Statistical Process Control for Software Acquisition

QFD Symposium AutoUni Wolfsburg
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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
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
### Pairwise Comparison – empty

<table>
<thead>
<tr>
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<tbody>
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<td>A1.</td>
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<td></td>
<td>21</td>
<td>100%</td>
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</table>

**Relative Weights 0 – ½ – 1**

### Pairwise Comparison – consistent

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<td>11%</td>
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<td>0.2</td>
<td>0.1</td>
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<td>1</td>
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<tr>
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<td>0.5</td>
<td>2%</td>
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</tr>
<tr>
<td>A7.</td>
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<td>1</td>
<td>1</td>
<td>0</td>
<td></td>
<td>5.0</td>
<td>24%</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
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<td></td>
<td></td>
<td>21</td>
<td>100%</td>
<td><strong>1</strong></td>
</tr>
</tbody>
</table>

**A6 < A7 and A6 < A5 and A5 < A7 ⇒ A6 < A5 < A7**
### Pairwise Comparison – inconsistent

<table>
<thead>
<tr>
<th>Requirements</th>
<th>A1</th>
<th>A2</th>
<th>A3</th>
<th>A4</th>
<th>A5</th>
<th>A6</th>
<th>A7</th>
<th>Importance of requirement (Points total)</th>
<th>Weighting of requirement (%)</th>
<th>Ranking of requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>0.7</td>
<td>0.2</td>
<td>0</td>
<td>0.5</td>
<td>1</td>
<td>0</td>
<td>2.4</td>
<td>11%</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>A2</td>
<td>0.3</td>
<td>1</td>
<td>0.2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2.5</td>
<td>12%</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>A3</td>
<td>0.8</td>
<td>0</td>
<td>0.1</td>
<td>0</td>
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<td>0</td>
<td>1.9</td>
<td>9%</td>
<td>6</td>
<td>6</td>
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<tr>
<td>A4</td>
<td>1</td>
<td>0.8</td>
<td>0.9</td>
<td>1</td>
<td>0.5</td>
<td>0</td>
<td>4.2</td>
<td>20%</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>A5</td>
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<td>1</td>
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<td>0</td>
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<td>17%</td>
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<td>0</td>
<td>5.0</td>
<td>24%</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
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<td></td>
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<td></td>
<td></td>
<td>21</td>
<td>100%</td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

- Expert says: A7 < A5 – but overall A5 < A7!

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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!**
The Solution: Eigenvector

- We need to consider Priority Vectors $x$
  - Numerical Ranking among alternatives
  - Ordering reflects intensity or cardinal preference

- Under the AHP Matrix $A$, a priority vector must remain invariant
  - $A$ needs to be positive
  - If an $x$ exists that satisfies $A(x) = \lambda^*x$ then $x$ is a positive multiple of the principal eigenvector
  - Such an $x$ is called Perron Vector

Near Consistent Matrix

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

\[
\kappa = \frac{|z - y|}{\sqrt{m}} = \sqrt{\frac{\sum_{j=1}^{m} (\zeta_j - \psi_j)^2}{m}}
\]
The Meaning of Eigenvector

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

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 $G$, the Google Matrix
  - Searches for eigenvectors of $G^T \cdot G$ with power iteration (“Potenzmethode”)
    - Yielding a matrix with spectrum $\{1, a \lambda_2, \ldots, a \lambda_s\}$ that allows to find the solutions very rapidly
    - $\pi^{(k+1)T} = \pi^{(k)T} \cdot H$
- Details see Mattia Bergomi, ETHZ, December 07
Prof. Daniel Kressner, ETHZ

- Seminar für Angewandte Mathematik (SAM)
  HG G 58.1, Rämistrasse 101
  8092 Zürich, Switzerland

  Email: daniel.kressner@sam.math.ethz.ch
  Phone: +41 44 632 8710

- News

- 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
Statistical Process Control

Input → Process → Output

Specifications
Checklists
Templates

Resources

Methods
Tools
ICT–Support

\( Cp = \frac{USL - LSL}{6\sigma} = \frac{1}{6} \)
Defects outside tolerance!

\( Cp = \frac{USL - LSL}{6\sigma} > 1 \)
Defects within tolerance!
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)

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)
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)

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!
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

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”
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!

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!

