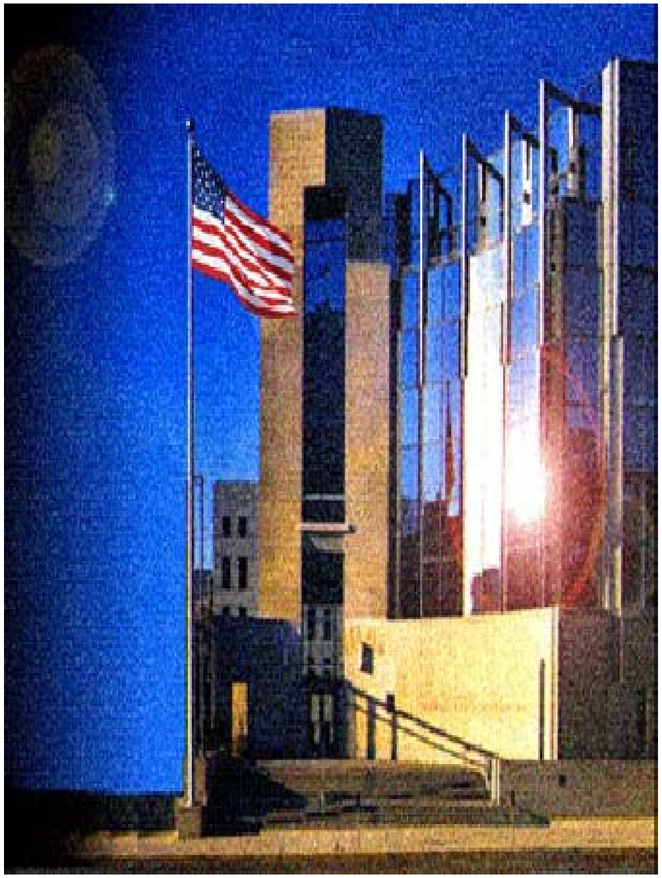
Carnegie Mellon
Software Engineering Institute
Pittsburgh, PA 15213-3890

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



By Robert W. Stoddard
Motorola Six Sigma Master Black Belt
Senior Member of Technical Staff
Software Engineering Institute

Sponsored by the U.S. Department of Defense

CMU Service Marks

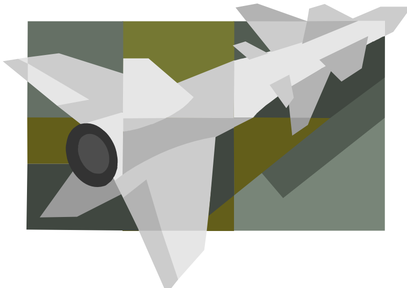
The following are service marks of Carnegie Mellon University:

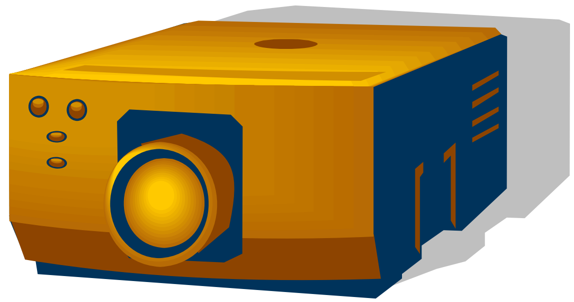
- Personal Software Process^{SM}
- PSP^{SM}
- Team Software Process^{SM}
- TSP^{SM}

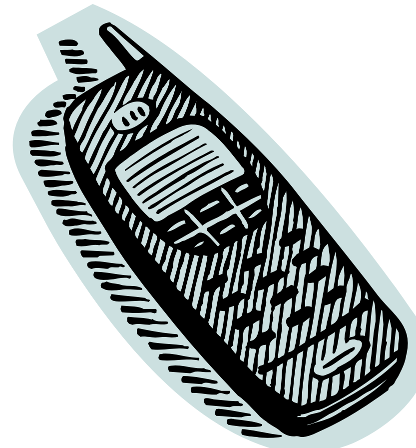
The following are registered in the U.S. Patent & Trademark Office by Carnegie Mellon University:

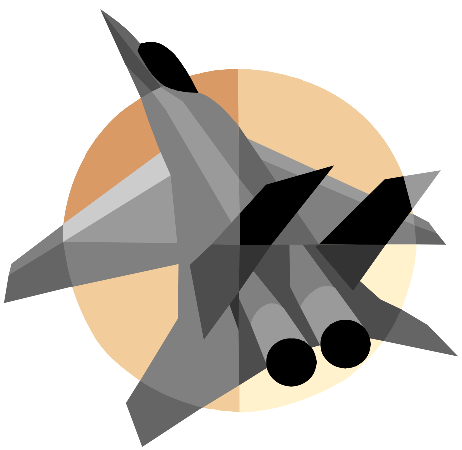
- Capability Maturity Model®
- CMM®
- Capability Maturity Model Integration®
- CMMI®
- SEI's Architecture Tradeoff Analysis Method®
- ATAM®

Product Experience









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

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!

