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Software Design-for-Six Sigma (SDFSS) and SEI Technologies meet!

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- CMM®
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- CMMI®
- SEI's Architecture Tradeoff Analysis Method®
- ATAM®

![Carnegie Mellon Software Engineering Institute]

Product Experience

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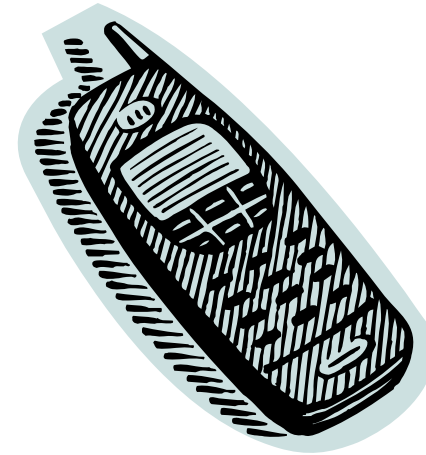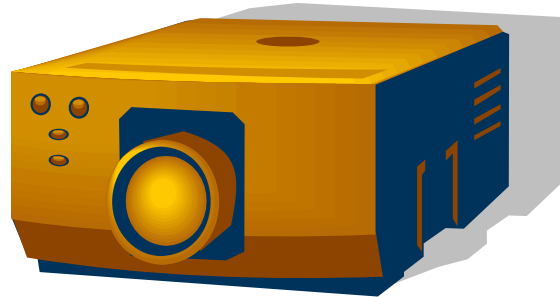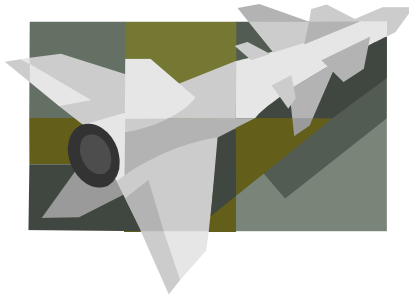
SDFSS Opportunities

Impacts without SDFSS

- Multi-year development projects failed to deliver a working product (min cost=$7M)

- Failure 1: Did not model performance of new chipset, processor or language

- Failure 2: Did not adequately characterize the market and business case

- Failure 3: Did not adequately test the product

Benefits with SDFSS

- Business cases modeling all reasonable uncertainties in market and customer segments

- Schedules with uncertainties modeled

- Req'ts identified, with KJ analysis, to delight customers

- Design of Experiments used to: optimize and patent fuel efficiency; test object-oriented software; test robustness with fault insertion testing; reduce flight test by 10x

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Purpose of this Talk

• To proclaim that software DFSS, within a holistic DFSS approach to product development, is coming of age,

• To demonstrate that many gaps, in translating traditional DFSS concepts to software engineering, may be solved by the adoption of a number of Software Engineering Institute (SEI) technologies.

Thus, DFSS does not have to be re-invented for Software Engineering!

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Target Audience

• Executives and Directors contemplating investing in Software DFSS

• Deployment champions who may be tasked with the training and roll-out of Software DFSS

• DFSS and Software Engineering Leaders who need to understand both disciplines, and who can lead in translating and interpreting key concepts and tools between the two disciplines.

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A Philosophy

From the inception of Six Sigma, the overriding objective has been "the degree of confidence a customer has that his (or her) product and service-related expectations will be met by the producer."[1]

Today, it is "a business process that allows companies to drastically improve their bottom line by designing and monitoring everyday business activities in ways that minimize waste and resources while increasing customer satisfaction."[2]

[1] Michael J. Harry & J. Ronald Lawson, *"Six Sigma Producibility Analysis and Process Characterizatio*n," Addison-Wesley Publishing Company, Inc., 1992.

[2] *Michael J. Harry, & Richard Schroeder, "Six Sigma: The Breakthrough Management Strategy Revolutionizing the World's Top Corporations", 2000.*

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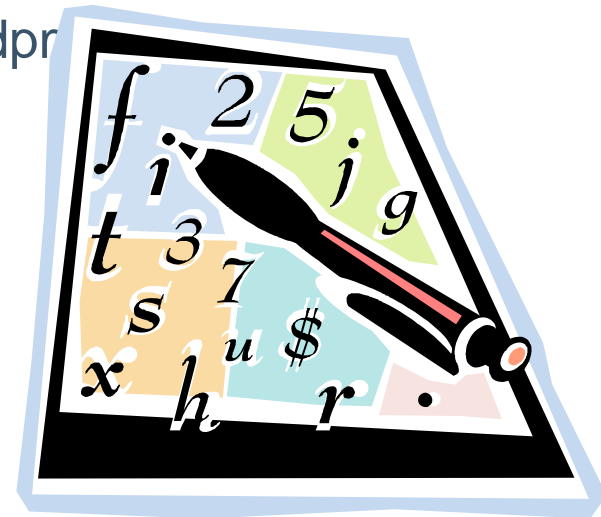**Software Engineering Institute**

