



Statistical Process Control for Software Acquisition

QFD Symposium AutoUni Wolfsburg
October 1, 2009



Dr. Thomas Fehlmann



- 1981: Dr. Math. ETHZ
 - Mathematical Logic, Combinatory Logic
- 1982-89: Manager Software–Development Datacolor AG
 - Color Quality Management
- 1990-95: Senior Consultant – Project Office DEC CH
 - Six Sigma Black Belt for Systems Integration
- 1996-99: Sales Support Manager – Proposal Center
 - Unisys Schweiz and Italy
- 1999ff: Euro Project Office AG, Zürich
 - Project Management, Coaching & Support
 - SwiSMA: Software – Metrics, Function Points, COSMIC FFP
 - Effort & Defect Prediction for SW Project
 - Akao–Price 2001 for original contributions to QFD
 - Member of the Board of QFD Institute Germany – QFD Architect
 - Six Sigma Black Belt for GMC Software AG
 - Master Black Belt for Siemens Building Technologies

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Agenda

- Analytical Hierarchical Process
- Statistical Process Control
- Transfer Functions in Six Sigma
- Cause-Effect Matrices
- The Convergence Gap
- Fully Deployed Six Sigma Metrics Example
- Conclusions

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Agenda

- **Analytical Hierarchical Process**
- Statistical Process Control
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Pairwise Comparison – empty

Requirements	A1.	A2.	A3.	A4.	A5.	A6.	A7.	Importance of requirement (Points total)	Weighting of requirement (%)	Ranking of requirement
A1.								0.0	0%	7
A2.	1							1.0	5%	6
A3.	1	1						2.0	10%	5
A4.	1	1	1					3.0	14%	4
A5.	1	1	1	1				4.0	19%	3
A6.	1	1	1	1	1			5.0	24%	2
A7.	1	1	1	1	1	1		6.0	29%	1
Total	Relative Weights 0 – ½ – 1							21	100%	

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Pairwise Comparison – consistent

Requirements	A1.	A2.	A3.	A4.	A5.	A6.	A7.	Importance of requirement (Points total)	Weighting of requirement (%)	Ranking of requirement
A1.		0.7	0.2	0	0.5	1	0	2.4	11%	5
A2.	0.3		1	0.2	0	1	0	2.5	12%	4
A3.	0.8	0		0.1	0	1	0	1.9	9%	6
A4.	1	0.8	0.9		1	0.5	0	4.2	20%	3
A5.	0.5	1	1	0		1	1	4.5	21%	2
A6.	0	0	0	0.5	0		0	0.5	2%	7
A7.	1	1	1	1	0	1		5.0	24%	1
Total	A6 < A7 and A6 < A5 and A5 < A7 ⇒ A6 < A5 < A7							21	100%	


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Pairwise Comparison – inconsistent

Requirements	A1.	A2.	A3.	A4.	A5.	A6.	A7.	Importance of requirement (Points total)	Weighting of requirement (%)	Ranking of requirement
A1.		0.7	0.2	0	0.5	1	0	2.4	11%	5
A2.	0.3		1	0.2	0	1	0	2.5	12%	4
A3.	0.8	0		0.1	0	1	0	1.9	9%	6
A4.	1	0.8	0.9		1	0.5	0	4.2	20%	2
A5.	0.5	1	1	0		1	0	3.5	17%	3
A6.	0	0	0	0.5	0		1	1.5	7%	7
A7.	1	1	1	1	1	0		5.0	24%	1
Total	Expert says: A7 < A5 – but overall A5 < A7!							21	100%	

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Warning!



- Pairwise Comparison is unsafe
 - Can lead to inconsistencies
 - People don't notice
 - Ranking is wrong
 - ⇒ **Wrong Decisions made!**

- For applications of AHP in medicinal diagnostics this is a problem!
 - **For QFD in Product Development as well!**

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The Solution: Eigenvector

- We need to consider Priority Vectors \underline{x}
 - Numerical Ranking among alternatives
 - Ordering reflects intensity or cardinal preference
- Under the AHP Matrix \mathbf{A} , a priority vector must remain invariant
 - \mathbf{A} needs to be positive
 - If an \underline{x} exists that satisfies $\mathbf{A}(\underline{x}) = \lambda^* \underline{x}$ then \underline{x} is a positive multiple of the principal eigenvector
 - Such an \underline{x} is called Perron Vector

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Near Consistent Matrix

- Positive reciprocal matrices can be transformed to a near consistent matrix
 - Near consistent means: almost has a Perron vector \underline{x} such that $\mathbf{A}(\underline{x}) \cong \lambda^* \underline{x}$
 - Requires a topology that allows defining “almost”
 - Iterating the reciprocal matrix (“Linear Optimization”)
 - Minimizes by the L_2 norm:

$$\kappa = \frac{|z-y|}{\sqrt{m}} = \sqrt{\frac{\sum_{j=1..m} (\zeta_j - \psi_j)^2}{m}}$$

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The Meaning of Eigenvector



- Given matrix $\mathbf{T} = (a_{i,j})$ of dimensions $n \times m$
 - You can take its transpose $\mathbf{T}^T = (a_{j,i})$, it has dimensions $m \times n$
 - And multiply $\mathbf{A} = \mathbf{T} \cdot \mathbf{T}^T$ to get back a matrix of dimensions $m \times m$
 - Now if \mathbf{A} is near consistent for Priority Vector \underline{y} :
 $\mathbf{A}(\underline{y}) \cong \lambda^* \underline{y}$
 - It means $\mathbf{T} \cdot \mathbf{T}^T(\underline{y}) \cong \lambda^* \underline{y}$
 - Or $\mathbf{T}(\underline{x}) \cong \underline{y}$ for $\underline{x} = \mathbf{T}^T(\underline{y})$
- In other words
 - \underline{x} is a solution for $\underline{y} = \mathbf{T}(\underline{x})$
 - If we know the transfer function \mathbf{T} and know our goal \underline{y} , we can calculate the solution $\underline{x} = \mathbf{T}^T(\underline{y})$

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Application of Eigenvectors

- Best known: Google Matrix
 - Google's PageRank
 - Crawls the web and collects links to information
 - After modifications, yields dense, stochastic, primitive matrix \mathbf{G} , the Google Matrix
 - Searches for eigenvectors of $\mathbf{G}^T \cdot \mathbf{G}$ with power iteration ("Potenzmethode")
 - Yielding a matrix with spectrum $\{1, a^* \lambda_2, \dots, a^* \lambda_s\}$ that allows to find the solutions very rapidly

$$\pi^{(k+1)T} = \pi^{(k)T} \cdot H$$

- Details see Mattia Bergomi, ETHZ, December 07

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- News
 - Web site of the Numerical Linear Algebra Group
available: <http://www.sam.math.ethz.ch/NLAGroup/>
- Book:
 - Numerical Methods for General and Structured Eigenvalue Problems