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.

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 Characterization*," Addison-Wesley Publishing Company, Inc., 1992.

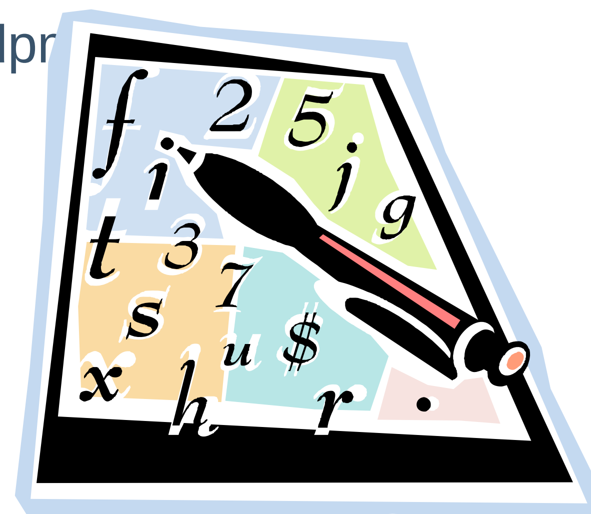
[2] *Michael J. Harry, & Richard Schroeder, "Six Sigma: The Breakthrough Management Strategy Revolutionizing the World's Top Corporations", 2000.*

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



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

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

Holistic View of Software DFSS

Portfolio for Six Sigma

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

Carnegie Mellon
Software Engineering Institute

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

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.

Carnegie Mellon
Software Engineering Institute

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

SEI Technologies Boost DFSS!

Portfolio for Six Sigma

Marketing for Six Sigma

Product Commercializati

Technology Platform R&D for Six Si

Sales & Distribution for Six Sigma

Supply Chain for Six Sigma

The **SEI Capability Maturity Model Integrated (CMMI)** has a product development perspective that overlaps significantly with all of the DFSS methodologies!

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

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

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

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

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

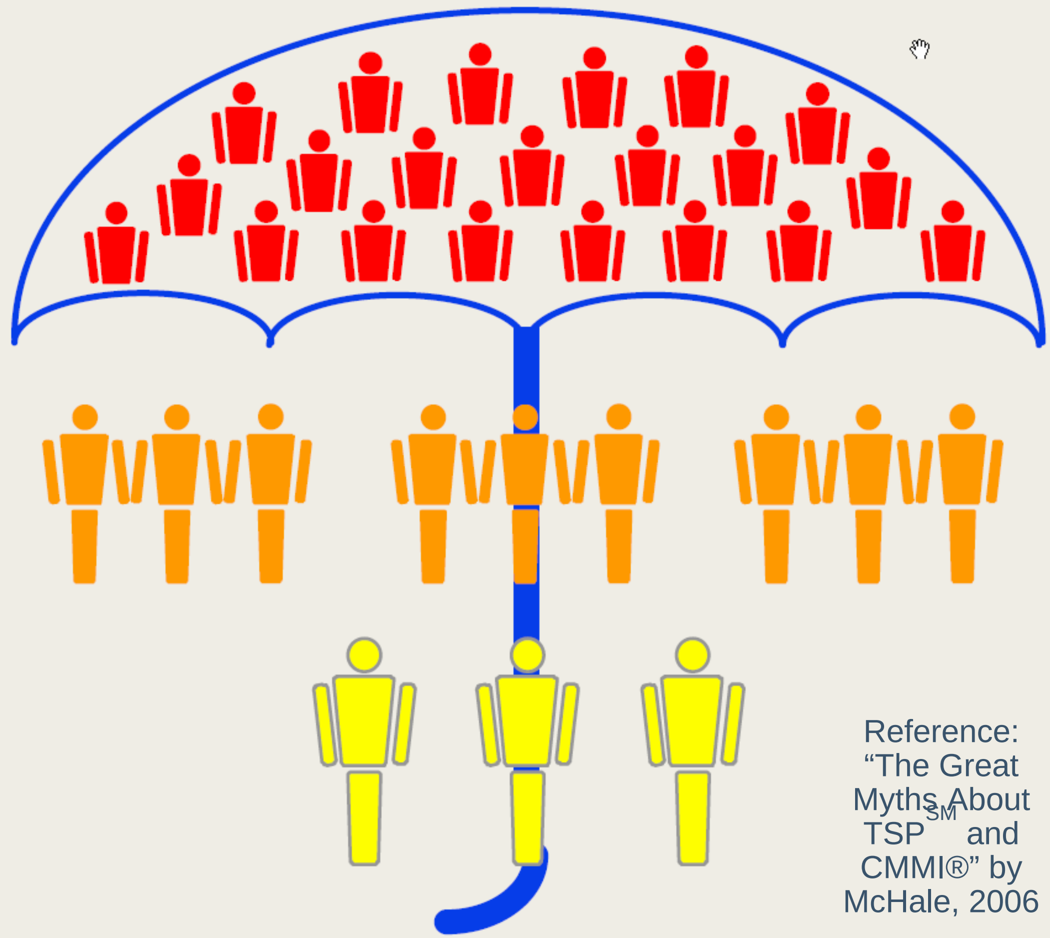
SG2 Deploy Improvements → Process and Design FMEA; Organizational Readiness for Change; Change Agents; Sponsors; Champions; Influence Leaders; Adoption Curve; Piloting; Risk-based deployment; Before and After comparisons with Hypothesis tests; Results compared to prediction models; Proactive mitigation of risks