Example Six Sigma Measures

The most-cited measure is "3.4 ppm."
Other measures
- defect rate, parts per million (ppm)
- Sigma level
- defects per unit (dpu)
- defects per million opportunities (dpr
- yield

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Alternative Six Sigma Approaches

DMAIC	Define-Measure-Analyze-Improve-Control	To solve problems and drive incremental business improvements (e.g. fine-tuning an existing process or product)
DMAD(O)V	Define-Measure-Analyze-Design-(Optimize)-Verify	To solve problems and drive radical improvement (e.g. blowing up and re-engineering an existing process or product)
Lean	5S's; Value Stream Mapping; Cycle Time Analysis	To lean a process by simplification, reducing non-value added tasks, optimizing cycle times
DFSS	Design-For-Six-Sigma	Applying the Six Sigma toolkit and intent to product development beginning with portfolio, marketing, engineering, research, sales, and supply chain

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Holistic View of Software DFSS

Portfolio for Six Sigma

Marketing for Six Sigma

Product Commercialization for Six Sigma

Technology Platform R&D for Six Sigma

Sales & Distribution for Six Sigma

Supply Chain for Six Sigma

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Holistic View of Software DFSS

Portfolio for Six Sigma

Using Statistical Methods:

1. Identify Opportunities, Markets and Market Segments,

2. Gather Long Range Voice of the Customer,

3. Obtain Technology Roadmap and Technology Characterizations from the R&D / Platform Group,

4. Define Product Portfolio Requirements,

5. Generate Product Portfolio Architectures,

6. Support Portfolio decisions with Real-Options analysis

7. Evaluate and Select a Product Portfolio, and

8. Develop a Prioritized List of Products within a Product Line Strategy.

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Holistic View of Software DFSS

Portfolio for Six Sigma

Marketing for Six Sigma

Using Statistical Methods:

* Adapted from Clyde Creveling, *Marketing for Six Sigma* and *Product Development with Six Sigma*

1. Understand Customer Value and create a Customer Value Dashboard,

2. Develop the Value Stream analysis,

3. Conducting Marketing FMEA risk analysis and Business SWOT,

4. Creating Marketing Process measures and data collection methods,

5. KJ and Kano Analysis,

6. Marketing Composite Design and Product Line Strategies

7. Market Forecasting, Price Model Planning, Channel Analysis,

8. Portfolio Management, Branding Decision-making and Promotion Analysis

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Holistic View of Software DFSS

Portfolio for Six Sigma

Marketing for Six Sigma

Product Commercialization for Six Sigma

Using Statistical Methods:

* Adapted from Clyde Creveling, Marketing for Six Sigma and Product Development with Six Sigma

1. Participate in KJ and QFD Voice of the Customer Activities,

2. Develop functional models, architecture and behavioral models,

3. Generate product solution concepts and identify critical parameters for CTQs,

4. Develop mathematical and statistical models of CTQs,

5. Select solution, implement robust design and track Critical Parameters,

6. Create optimized designs using designed experiments,

7. Establish critical parameter tolerances, and verify CTQ achievement.

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Holistic View of Software DFSS

Portfolio for Six Sigma

Marketing for Six Sigma

Product Commercialization for Six Sigma

Technology Platform R&D for Six Sigma

Using Statistical Methods:

1. Characterize existing technologies, capabilities, gaps, risks, expected life

2. Identify and evaluate anticipated technology breakthroughs including probabilistic assessment of timing and capability

3. Optimize the portfolio of technologies to be pursued in context of the business strategy and latest product portfolio

4. Develop robust platforms that are optimized for the Customer Req'ts and CTQs of product lines

5. Develop performance models of platform technology and it's capabilities

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SEI Technologies Boost DFSS!

Portfolio for Six Sigma

Marketing for Six Sigma

Product Commercializati

Technology Platform R&D for Six S
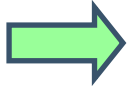
The **SEI Capability Maturity Model Integrated (CMMI)** has a product development perspective that overlaps significantly with all of the DFSS methodologies!