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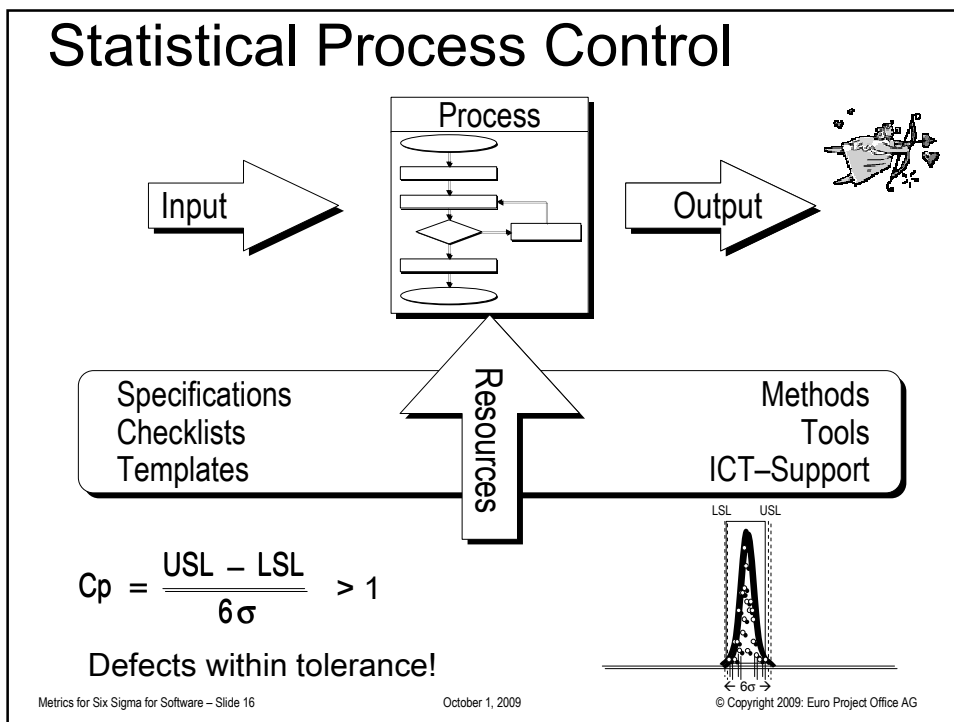
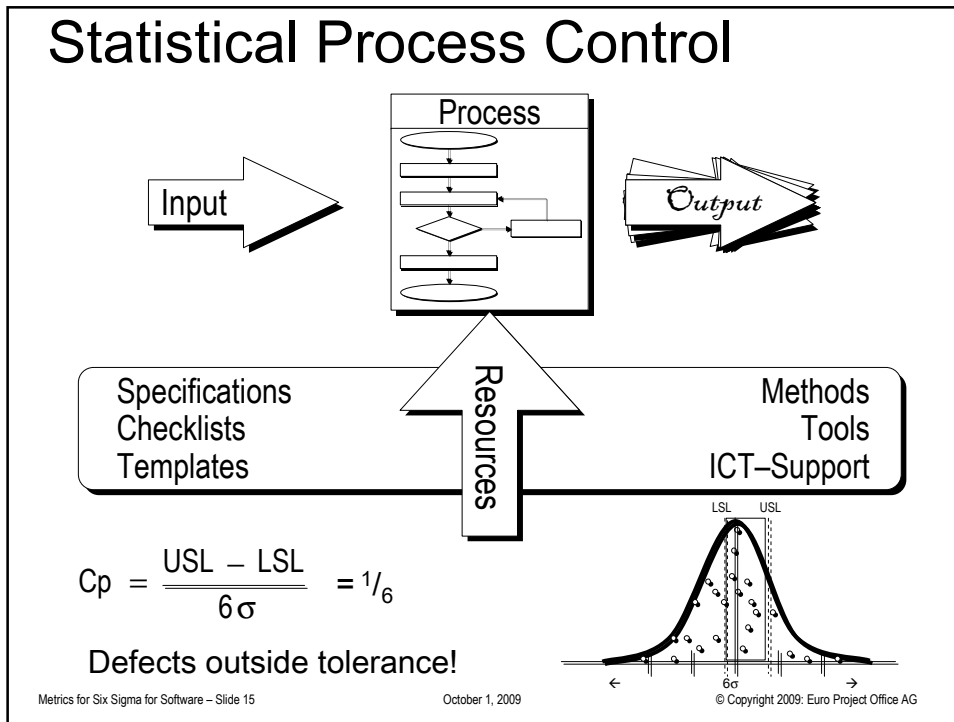
Agenda

- Analytical Hierarchical Process
- **Statistical Process Control**
- Transfer Functions in Six Sigma
- Cause-Effect Matrices
- The Convergence Gap
- Fully Deployed Six Sigma Metrics Example
- Conclusions

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Statistical Process Control for Software Acquisition

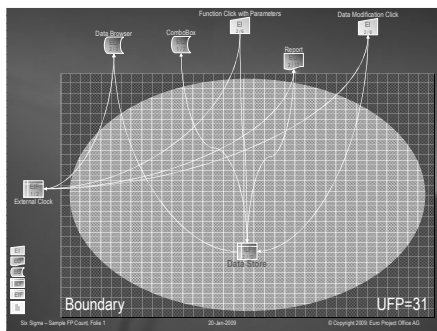
- Two major Measurement Challenges:
 - Measuring Size of Software
 - Functional Size
 - Technical complexity
 - Measuring Effort
 - Effort for REQ (Requirements Elicitation)
 - Effort for TS (Technical Solution)
 - Efforts for VER and VAL (Requirements Validation)
 - Effort for PI (Product Integration)
 - Effort for PM (Project Management)

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Functional Size of Business Requirements



- IFPUG Functional Size (ISO/IEC 20926:2003) is easily derived from Use Case Analysis, or from the User Manual
 - Good choice for understanding and sizing user requirements
 - Business Requirements Sizing Unit (UFP = Unadjusted FP)

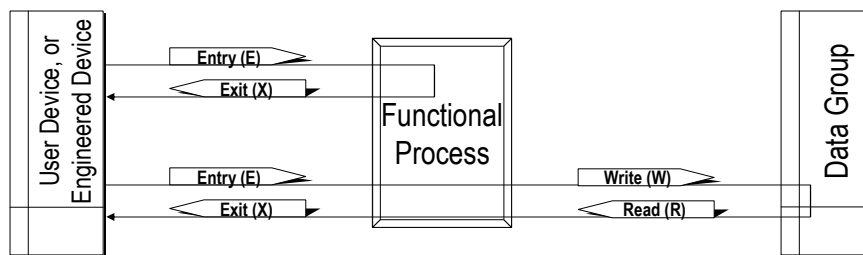
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Functional Size of Technical Requirements

- The COSMIC Full Function Points measurement method (ISO/IEC 19761:2003) sizes requirements from different viewpoints (*Functional User Requirements*)
 - No. of Entry/Exits to/from Functional Processes
 - No. of Read and Writes to/from Data Groups (Storage)



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Measuring Effort



- Writing Software is **Knowledge Acquisition**
 - We measure knowledge by the time it needs to acquire enough domain and technical know-how to solve the problem under investigation
- Different people need different amount of time
 - For the purpose of this talk, we assume that expertise is high enough
 - We don't take learning curve into account!
- Be warned: There are some additional practical problems with measuring effort!

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Learning Opportunity Ratio (LeOR)

- We can avoid counting defects if we ask for the effort needed for fixing defects rather than for a count
 - Since we consider both A-Defects and B-Defects, we don't distinguish between Bug Fixes and Change Requests
 - Change Requests are indicative for a lack of our processes to identify appropriate business or technical requirements
 - Bug Fixes are indicative for lack of validation and verification (VER and VAL) process capability
- In order to avoid the insipid after-touch that "Bug Fixing Effort" means for developers, we prefer the term "Learning Opportunities"
 - We don't want to miss learning opportunities by biased reporting
 - We have no other means to distinguish effort spent on defects from effort spent on development than by asking our team

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Measuring LeOR

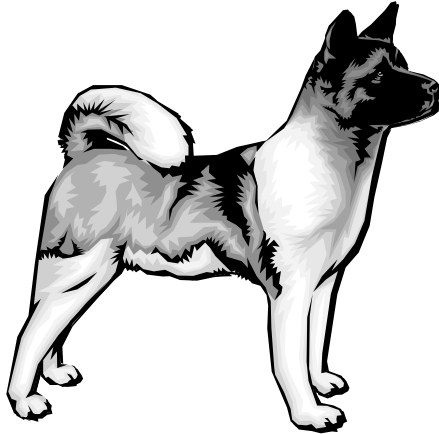
- Time is of Essence:
 - Time \cong Functional Size
 - Measure time by two categories:
 - Time spent (PD) per Work Packages
 - Percentage of time used per Work Package for
 - Learnings
 - Refactoring
 - Tracing
 - Debugging
 - Rework
 - Bug Fixes
 - Percentage of time needed for reviews and tests
 - Ratio in Percent (%) or "5 PD out of 12 PD"

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Measurement Concept



- Measure **“Learning Time”**
- Not “cost of finding and removing defects”
- Let your team be proud of time spent for learnings and mistakes found
- Never blame anybody for his or her shortcomings
- *Always blame the process when it didn't detect defects in time!*

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What means LeOR?