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℠ and CMMI®” by McHale, 2006

SEI Technologies Boost DFSS!

Portfolio for Six Sigma

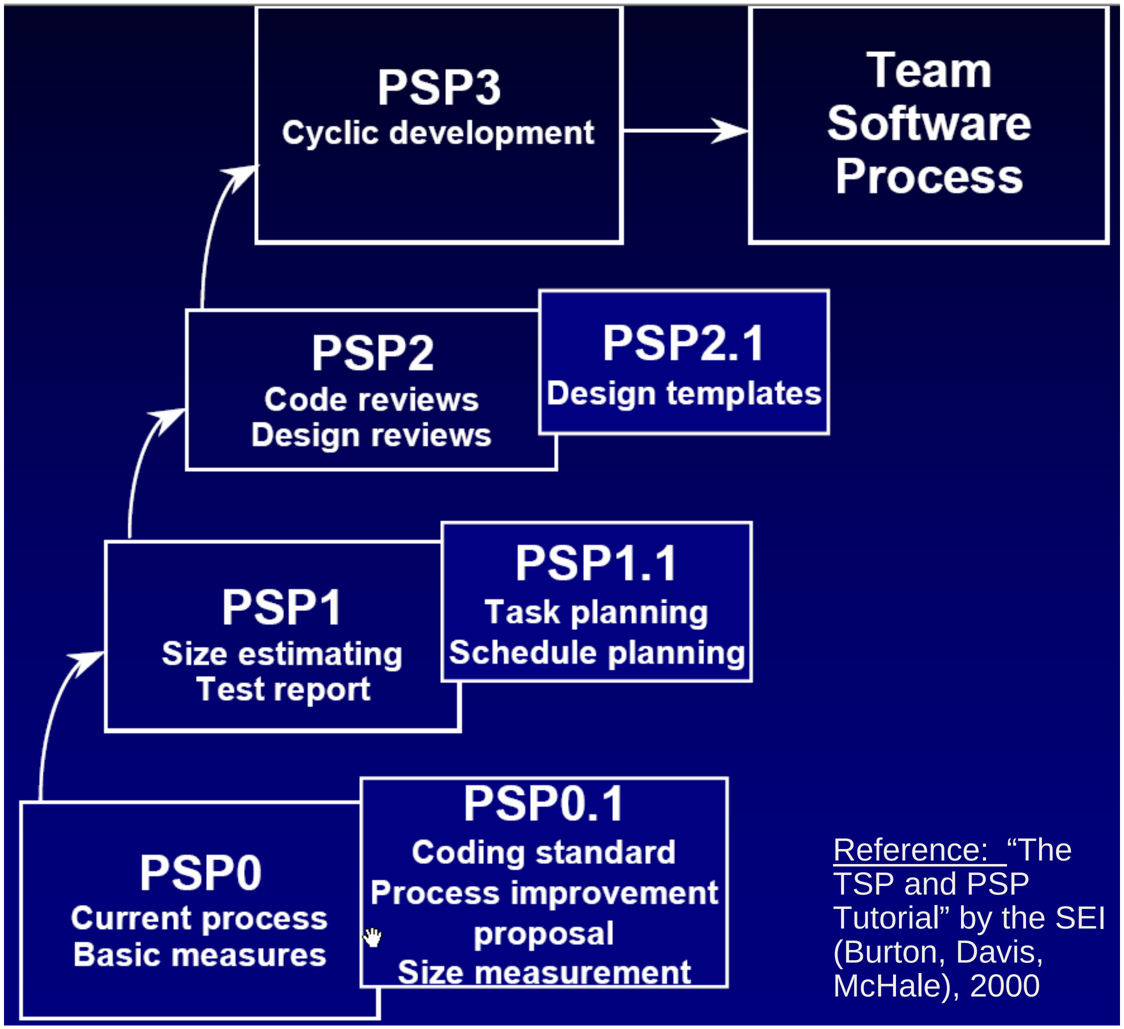
Marketing for Six Sigma