Sales & Distribution for Six Sigma

Supply Chain for Six Sigma

CMMI & Six Sigma (DFSS) Connections

- Many connections exist, specifically with the following basic process areas:
  - RD, REQM, TS
  - VER, VAL
  - DAR, RSKM, MA

- Connections are further highlighted on the following slides with CMMI High Maturity Process Areas:
  - QPM, OPP
  - CAR, OID

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CMMI OPP and Six Sigma

SP1.1 Processes → Big Y Business Goal-to-Vital x Process; Processes driving central tendency and variation

SP1.2 Measures → Critical Parameter Management; CTQ factors; Root Cause Analysis of subprocess factors

SP1.3 Objectives → KJ Analysis®; Analytic Hierarchy Process; Categorical Survey Data Analysis; Six Sigma Scorecards

SP1.4 Baselines → Control Charts; Graphical Summaries in Minitab; Central Tendency and Variation; Confidence and Prediction Intervals

SP1.5 Models → ANOVA; Regression; Chi-Square; Logistic Regression; Monte Carlo Simulation; Discrete Event Process Simulation; Design of Experiments; Response Surface Methodology; Multiple Y Optimization; Probabilistic Models

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CMMI QPM and Six Sigma

SG1
Quantitatively
Manage the
Project

→ KJ Analysis®; Analytic Hierarchy Process;
Categorical Survey Data Analysis; Six Sigma
Scorecards;   Big Y Business Goal-to-Vital x
Process; Process Mapping Methods and Value-
Stream Analysis;
Processes driving central tendency and variation;
Critical Parameter Management; CTQ factors; Root
Cause Analysis of Sub-process factors; Cockpit
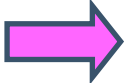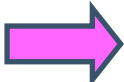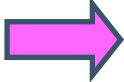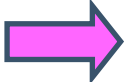
SG2
Statistically
Manage
Subprocess
Performance

→ Control Charts; Graphical Summaries in Minitab;
Central Tendency and Variation; Confidence and
Prediction Intervals; ANOVA; Regression; Chi-
Square; Logistic Regression; Monte Carlo
Simulation; Discrete Event Process Simulation;
Design of Experiments; Response Surface
Methodology; Multiple Y Optimization; Probabilistic
Models

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CMMI CAR and Six Sigma

SP1.1 Select Defect Data for Analysis ⟶ Measure Phase tools and methods within DMAIC or DMAD(O)V; Models provide insight to the areas of defect data to concentrate on

SP1.2 Analyze Causes ⟶ Root Cause Methods, e.g. Ishikawa Diagrams, statistical hypothesis tests to determine if segments are different

SP2.1 Implement the Action Proposals ⟶ Piloting; Comparative Studies; Technological and Cultural Change Management techniques
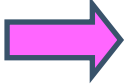
SP2.2 Evaluate the Effect of Changes ⟶ Before and After studies and Hypothesis tests; Survey categorical data analysis; compare to results of prediction models

SP2.3 Record Data ⟶ Study results; Lessons Learned shared across the organization; Institutional learning

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CMMI OID and Six Sigma

SG1 Select
Improvements

→ Six Sigma Big Y to Vital x semi-annual workshops; Business Goal simulation and optimization models; Benchmarking; Capability data sharing; Theory of Inventing (TRIZ) methods; Usage of performance models to identify the major opportunities for improvement with innovation; Assumption Busters; Empowered innovative thinking; Incentives for Innovation; Strong Teaming for Innovation; Various decision models such as AHP, Pugh Method, Probabilistic decision trees