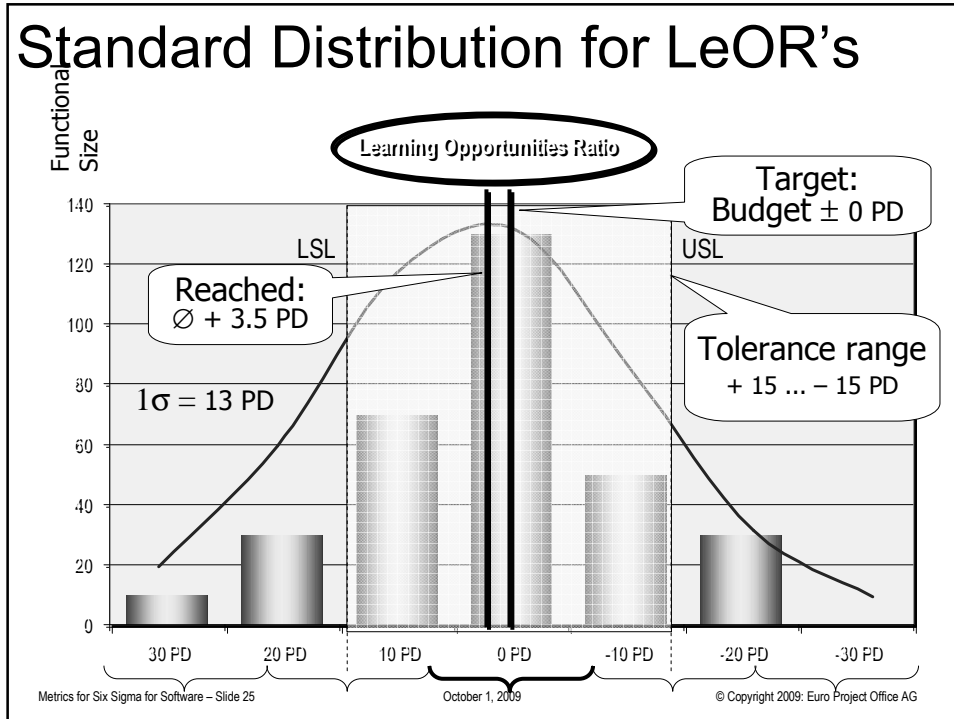
- You can X-check LeOR measurements by quality of software requirements
 - Sigma 1: initial
 - Sigma 2: basic
 - Sigma 3: acceptable
 - Sigma 4: mature
 - Sigma 5: excellent
 - Sigma 6: a dream!

Learning Opportunity Ratio	Success Rate	Sigma Value
93.0%	7.00000%	0.0
84.0%	16.00000%	0.5
69.0%	31.00000%	1.0
50.0%	50.00000%	1.5
30.9%	69.10000%	2.0
15.9%	84.10000%	2.5
6.7%	93.32000%	3.0
2.3%	97.72000%	3.5
0.6%	99.37900%	4.0
0.1%	99.86500%	4.5
0.0%	99.97670%	5.0
0.0%	99.99680%	5.5
0.0%	99.99966%	6.0

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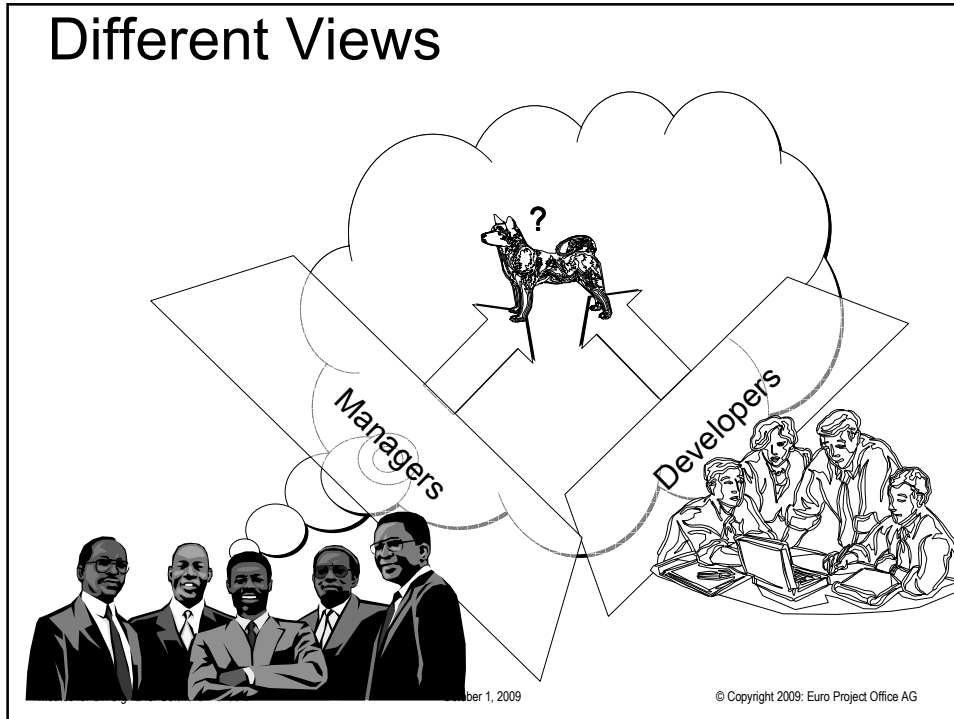
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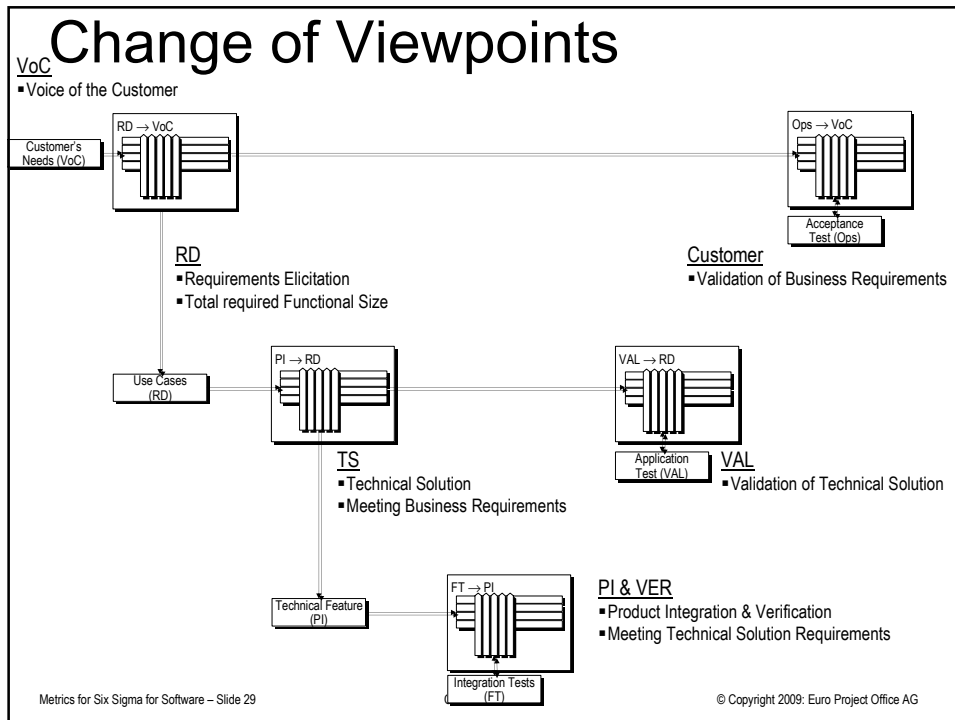
- Analytical Hierarchical Process
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Transfer Functions

- $y = \mathbf{T}(x)$:
 - The Use Case Solution x yields the Customer's Needs $y = \mathbf{T}(x)$
 - Response to Customer's Needs is a function of Use Case Solution $\mathbf{T}(x)$
- Select critical parameters
 - Representative profiles for business and technical requirements
 - Given technical requirements profile $x = \langle \xi_1, \dots, \xi_n \rangle$, response profile to business needs is $y = \mathbf{T}(x) = \langle \varphi_1(x), \dots, \varphi_m(x) \rangle$
- \mathbf{T}^{-1} is the inverse transfer function
 - \mathbf{T}^{-1} predicts the solution x that yields $y = \mathbf{T}(x)$, given goal y : $x = \mathbf{T}^{-1}(y)$
 - For a matrix representation of \mathbf{T} , \mathbf{T}^T is the transposed matrix
 - \mathbf{T}^T approximates \mathbf{T}^{-1} if \mathbf{T} has an Eigenvalue

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Eigenvector of a Transfer Function **T**

