Lean Aerospace Initiative
Plenary Workshop

Key Characteristic Maturity Model

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MIT

Research Sponsored By Lean Aerospace Initiative
Presentation Outline

- Key Characteristic (KC) Overview
- Benchmarking and KC Maturity Model
- Company Assessment Using KC Maturity Model
  - KC practices for enhanced supplier interaction
**Key Characteristics**

Critical few product features that significantly affect the quality, performance, or cost of the product.

Critical parameters that cannot withstand variation – thus causing a loss (rework, scrap, repair, or failure).
<table>
<thead>
<tr>
<th>System</th>
<th>Subsystem</th>
<th>Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Automotive</strong></td>
<td>Door Sealing</td>
<td>Door shape – Frame shape</td>
</tr>
<tr>
<td><strong>Aircraft</strong></td>
<td>Horizontal Stabilizer -- Contour</td>
<td>Main Torque Box -- Contour Angle</td>
</tr>
<tr>
<td><strong>Defense Electronics</strong></td>
<td>Night vision goggle image resolution</td>
<td>Image Intensifier tube S\N ratio</td>
</tr>
<tr>
<td><strong>Copier</strong></td>
<td>Copy uniformity</td>
<td>Film voltage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Power supply current</td>
</tr>
</tbody>
</table>
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KC Levels

System KCs

Subassembly KCs

Feature KCs

Contour

Aerodynamics

Torque Box Contour

Skin Gap

Height

Angle

Distance

Angle
Variation risk management involves identification, assessment, and mitigation.
Key Characteristic
Research Topics at MIT

- Capturing Design Intent Using Key Characteristics
  - Mark Ardayfio
- Aligning Organizational Structures and KC Processes
  - Basak Ertan
- KC Methods: Utilization of KC Tools and Techniques
  - Don Jay
- Variation Risk Management for Key Characteristics
  - Tony Chen
  - Young J Jang
- KC Maturity Model
  - KC Group

Research Approach

- **Data Gathering**
  - 15 Site Interviews (86 people)
  - 2 Key Characteristics Symposia
  - 3 Intern-based Assessments

- **Develop KC Maturity Model**
  - Tool to qualitatively evaluate the maturity of KC efforts within an organization
  - 22 supporting practices for assessment
    - Description of practice
    - 4 levels of maturity
    - Relationship of the practices

- **Company assessments**
  - KC Maturity Model Survey
  - Questionnaire
**KC Maturity Model**

**Areas of Assessment**

- **KC Definitions and Methods**
  - KC Identification Phase
  - KC Definition and Methods
  - KC Validation
  - KC Prioritization
  - Documentation
  - Modeling
  - KC Flowdown

- **Organization**
  - Customer Interaction
  - Integrated Product Teams
  - Supplier Interactions
  - Management Support
  - Incentive Structures
  - KC Training
  - Existence of KC Objectives

- **Measurement and Feedback**
  - Measurement Plans
  - Capability Feedback
  - Capability Uncertainty

- **Design Process**
  - Design Changes/Robust Design
  - New Technology
  - Cost Tradeoffs
  - Reuse/Legacy Data
  - Tolerancing & Dimensioning
## KC Maturity Model Example: Process Capability Feedback

<table>
<thead>
<tr>
<th>Process Capability Feedback</th>
<th>Level</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definitions</td>
<td>Not used at all</td>
<td>Reactive</td>
<td>Semi-Proactive</td>
<td>Fully Proactive</td>
<td></td>
</tr>
<tr>
<td>The process by which historical data on process capability is made available to functional organizations outside the manufacturing group.</td>
<td>No feedback into design.</td>
<td>Capability fed back when problems occur.</td>
<td>SPC data captured and recorded for a variety of features, but data is hard to find and isn't used throughout the organization.</td>
<td>SPC data fed back to design, updated, and is available electronically in a form that is simple to incorporate in a design.</td>
<td></td>
</tr>
</tbody>
</table>
Surveyed Companies

- **Aerospace**
  - Boeing (Commercial, D&S, St. Louis, Long Beach)
  - Northrop Grumman
  - British Aerospace
  - Lockheed Martin (JSF)
  - AlliedSignal Engines
  - Pratt & Whitney
  - Textron
  - ITT (Aerospace/Communications)

- **Non Aerospace**
  - Ford
  - GM
  - Chrysler
  - Xerox
  - Eastman Kodak

- KC Assessment Sample Size 25
- Additional Survey Sample Size 41
What were issues examined

- Differences between Aerospace companies and Non Aerospace companies
- Existence of organizational support and processes
- Consistency in definitions and methods
- Usage of process capability
- ...