SG2 Deploy
Improvements

→ Process and Design FMEA; Organizational Readiness for Change; Change Agents; Sponsors; Champions; Influence Leaders; Adoption Curve; Piloting; Risk-based deployment; Before and After comparisons with Hypothesis tests; Results compared to prediction models; Proactive mitigation of risks
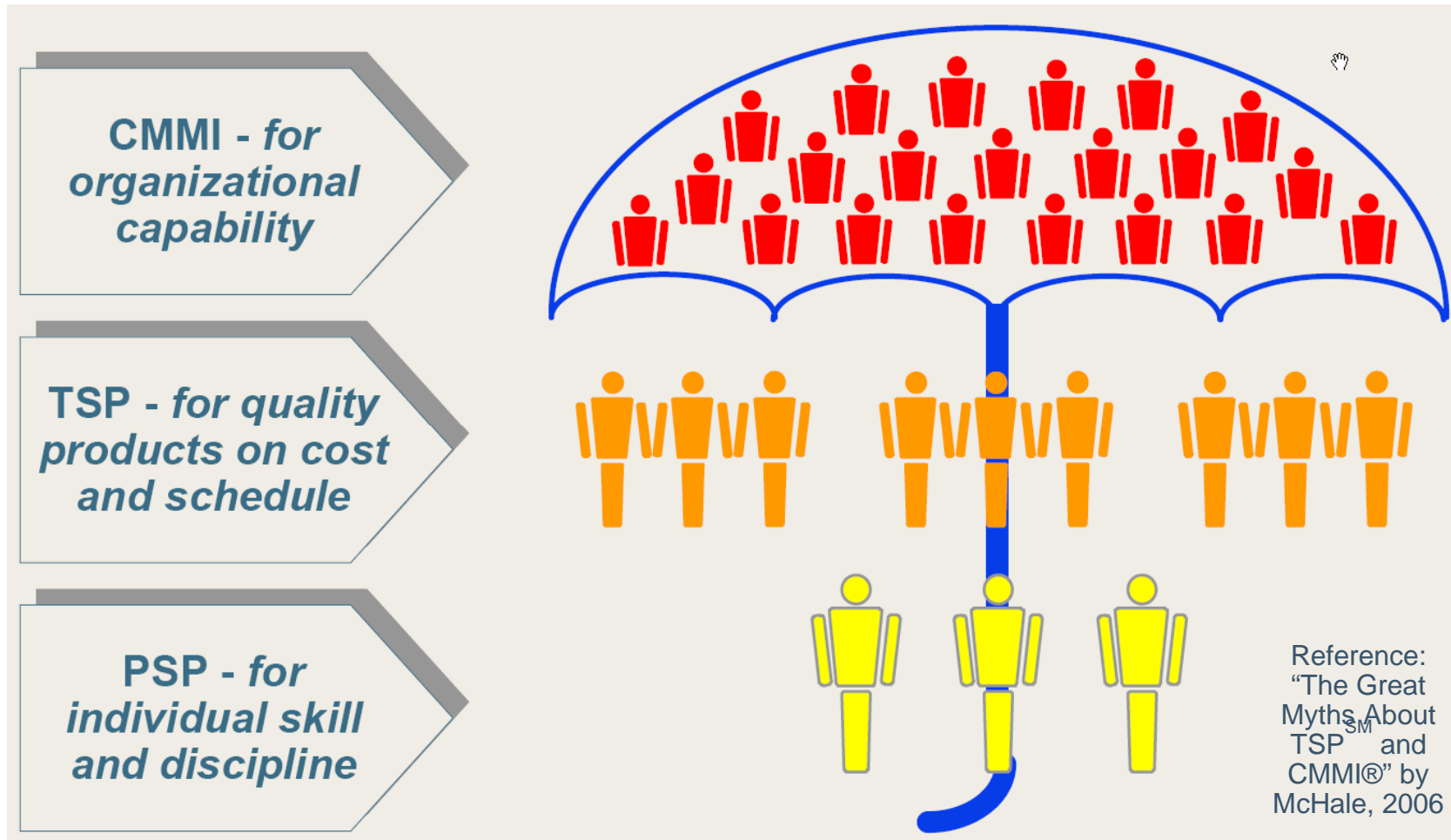
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The CMMI, TSP and PSP

CMMI - *for organizational capability*

TSP - *for quality products on cost and schedule*

PSP - *for individual skill and discipline*

Reference: "The Great Myths About TSP[SM] and CMMI®" by McHale, 2006

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SEI Technologies Boost DFSS!

Portfolio for Six Sigma

Marketing for Six Sigma

Product Commercialization for Six Sigma

Technology Platform R&D for Six Sigma

The **SEI Team Software Process (TSP) and Personal Software Process (PSP)** significantly enhance the software development teaming within Product Commercialization and Technology Platform R&D for Six Sigma!

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The Personal Software Process