- Note: $\mathbf{T}^T \cdot \mathbf{T}$ is a square matrix ($n \times n$)
- Note that $[\mathbf{T}^T \cdot \mathbf{T}]$ needs not to be the Identity function
 - Which means, cause/effect cannot be reversed!
- An **Eigenvector** is a solution of the equation

$$[\mathbf{T}^T \cdot \mathbf{T}](x) = \lambda x$$
 - λ a real number; usually set to $\lambda = 1$
- We need to know how good the solution x is
- $\| [\mathbf{T}^T \cdot \mathbf{T}](x) - \lambda x \|$ is called the **Convergence Gap**
- A small Convergence Gap means a good prediction

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Quality Function Deployment for Cause/Effect Analysis

- Goal Profile

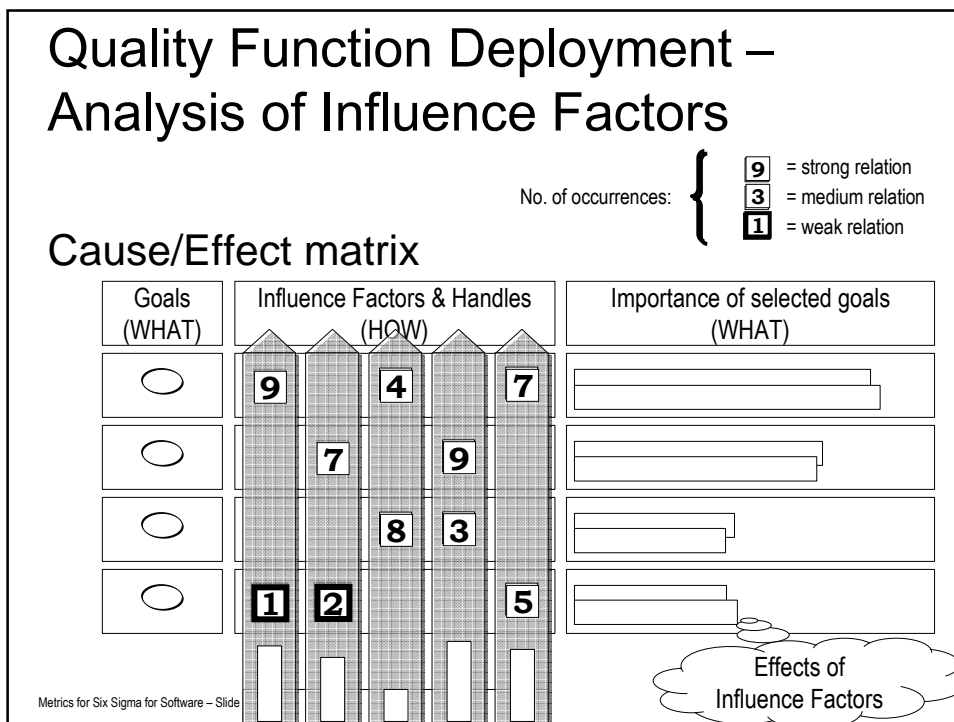
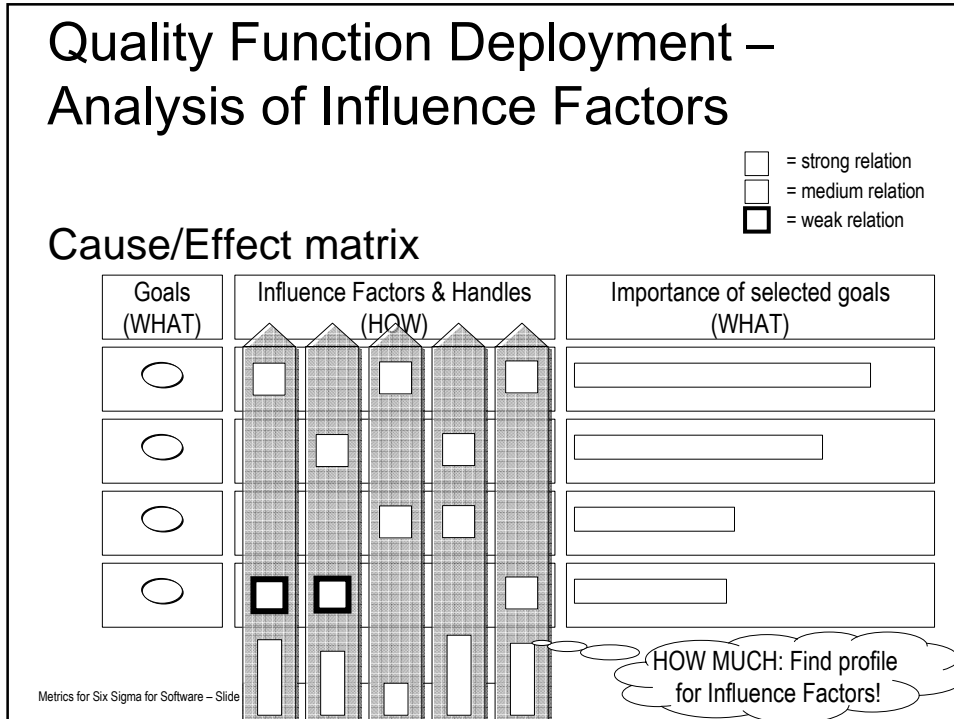
Goals (WHAT)	Importance of selected goals
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<input type="radio"/>	<input type="text"/>
<input type="radio"/>	<input type="text"/>
<input type="radio"/>	<input type="text"/>



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Finding the Correlation Values

- Count the occurrences
 - For instance, hits on Web Pages
 - E.g., how many time do you need feature x for Use Case y
 - Start with a QFD Workshop to get initial estimates, then...
 - Use countable entities, as the project advances
 - Correlation values are not restricted to 1, 3, 9, but...
- Do not allow negative numbers!
- The initial QFD transforms to statistical methods, based on data acquired during software development

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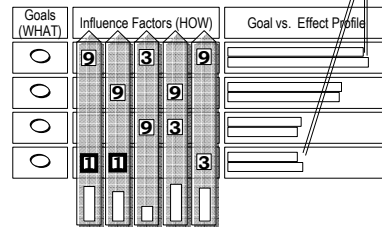
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The Convergence Gap

$$\kappa = \frac{|z-y|}{\sqrt{m}} = \sqrt{\frac{\sum_{j=1..m} (\zeta_j - \psi_j)^2}{m}}$$



κ = Minimum!