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Is process capability from suppliers used in new designs, derivative designs, and redesigns?

- Comparison of Aerospace to Non Aerospace companies
- Comparison of Internal to External suppliers
- Level and stage of supplier interaction
Process Capability Feedback

The process by which historical data is made available to functional organization outside of the manufacturing group.

<table>
<thead>
<tr>
<th>Maturity Level</th>
<th>Percentage of Respondants</th>
</tr>
</thead>
<tbody>
<tr>
<td>0: Not used at all.</td>
<td>&lt;10%</td>
</tr>
<tr>
<td>1: Reactive</td>
<td>10-20%</td>
</tr>
<tr>
<td>2: Semi-proactive</td>
<td>20-30%</td>
</tr>
<tr>
<td>3: Fully Proactive</td>
<td>&gt;30%</td>
</tr>
</tbody>
</table>

- **No data requested.**
- **Data requested only when problems occur.**
- **Data fed back but hard to find and use.**
- **Data fed back, updated, and is available electronically in a easy to use form.**

Source: KC Maturity Model Survey
What % of the time is KC supplier data fed back to the organization?

Source: Additional Questionnaire
how often is KC supplier data reused by design?

Source: Additional Questionnaire
Internal Process Capability Feedback

What % of the time is internal capability data fed back to the organization?

Source: Additional Questionnaire
Internal Process Capability
Reuse

How often is internal capability data reused by design?

Source: Additional Questionnaire
The interaction between the supplier and the product development organization.

- Suppliers are integrated into IPT to evaluate producibility during design.
- Suppliers brought in at end of design to verify producibility.
- Suppliers brought in only if problems occur.
- Drawings and designs handed over the wall.

Source: KC Maturity Model Survey
Conclusions

- To reduce late design iterations due to variation quality problems, suppliers need to be proactively included in early stages of KC identification.

- The successes in KC implementation which non-aerospace companies have experienced needs to be translated to aerospace companies.

- KC Maturity Model provides an indication of where a company is and direction for continuous improvement.
**Other Practice Results from KC Maturity Model Survey**

<table>
<thead>
<tr>
<th>Practice Area</th>
<th>Aerospace Level</th>
<th>Non Aerospace Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existence of Objectives</td>
<td>Level 1</td>
<td>Level 2</td>
</tr>
<tr>
<td>KC Definitions and Methods</td>
<td>Level 1</td>
<td>Level 2</td>
</tr>
<tr>
<td>Management Support</td>
<td>Level 1</td>
<td>Level 2</td>
</tr>
<tr>
<td>KC Training</td>
<td>Level 1</td>
<td>Level 2</td>
</tr>
<tr>
<td>Incentive Structures</td>
<td>Level 1</td>
<td>Level 2</td>
</tr>
<tr>
<td>Customer Interaction</td>
<td>Level 1</td>
<td>Level 3</td>
</tr>
</tbody>
</table>
Research Deliverables

- **KC Maturity Model**
  - Description of the Practices
  - Proposed Core of Practices

- **KC Survey Data**

- **Case Study**
  - Importance of Information Flow and Team Structure to Successful KC Implementation

- **LEM will be linked to KC Maturity Model**
Next Steps

- **Disseminate best practices**
  - System view of variation
  - Modeling and simulation techniques to prioritize and validate KC selection
  - Selection of appropriate variation mitigation techniques

- **Wider testing of KC Maturity Model**

- **Develop solutions to gaps in current practices**
  - Clear objectives, common definitions, and improved methods KC implementation
  - Tools to enable a system view to variation
  - Tools to enhance communication and documentation throughout the process and organization
Relationships

* Matrix represents the observed dependencies that support the recommended order of implementation