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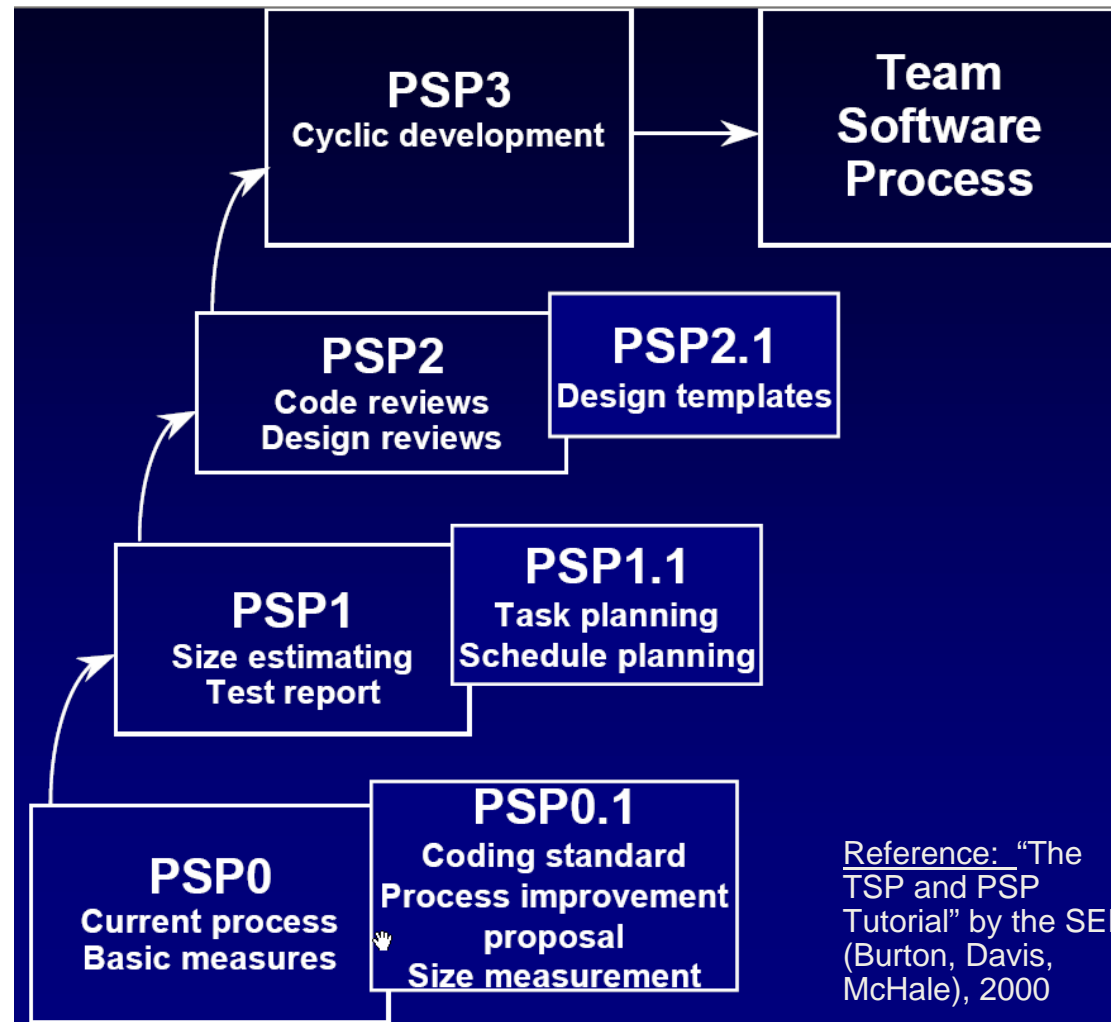
TSP Builds Software Teams

Skill-building

Personal plans
Practice in planning
Planning methods
Quality measures
Defined processes

Engineering Disciplines

Team-building

Commitment
Aggressive plans
Quality ownership
Project goals
Plan ownership
Plan detail
Team roles
Team resources

Team Disciplines

Team-working

Quality priority
Cost of quality
Follow the process
Review status
Review quality
Communication
Change management

Management Disciplines

Integrated Product Teams

Reference: "The TSP and PSP Tutorial" by the SEI (Burton, Davis, McHale), 2000

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The TSP Launch Process

Day 1	Day 2	Day 3	Day 4
1. Establish product and business goals	4. Build top-down and next-phase plans	7. Conduct risk assessment	9. Hold management review
2. Assign roles and define team goals	5. Develop the quality plan	8. Prepare management briefing and launch report	New teams: TSP process review
3. Produce development strategy	6. Build bottom-up and balanced plans	Launch postmortem	Reference: "The TSP and PSP Tutorial" by the SEI (Burton, Davis, McHale), 2000

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SEI Technologies Boost DFSS!

Portfolio for Six Sigma

Marketing for S

Product Commercialization for Six Sigma

Technology Platform R&D for Six Sigma

Sales & Distribution for Six Sigma

Supply Chain for Six Sigma

> The **SEI Product Line Practice** work overlaps significantly with both Portfolio for Six Sigma, and Technology Platform R&D for Six Sigma!

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Software Product Lines

pertain to → **Market strategy/ Application domain**

is satisfied by

Products

share an → *Architecture*

used to structure

are built from → *Components*

CORE ASSETS

Product lines
- take economic advantage of commonality
- bound variability

Reference: "Software Product Lines", Paul Clements, Linda Northrop, 2003.