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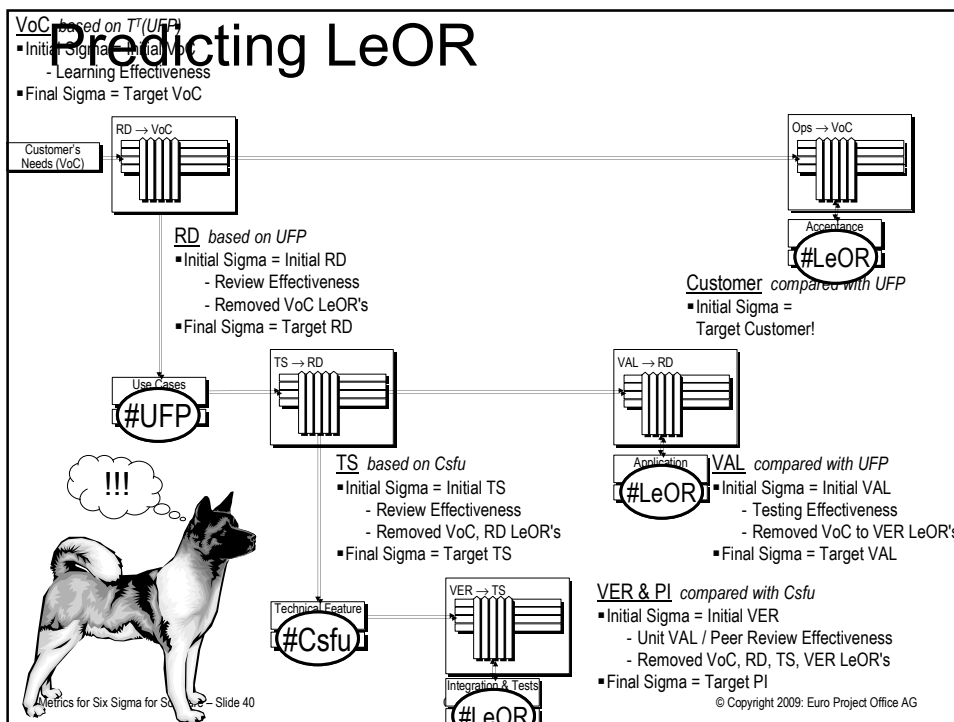
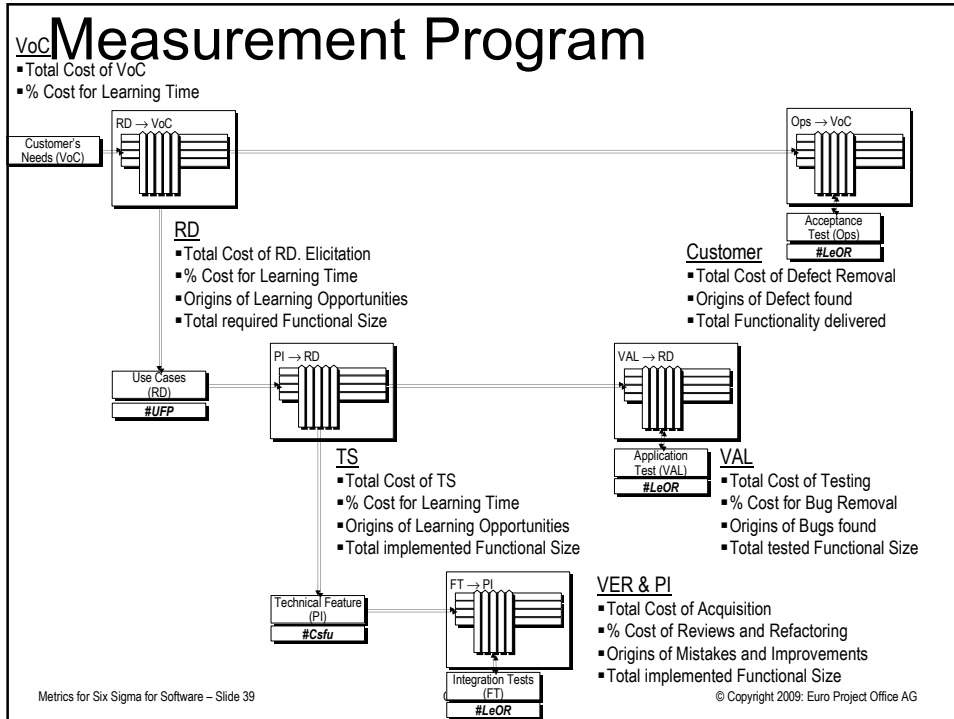
The Convergence Gap

- The Convergence Gap measures the gap between
 - the importance of solution requirements, and
 - the response they effectuate on the goal topic
- Small gap means **robust** selection of solution components
 - The transfer function yields repeatable results!
 - Even if we don't know much more than the three level cause/effect relationships

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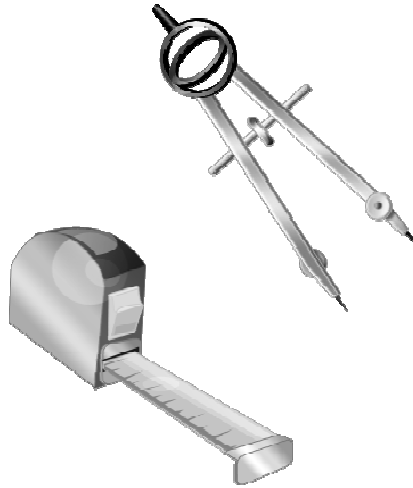
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You Need to Measure

- Functional Size
 - Of Requirements
 - Of Your Design
- Effort Spent
 - On Development
 - On Reviews & Tests
 - On Learning (LeOR)



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Sample case “Movie Tickets”

- Build a system that
 - Allows purchasing movie theatre tickets over the Web
 - Lets user select date and time of the performance
 - Graphically represents the theatre for seat selection
 - Accepts user’s selection as a legal contract
 - Prints movie tickets at the home printer (no refund)
 - Acknowledges printing and money transaction
 - Manages several movie theatres
 - Automatically feeds purchases into accounting
 - Shows remaining seat status per performance
 - Creates statistics and reports

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Two groups of Use Cases

- Visitor's Use Cases
 - UC-1.1: Easy access to the movie theatre ticket shop
 - UC-1.2: Let user select date and time of the performance
 - UC-1.3: Graphically represent the theatre for seat selection
 - UC-1.4: Select tickets and confirm purchase (with push-button)
 - UC-1.5: Print movie tickets at the home printer (no refund)
- Theatre Operator's Use Cases
 - UC-2.1: Record ticket printing and feed purchases into accounting
 - UC-2.2: Manage several movie theatres
 - UC-2.3: Manage performances
 - UC-2.4: Show remaining seat status per performance
 - UC-2.5: Create statistics and reports

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Assumptions

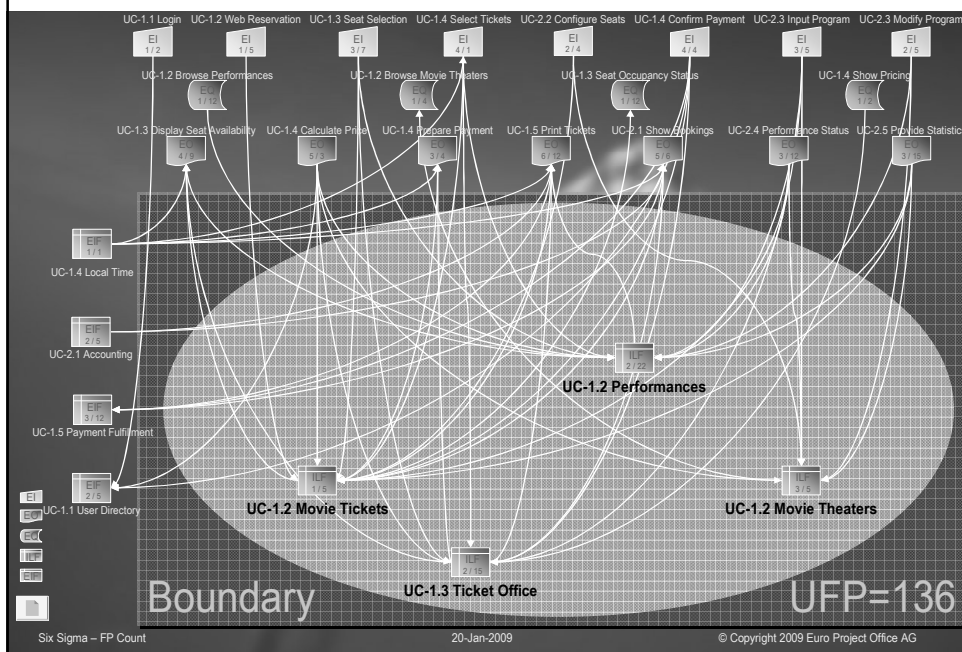
- There is another application that provides Customer Relationship Management
 - User Accounts
 - Membership
 - Payment Preferences
 - Frequent Visitor's Program
- Another service provider provides payment fulfillment using its own application
 - A Bank, Credit Card Institute, PostFinance
 - Or PayPal

