Agenda Lecture 6
Jan 29, 2015

Some thoughts on Process, Innovation and Rehabilitation Engineering
The idea of Process

• A series of actions or steps taken in order to achieve a particular end.
• What are some of the processes in daily life?
Life Processes
What are the processes in a business?
Business Processes
These boil down to three

• Strategic Processes
• Product Development
• Make/Sell/Collect
What is the Product Development Process?

- Systematic way of creating new products
- Set of discrete steps from studying/understanding a customer need to actual design and test to transferring a design to manufacturing
What is the Product Development Process?

• By being systematic and learning from repetition we achieve
• Higher success probability with
• Shorter time for design and
• Less effort required and
• Less resources (lower costs) and
• Sustainable (more predictive) results
What Has Changed
In The Way We Develop Products?

• Information enabled
• Outsourcing and Globalization
• Stronger Customer focus
• Rise of new start-ups- Entrepreneurialism and Faster access to capital
• Fast Manufacturing
• First time success (6 sigma)
What Has Changed In The Way We Develop Products?

• Higher Quality (meets specs)
  – Durability
  – Reliability
  – Functionality
  – Accessible to user

• Rapid prototyping/3D printing

• Fast and approximate with rapid iteration
A proactive idea-generating system
A focal point
Identify sources
Access sources inside & outside the company

Preliminary market assessment
Preliminary technical assessment
Preliminary financial assessment
Recommendations & Plans for Stage 2

User needs-and-wants study
Competitive analysis
Market analysis
Detailed technical assessment
Concept test
Financial analysis
Develop business case:
  * Product definition (Protocol)
  * Project justification
  * Project plans (Stage 2 & beyond)
The Product Development Process

1. Needs identification
The Product Development Process

1. Needs identification
2. Context Discovery

1. Marketing
The Product Development Process

1. Needs identification
2. Context Discovery
   2. Manufacturing
The Product Development Process

1. Needs identification
2. Context Discovery
3. Technology
The Product Development Process

1. Needs identification
2. Context Discovery
4. Core Competencies
The Product Development Process

1. Needs identification
2. Context Discovery
5. Financial Objectives and Financial Constraints
The Product Development Process

3. Concept Selection
The Product Development Process

4. Ideation (Brainstorming)
The Product Development Process

5. Concept Development
The Product Development Process

6. System Specification
The Product Development Process

7. Architectural Decomposition
The Product Development Process

8. Product Plan
The Product Development Process

9. Detailed Development
The Product Development Process

10. Systems Integration and Test
The Product Development Process

11. Pre-production
The Product Development Process

12. Ramp up
The Product Development Process

13. Field Support
Funnel for *early* part of process

Lots of ideas

Only a few emerge
Funnel for *later* part of process

A few ideas

Only 1(or 2) emerges
• Product Development is not deterministic
Product Development is not deterministic

Rapid iteration and prototyping
Process early stages

- Product Development is not deterministic
- Rapid iteration and prototyping
  - Tests early concepts repeatedly
Process early stages

- Product Development is not deterministic
- Rapid iteration and prototyping
  - Tests early concepts repeatedly
  - Cycles of learning
Process early stages

- Product Development is not deterministic
- Rapid iteration and prototyping
  - Tests early concepts repeatedly
  - Cycles of learning
  - Raises success probability by testing concepts cheaply
Process early stages

- Product Development is not deterministic
- Rapid iteration and prototyping
  - Tests early concepts repeatedly
  - Cycles of learning
  - Raises success probability by testing concepts cheaply
  - Avoids downstream surprises
Process later stages

• Detailed design and later
  – Success probability of moving to the next step is high
  – Number of alternatives you are working on is few
  – End stage failure is rare
DFX or Design For (lots of stuff)

A good product development process is characterized by the inclusion of anticipatory team-driven tasks which will

• Avoid downstream surprises
• Cause the product to meet specifications

1. Performance
2. Quality
3. Cost
4. Time to market
Design For “X” (DFX) cont.

- Performance
- Cost
- Quality
  - Minimization of “Cost of Poor Quality”
- Time
- Reliability
  - How does it survive
  - Consider unintended customer use
  - Adaptability to various use conditions
- Serviceability
  - Ease of repair/replace
Design For “X” (DFX) cont.

• Societal Constraints
  – Compliance with Regulatory Agencies
  – All other Legal constraints (International?)
  – Intellectual property protection
  – Industry Standards

• Environmental
  – Safety
  – Pollution and toxicity
  – Safety of use and manufacture
  – Disassembly
  – Recycling and disposal
  – Reuse/remanufacture

• Ethical issues
  – Product
  – Process
Design For “X” (DFX) cont.

Customer alignment
• Meets Customers’ needs
• Promotion strategy, plan and literature
• Gets the product to the customer
  — Distribution
  — Sales
  — Marketing
• Time to market
• Packaging and Labels
Design For “X” (DFX) cont.

- Human Factors
- User-Friendliness
- Ergonomics
- Aesthetics
- Instructions and Training
Design For “X” (DFX) cont.