Product Commercialization for Six Sigma

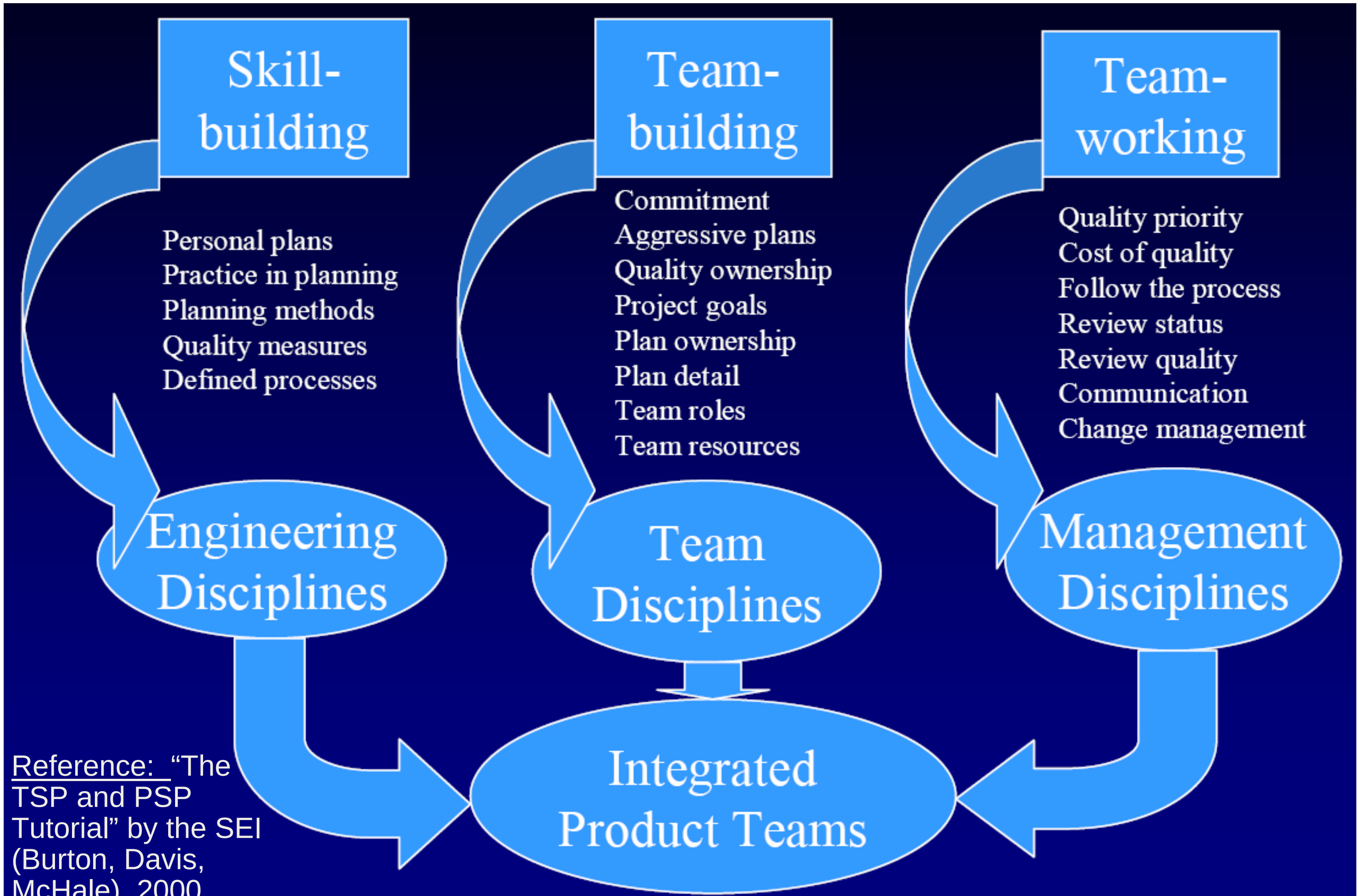
Technology Platform R&D for Six Sigma

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!

The Personal Software Process

