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SIX SIGMA ADVANTAGE
The Third Wave™

A Measurement & Analysis Training Solution Supporting CMMI & Six Sigma Transition

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Objectives

Primary

- Trace the design and development of a measurement & analysis course that integrates CMMI and Six Sigma
- Show why such integration is important

Secondary

- Highlight the complexities of process improvement in a “multi-technology world”
- Share issues related to technology transition
- Describe instructional design choices
- Illustrate a course case study in Six Sigma project form

Outline

Motivations for process improvement

Process improvement solutions
- Roots, evolutions, and integrations
- Transitioning your solution

Training as part of your "whole product"
- Designing an integrated training solution
- Illustration(s)

What Drives "Process Improvement"?

Performance issues: product, project

- And, eventually, process issues

Regulations and mandates

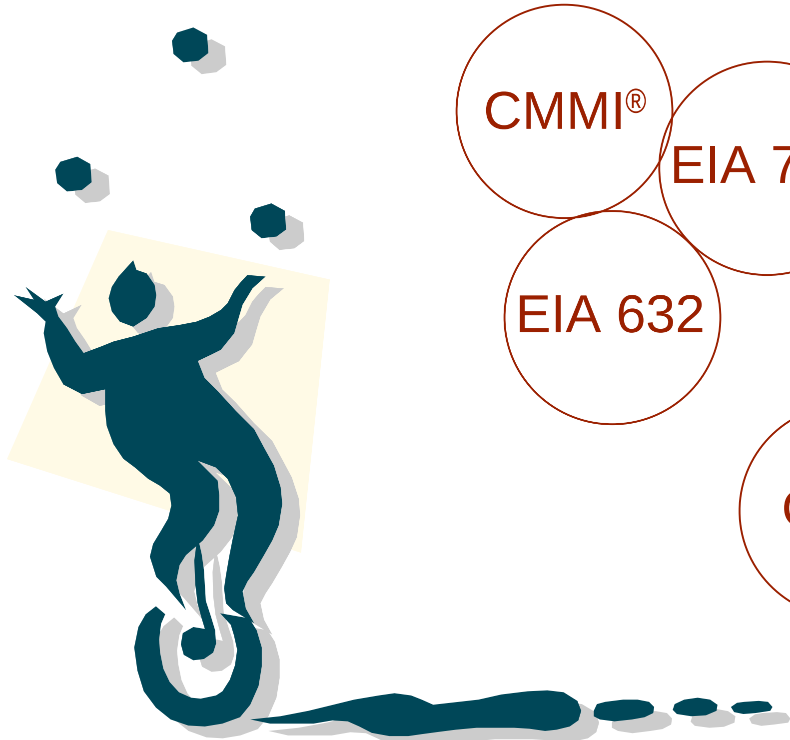
- Sarbanes Oxley
- "Level 3" requirements to win contracts

Business issues and "burning platforms"

- Lost market share or contracts
- Continuous cost and cycle time improvement
- Capitalizing on new opportunities

There is compliance-driven improvement.
And there is performance-driven improvement.