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Movie Ticket FPA Count

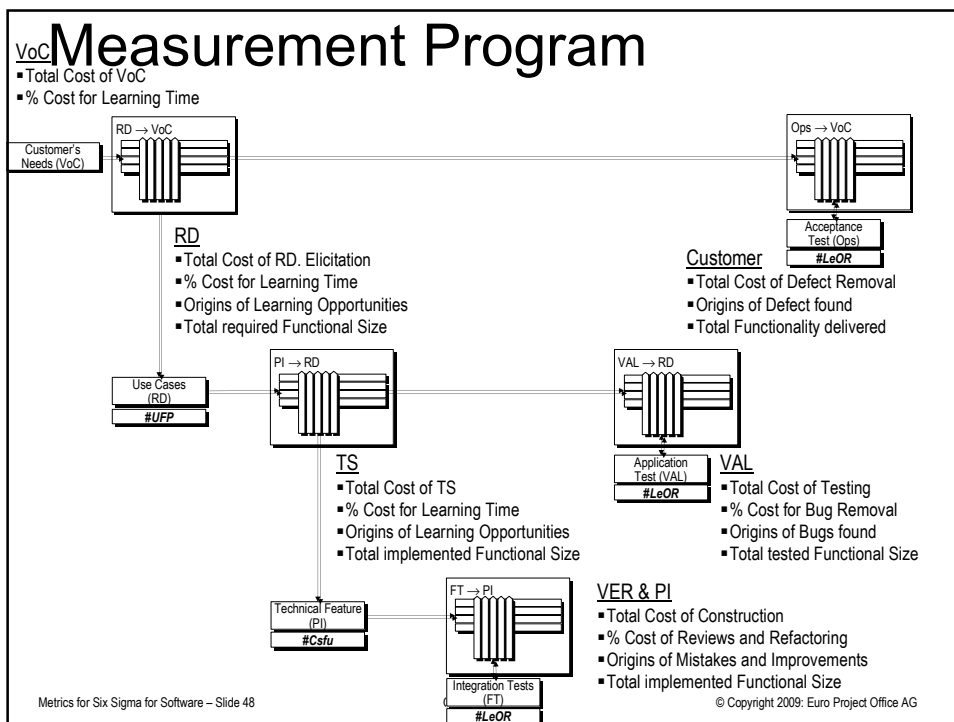


Movie Ticket FPA Count

Function Points Count							
fit Element	fit Type	UFP Count	FP Count	New Development	Total Hours	Total Days	
				9.7 PDR ←			
UC-1.1 Login	EI	3 UFP	3 FP	100%	3 FP	29 hours / 4 days	
UC-1.1 User Directory	EI	5 UFP	5 FP	100%	5 FP	49 hours / 6 days	
UC-1.2 Browse Movie Theaters	EQ	3 UFP	3 FP	100%	3 FP	29 hours / 4 days	
UC-1.2 Browse Performances	EQ	3 UFP	3 FP	100%	3 FP	29 hours / 4 days	
UC-1.2 Movie Theaters	ILF	7 UFP	7 FP	100%	7 FP	68 hours / 8 days	
UC-1.2 Movie Tickets	ILF	7 UFP	7 FP	100%	7 FP	68 hours / 8 days	
UC-1.2 Performances	ILF	10 UFP	10 FP	100%	10 FP	97 hours / 12 days	
UC-1.2 Web Reservation	EI	3 UFP	3 FP	100%	3 FP	29 hours / 4 days	
UC-1.3 Display Seat Availability	EO	7 UFP	7 FP	100%	7 FP	68 hours / 8 days	
UC-1.3 Seat Occupancy Status	EQ	3 UFP	3 FP	100%	3 FP	29 hours / 4 days	
UC-1.3 Seat Selection	EI	6 UFP	6 FP	100%	6 FP	58 hours / 7 days	
UC-1.3 Ticket Office	ILF	7 UFP	7 FP	100%	7 FP	68 hours / 8 days	
UC-1.4 Calculate Price	EO	5 UFP	5 FP	100%	5 FP	49 hours / 6 days	
UC-1.4 Confirm Payment	EI	4 UFP	4 FP	100%	4 FP	39 hours / 5 days	
UC-1.4 Local Time	EI	5 UFP	5 FP	100%	5 FP	49 hours / 6 days	
UC-1.4 Prepare Payment	EO	4 UFP	4 FP	100%	4 FP	39 hours / 5 days	
UC-1.4 Select Tickets	EI	4 UFP	4 FP	100%	4 FP	39 hours / 5 days	
UC-1.4 Show Pricing	EO	3 UFP	3 FP	100%	3 FP	29 hours / 4 days	
UC-1.5 Payment Fulfillment	EI	5 UFP	5 FP	100%	5 FP	49 hours / 6 days	
UC-1.5 Print Tickets	EO	7 UFP	7 FP	100%	7 FP	68 hours / 8 days	
UC-2.1 Accounting	EI	5 UFP	5 FP	100%	5 FP	49 hours / 6 days	
UC-2.1 Show Bookings	EO	7 UFP	7 FP	100%	7 FP	68 hours / 8 days	
UC-2.2 Configure Seats	EI	3 UFP	3 FP	100%	3 FP	29 hours / 4 days	
UC-2.3 Input Program	EI	6 UFP	6 FP	100%	6 FP	58 hours / 7 days	
UC-2.3 Modify Program	EI	4 UFP	4 FP	100%	4 FP	39 hours / 5 days	
UC-2.4 Performance Status	EO	5 UFP	5 FP	100%	5 FP	49 hours / 6 days	
UC-2.5 Provide Statistics	EO	5 UFP	5 FP	100%	5 FP	49 hours / 6 days	
Total		136 UFP	136 FP	100%	136 FP	1319 hours / 165 days	
		EI	33 UFP	33 FP	100%	33 FP	330 hours / 40 days
		EO	40 UFP	40 FP	100%	40 FP	388 hours / 49 days
		EQ	12 UFP	12 FP	100%	12 FP	116 hours / 15 days
		ILF	31 UFP	31 FP	100%	31 FP	301 hours / 38 days
		EI	20 UFP	20 FP	100%	20 FP	194 hours / 24 days

Product Delivery Rate
PDR = 9.7 hours / FP

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Customer's Needs Profile

	Topics	Attributes
VoC-F Function	VoC-F.1 Trendy Program	VoC-F.1.1 <i>It must attract people and follow the trends</i>
	VoC-F.2 Wide selection	VoC-F.2.1 <i>Get all information handy and be able to select what you want</i>
	VoC-F.3 Easy to get tickets	VoC-F.3.1 <i>The movie experience is just a few clicks away</i>
VoC-Q Quality	VoC-Q.1 Complete information	VoC-Q.1.1 <i>Give all relevant information</i>
	VoC-Q.2 Secure reservation	VoC-Q.2.1 <i>Fail safe - no tolerance for defects</i>

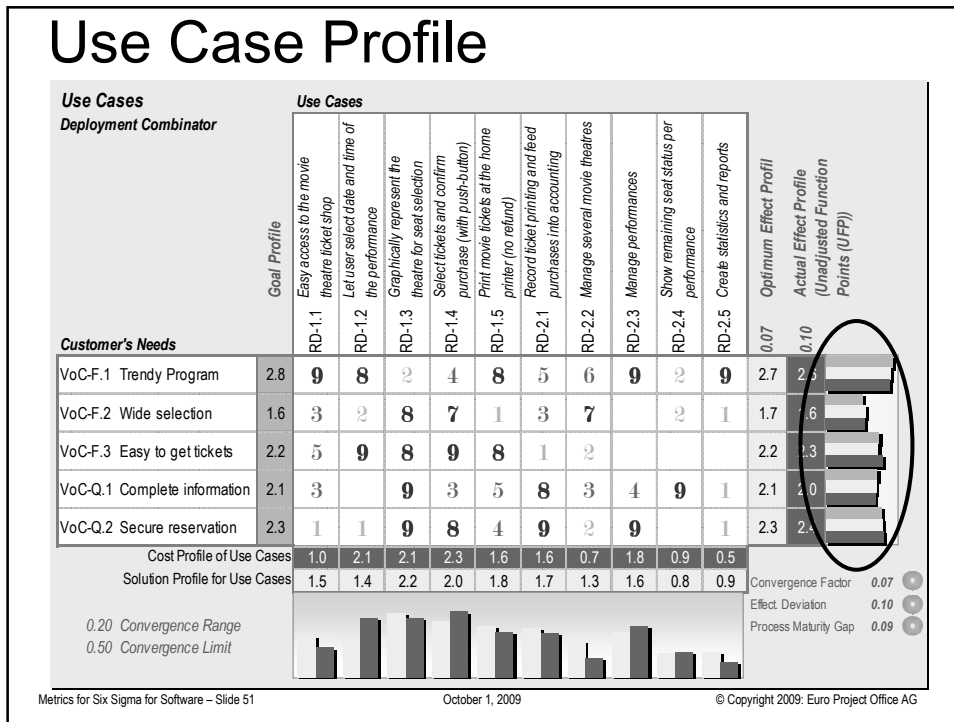
Weights for Profile:

- VOC Customer Questionnaire
- Market Share & Competition
- Kano Analysis

Customer's Needs	Combined Profile	Σ	3	5	2
VoC-F.1 Trendy Program	2.8	27	10.6	9.4	7.1
VoC-Q.2 Secure reservation	2.3	23	5.4	13.5	3.8
VoC-F.3 Easy to get tickets	2.2	22	5.5	12.2	4.1
VoC-Q.1 Complete information	2.1	21	6.5	10.3	3.9
VoC-F.2 Wide selection	1.6	15	3.4	10.0	1.8