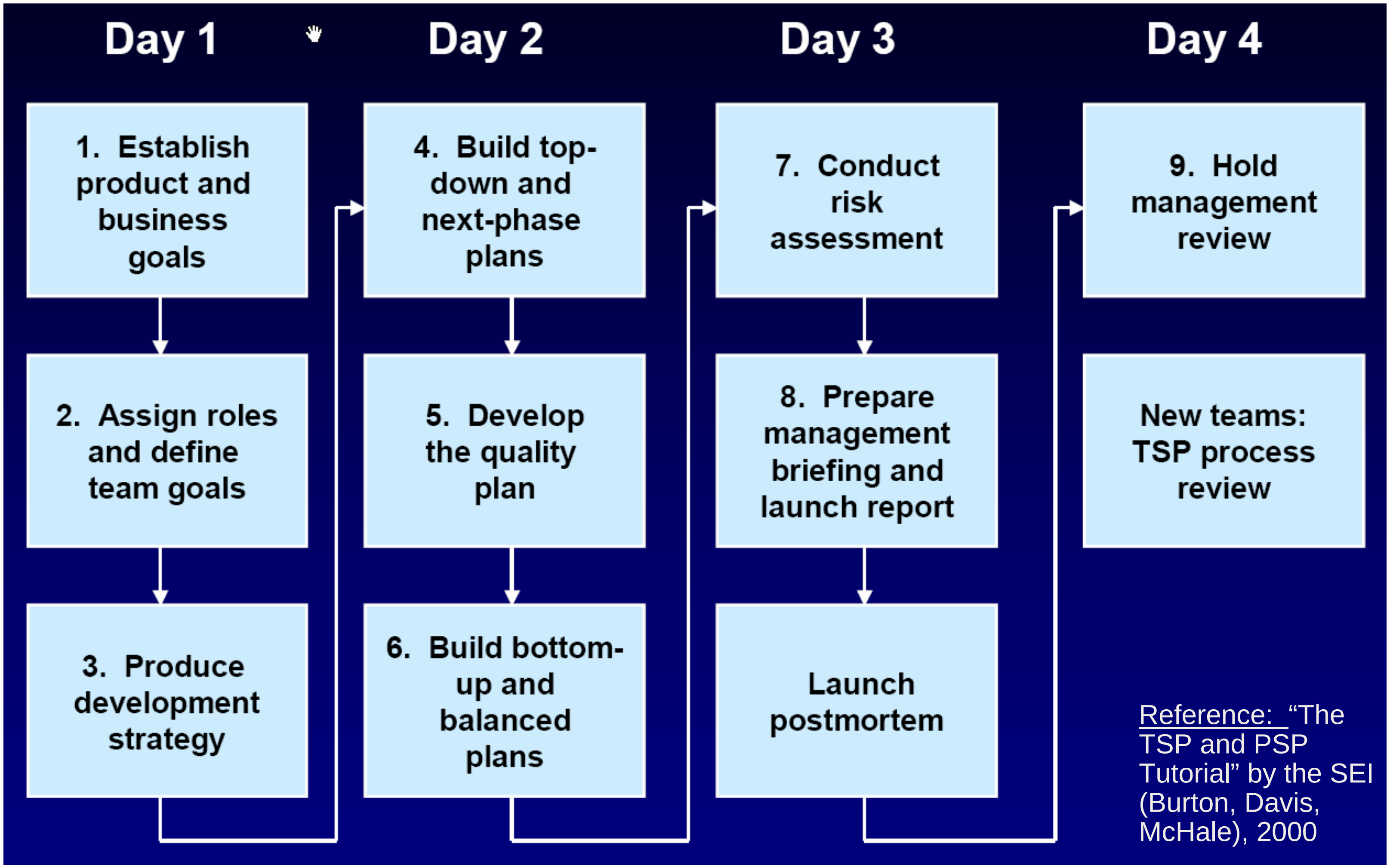


TSP Builds Software Teams



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

The TSP Launch Process



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

SEI Technologies Boost DFSS!