Solutions



CMMI®

EIA 731

EIA 632

ISO 9000

ISO 12207

Score-card

COBIT

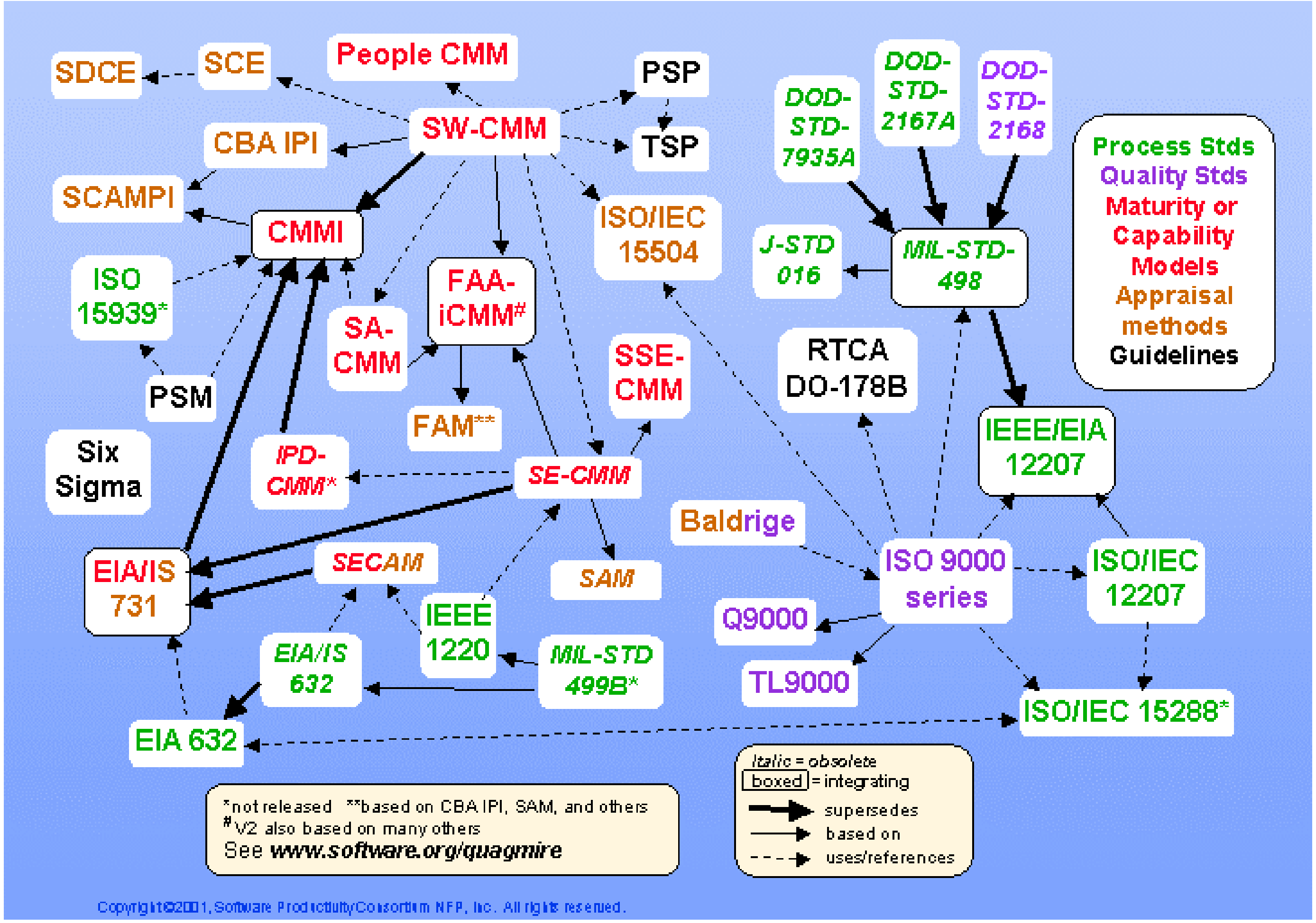
ITIL

GQIM

PSM

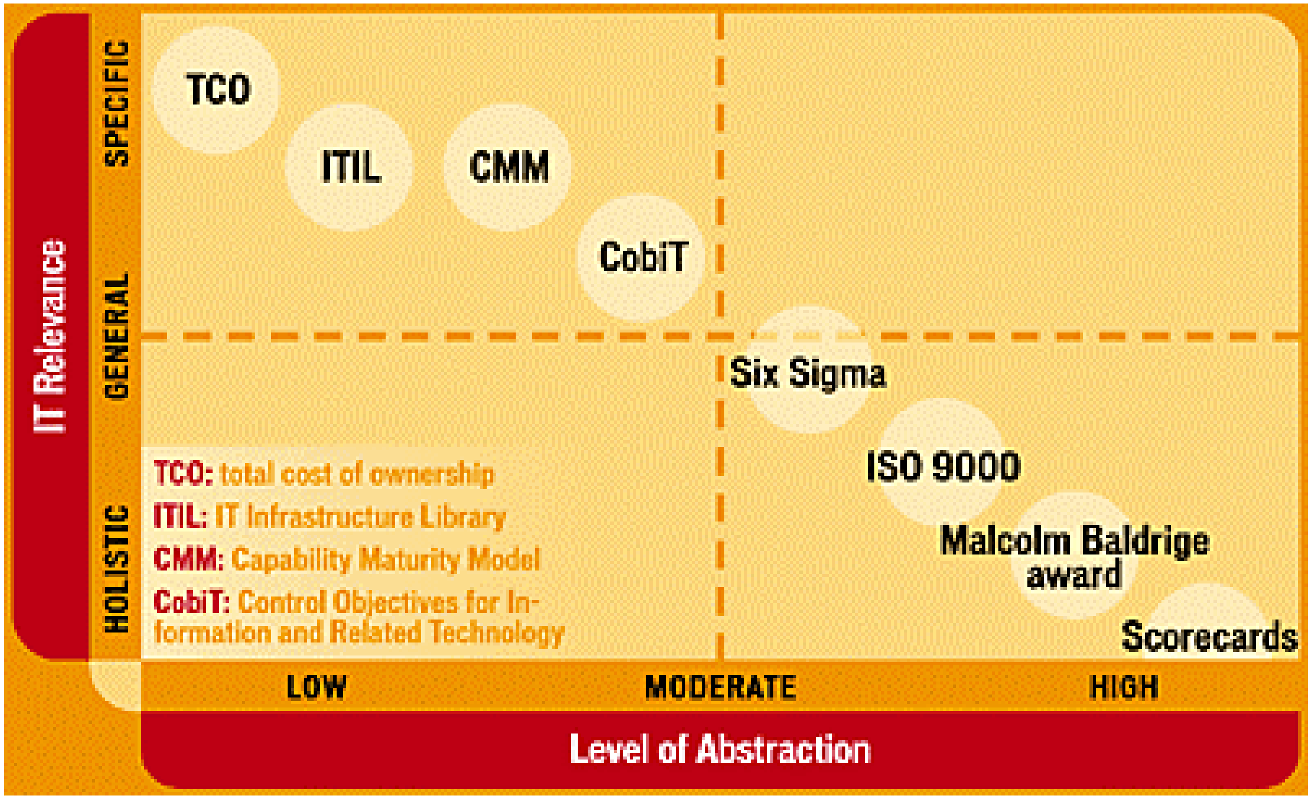
TSP℠

More Solutions: SPC Frameworks Quagmire



And Yet More Solutions

CIO Magazine: “Quality Model Mania”



[CIO 04]

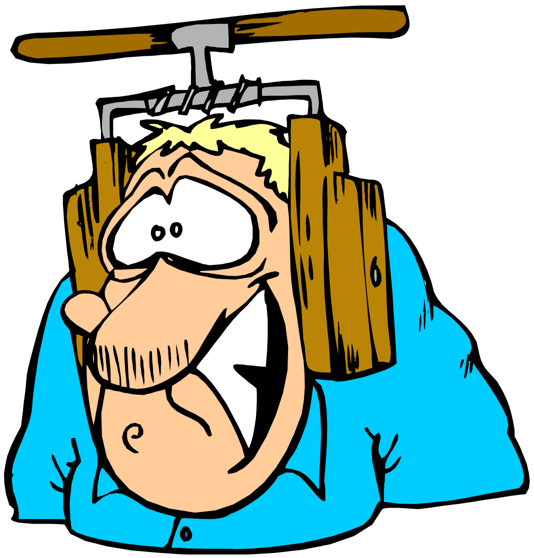
And There Are Still More…

In addition to the traditional list of "process improvement" models, methods, and standards, there are life-cycle, business-sector-specific, and other types of relevant technologies.

For instance:

- Rational Unified Process (RUP)
- Agile
- Architecture Tradeoff Analysis Method (ATAM)
- TL9000
- People CMM

Do You Have a Headache Yet?



Observations

Organizations are implementing one or more of these solutions simultaneously.

Economies of scale are needed in training.

A holistic, "connected" approach is needed in training

- Leaving students to their own devices to make connections can be risky and/or time-consuming.

Before we discuss our project, let's unfold the story…

Evolutions (examples)

Six Sigma

- Evolved at Motorola in the 1980s from TQM
- First focused on reducing process defects and cycle time in manufacturing
- Later expanded to address design (DFSS)
- Spread to services and is in early stages in software

CMMI

- Released in 2000
- Evolved from several Capability Maturity Models, reflects Crosby's 5 maturity levels
- Focuses on infrastructure and process maturity
- Intended for software and systems engineering

Common roots and common improvement intent

[BPD]