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<tr>
<th>Learning Opportunity Ratio</th>
<th>Success Rate</th>
<th>Sigma Value</th>
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<td>7.00000%</td>
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<tr>
<td>84.0%</td>
<td>16.00000%</td>
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<tr>
<td>69.0%</td>
<td>31.00000%</td>
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<td>50.0%</td>
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<td>1.5</td>
</tr>
<tr>
<td>30.9%</td>
<td>69.10000%</td>
<td>2.0</td>
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<tr>
<td>15.9%</td>
<td>84.10000%</td>
<td>2.5</td>
</tr>
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<td>6.7%</td>
<td>93.32000%</td>
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<td>99.99968%</td>
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</table>
Standard Distribution for LeOR’s

Learning Opportunities Ratio

- Target: Budget ± 0 PD
- Reached: ∅ + 3.5 PD
- 1σ = 13 PD
- Tolerance range +15 ... – 15 PD

Functional Size

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### Different Views

- **Developers**
- **Managers**

### Transfer Functions

- $y = T(x)$:
  - The Use Case Solution $x$ yields the Customer’s Needs $y = T(x)$
  - Response to Customer’s Needs is a function of Use Case Solution $T(x)$
- Select critical parameters
  - Representative profiles for business and technical requirements
  - Given technical requirements profile $x = \langle \xi_1, \ldots, \xi_n \rangle$, response profile to business needs is $y = T(x) = \langle \phi_1(x), \ldots, \phi_m(x) \rangle$
- $T^T$ is the inverse transfer function
  - $T^T$ predicts the solution $x$ that yields $y = T(x)$, given goal $y$: $x = T^T(y)$
  - For a matrix representation of $T$, $T^T$ is the transposed matrix
  - $T^T$ approximates $T^{-1}$ if $T$ has an Eigenvalue

$\text{Use Case Solution (} x \rightarrow \text{Customer's Needs (} y)$

$T(x)$

$x$

$y = T(x)$

$T^{-1}$

$T^T$
Change of Viewpoints

- VoC (Voice of the Customer)
- RD (Requirements Elicitation)
- TD (Technical Solution)
- VAL (Validation of Technical Solution)
- PI (Product Integration & Verification)
- Ops (Operations)
- VoC
- RD
- TD
- VAL
- PI & VER

VoC → RD
RD → TD
TD → VAL
VAL → PI
PI & VER → VoC

Customer → VoC
VoC → RD
RD → TD
TD → TD

Eigenvector of a Transfer Function \( \mathbf{T} \)

- Note: \( \mathbf{T}^T \circ \mathbf{T} \) is a square matrix \((n \times n)\)
- Note that \( \mathbf{T}^T \circ \mathbf{T} \) needs not to be the Identity function
  - Which means, cause/effect cannot be reversed!
- An Eigenvector is a solution of the equation
  \[ [\mathbf{T}^T \circ \mathbf{T}] (x) = \lambda x \]
  - \( \lambda \) a real number; usually set to \( \lambda = 1 \)
- We need to know how good the solution \( x \) is
- \( \| [\mathbf{T}^T \circ \mathbf{T}] (x) - \lambda x \| \) 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

<table>
<thead>
<tr>
<th>Goals (WHAT)</th>
<th>Importance of selected goals</th>
</tr>
</thead>
<tbody>
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</table>

Goal profile is known
Quality Function Deployment – Analysis of Influence Factors

Cause/Effect matrix

<table>
<thead>
<tr>
<th>Goals (WHAT)</th>
<th>Influence Factors &amp; Handles (HOW)</th>
<th>Importance of selected goals (WHAT)</th>
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<tbody>
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</tbody>
</table>

HOW MUCH: Find profile for Influence Factors!

No. of occurrences: 

- 9 = strong relation
- 8 = medium relation
- 3 = weak relation
Finding the Correlation Values

- Count the occurrences
  - For instance, hits on Web Pages
  - E.g., how many times 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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The Convergence Gap

\[ \kappa = \frac{|z - y|}{\sqrt{\frac{\sum (\zeta_j - \psi_j)^2}{m}}} \]

\[ \kappa = \text{Minimum!} \]

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
Measurement Program

VoC based on T
- Initial Sigma = Initial VoC
- Learning Effectiveness
- Final Sigma = Target VoC

RD based on UFP
- Initial Sigma = Initial RD
- Review Effectiveness
- Removed VoC LeOR's
- Final Sigma = Target RD

TS based on Csfu
- Initial Sigma = Initial TS
- Review Effectiveness
- Removed VoC, RD LeOR's
- Final Sigma = Target TS

Customer based on UFP
- Initial Sigma = Initial Customer
- Learning Effectiveness
- Final Sigma = Target Customer