Portfolio for Six Sigma

Marketing for S

Product Commercialization for Six Sigma

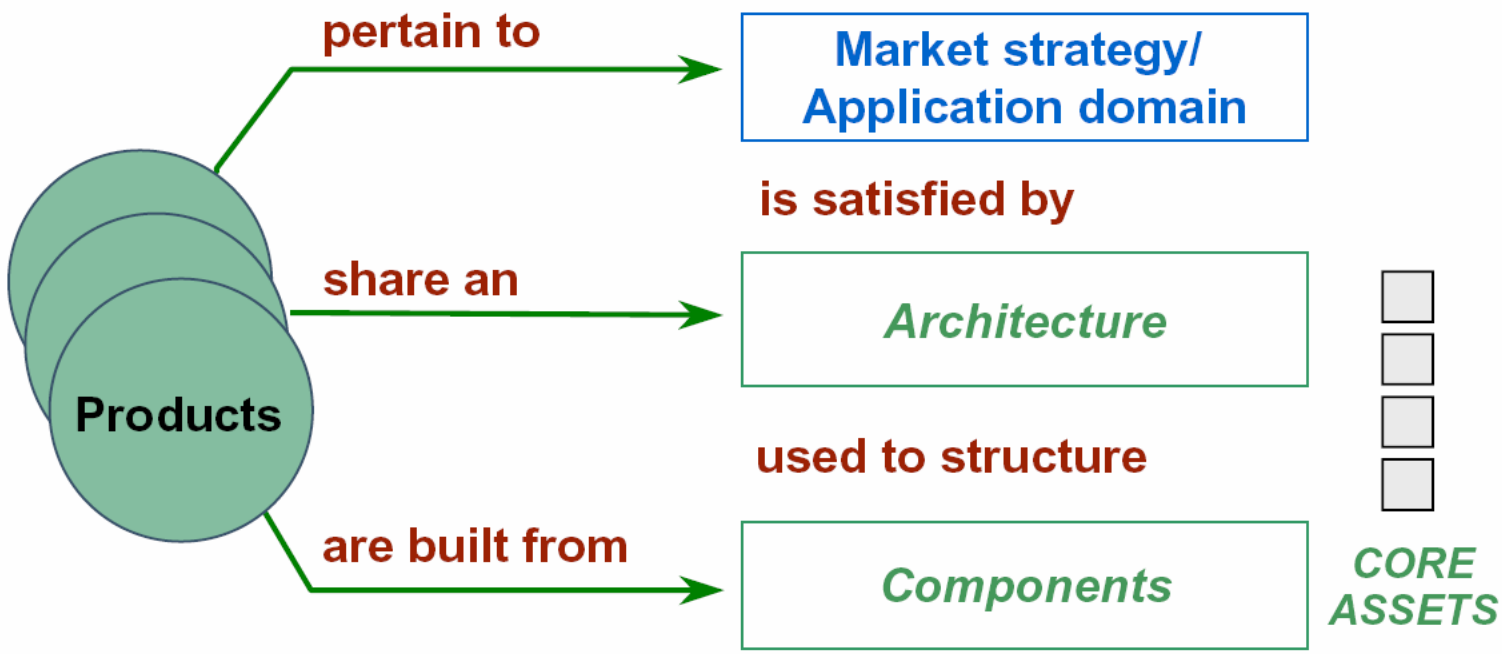
Technology Platform R&D for Six Sigma

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!