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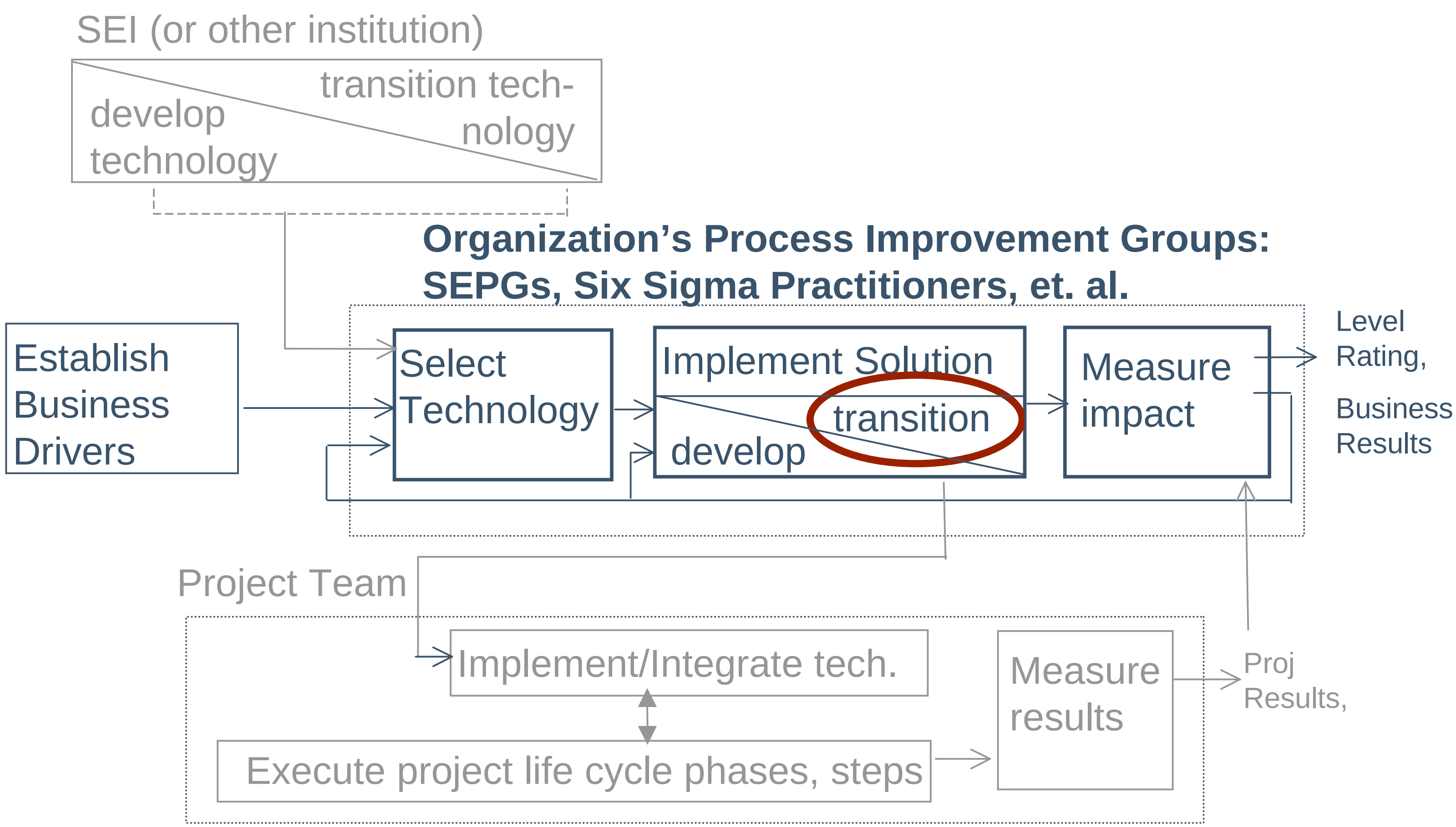
A Technology Adoption Process



Designing Your Approach

Selection and development considerations include:

- What is the goal?
- What model(s) or references should be used?
- Should they be implemented in parallel or sequentially?
- Can they be used "off the shelf" or is tailoring needed?
- What needs to be created internally?

Integrated process solutions that are seamless and transparent to the engineer in the field significantly contribute to an organization's success.

Your Six Sigma skills can play a role in the design.

Transitioning Your Solution

Technology transition is the process of creating or maturing a technology, introducing it to its intended adopters, and facilitating its acceptance and use.

Technology is

- Any tool, technique, physical equipment or method of doing or making, by which human capability is extended.”
- “The means or capacity to perform a particular activity.”

Do you use the words maturation, introduction, adoption, implementation, dissemination, rollout, deployment, or fielding in your improvement approach? Each indicates transition.

[Forrester], [Schon], [Gruber]

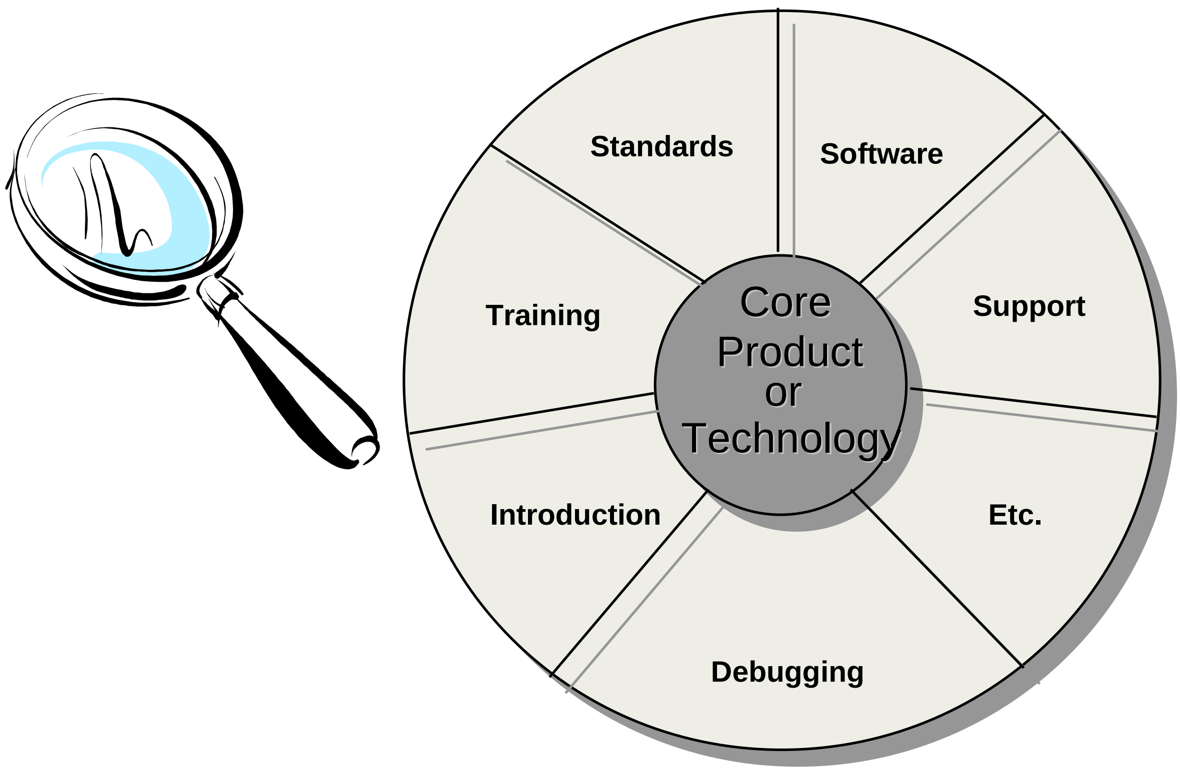
Effective Transition Planning

Features include:

- Precision about the problem, clarity about the solution
- Transition goals & a strategy to achieve them
- Definition of all adopters and stakeholders and deliberate design of interactions among them
- Complete set of transition mechanisms — a whole product
- Risk management
- Either a documented plan or extraordinary leadership throughout transition

[Forrester]

The "Whole Product" Concept*



[Moore]

Outline

Motivations for process improvement

Process Improvement Solutions

- Roots, evolutions, and integrations
- Transitioning your solution

➡ Training as part of your “whole product”

- Designing an integrated training solution
- Illustration(s)

Training Challenges

Many technologies have their own training.