Producability
• Make/buy
• Choice of supplier
• Integration of new manufacturing into previous manufacturing process with minimum disruption and capitalization costs
• Maximum responsiveness to surges (and declines!) in demand
• Ease of Assembly/Manufacturability /Modularity
• Parts minimization
• Testability
• Standardization
Design For “X” (DFX) cont.

- After market Support and Servicing
  - Training of factory personnel, sales force, customers. Documentation
  - Maintainability
  - Spare Parts availability
  - Logistics
  - Upgradability
  - Shelf life and Storage
  - Installability
  - Warranties
Rate these Product Development Processes

• Drug Delivery
• JPL
• Smart Phone
• Wheelchair
• Robotic Walker
• Apps
Metrics

• Speed
• Cost
• Quality
• Performance
Some observations

• Much more attention is spent in building an effective product then in scaling the product to a large market

• Issues of scalability can be considered up front and imbedded into the product design
  – These can include
  – Distribution Partnerships
  – Manufacturing scale-up through multiple replication

• Building these partnerships can be much more difficult than building the original product.
DFX

• What we have discussed is the bare minimum of the issues arising in product design
• We will go into more detail as the course evolves
• We will try to build “new science” by creating a tool which will aid subsequent students in designing rehabilitation products
Innovation
CHARACTERISTICS OF SUCCESSFUL Innovating Organizations

• Systematic collection of all impulses that could lead to innovation
• Creativity of participants/culture
• Ability to evaluate the possibility of the innovation idea
• Good team work
• Project-based approach and ability to manage projects
CHARACTERISTICS OF SUCCESSFUL Innovating Organizations

• Cooperation with external experts (Stakeholders)
• risk-taking
• Motivation (tolerance of failure)
• Focus
Definition of innovation (Technical)

- New products and processes or
- Modifying existing products and processes and
- Introduced to the market or
- Changed Production process or
- Changed Marketing process
Innovation

• **Product innovation**
  
  A good or service that is new or significantly improved
  
  – Performance
  
  – Components and materials
  
  – Software in the product
  
  – User friendliness
  
  – Cost

• **Process innovation**
  
  – production or delivery method. This includes significant changes in techniques, equipment and/or software.

• **Marketing innovation**
  
  – A new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing.

• **Organizational innovation**
  
  – business practices, workplace organisation or external relations.
Innovation

• Product, Process or Marketing

• Sometimes Context changes – Enablers such as computation, data availability, zero cost of memory, cultural or social change
DEGREE OF NOVELTY

- Incremental innovations
- Radical innovations
- Systemic innovations
## Classification of innovations

<table>
<thead>
<tr>
<th>SYSTEM</th>
<th>COMPONENT</th>
<th>SYSTEM IMPROVEMENT</th>
<th>COMPONENT IMPROVEMENT</th>
<th>COMPONENT IMPROVEMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>New series of cars, planes, computers, TV</td>
<td>Improvement of components</td>
<td>New generation (MP3 and download as substitution of CD)</td>
<td>New components for existing systems</td>
<td>Steam engine, ICT, biotechnology, nanotechnology</td>
</tr>
<tr>
<td>New generation (MP3 and download as substitution of CD)</td>
<td>New components for existing systems</td>
<td>Improved materials improving component properties</td>
<td>Advanced materials improving component properties</td>
<td></td>
</tr>
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<td>Steam engine, ICT, biotechnology, nanotechnology</td>
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<td>Advanced materials improving component properties</td>
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</tr>
</tbody>
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**INCREMENTAL**
- „do better what we already do“
- „new for the company“

**RADICAL**
- „new for the world“
INNOVATION PROCESS

• Research and development (R&D)
• Production
• Marketing

Innovation is an opportunity for something new, different. It is always based on change.

Innovators do not view any change as a threat but as an opportunity
FOCUS for this Class

• Don’t try to plough the sea
• Honor/develop stakeholders. partners
• Recognize your limitations (partner is Apple)
• Balance short/long term
• Rethink how to do things
• Appreciate risk but don’t be overwhelmed by fear
Focus for this Class

1. Solve the correct problem correctly – be effective and efficient
2. Manage innovation as a project
3. Analyze risks
4. Use models, scenarios, computer simulation
5. Study examples of successful and unsuccessful innovation projects - particularly in your space
Focus for this Class

6. Iterate the project and your thoughts rapidly as new information is acquired.

7. Fast and approximate beats slow and exact.
WHAT TO DO

1. Start with analysis and study of opportunities.
2. Go among people, ask questions, listen
3. Effective innovations are surprisingly simple. They must be focused on specific needs and on specific final products.
4. Effective innovation starts on a small scale.
5. A successful growth innovation always tries to win a leading position, otherwise you create opportunities for your competitors.
WHAT TO AVOID

1. Don’t try to be too “clever”. All that is too sophisticated will almost certainly go wrong.

2. Don’t try to do too many things at once. Focus on the core (or an important aspect) of the general problem.

3. Don’t try to make innovations for the future but for today. An innovation can have a long-term impact but there must be an immediate need for it.
Three conditions for innovations

1. Innovation means work, hard, concentrated and thorough work. If these qualities are lacking then there is no use for the big talent, cleverness or knowledge.