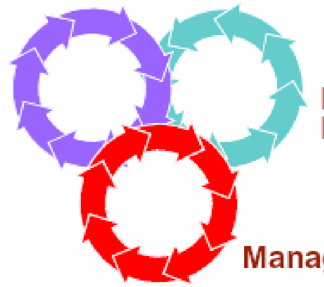
Software Product Lines



Product lines
- take economic advantage of commonality
- bound variability

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

Product Line Practice Framework

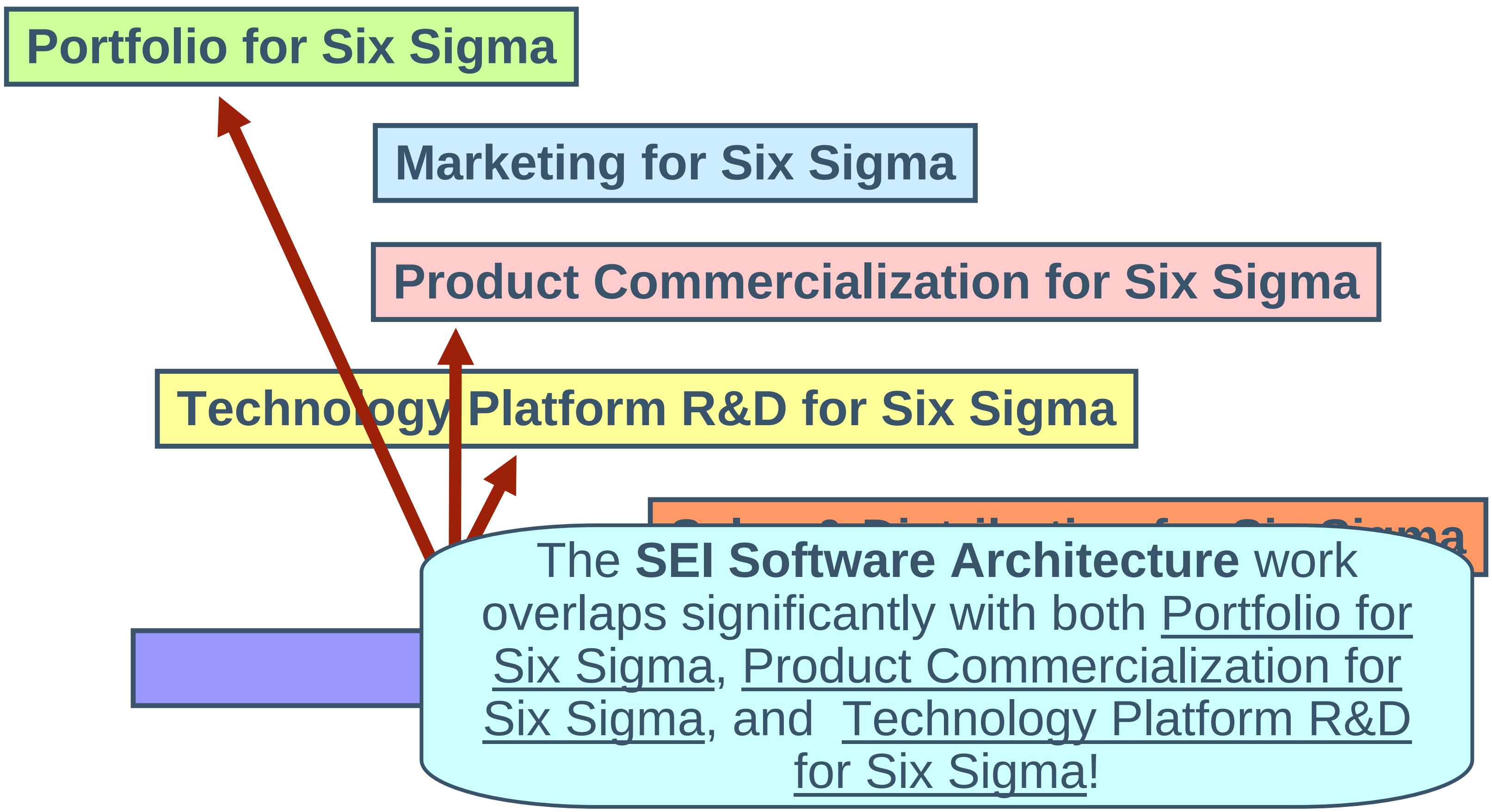


Reference: "Software Product Lines", Paul Clements, Linda Northrop, 2003.

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

SEI Technologies Boost DFSS!