- It's not practical to send everyone to all training courses.
- Yet it's also not practical to custom build all training.

Cross training (i.e., CMMI & Six Sigma)

- At a strategic level: how to increase awareness so that experts in one technology can make judicious decisions about adoption and implementation of another technology
- At a tactical level: how to balance the expertise

Who and how many should be trained? For instance,

- Train whole organization in internal process standards and possibly basic Six Sigma concepts
- Train fewer in Six Sigma BB, CMMI, measurement and analysis, other specialty areas

Benchmarking

Integrated training solutions underway:

- DFSS training that includes awareness sessions of relevant technologies
  - SEI's Product Line Practices, ATAM, CMMI engineering PAs
- DFSS training that leverages ATAM
- DMAIC training that references PSP-based instrumented processes

Strategic Emphasis (first bullet)

Tactical Emphasis (second and third bullets)

Our approach uses *measurement & analysis* as an *integrator*.

Highlights of our course design and content follow.

Scope of New Analysis Courses

Our task is to build new courses that

- Focus on *analysis*
  - But more than just SPC
- Focus on skills-building
- Support CMMI
- Appeal to many roles
  - process improvement personnel
  - measurement personnel
  - project team members
  - CMMI appraisers (maybe)
  - Six Sigma practitioners
  - and so on
- Resonate with organizations at any maturity level

Approach

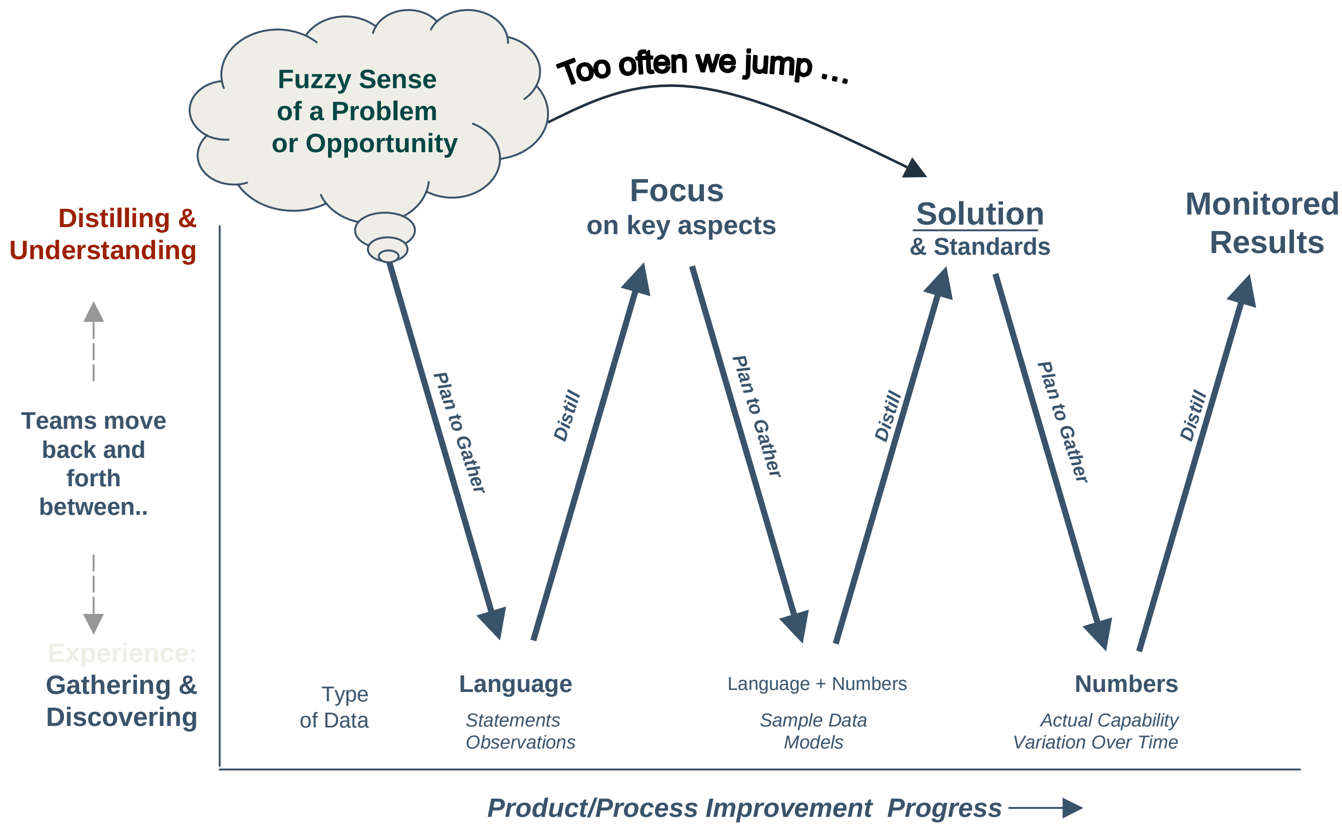
- Leverage other technologies and initiatives.
  - Reuse demonstrated frameworks and toolkits
  - Build explicit connections to models
  - Define "certification" boundaries and options
  - Return to common roots but don't reinvent the wheel
- Assemble a cross-organizational, cross-functional development team
- Use Gagne's Model for Instructional Design
- Use Kirkpatrick's Four-Level Evaluation Model
- Design for extensibility: case study approach
  - Allows easy swap-in of other domains, technologies
  - Allows easy updates as core technologies evolve

Considerations

- Integrate product, process, project analysis
  - Focus on process
  - Reuse SEI "Analysis Dynamics"
- Use aspects of Six Sigma
  - DMAIC problem solving framework
  - Toolkit
  - Training philosophy (hands on, practitioner focus)
- Make CMMI links explicit
- Determine fit with existing measurement courses
- Couple with an annual Measurement Practices Workshop (future)