VER & PI compared with UFP
- Initial Sigma = Initial VER
- Review Effectiveness
- Removed VoC, RD, TS, VER LeOR's
- Final Sigma = Target PI

VAL compared with UFP
- Initial Sigma = Initial VAL
- Testing Effectiveness
- Removed VoC to VER LeOR's
- Final Sigma = Target VAL

Predicting LeOR
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

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
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
### Movie Ticket FPA Count

**Function Points Count**

<table>
<thead>
<tr>
<th>Use Case</th>
<th>FP Count</th>
<th>% Cost</th>
<th>Total Cost of VoC</th>
</tr>
</thead>
<tbody>
<tr>
<td>UC-1.1 Log in</td>
<td>136 FP</td>
<td>100%</td>
<td>136 hours</td>
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<tr>
<td>UC-1.2 Buy Movie Tickets</td>
<td>20 FP</td>
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<td>20 hours</td>
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<tr>
<td>UC-1.3 Seat Selection</td>
<td>31 FP</td>
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<td>31 hours</td>
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<tr>
<td>UC-1.4 Calculate Price</td>
<td>12 FP</td>
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<td>12 hours</td>
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<tr>
<td>UC-1.5 Print Tickets</td>
<td>40 FP</td>
<td>100%</td>
<td>40 hours</td>
</tr>
<tr>
<td>UC-1.6 Select Tickets</td>
<td>33 FP</td>
<td>100%</td>
<td>33 hours</td>
</tr>
<tr>
<td>UC-1.7 Accounting</td>
<td>33 FP</td>
<td>100%</td>
<td>33 hours</td>
</tr>
<tr>
<td>UC-1.8 Show Bookings</td>
<td>7 FP</td>
<td>100%</td>
<td>7 hours</td>
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<tr>
<td>UC-1.9 Show Pricing</td>
<td>40 FP</td>
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<td>40 hours</td>
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<td>UC-1.10 Print Tickets</td>
<td>7 FP</td>
<td>100%</td>
<td>7 hours</td>
</tr>
<tr>
<td>UC-1.11 Login</td>
<td>6 FP</td>
<td>100%</td>
<td>6 hours</td>
</tr>
<tr>
<td>UC-1.12 Web Reservation</td>
<td>7 FP</td>
<td>100%</td>
<td>7 hours</td>
</tr>
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<td>UC-1.13 Seat Occupancy Status</td>
<td>3 FP</td>
<td>100%</td>
<td>3 hours</td>
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<tr>
<td>UC-1.14 Choose Performance</td>
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<td>UC-1.15 Choose Movie</td>
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<td>UC-1.16 Calculate Price</td>
<td>4 FP</td>
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<td>UC-1.17 Print Tickets</td>
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<td>UC-1.18 Choose Performance</td>
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<td>UC-1.19 Choose Movie Theaters</td>
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<td>7 hours</td>
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<td>UC-1.20 Choose Seating</td>
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<td>UC-1.21 Choose Seating</td>
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<td>UC-1.22 Choose Seating</td>
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<td>UC-1.23 Choose Seating</td>
<td>7 FP</td>
<td>100%</td>
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<td>UC-1.24 Choose Seating</td>
<td>7 FP</td>
<td>100%</td>
<td>7 hours</td>
</tr>
</tbody>
</table>

**Total Required Functional Size**

- **Origins of Learning Opportunities**
  - Total Learning Hours: 165 days
  - Total Learning Time: 3319 hours

**Total Implemented Functional Size**

- **Origins of Mistakes and Improvements**
  - Total Testing Hours: 136 days
  - Total Testing Time: 3319 hours

**Product Delivery Rate**

- PDR = 9.7 hours / FP

---

### Measurement Program

- **VoC**
  - Total Cost of VoC
  - % Cost for Learning Time

- **RD**
  - Total Cost of RD: Elicitation
  - % Cost for Learning Time
  - Origins of Learning Opportunities
  - Total required Functional Size

- **PI**
  - Total Cost of PI: Reviews and Refactoring
  - % Cost for Bug Removal
  - Origins of Bugs found
  - Total Functionality delivered

- **VER & PI**
  - Total Cost of Construction
  - % Cost for Reviews and Refactoring
  - Origins of Mistakes and Improvements
  - Total implemented Functional Size

---

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**Customer’s Needs Profile**