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

Carnegie Mellon
Software Engineering Institute

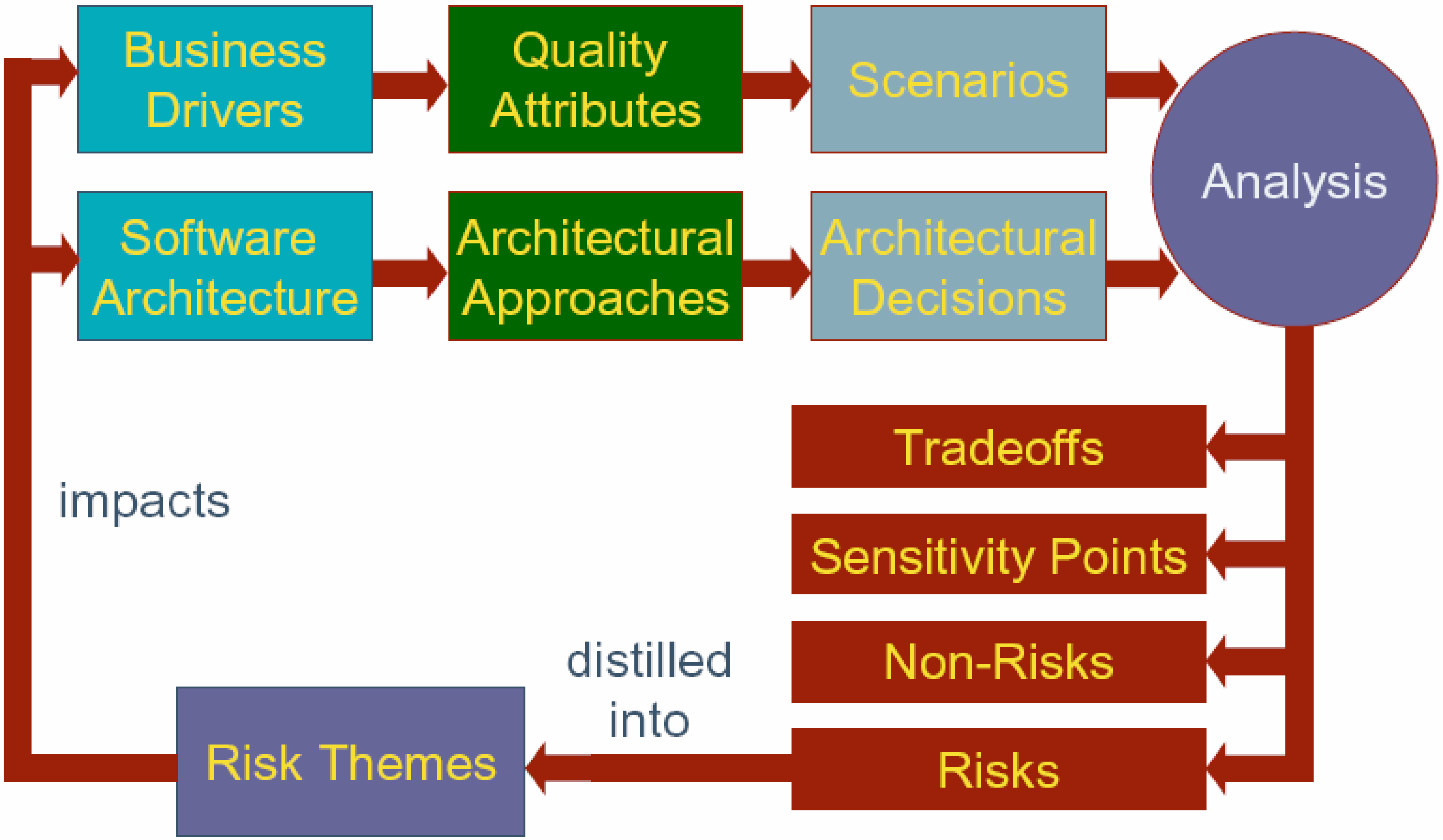
SEI's Architecture Tradeoff Analysis Method® (ATAM®)

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

ATAM Led to the Development of Other Methods and Techniques

What if the quality requirements are not well-understood?

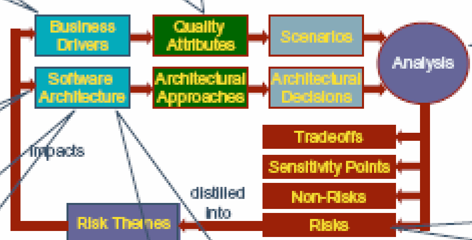
Quality Attribute Workshop

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

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!

Contact Information

Robert Stoddard
Software Engineering Institute (Office 3110)
4500 Fifth Avenue
Pittsburgh, PA 15213

412.268.1121
rws@sei.cmu.edu

Or, contact SEI Customer Relations:

Customer Relations
Software Engineering Institute
Carnegie Mellon University
Pittsburgh, PA 15213-3890
FAX: (412) 268-5800
customer-relations@sei.cmu.edu

Questions