A Base Architecture

- Connecting all the Improvement Models

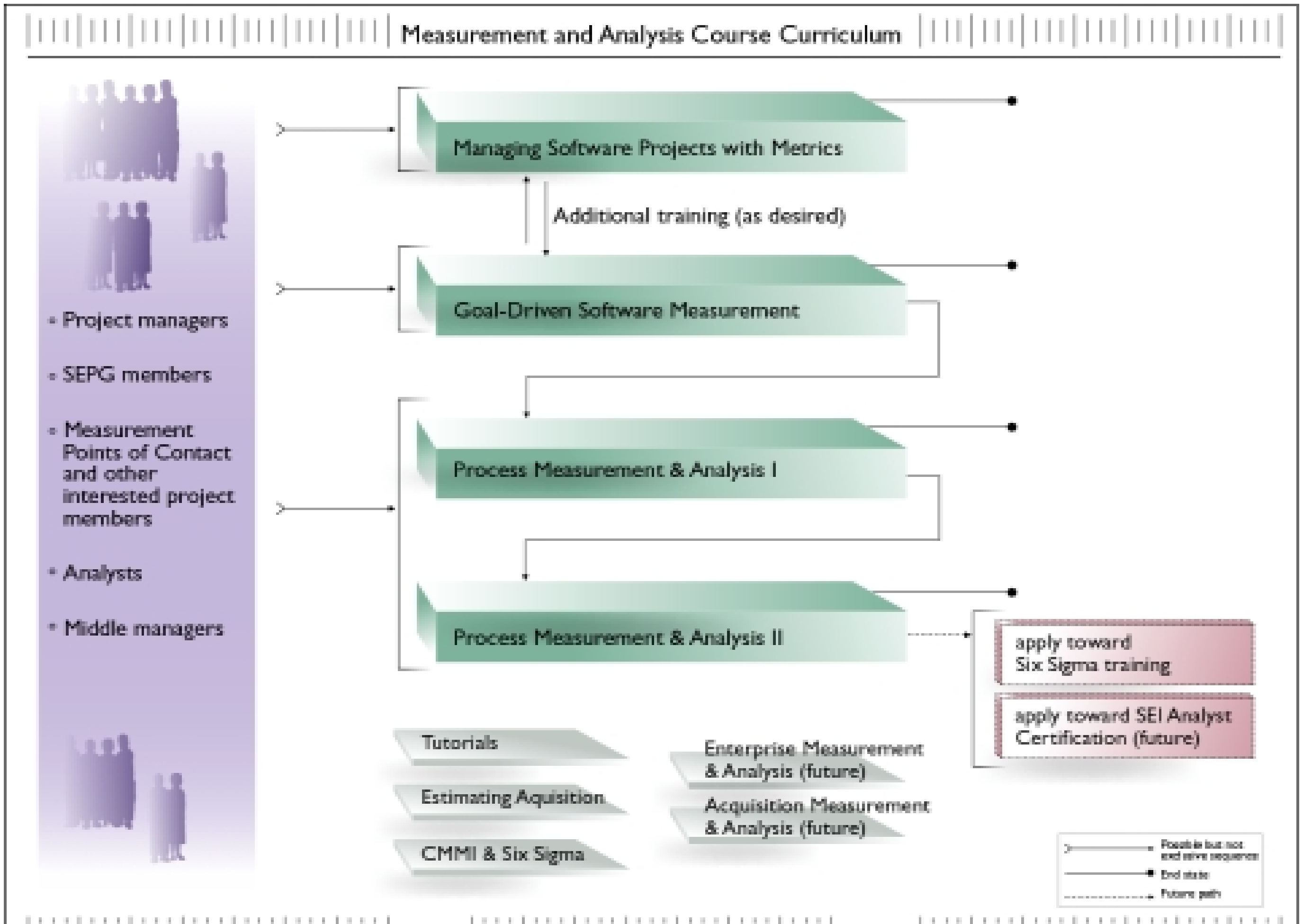


[Kawakita], [Shiba]

Design & Development Process

- Identify needs, requirements
- Update overall measurement curriculum design
  - Integrate with “certificate programs”
- Establish learning objectives
- High-level design of measurement & analysis courses
  - Course themes and storyboards
  - Desired student capability level in specific methods
- Detailed design of measurement & analysis courses
  - Including case study storylines
- Module development, including reviews
- Pilot

Curriculum


Measurement and Analysis Course Curriculum
Project managers
SEPG members
Measurement Points of Contact and other interested project members
Analysts
Middle managers
Managing Software Projects with Metrics
Additional training (as desired)
Goal-Driven Software Measurement
Process Measurement & Analysis I
Process Measurement & Analysis II
apply toward Six Sigma training
apply toward SEI Analyst Certification (future)
Tutorials
Estimating Aquisition
CMMI & Six Sigma
Enterprise Measurement & Analysis (future)
Acquisition Measurement & Analysis (future)

Certificates and Certifications

SEI Certificate Programs

- Analyst (future)

Six Sigma Practitioner Certification

- SEI Partners who provide Six Sigma training and certification can leverage courses
  - Adjunct, domain-specific, Black Belt training
  - Domain-specific Yellow Belt training

Learning Objectives

Students should be able to

- Describe the methodology (DMAIC + thoughtmap), incl
  - improved process behavior for business benefit
  - how this methodology "plays" in the CMMI world
- Decide how, when and why to use selected key tools and interpret their outputs.
- Demonstrate how effective measurement & analysis contributes to a paradigm shift from a compliance-driven to performance-driven improvement.
- Analyze, interpret, and report data using "x" tools.
- Explain statistical thinking, central tendency, uncertainty and risk.

Design Highlights: Course Themes

	Process Measurement & Analysis I	**Process Measurement & Analysis II**
Improvement Orientation	**Reduce** defects, waste (effort, resources, etc), and cycle time **by correcting special cause variation, repairing, and/or improving processes.**	**Prevent** defects, ensure cost/schedule performance by using real-time data and **optimizing** front-end planning, requirements, and design **processes.**
CMMI Relationship	**Maps to GP2.8 and GP3.2 at any maturity level.** **Maps to Level 4 thinking.**	**Maps to GP3.2 and GP4.2 at any maturity level.** **Maps to Level 5 thinking.**

Design Highlights: Course Outline

illustration

Process Measurement & Analysis I

- Introduce DMAIC flowchart
- Call Center Case: DMAIC Process
- Defect Containment Case: Data Stratification
- Cost & Schedule Case: Variance Reduction

Process Measurement & Analysis II

- Recap DMAIC
- Project Simulation: Organization and Project Baseline
- Defect Containment Case:
  - Optimize inspections and improve design
- Cost & Schedule Case:
  - Optimize estimating and improve requirements

Skills Capability Matrix (excerpt)

Analytical Methods	desired student capability	addressed in course
7+ basic tools (histogram, scatterplot, pareto, etc.)	skill	1
process mapping / SIPOC	skill	1
systems thinking - current/future reality trees, causal loop diagrams	tbd	tbd
sampling, grouping, alpha/beta risk	understand	
FMEA	skill	1
Orthogonal decomposition	knowledge	tbd
multivariate analysis (principle components)	awareness	tbd
Confidence and prediction intervals	understand	2
hypothesis tests, Means comparison tests	skill	1
Variance comparison tests	knowledge	tbd
design of experiments (DOE)	understand	2
analysis of variance, incl analysis of error	knowledge	2
modeling - regression, residual analyis, response surface	knowledge	2
Rayleigh distributions	understand	2
chi square distributions	understand	tbd
capability analysis	understand	2
KJ	skill	2
VOC	skill	2
QFD	awareness	2
pughs concept selection	skill	2
process simulation	awareness	2

Awareness = on the radar
Knowledge = knows basic information

Skill = can do it
Understand = can do, interpret, explain

Case 1 Storyline 1

Define

- organization project portfolio includes both new development and maintenance
- project size and complexity varies significantly
- project schedules vary from <1 month to >18 months
- Primary focus: customer satisfaction as proxied by field defects and effort & schedule variance
- Organization is transitioning from CMM to CMMI, working toward high maturity
- Organization is not a Six Sigma adopter (yet)

Measure

- Earned value data
- Defect data
- Customer satisfaction survey (new)