Use Cases

	Topics	Attributes
RD-1 Visitor's Use Cases	RD-1.1 Easy access to the movie theatre ticket shop	RD-1.1.1 <i>Easy retrieval by Google</i>
	RD-1.2 Let user select date and time of the performance	RD-1.2.1 <i>Graphical navigation and click selection</i>
	RD-1.3 Graphically represent the theatre for seat selection	RD-1.3.1 <i>Contract established according EU rules</i>
	RD-1.4 Select tickets and confirm purchase (with push-button)	RD-1.4.1 <i>Use a standard component</i>
	RD-1.5 Print movie tickets at the home printer (no refund)	RD-1.5.1 <i>Use browser printing</i>
RD-2 Operator's Use Cases	RD-2.1 Record ticket printing and feed purchases into accounting	RD-2.1.1 <i>Automatic without costly interventions</i>
	RD-2.2 Manage several movie theatres	RD-2.2.1 <i>Flexible for growth</i>
	RD-2.3 Manage performances	RD-2.3.1 <i>Adapt rapidly and on short notice</i>
	RD-2.4 Show remaining seat status per performance	RD-2.4.1 <i>Available for visitors as well</i>
	RD-2.5 Create statistics and reports	RD-2.5.1 <i>Real-time</i>



Use Cases and Transactions

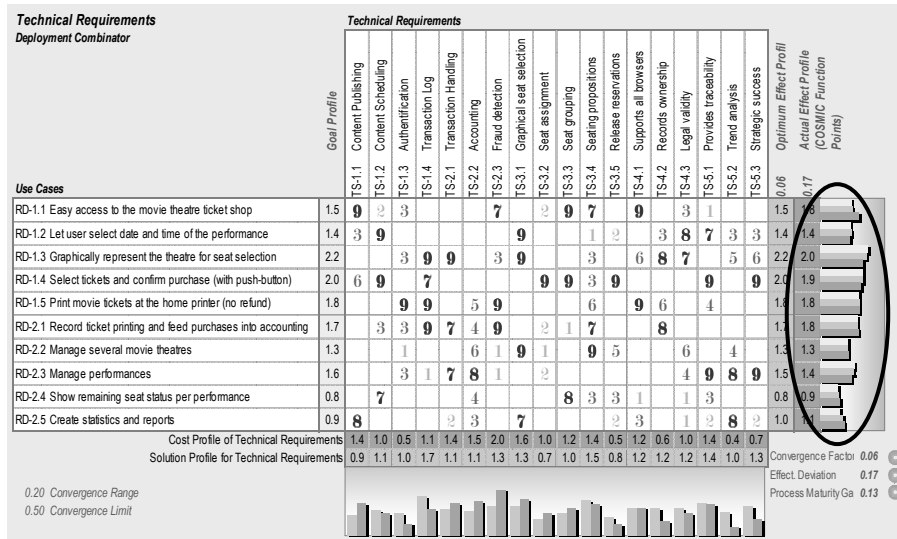
Function Points Count

Use Case	Type	UFP Count	Use Cases														
			RD-1.1	RD-1.2	RD-1.3	RD-1.4	RD-1.5	RD-2.1	RD-2.2	RD-2.3	RD-2.4	RD-2.5					
UC-1.1 Login	EI	3 UFP	100%														
UC-1.1 User Directory	EIF	5 UFP	100%														
UC-1.2 Browse Movie Theaters	EQ	3 UFP		100%													
UC-1.2 Browse Performances	EQ	3 UFP		100%													
UC-1.2 Movie Theaters	ILF	7 UFP		50%						50%							
UC-1.2 Movie Tickets	ILF	7 UFP		50%							50%						
UC-1.2 Performances	ILF	10 UFP		33%							33%	33%					
UC-1.2 Web Reservation	EI	3 UFP		100%													
UC-1.3 Display Seat Availability	EQ	7 UFP			100%												
UC-1.3 Seat Occupancy Status	EQ	3 UFP			100%												
UC-1.3 Seat Selection	EI	6 UFP			100%												
UC-1.3 Ticket Office	ILF	7 UFP			50%			50%									
UC-1.4 Calculate Price	EO	5 UFP					100%										
UC-1.4 Confirm Payment	EI	4 UFP					100%										
UC-1.4 Local Time	EIF	5 UFP	33%				33%	33%									
UC-1.4 Prepare Payment	EO	4 UFP					100%										
UC-1.4 Select Tickets	EI	4 UFP					100%										
UC-1.4 Show Pricing	EQ	3 UFP					100%										
UC-1.5 Payment Fulfillment	EIF	5 UFP						50%	50%								
UC-1.5 Print Tickets	EO	7 UFP					100%										
UC-2.1 Accounting	EIF	5 UFP						100%									
UC-2.1 Show Bookings	EO	7 UFP						100%									
UC-2.2 Configure Seats	EI	3 UFP							100%								
UC-2.3 Input Program	EI	6 UFP								100%							
UC-2.3 Modify Program	EI	4 UFP									100%						
UC-2.4 Performance Status	EO	5 UFP										100%					
UC-2.5 Provide Statistics	EO	5 UFP											100%				
Total		136 UFP	9.7 UFP	19.3 UFP	19.5 UFP	21.7 UFP	14.7 UFP	14.5 UFP	6.5 UFP	16.8 UFP	8.3 UFP	5.0 UFP					

Technical Features

	Topics	Attributes
TS-1 Web Server	TS-1.1 Content Publishing	TS-1.1.1 Simple content updating interface
	TS-1.2 Content Scheduling	TS-1.2.1 Publishes content within time constraint
	TS-1.3 Authentication	TS-1.3.1 Attribute 3
	TS-1.4 Transaction Log	TS-1.4.1 Attribute 4
TS-2 Billing	TS-2.1 Transaction Handling	TS-2.1.1 Credit Card or Debit Card
	TS-2.2 Accounting	TS-2.2.1 Batch file transaction interface
	TS-2.3 Fraud detection	TS-2.3.1 Detects fraudulent cash in attempts
TS-3 Seating	TS-3.1 Graphical seat selection	TS-3.1.1 Using standard component interface
	TS-3.2 Seat assignment	TS-3.2.1 Smart assignment algorithm avoiding widows
	TS-3.3 Seat grouping	TS-3.3.1 Can assign batches of adjacent seats
	TS-3.4 Seating propositions	TS-3.4.1 Proposes alternate seating if fully booked
	TS-3.5 Release reservations	TS-3.5.1 For no shows
TS-4 Printing	TS-4.1 Supports all browsers	TS-4.1.1 Creates PDF for download
	TS-4.2 Records ownership	TS-4.2.1 Can trace back who tried to print what
	TS-4.3 Legal validity	TS-4.3.1 Printed tickets have legal value as a contract
TS-5 Administration	TS-5.1 Provides traceability	TS-5.1.1 Business transactions are traceable avoiding dispute
	TS-5.2 Trend analysis	TS-5.2.1 Statistical package for assessing attractiveness
	TS-5.3 Strategic success	TS-5.3.1 Success factors are identified by statistical means

Technical Profile



Feature Cost – COSMIC Functional Size Units

	Topics	Profile	Cfsu		
TS-1	Web Server	TS-1.1 Content Publishing	1.4	Csfu 32	
		TS-1.2 Content Scheduling	1.0	Csfu 22	
		TS-1.3 Authentication	0.5	Csfu 12	
		TS-1.4 Transaction Log	1.1	Csfu 26	
TS-2	Billing	TS-2.1 Transaction Handling	1.4	Csfu 32	
		TS-2.2 Accounting	1.5	Csfu 34	
		TS-2.3 Fraud detection	2.0	Csfu 45	
TS-3	Seating	TS-3.1 Graphical seat selection	1.6	Csfu 36	
		TS-3.2 Seat assignment	1.0	Csfu 22	
		TS-3.3 Seat grouping	1.2	Csfu 27	
		TS-3.4 Seating propositions	1.4	Csfu 31	
		TS-3.5 Release reservations	0.5	Csfu 11	
TS-4	Printing	TS-4.1 Supports all browsers	1.2	Csfu 28	
		TS-4.2 Records ownership	0.6	Csfu 14	
		TS-4.3 Legal validity	1.0	Csfu 22	
TS-5	Administration	TS-5.1 Provides traceability	1.4	Csfu 31	
		TS-5.2 Trend analysis	0.4	Csfu 9	
		TS-5.3 Strategic success	0.7	Csfu 16	

