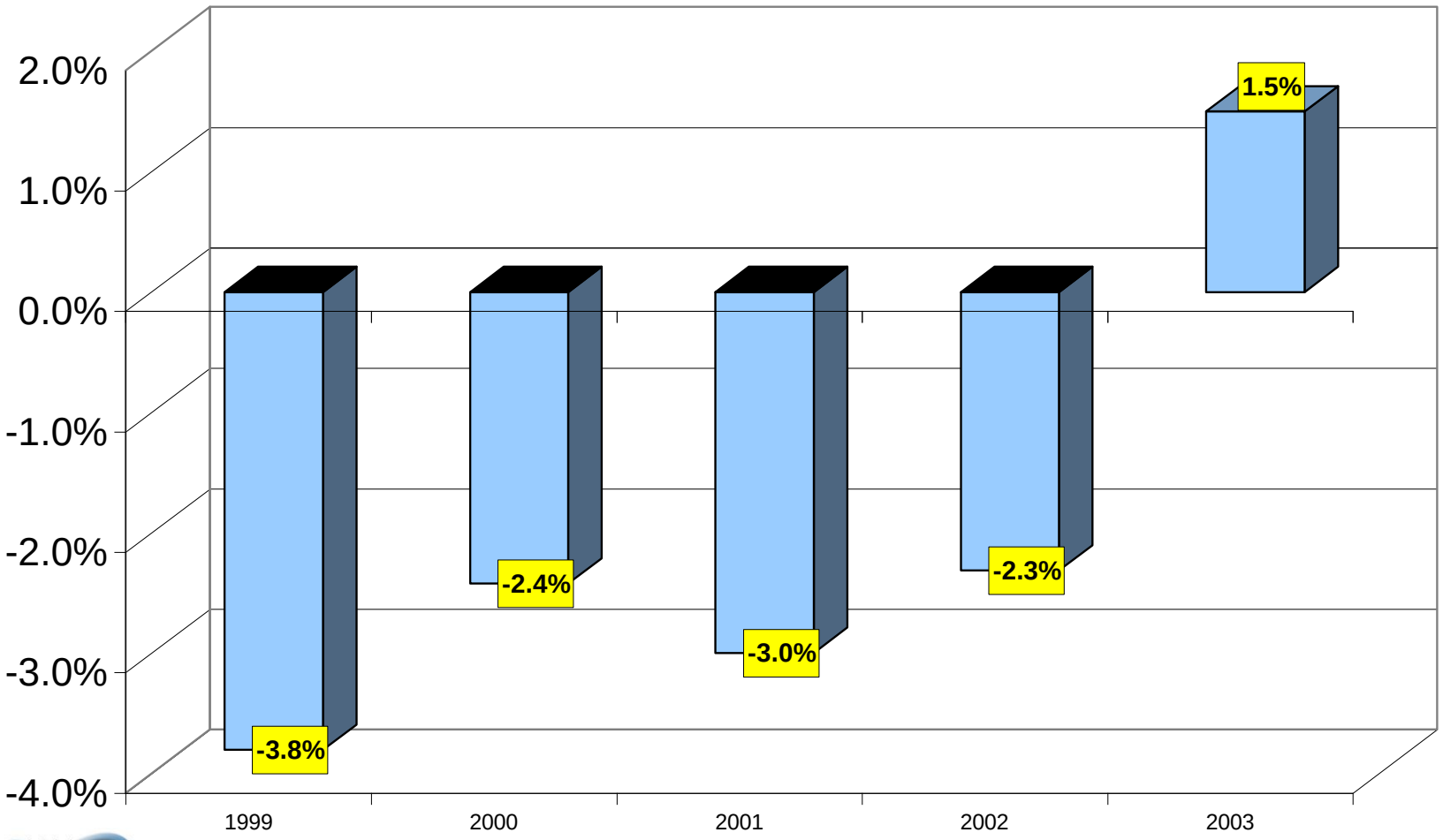
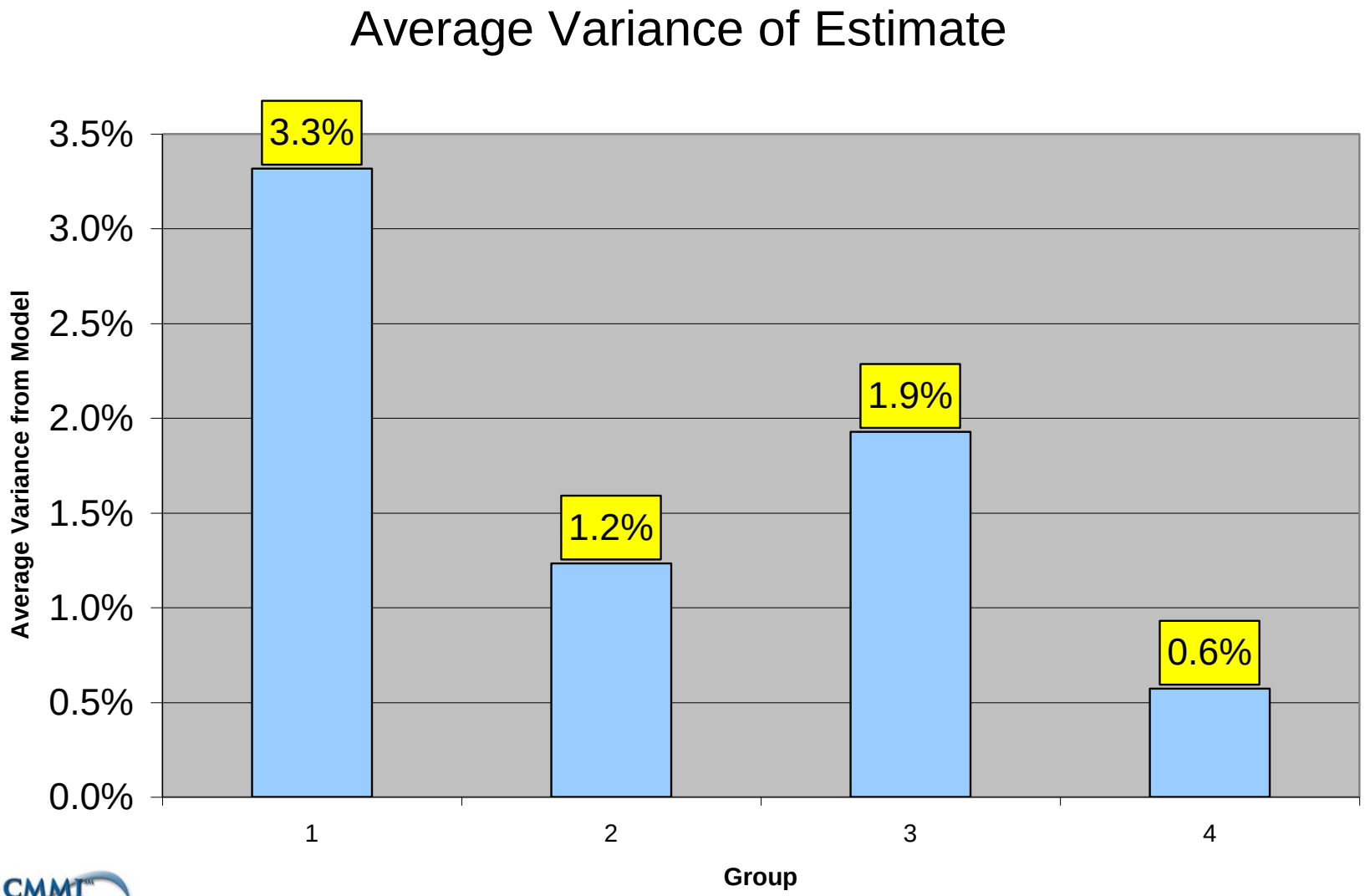
Are estimates consistent with the model?

Average Deviation from Model



Estimates were consistently below the model based on actuals, until 2003. Guidelines were published in mid 2002.

How consistent?



Based on 34 Software Cost Estimates over 4 years.

Summary

- PPQA cost estimating process has been successfully used as guidance for SQE cost estimates on programs in North Texas.
- Started with basic tasks for a CMM level 3 organization.
- Cost estimates are refined as actuals are included in the model.
- A tool for estimating essential PPQA tasks based on the size of projects, with estimates declining in percentage as the size of the project grows.
- Reviewing estimates against guidelines results in estimates which are more consistent with actuals.