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

**Weights for Profile:**
- VOC Customer Questionnaire
- Market Share & Competition
- Kano Analysis

**Use Cases**

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

#### Deployment Combinator

- Easy access to the movie theatre ticket shop
- Let user select date and time of the performance
- Graphically represent the theatre for seat selection
- Select tickets and confirm purchase (with push-button)
- Print movie tickets at the home printer (no refund)
- Record ticket printing and feed purchases into accounting
- Manage several movie theatres
- Manage performances
- Show remaining seat status per performance
- Create statistics and reports

#### Customer's Needs

<table>
<thead>
<tr>
<th>VoC-F.1</th>
<th>Trendy Program</th>
<th>2.8</th>
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<td>1</td>
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<td>99</td>
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#### Cost Profile of Use Cases

- 1.0
- 2.1
- 2.1
- 2.3
- 1.6
- 1.6
- 0.7
- 1.8
- 0.9
- 0.5

#### Solution Profile for Use Cases

- 1.5
- 1.4
- 2.2
- 2.0
- 1.8
- 1.7
- 1.3
- 1.6
- 0.8
- 0.9

#### Convergence Factor

- 0.07

#### Effect. Deviation

- 0.10

#### Convergence Range

- 0.20

#### Process Maturity Gap

- 0.09

#### Convergence Limit

- 0.50

### Use Case Profile

<table>
<thead>
<tr>
<th>Use Case</th>
<th>Transaction Type</th>
<th>UFP Count</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>UC-1.1 Login</td>
<td>EI</td>
<td>3</td>
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<tr>
<td>UC-1.1 User Directory</td>
<td>EIF</td>
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<tr>
<td>UC-1.2 Browse Movie Theaters</td>
<td>EQ</td>
<td>3</td>
<td>100%</td>
</tr>
<tr>
<td>UC-1.2 Browse Performances</td>
<td>EQ</td>
<td>3</td>
<td>100%</td>
</tr>
<tr>
<td>UC-1.2 Movie Theaters</td>
<td>ILF</td>
<td>7</td>
<td>50% 50%</td>
</tr>
<tr>
<td>UC-1.2 Movie Tickets</td>
<td>ILF</td>
<td>7</td>
<td>50% 50%</td>
</tr>
<tr>
<td>UC-1.2 Performances</td>
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<td>33% 33% 33%</td>
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<td>UC-1.2 Web Reservation</td>
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<td>UC-1.3 Display Seat Availability</td>
<td>EO</td>
<td>7</td>
<td>100%</td>
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<tr>
<td>UC-1.3 Seat Occupancy Status</td>
<td>EQ</td>
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<td>100%</td>
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<tr>
<td>UC-1.3 Seat Selection</td>
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<td>100%</td>
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<td>UC-1.3 Ticket Office</td>
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<td>UC-1.4 Calculate Price</td>
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<td>100%</td>
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<td>UC-1.4 Confirm Payment</td>
<td>EI</td>
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<td>UC-1.4 Local Time</td>
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<td>100%</td>
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<td>UC-1.4 Show Pricing</td>
<td>EQ</td>
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<td>100%</td>
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<td>UC-1.5 Payment Fulfillment</td>
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<td>UC-2.1 Accounting</td>
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<td>UC-2.1 Show Bookings</td>
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<td>100%</td>
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<td>UC-2.2 Configure Seats</td>
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<td>UC-2.3 Input Program</td>
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<td>UC-2.3 Modify Program</td>
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<td>UC-2.4 Performance Status</td>
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<tr>
<td>UC-2.5 Provide Statistics</td>
<td>EO</td>
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**Total UFP:** 136
Technical Features

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

Technical Profile

Deployment Concept

<table>
<thead>
<tr>
<th>Use Case</th>
<th>TS-1.1 Easy access to the movie theatre ticket shop</th>
<th>TS-1.1.1 Simple content updating interface</th>
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</thead>
<tbody>
<tr>
<td>TS-1.2</td>
<td>Let user select date and time of the performance</td>
<td>TS-1.2.1 Publishes content within time constraint</td>
</tr>
<tr>
<td>TS-1.3</td>
<td>Graphically represent the theatre for seat selection</td>
<td>TS-1.3.1 Using standard component interface</td>
</tr>
<tr>
<td>TS-1.4</td>
<td>Select tickets and confirm purchase (self-pick-up)</td>
<td>TS-1.4.1 Proposes alternate seating if fully booked</td>
</tr>
<tr>
<td>TS-2.1</td>
<td>Credit Card or Debit Card</td>
<td>TS-2.1.1 Credit Card or Debit Card</td>
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<td>TS-2.2</td>
<td>Batch file transaction interface</td>
<td>TS-2.2.1 Batch file transaction interface</td>
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<td>TS-3.1</td>
<td>Graphical seat selection</td>
<td>TS-3.1.1 Using standard component interface</td>
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<td>TS-3.2</td>
<td>Seat assignment</td>
<td>TS-3.2.1 Smart assignment algorithm avoiding widows</td>
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<td>Provides traceability</td>
<td>TS-5.1.1 Business transactions are traceable avoiding dispute</td>
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<td>TS-5.2</td>
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<td>TS-5.3</td>
<td>Strategic success</td>
<td>TS-5.3.1 Success factors are identified by statistical means</td>
</tr>
</tbody>
</table>