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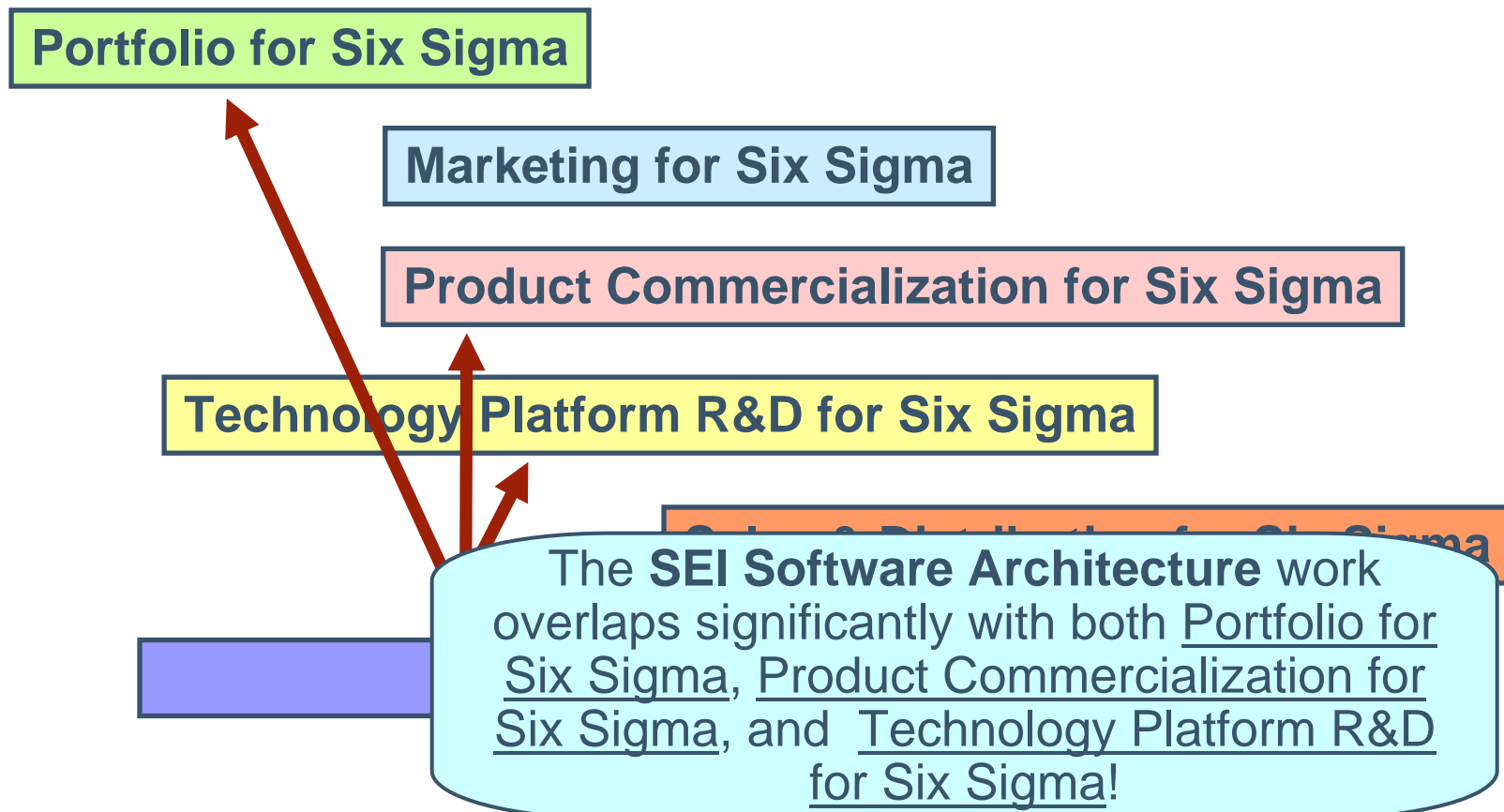**Software Engineering Institute**

Product Line Practice Framework

Core Asset Development

Product Development

Management

Reference: "Software Product Lines", Paul Clements, Linda Northrop, 2003.

Essential Activities

Software Engineering	Technical Management	Organizational Management
Architecture Definition	Configuration Management	Building a Business Case
Architecture Evaluation	Data Collection, Metrics, and Tracking	Customer Interface Management
Component Development	Make/Buy/Mine/Commission Analysis	Implementing an Acquisition Strategy
COTS Utilization	Process Definition	Funding
Mining Existing Assets	Scoping	Launching and Institutionalizing
Requirements Engineering	Technical Planning	Market Analysis
Software System Integration	Technical Risk Management	Operations
Testing	Tool Support	Organizational Planning
Understanding Relevant Domains		Organizational Risk Management
		Structuring the Organization
		Technology Forecasting
		Training

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SEI Technologies Boost DFSS!

Portfolio for Six Sigma

Marketing for Six Sigma

Product Commercialization for Six Sigma

Technology Platform R&D for Six Sigma

The **SEI Software Architecture** work overlaps significantly with both <u>Portfolio for Six Sigma</u>, <u>Product Commercialization for Six Sigma</u>, and <u>Technology Platform R&D for Six Sigma</u>!

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Software Architecture Technology (SAT) Initiative's Focus

Ensure that business and mission goals are predictably achieved by using effective software architecture practices throughout the development lifecycle.

Axioms Guiding Our Work
- Software architecture is the bridge between business and mission goals and a software-intensive system.
- **Quality attribute requirements drive software architecture design.**
- Software architecture drives software development throughout the life cycle.

