Contemporary Design Processes and Related Issues

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Presentation Overview
- Objective: To Provide Examples of Engineering Design Processes Currently in Use
  - Highlight Similarities to the Methods We Have Been Taught
  - Address other Associated Contemporary Issues

Features
- Benefits of a Defined Development Process
- The Theory of Inventive Problem Solving (TRIZ Method)
- Linking Teams With the Web
- Importance of Using a Knowledge Based Process
- Internationalization and Outsourcing
- Case Study
- Do's of the Design Process

Why is a Well-Defined Development Process Needed?
- Quality Assurance - Phases and Checkpoints
- Coordination - Master Plan which Defines Roles of Each Team Member
- Planning - Timing of Milestones Give Concrete Schedule
- Management - Comparing Actual Events to Established Process can Identify Possible Problem Areas
- Improvement - Careful Documentation Helps Identify Opportunities for Improvement

Different Development Processes for Different Situations
- Market Pull - Begins with Market Opportunity, then Finds Appropriate Technologies to Satisfy Need
- Technology Push - Begins with New Technology and Finds Appropriate Market
- Platform - New Product Built Around Established Technological Sub-Systems
- Process Intensive - Product is Highly Constrained by Production Process
- Customized - Products are Slight Variations of Existing Configurations

Mission Statements
- Brief Description (One Sentence)
- Key Business Goals
- Target Markets
- Assumptions and Constraints that Guide Development
- Stakeholders
Example Mission Statement

5 Step Method for Identifying Customer Needs
- 1) Gather Raw Data from Customers
- 2) Interpret Raw Data in Terms of Customer Needs
- 3) Organize the Needs into a Hierarchy
- 4) Establish Relative Importance of Needs
- 5) Reflect on Results and Process

Gathering Raw Data from Customers
- Three Commonly Used Methods
  - Interviews, Focus Groups, Observing Product in Use
- Choosing Customers
  - Lead Users Identify Needs More Efficiently
- What Happens When There are Several Different Customer Groups?
- Identifying Latent Needs

Interpreting Raw Data in Terms of Customer Needs
- Express the Need in Terms of WHAT the Product has to do, not in Terms of HOW it Might do it
- Express the Need as Specifically as the Raw Data
- Use Positive, not Negative, Phrasing
- Express the Need as an Attribute of the Product
- Avoid the Words “MUST” and “SHOULD”

Interpreted Customer Needs for Cordless Screwdriver

Organize the Needs into a Hierarchy
- Eliminate Redundant Statements
- Group Needs According to Similarity
- Create Label for Each Group
- Identify Primary, Secondary and Tertiary (if Necessary) Needs of Each Group.
Establish the Relative Importance of Needs

- 2 Basic Approaches
  - 1 - Consensus of Team Members Based on Experience with Customers
  - 2 - Further Customer Surveys
  - Trade Off – Cost and Speed vs. Accuracy

Reflect on Results and Process

- Have we interacted with all important customer types in market?
- Can we see beyond needs related to existing products to determine latent needs of our customers?
- Which of the customers we used would be useful as a consultant later in the development process?
- Are we surprised by any of the needs?
- Is there any further investigation needed?

Product Specifications

- Product Specifications are the Precise Description of What the Product has to Do
- After Identifying Customer Needs, the Design Team Sets TARGET Specifications
- After Concept Selection and Testing, the Design Team Sets FINAL Specifications

Establishing Target Specifications

- Prepare List of Metrics, Using Needs-Metrics Matrix, if Necessary.
- Collect the Competitive Benchmarking Information.
- Set Ideal and Marginally Acceptable Target Values for Each Metric.
- Reflect on the Results and the Process.

Target Specifications for Bicycle Suspension Fork

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The TRIZ Method (History)

- The Theory of Inventive Problem Solving
  - Developed by Genrich S. Altshuller
  - Screened Over 200,000 Patents
  - Observation: Over 90% Eng. Probs. Solved Before
  - Conclusion: Most Solutions Can Be Derived From Knowledge Already in Industry
Overview of the TRIZ Method

Steps 1-3: Identify and Formulate the Problem

- Identification: Based on Operating Environment, Resource Requirements, Primary Function, Harmful Effects, etc.
- Formulation: Could Improving One Characteristic Worsen Another One?