2. Successful innovations must build on your strong points. The innovation must be important to the innovator.

3. Innovation must focus on a market, must be controlled by the market (market-pull).
• We have begun
Brief one sentence description of the product

- **Key business goals**
  - Timing
  - Profitability
  - Market share

- **Target Markets for the product**
  - Primary
  - Secondary

- **Assumptions that constrain the development effort**

- **Stakeholders**

Work iteratively!
Creativity

- Present at all stages of the Process
- Economic Analysis
- Project Planning
- Consider Process front end
- Identifying Customer Needs
- Establishing Target Specs
- Analysis of Competitive products
  - Concept generation
  - Concept selection
  - Spec Refinement
# Levels of Inventive Problems and Their Solutions

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>PROBLEM LEVEL</th>
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</thead>
<tbody>
<tr>
<td>1. Invention Level</td>
<td></td>
</tr>
<tr>
<td>Weakest</td>
<td>Weak</td>
</tr>
<tr>
<td>Moderate</td>
<td>Strength</td>
</tr>
<tr>
<td>Strong</td>
<td>Strongest</td>
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<tr>
<td>2. Trials per Invention</td>
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<tr>
<td>1-10</td>
<td>10-100</td>
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<tr>
<td>100-1000</td>
<td>1000-10,000</td>
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<tr>
<td>&gt; 10,000</td>
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<tr>
<td>3. % of all Global Patents</td>
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<tr>
<td>32</td>
<td>45</td>
</tr>
<tr>
<td>19</td>
<td>3.7</td>
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<tr>
<td>0.3</td>
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<tr>
<td>4. Technical Conflict Present in Problem?</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Clear Technical Conflict</td>
<td>Invisible Technical Conflict</td>
</tr>
<tr>
<td>Group of Contradictions</td>
<td></td>
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<tr>
<td>5. Problem Selection</td>
<td></td>
</tr>
<tr>
<td>Problem was already available</td>
<td>Problem chosen was one of several</td>
</tr>
<tr>
<td>Initial problem was changed</td>
<td>New task was found</td>
</tr>
<tr>
<td>New problem was found</td>
<td></td>
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<tr>
<td>6. Knowledge base required to solve</td>
<td></td>
</tr>
<tr>
<td>Within one specialty area</td>
<td>From one branch of technology</td>
</tr>
<tr>
<td>From other branches of technology</td>
<td>From rarely applied effects of physics &amp; chemistry</td>
</tr>
<tr>
<td>As of yet undiscovered knowledge is required</td>
<td></td>
</tr>
<tr>
<td>7. Degree of change in objects in the system, or the system itself</td>
<td></td>
</tr>
<tr>
<td>Almost no changes</td>
<td>Only slight changes</td>
</tr>
<tr>
<td>Significant changes</td>
<td>Changes completely</td>
</tr>
<tr>
<td>Supersystem changes</td>
<td></td>
</tr>
<tr>
<td>8. Degree of scientific or technical influence</td>
<td></td>
</tr>
<tr>
<td>No influence</td>
<td>Slight</td>
</tr>
<tr>
<td>Influences</td>
<td>Great influence</td>
</tr>
<tr>
<td>Revolutionary influence</td>
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</table>
Functional Performance of a Technical System

Time

Infancy

Rapid Evolution

Maturity

Old Age

Where would you put

Semiconductors
Automobiles
Big Data
Biotech
Aerospace
Communications
Computers
Toys
Agriculture
Education

New
What are examples of Breakthrough technologies?
Where to look for Breakthrough Products

• Rapidly evolving underlying or enabling technology (Smart phones, Biotech)
• Product which serve areas of rapid social/economic change (meet new needs)
• Clearly recognizable problem with current products (e.g. air bags, traffic congestion, personal device profusion)
• Bottleneck products (clothes dryers)
• Bottleneck parts (e.g. batteries)
• Niche areas in developing countries which have not gotten attention
• Exploit diffusion lag of new technologies into developing countries
“The formulation of a problem is far more essential than its solution which may be merely a matter of mathematical or experimental skill”

- Albert Einstein

ask what problem you are trying to solve
Rehabilitation Engineering and Engineering Product Design

Some thoughts
Buy/Use Sequence (after Cooper p 14)

• Consumer provided with assistive device based on clinical or personal selection process
• Often based upon limited information about the device
• Consumer uses device - not completely satisfied - until device is obsolete and is then abandoned
• Consumer selects another device which meets some of the shortcomings of previous device but has problems of its own . . .
• Etc.
Buy/Use Sequence (after Cooper p 14)

• Problems avoided by working with consumers early in design process from concept stage
• Consumers should be full partners through process
• Because of specificity of needs, there will remain the need for one-off products
• When people have a complex set of issues they may require more than one device
• But the devices have been separately optimized and do not play well together
• Lack of standardization amongst designers