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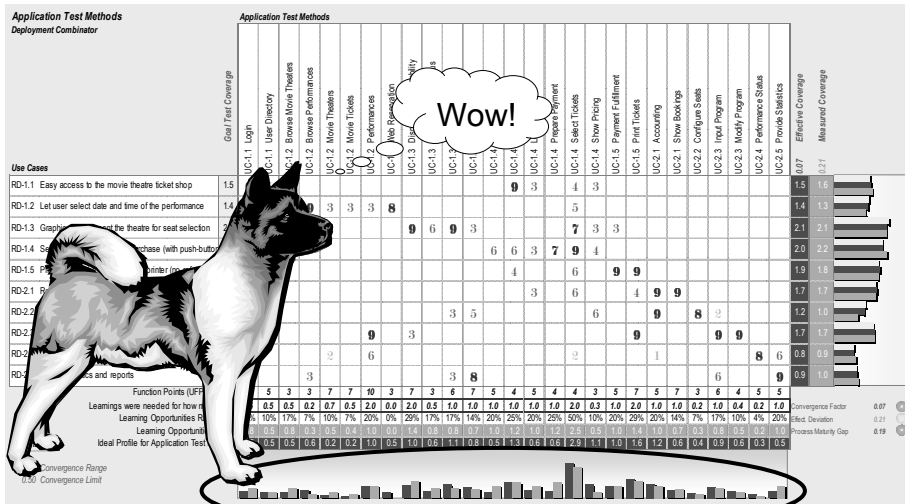
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Application Test Cases

Application Test Methods

	Transaction	Test Case
RD-1.1 Easy access to the movie theatre ticket shop	UC-1.1 Login	UC-1.1.1 Valid User/PW
RD-1.2 Let user select date and time of the performance	UC-1.1 User Directory	UC-1.1.1 Invalid User
	UC-1.2 Browse Movie Theaters	UC-1.2.1 See all theaters entered (see UC-1.2 Movie Theaters)
	UC-1.2 Browse Performances	UC-1.2.1 See all performances entered (see UC-1.2 Performances)
	UC-1.2 Movie Theaters	UC-1.2.1 Contains all attributes needed for describing where the ticket is valid
	UC-1.2 Movie Tickets	UC-1.2.1 Tickets contain all information the visitor needs to know (time, location, title)
	UC-1.2 Performances	UC-1.2.1 Contains all attributes needed for describing when the ticket is valid
RD-1.3 Graphically represent the theatre for seat selection	UC-1.2 Web Reservation	UC-1.2.1 HTML links are redirected to portal page
	UC-1.3 Display Seat Availability	UC-1.3.1 Performance details: date, time, location correspond to UC-1.2 Performances
	UC-1.3 Seat Occupancy Status	UC-1.3.1 Upon click, color changes from green to orange
	UC-1.3 Seat Selection	UC-1.3.1 Upon click, color changes from green to orange
RD-1.4 Select tickets and confirm purchase (with push-button)	UC-1.3 Ticket Office	UC-1.3.1 Upon click on "Purchase" button, all reserved tickets are available for purchase
	UC-1.4 Calculate Price	UC-1.4.1 Price is correct
	UC-1.4 Confirm Payment	UC-1.4.1 Confirmation is a unique button click
	UC-1.4 Local Time	UC-1.4.1 In sync with DB
	UC-1.4 Prepare Payment	UC-1.4.1 Offers all available payment methods
RD-1.5 Print movie tickets at the home printer (no refund)	UC-1.4 Select Tickets	UC-1.4.1 Tickets can be de-selected and reservations freed (UC-1.3 Ticket Office)
	UC-1.4 Show Pricing	UC-1.4.1 Price is correct
	UC-1.5 Payment Fulfillment	UC-1.5.1 Acknowledges successful payment
RD-2.1 Record ticket printing and feed purchases into accounting	UC-1.5 Print Tickets	UC-1.5.1 Receipts confirmed by visitor
	UC-2.1 Accounting	UC-2.1.1 At end-of-day, income corresponds to tickets sold
RD-2.2 Manage several movie theatres	UC-2.1 Show Bookings	UC-2.1.1 In sync with UC-1.3 Seat Occupancy Status
	UC-2.2 Configure Seats	UC-2.2.1 Each seat has pricing schema assigned
	UC-2.3 Input Program	UC-2.3.1 Checks whether all required performance data is available
	UC-2.3 Modify Program	UC-2.3.1 Checks whether all required performance data is available
RD-2.3 Manage performances	UC-2.4 Performance Status	UC-2.4.1 Report is complete
RD-2.4 Show remaining seat status per performance	UC-2.5 Provide Statistics	UC-2.5.1 Fixed time range

Predicting LeOR



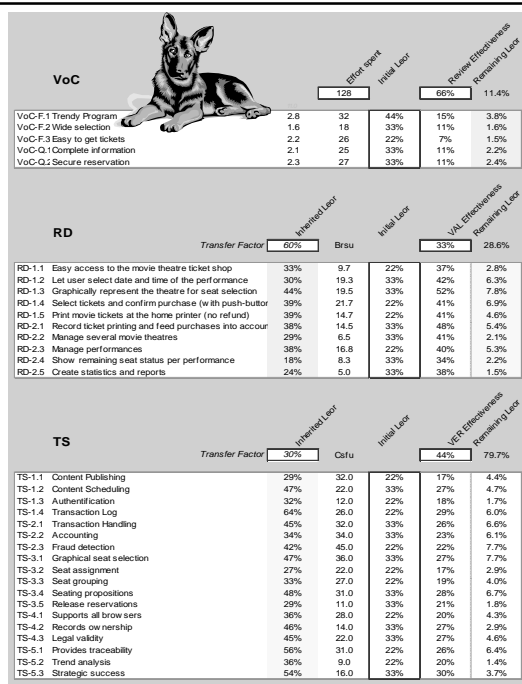
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A Practical Example

- Using the prediction matrix T^T , mistakes not detected in previous stages are transferred to next step
 - Where the LeOR costs more
 - Where missed LeOR's finally become defects, when released to customers



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The Starting Point

- Six Sigma effectively predicts defect density, i.e. the Learning Opportunities Ratio “LeOR”
 - Provided you have some initial starting point
 - Which you can get from previous projects
 - Rule of thumb:
 - For inexperienced teams: Initial Sigma = 1
 - For good, knowledgeable teams: Initial Sigma = 2
 - For very experienced teams only: Initial Sigma = 2.5
 - Target Sigma depends from industry
 - Target Sigma = 4 is very good already!

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Agenda

- Analytical Hierarchical Process
- Statistical Process Control
- Transfer Functions in Six Sigma
- Cause-Effect Matrices
- The Convergence Gap
- Fully Deployed Six Sigma Metrics Example
- **Conclusions**

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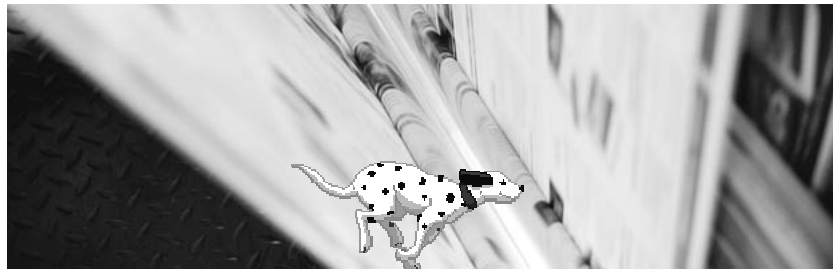
Conclusion

- The Eigenvector theory changes the way we're looking at QFD and Six Sigma
 - Requires sophisticated measurement program
 - And sound mathematical statistics!
- Don't underestimate impact of early stages
 - Voice of the Customer, Requirements Elicitation
 - Insist on near consistent transfer functions!
- To predict software development
 - You must measure Functional Size!
 - You must measure Time Spent for LeOR!
 - Insist on QFD in the large sense – manage requirements for the different levels differently

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Thank You.

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