Overview of the TRIZ Method

Search for Previously Well-Solved Problem

- Find the Contradicting Principles (Metrics)
- Find the Metric that Needs to Improve
- Find the Metric that has a Negative Effect

Overview of the TRIZ Method

Adapt Solution Based on Analogous Solutions

- Altshuller Developed 40 Primary Inventing Principles
- Look at Table of Contradictions
  - Undesirable Metrics on X-axis
  - Metric to Improve on Y-axis
  - Inside of Intersecting Cells, are the Appropriate Inventive Principles to Use for the Solution
Examples of Inventive Principles

- Segregation
- Asymmetry
- Combining
- Counterweight
- Inversion
- Periodic Action

Table of Contradictions

Linking Teams With the Web

Connecting Teams

- Communication Among Team Members is Important to Keep the Design Process Moving Forward
- Daily Team Meetings are Difficult, and Sometimes Impossible to Coordinate
  - Conflicting Schedules, Geographic Obstacles

The Old Process

- The Old Multi-Team Process Involved Handing Information Between Departments
  - Involved a Lot of Waiting Time in Other Departments
  - Wastes Time, Money, and Resources

The Solution

- Many Companies Began Implementing an Electronic Billboard System
  - Allows for Decisions to be Made in a Timely and Cost-Effective Manner
  - Ensures Input From Every Group Member
  - Includes Representatives From Every Department in Every Step of the Project
Electronic Billboard

- Allows Easy Tracking of Information About the Product
  - Project Manager Can View Timeline Progression, and Costs of the Design Process
- Staff Can Enter Completed Data Daily and Descriptions of the Process
- Companies that Used this System Saw a 20-50% Increase in Efficiency

Drawbacks

- With Pure Online Meetings, it is Difficult to Develop a Basic Operating Structure and a Set of Ground Rules for the Design Process
- Studies have Shown that Individual Activity and Interaction Increases Among Teams Who Meet in Person

NASA - Negative Outcomes

- X-33
  - Unmanned Demonstrator for Reusable Launch Vehicles
  - $75 Million Over Budget, 1 Year Behind Schedule
  - Eventually Terminated
- Space Launch Initiative
  - Half Scale Demonstrator
  - Indefinitely postponed Systems Readiness Review

NASA - Negative Outcomes (continued)

- Comet Nucleus Tour
  - Mission to Visit Two Comets and Gather Data
  - $159 Million Spacecraft Crashed
  - Inadequate Systems Engineering Processes
- Prometheus I
  - Develop Nuclear Power as a Propulsion System
  - Project Deferred Over Cost and Technology Concerns
U.S. Government Accountability Office Findings

- NASA Should Apply a Knowledge Based Acquisition Framework
- Main Concern is Sufficient Level of Maturity for Technology
- NASA Policy Does Not Require Major Decision Reviews During Product Development

Knowledge Based Acquisition Life Cycle

Technology Maturity Levels

What Can be Learned from the GAO Report

- Sufficient Subsystem Development
  - Technology Maturity
- Employ Multiple Process Checks
  - Knowledge Points

Internationalization and Outsourcing

- Outsourcing: Def. Management and/or Day-to-Day Execution of an Entire Business Function by a Third Party Service Provider
- Application to Engineering Design Process
  - Technology Outsourcing
  - Project Outsourcing

Technology Outsourcing

- Def. Sourcing of Technological Knowledge for Developing New Products and Processes from Outside a Firm
- Advantages
  - Domestic Technology Shortages
  - Lower Costs of R&D Personnel
  - Access to Qualified R&D Personnel
- Disadvantages
  - Increased Communication & Transaction Costs
  - Costs of Maintaining Secrecy
  - Slowed R&D Processes
**Technology Outsourcing**

- Risk Factors
  - Small Number of Suppliers
  - Uncertainty
  - Relatedness
  - Measurement Problems
  - Degree of Expertise

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**Project Outsourcing**

- **Def.** Sourcing of Product Development from Outside a Firm

- Internationalization Driven by:
  - Discontinuous Technological Change
  - Increasing Cost of R&D
  - Globalization and Lower Cost of Production in Less-Developed Countries