Reference: **"Future Directions of the Software Architecture Technology Initiative",** Second Annual SATURN Workshop, Mark Klein, 2006

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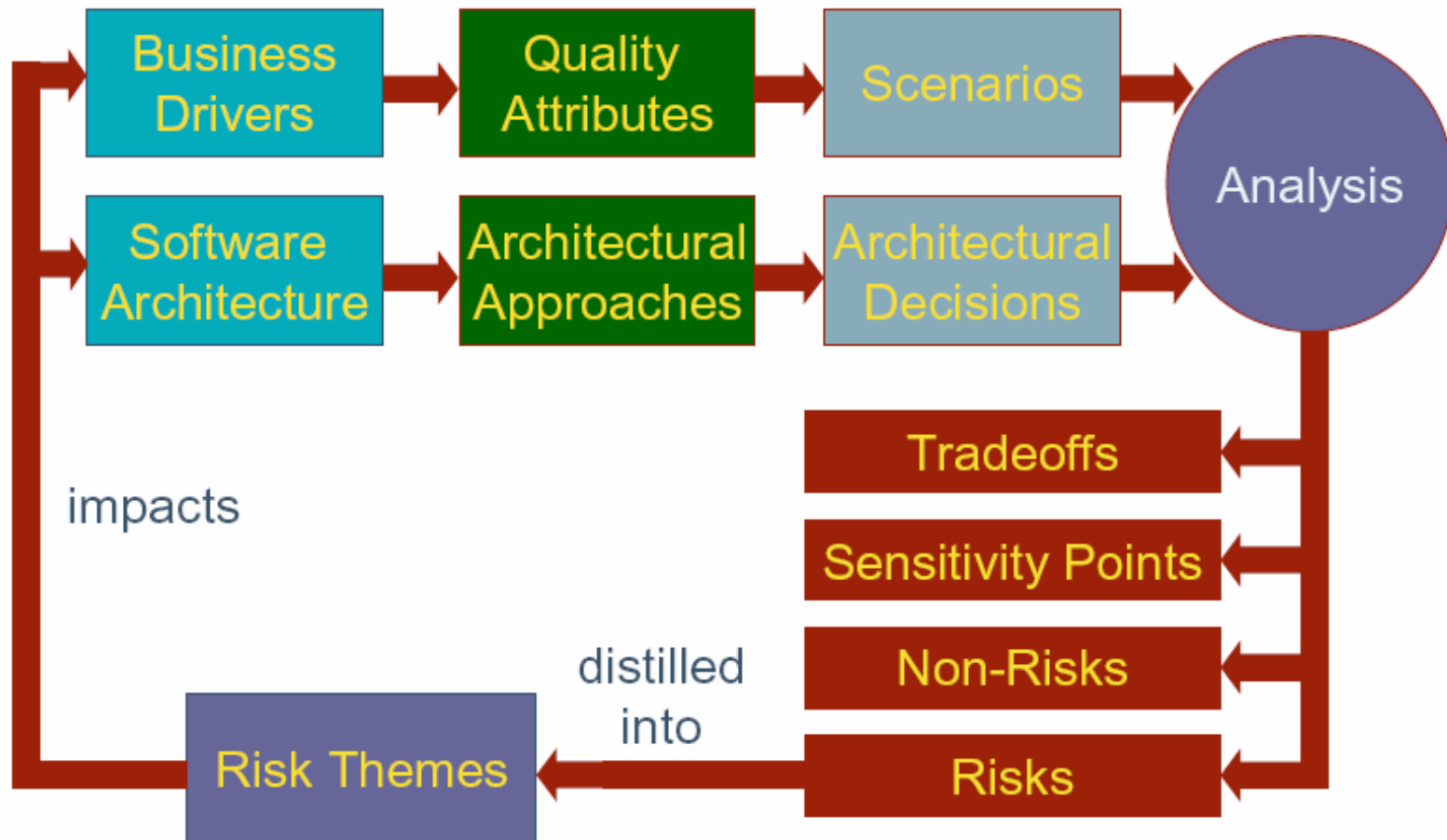# SEI's Architecture Tradeoff Analysis Method® (ATAM®)

ATAM is an architecture evaluation method that

- focuses on multiple quality attributes

- illuminates points in the architecture where quality attribute *tradeoffs* occur

- generates a context for ongoing quantitative analysis

- utilizes an architecture's vested stakeholders as authorities on the quality attribute goals