Process Maturity Gap

Convergence Factor

Optimum Effect Profiles

(COSMIC Function Points)

0.06 0.17

0.13 0.17 0.06
Feature Cost – COSMIC Functional Size Units

### Functional Size Units (FSUs)
- **TS-1 Web Server**
  - Content Publishing: 1.4 FSUs
  - Content Scheduling: 1.0 FSUs
  - Authentication: 0.5 FSUs
  - Transaction Log: 1.1 FSUs
- **TS-2 Billing**
  - Transaction Handling: 1.4 FSUs
  - Accounting: 1.5 FSUs
  - Fraud detection: 2.0 FSUs
- **TS-3 Seating**
  - Graphical seat selection: 1.6 FSUs
  - Seat assignment: 1.0 FSUs
  - Seat grouping: 1.2 FSUs
- **TS-4 Printing**
  - Supports all browsers: 1.2 FSUs
  - Records ownership: 0.6 FSUs
  - Legal validity: 1.0 FSUs
- **TS-5 Administration**
  - Provides traceability: 1.4 FSUs
  - Trend analysis: 0.4 FSUs
  - Strategic success: 0.7 FSUs

### Application Test Methods
- **TS-1 Web Server**
  - Login
  - Invalid User
  - User Directory
  - Invalid User
  - Browse Movie Theaters
  - Save all theaters entered (see UC-1.2 Movie Theaters)
  - Browse Performances
  - See all performances entered (see UC-1.2 Performances)
  - Movie Theaters
  - Contains all attributes needed for describing when the ticket is valid
  - Movie Tickets
  - Tickets contain all information the visitor needs to know (time, location, title)
- **TS-2 Billing**
  - Transaction Handling
  - Checks whether all required performance data is available
  - Fraud detection
  - Checks whether all required performance data is available
- **TS-3 Seating**
  - Graphical seat selection
  - Each seat has pricing schema assigned
  - Seat Selection
  - In sync with UC-1.3 Seat Occupancy Status
- **TS-4 Printing**
  - Ticket Office
  - Receipts confirmed by visitor
  - Price is correct
- **TS-5 Administration**
  - Provides traceability
  - Trend analysis
  - Strategic success

### Application Test Cases

#### RD-1 Easy access to the movie theatre ticket shop
- UC-1.1 Login
- UC-1.1 User Directory
- UC-1.2 Browse Movie Theaters
- UC-1.2 Browse Performances
- UC-1.2 Movie Theaters
- UC-1.3 Seat Selection
- UC-1.3 Seat Occupancy Status
- UC-1.4 Calculate Price
- UC-1.4 Theatre Payment
- UC-1.4 Confirmate in a unique button dialog
- UC-1.4 Local Time
- UC-1.4 In sync with DB
- UC-1.4 Prepay Payment
- UC-1.4 Offers all available payment methods
- UC-1.4 Select Tickets
- UC-4.1 Tickets can be deselected and reservations freed (UC-1.3 Ticket Office)
- UC-1.5 Print Tickets
- UC-1.5 Print Tickets can be deselected and reservations freed (UC-1.3 Ticket Office)
- UC-1.6 Show Printing
- UC-1.6 Price is correct
- UC-1.6 Payment different
- UC-1.6 Acknowledges successful payment
- UC-1.7 Print Tickets
- UC-1.7 Always confirmed by visitor
- UC-2.1 Accounting
- UC-2.1.1 All end-of-day income corresponds to tickets sold
- UC-2.1.2 Show Bookings
- UC-2.1.3 In sync with UC-1.3 Seat Occupancy Status
- UC-2.2 Configure Seats
- UC-2.2.1 Block seat (no printing) schema assigned
- UC-2.3 Legal 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
- UC-2.4 Performance Status
- UC-2.4.1 Report is complete
- UC-2.5 Provide Statistics
- UC-2.5.1 Fixed time range
Predicting LeOR

### 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
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!

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
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

Thank You.