- Distinct Impact on Organizational Learning

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**Project Outsourcing; Impacts on Organizational Learning**

- **Internal Development Projects**
  - Knowledge is Architectural, Tacit
  - Learning is Synthetic

- **Outsourced Projects**
  - Knowledge is Explicit and Component-Based
  - Learning is Analytic

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**Why is This Important?**

- **With Outsourcing:**
  - Internal Architectural Knowledge is Limited
  - Product Modifications
  - Developing New, Related Products
  - Chance of Guile Increases

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**Case Study: “Spike”**

- Automatic Number Plate Recognition System (License Plate Camera)
- Designed by PIPS Technology
- Won the “Queen’s Award for Innovation” in 2005.
- Attribute Success to Effective Design Process

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**“Designing for Excellence”**

- Creativity: Paramount, Not Easily Managed
- Design Methodology: Series of Cyclic Steps that Continually Assess and Evaluate Concepts Based on Continual Knowledge Acquisition; Iterative
- Early Stages of Extreme Importance: Commit 70-80% of Final Cost

- Expectations, Restraints, and Needs Referred to Collectively as Concerns (Analogous to Metrics)
- PIPS Based on “Thorough and Early Understanding of User, Manufacturer, and Market Concerns”
- Concerns Continually Modified as Knowledge is Gained and Observations are Made

*“Design is a journey and leaving the house without an overnight bag including toothbrush, towel, shower gel, toothpaste and a clean set of clothes will only lead to disappointment.”*
The User
Understanding and Designing for the User at all Stages of the Game

- "There are Users at all Stages of the Product Life Cycle"
  - ATSMI (Assembly, Test, Service, Manufacture, International Sale)
  - Market
  - End User
- Empathic Consideration of Concerns with Respect to Different Users: "Intellectual Backpack"
- Compromise
- Matrix of Relationships

Decisions, Decisions...

- Revisions to the Compromise Matrix are Almost Always Necessary
- Too Much Revision can Cause Matrix to become Chaotic
- Effort Must be made for Effective Concern Evaluation, So Design Changes can be Kept to a Minimum Once the Team Moves from the "Fluid" Stage to the "Semi-Viscous" Stage.
- By Using Compromise Matrix, Designer can Deduce Most Important Concerns and Design Around Them
- Concept Product is Evaluated with Respect to Necessary Concerns: Fulfilled, Unfulfilled, Surpassed

Case Study Summary

PIPS Spike Design was Successful for Several Reasons:
- Effective Management of Innovation and Creativity
- Decisions Directly Linked to Empathic Knowledge of User Wants and Needs (Concerns)
- Constant Reevaluation of Concerns During the "Fluid" Stages of the Design Process
- Strict Adherence Defined Engineering Approach:
  - "A systematic approach to integrated product development that emphasizes response to customer expectations and embodies team values of cooperation, trust and sharing in such a manner that decision-making proceeds with large intervals of parallel working by all life-cycle perspectives, synchronized by comparatively brief exchanges."

The Do’s of Product Design

- Understand What Your Customers Want
  - Do Not Just Assume That You Know What They Want; Ask Them What They Want
- Produce Features and Technology Based on Consumer Input
  - Do Not Over-Engineer \( \Rightarrow \) Raises Costs

The Do’s of Product Design

- Develop and Manufacture on Time
  - Need to Meet Deadlines in Order to Develop a Competitive Product
- Streamline the Process to Get to the Product Development Stage
  - Use an Effectively Managed and Structured Process
The Do's of Product Design

- Create High-Quality Information Management
  - Good Collaboration Will Result in Shared Information at Every Step of Product Development, and Ensure Efficiency

Noted Resources

- Benefits of a Defined Development Process

- The Theory of Inventive Problem Solving (TRIZ method)

- Linking Teams With the Web

- The Impact of Internationalization on the Technology Sourcing Performance of High-Tech Business Units.

- Importance of Using a Knowledge Based Process


- Case Study

- Color Picture of the Spike Camera taken from the official PIPS website: http://www.pipstechnology.com/camera.asp?mode=eu&index=151