Case 1 Storyline 2

Analyze

- Iteration 1: baseline and problem/goal identification
  - Reduce cost and schedule variance (in process and closed project)
  - Improve data quality (presence, accuracy, etc.)
- Subsequent iterations:
  - baseline updates
  - problem/goal refinement
  - process understanding
- Tools used: boxplots, distributions, time series, pareto charts, capability analysis, basic descriptive statistics, indicator templates, survey analysis, SMART* goals, root cause analysis

Specific, Measurable, Attainable, Realistic, Timely

Case 1 Storyline 3

Improve

- Measurement infrastructure
- Cost and schedule variance cause code taxonomy
- Estimating (training, minor process adjustments)
- Adoption of “management by fact” (MBF) format
- Homogeneous samples for in-process charts

Control

- Organization: dashboards with charts for cost, schedule, defects, data quality, customer satisfaction
- Projects: Earned Value (EV) prediction model

Case 1 Sample Artifacts

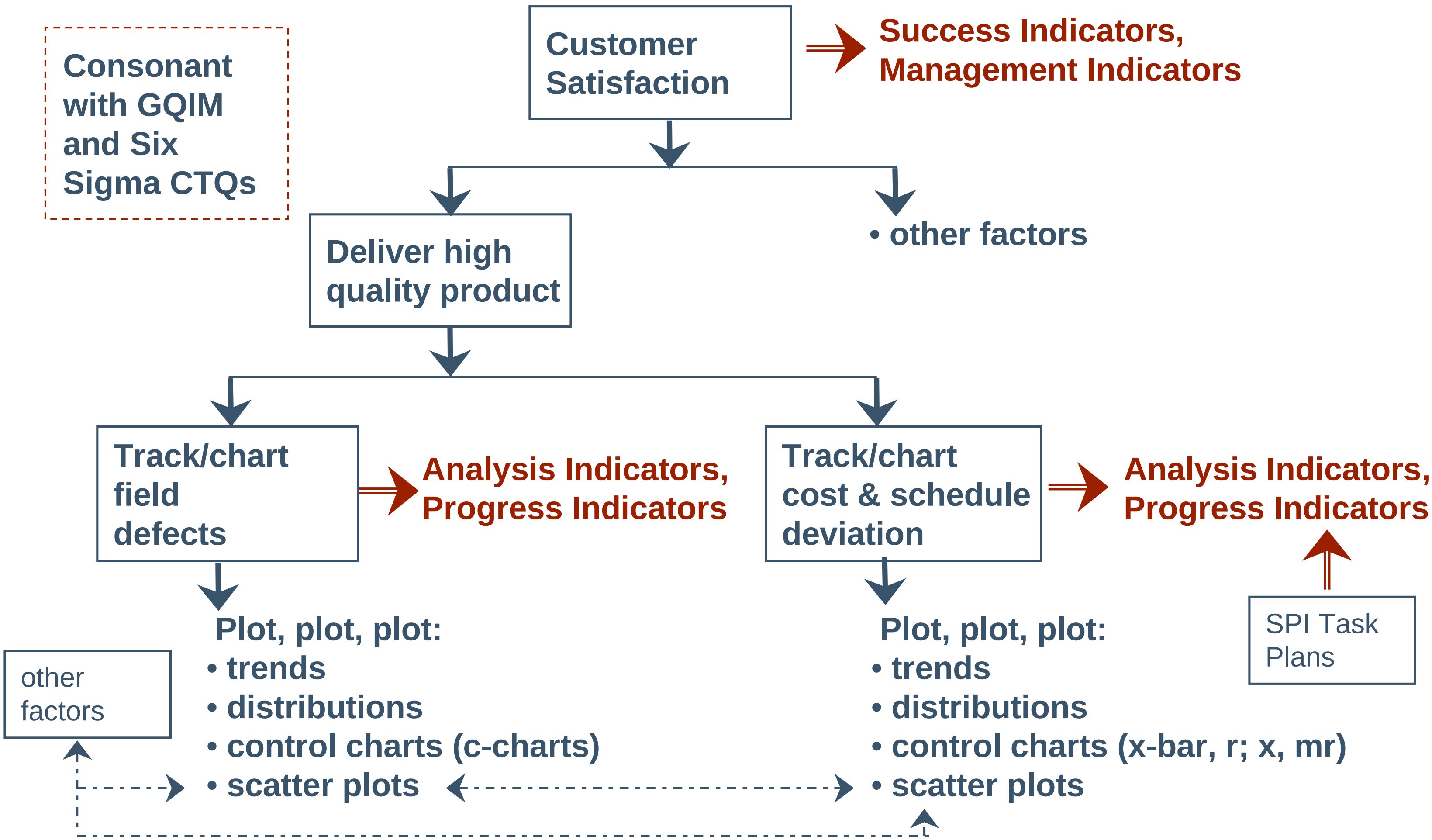
Sample artifacts on following slides include

- Baseline charts: boxplots, capability analysis
- Co-optimized pareto analysis
- SMART goals and root cause analysis
- Homogeneous sampling
- Earned Value prediction model
- Management by Fact

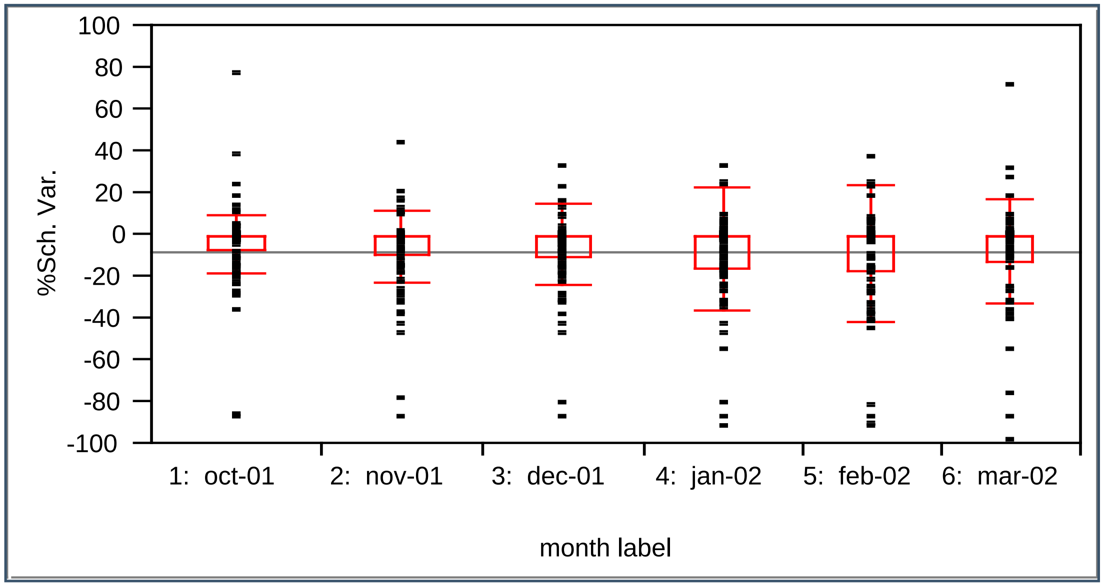
The full case storyline demonstrates the usage of an improvement process