Reference: "Future Directions of the Software Architecture Technology Initiative", Second Annual SATURN Workshop, Mark Klein, 2006
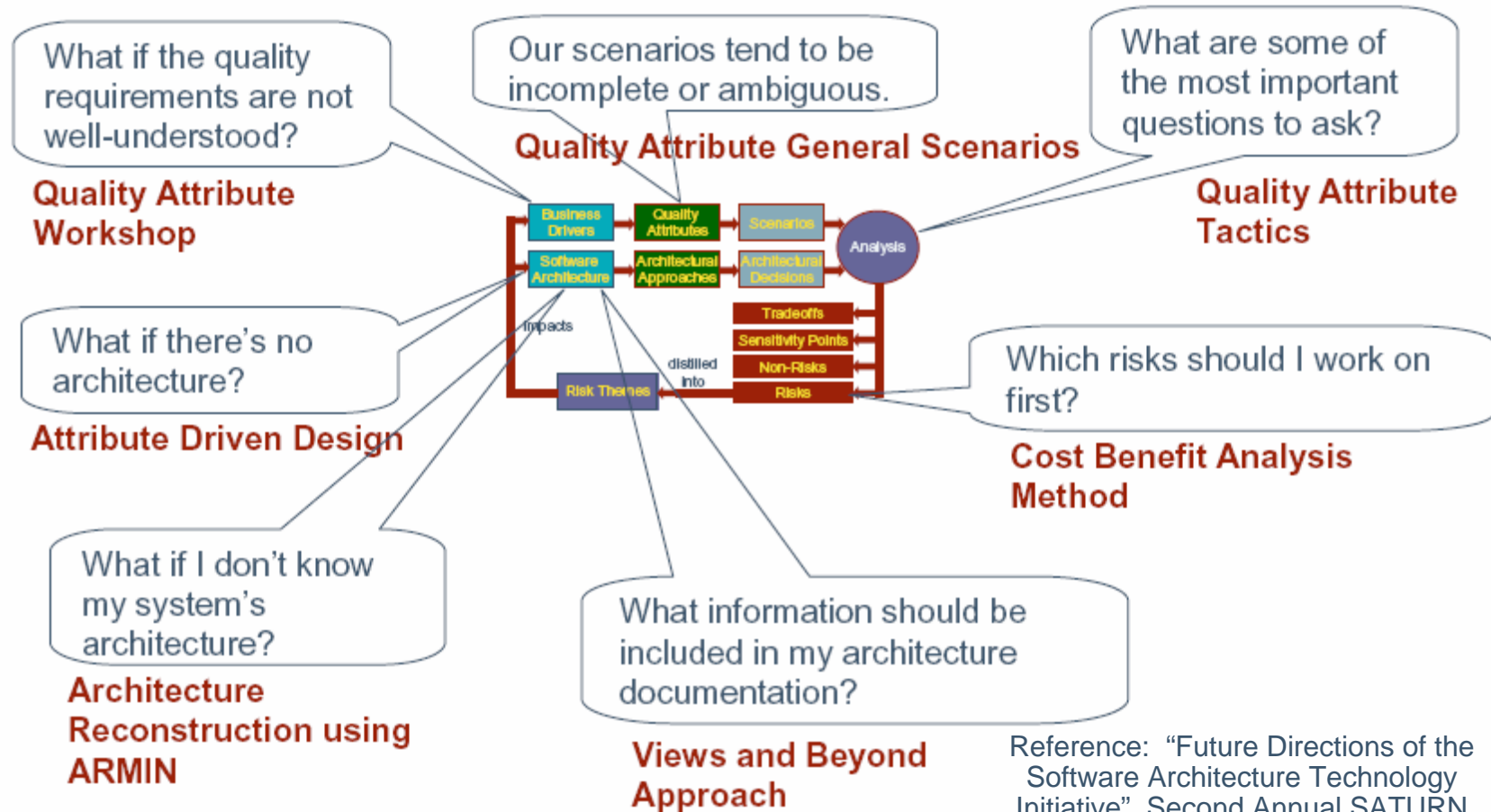
Conceptual Flow of the ATAM^{SM}

Reference: "Future Directions of the Software Architecture Technology Initiative", SATURN Workshop, Mark Klein, 2006

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ATAM Led to the Development of Other Methods and Techniques

What if the quality requirements are not well-understood?

Quality Attribute Workshop

Our scenarios tend to be incomplete or ambiguous.

Quality Attribute General Scenarios

What are some of the most important questions to ask?

Quality Attribute Tactics

What if there's no architecture?

Attribute Driven Design

Which risks should I work on first?

Cost Benefit Analysis Method

What if I don't know my system's architecture?

Architecture Reconstruction using ARMIN

What information should be included in my architecture documentation?

Views and Beyond Approach

Reference: "Future Directions of the Software Architecture Technology Initiative", Second Annual SATURN Workshop, Mark Klein, 2006

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In Summary

Software DFSS, within a holistic DFSS approach to product development, is coming of age,

Many gaps, in translating traditional DFSS concepts to software engineering, may be solved by the adoption of a number of Software Engineering Institute (SEI) technologies.

Thus, DFSS does not have to be re-invented for Software Engineering!

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Questions