- consistent with DMAIC, incl gates
- meeting CMMI specific practices
- leveraging measurement best practices

Case 1 Artifacts: Goal Structure



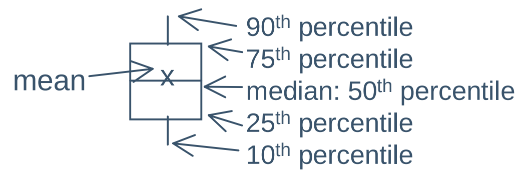
In-Process Schedule Variance Boxplot



This and following slides consonant with Six Sigma toolkit, CMMI QPM, OPP, CAR

Data reported monthly for all projects, cycle phases

Conclusion: need to address variability



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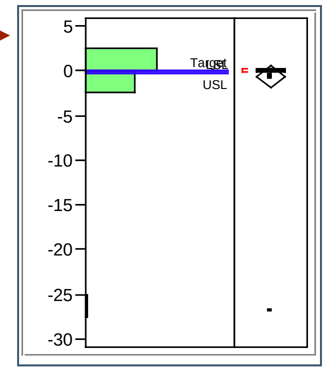
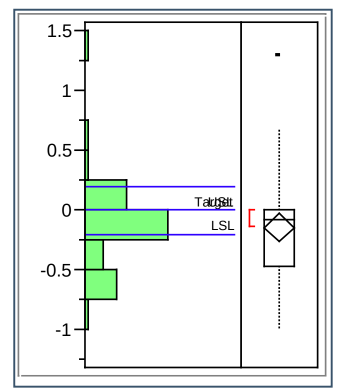
Completed Project Data Baseline

	% effort variance	% sched variance
average	-66.1%	-15.0%
standard deviation	415.9%	38.3%
median	0.9%	-8.1%
min to max	-2689.9% to 50.1%	-99.8% to 128.0%
n	42	42
capability notes (spec = +/- 20%)	45.2% outside spec	40.4% outside spec





This represents (initial plan – final actual)

- negative numbers are overruns
- schedule is in terms of calendar days

It is the <u>total cumulative variance</u>

- customer-requested/approved changes are included
- one way or another, this is what the customer sees

Cause Code Taxonomy

Transformed original brainstorm list

- initial experiential assessment of frequency, impact of each cause code
- refined “operational definitions” and regrouped brainstorm list
- tagged causes to historical data
- refined again

Final list included such things as

- Missed requirements
- Underestimated task
- Over commitment of personnel
- Skills mismatch
- Tools unavailable
- EV Method problem
- Planned work not performed
- External

Direct Cause vs. Root Cause

Causes resolved in-process vs. causes that affect final performance

Co-Optimized Pareto Analysis

Impact # (from Pareto)	Schedule	Effort	Organization Slice 1 Schedule	Organization Slice 1 Effort	Organization Slice 2 Schedule	Organization Slice 2 Effort
1	Under estimated Task	Tools	Under estimated Task	Under estimated Task	Tools	Tools
2	Tools	Assets not available	EV Problems	Under planned rework	Skills mismatch	Under estimated Task
3	EV Problems	Under planned rework	Missed requirements	Missed requirements	Under estimated Task	Missed requirements
4	Missed requirements	Planned work not performed	Under planned rework	EV Problems	Missed Requirements	Unexpected departure of personnel
5	Skills Mismatch	Under estimated task	Asset availability	Planned work not performed	Unexpected departure	EV Problems

SMART Schedule Variance Goal

Reduce the total variance by decreasing the variance of the top 3 internal causes by 50% in 1 year.

Reduce the impact of external causes by 50%.

Indicators:

- Trend for each cause independently
- Trend for total variance

STOP

Will focusing on these causes give us bottom-line results?

Schedule Variance Root Cause 1

Cause Code: Underestimated tasks
Process: Project Management
Subprocesses: Planning

- Establish requirements
- Define project process
- Perform detailed planning

Requirements Management

CMMI Friendly

As subprocesses are explored, **process mapping** may be used with (or based on) ETVX diagrams

Six Sigma Friendly

Schedule Variance Root Cause $_2$

Root causes of common cause variation

- Inexperience in estimation process
- Flawed resource allocation
- Estimator inexperience in product (system)
- Requirements not understood

Root causes of special cause variation

- Too much multitasking
- Budget issues

Improving Sampling Homogeneity

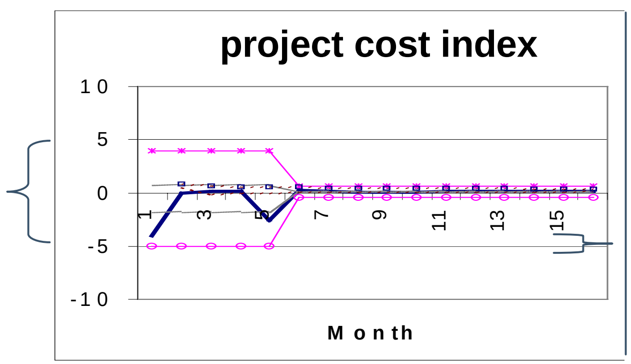
Overall rollup:

- group data by project milestones

Within project:

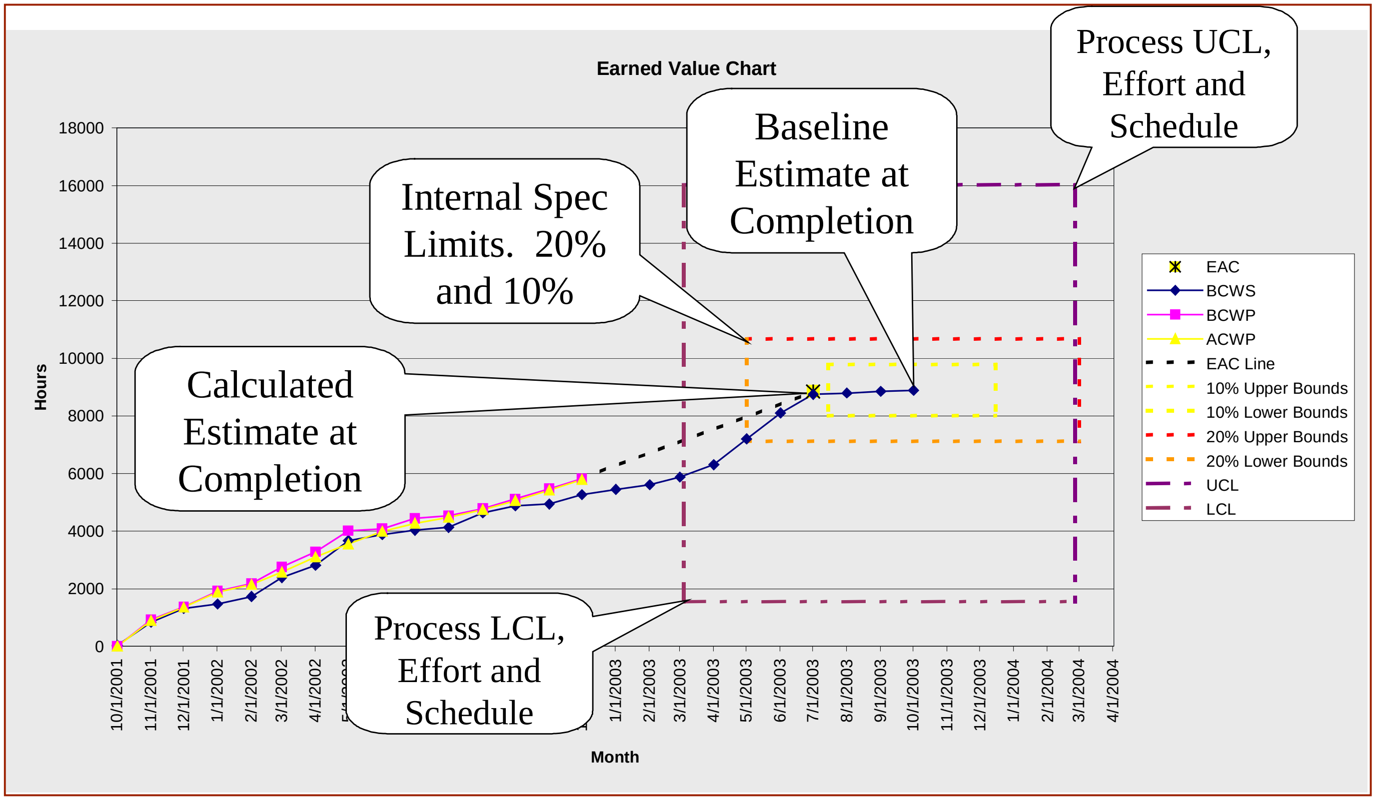
- identify control limits for each development phase
- compare each project's phase against the history of similar projects in that same phase
- robust sample for limit calculations is critical

wider limits for projects in planning phase



narrower limits for projects in execution phase

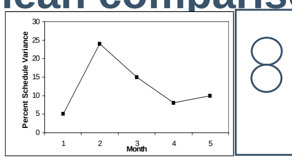
EV Estimate-At-Completion Model



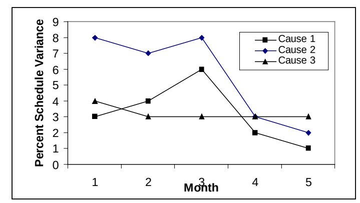
Management by Fact (see handout)

Reduce the total schedule variance by decreasing the variance of the top 3 internal causes by 50% in 1 year.

Total variance w/ mean comparison



Variance for top 3 causes:
- **Underestimated Tasks**
- **EV Method Problem**
- **Missed Requirements**



Prioritization & Root Cause

- Inexperience
- Resource Allocation
- Requirements not understood
- ….

Counter Measures

First: Gather realtime data and verify "data archaeology"
Then:
•….
•…

Impact, Capability

In total, these countermeasures will remove 15% of typical variance.
(as possible, list impact of each countermeasure)

Case Study 1: The Connections

CMMI

- Process Areas* used: MA, OPP, QPM, OID, CAR
- Process Areas touched: PP, PMC, RD, REQM
- Terms addressed: Baseline, process performance model

Measurement Best Practices

- Indicator template key component of measurement plan

Six Sigma

- Problem-solving approach influenced design and definition of measurement & analysis processes
- Used MBF as an organizational innovation
- Indicator templates added as a domain-specific tool to the Six Sigma toolkit

*See Addenda for list of CMMI Process Areas

Case Study: Skills-Building

In class practice: statistical skills-building

- Boxplots
- Tukey Kramer
- Adapted FMEA

In class discussions and other exercises

- Risks of using historical data
- Small sample sizes and homogeneous sampling
- Corrective action guidance (as part of indicator template, esp. for SPC charts)
- Evaluate and rewrite goals for SMARTness

Key Points

Effective training is a critical part of your process improvement approach.

Training can and should be "integrated" (as appropriate).

Measurement & Analysis is an effective platform for integration.

- It is a common root!

Integrated approaches to training are win-win propositions.

- If you are a Six Sigma adopter, you get exposure to domain specific technologies that will help solve your problems.
- If you are a CMMI adopter, you learn to better leverage the most current body of knowledge for problem-solving.
- If you are adopting both, you spend less time making the connections and more time making progress!

Contact Information

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Addenda

CMMI Process Areas and Structure

CMMI Process Areas

Category	Process Areas
Process Management	Organizational Process Focus Organizational Process Definition Organizational Training Organizational Process Performance Organizational Innovation and Deployment
Project Management	Project Planning (PP) Project Monitoring and Control (PMC) Supplier Agreement Management (SAM) Integrated Project Management Risk Management Quantitative Project Management (QPM)
Engineering	Requirements Management Requirements Development Technical Solution Product Integration Verification Validation
Support	Configuration Management Process and Product Quality Assurance Measurement and Analysis (MA) Causal Analysis and Resolution Decision Analysis and Resolution

CMMI Structure

Appendixes

Maturity Level 5
OID, CAR

Maturity Level 4
OPP, QPM

Maturity Level 3
REQD, TS, PI, VER, VAL, OPF, OPD, OT, IPM, RSKM, DAR

Maturity Level 2
REQM, PP, PMC, SAM, MA, PPQA, CM

Front Matter
- Introduction
- Structure of the Model
- Model Terminology
- Maturity Levels, Common Features, and Generic Practices
- Understanding the Model
- Using the Model

CMMI-SE/SE
Staged

Appendixes

Support
CM, PPQA, MA, CAR, DAR

Engineering
REQM, REQD, TS, PI, VER, VAL

Project Management
PP, PMC, SAM IPM, RSKM, QPM

Process Management
OPF, OPD, OT, OPP, OID

Front Matter
- Introduction
- Structure of the Model
- Model Terminology
- Capability Levels and Generic Model Components
- Understanding the Model
- Using the Model

CMMI-SE/SW
Continuous

CMMI-SE/SW/IPPD/A - Continuous

CMMI

Process Management

- Organizational Process Focus
- Organizational Process Definition
- Organizational Training
- Organizational Process Performance
- Organizational Innovation and Deployment

Project Management

- Project Planning
- Project Monitoring and Control
- Supplier Agreement Mgmt.
- Integrated Project Mgmt.
- Risk Management
- Quantitative Project Mgmt.

Engineering

- Requirements Management
- Requirements Development
- Technical Solution
- Product Integration
- Verification
- Validation

Support

- Configuration Mgmt.
- Process and Product Quality Assurance
- Measurement & Analysis
- Decision Analysis and Resolution
- Causal Analysis and Resolution

IPPD

- Organizational Environment for Integration
- Integrated Team

Acquisition

- Supplier Selection and Monitoring
- Integrated Supplier Management
- Quantitative Supplier Management