Managing the Innovation Process

Development Stage:
Technical Problem Solving,
Product Design & Engineering
Managing the Innovation Process – The Big Picture

Source: Lercher 2016, 2017
The Frontend of Innovation (FEI)

Source: Lercher 2016, 2017
Implementation and Project Phase
Development Stage

The Front End (FEI) vs. New Product (Service) Development

Opportunity → Ideas → Discovery (ideation and concept development) → Innovative Concepts → Realization → Invention → Nurture / Knowledge

Products / Services (market launch)

FEI activities are less structured and less predictable ("fuzzy")

Development activities can be structured by a formalized and prescribed set of activities

Based on Wheelwright / Clark 1992
**Concept:** A bundle of elaborated ideas. It is a verbal or prototype statement of what is going to be changed and how users stand to gain. Concepts include a statement about the primary features (user benefits) and the form of the intended innovation, combined with a broad understanding of the technology needed.

**Prototype:** A model built to communicate and/or test a product or process concept or to act as an object to be replicated or learned from. It is used to evaluate a new design by its users or internal experts to enhance its precision.

**Invention versus Innovation:**

An **invention** is something “new” (to the market, to the firm, to the world). An **innovation** is something new successfully adopted by its users (internal or external customers) or otherwise exploited by its originator.
Tasks of the development stage

The underlying activity of the development stage is to turn the concept into reality.

Disciplined problem solving:

Searching for solutions | “Trial and Error” learning
State of the art | Experimentation
Knowledge | Creativity
Transferring benefits into features via functions

**Benefits (needs)** are provided by **functions (form)** which are enabled by **features (technologies)**

<table>
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<tr>
<th>Example of a laptop computer</th>
<th>Technologies/Features</th>
<th>Form/Functions</th>
<th>Needs/Benefits</th>
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<tr>
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<td>Hard Drive</td>
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<td></td>
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<td>Data storage</td>
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</tbody>
</table>
What is a functional element (functions)?

- The functional elements of a product are the individual operations and transformations that contribute to the overall function of a product
- Requirements or functions (what the product does)
- Usually expressed as a [verb, noun] pair

**Function ≠ technologies (features, physical elements)**

The form of a product is embodied by physical elements which comprise the parts, components, and sub-assemblies that ultimately implement each function.

Functional elements combine to form a function structure which dictates what the product does at an abstract level.
Functions are not a technology

A “job” is a stable factor over time – products or services are temporary solutions which are evaluated based on their contribution to a solution.

**Job:** Listen to recorded music.

**Outcomes:**
As many selectable tracks as possible. Finding a track as fast as possible. Ordering tracks in playlist as fast as possible. Delete a track as fast as possible.

Customers intuitively apply three kinds of criteria to evaluate a solution:
- time required, (effort)
- error margin,
- productivity (outcome).

Different solutions over time -- outcomes, however, are constant over time! which dictates what the product is.
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Development Stage: Product protocol
Transferring the PIC into a Product Protocol

The Product Protocol...

... is one of **top success factors** distinguishing winning from losing projects

... involves **more than technical aspects**:
  - guidance for **technical development process** and **marketing activities**

... **sets standards**:
  - agreement among the functions about the required output or deliverables
  - easier to manage the process against specific targets, incl. timing importance

... **has the purpose** the create commitment and alignment in the project team!
Product Protocol

1. Target market
2. Product positioning
3. Product attributes (benefits)
4. Competitive comparison
5. Augmentation dimensions
6. Timing
7. Marketing requirements
8. Financial requirements
9. Production requirements
10. Regulatory requirements
11. Corporate strategy requirements
12. Potholes

Why Have A Product Protocol? – Integrate & Focus!

Source: Crawford & Di Benedetto, 2014
Managing the Development Process: What needs to be done, when, why, how, by whom,… ?

Purpose of the Product Protocol

WHY
- Determine
  - What do marketing and R&D groups need to do their work?
    - Identify key deliverables
    - Required outputs (as product benefits and other dimensions)
- Communicate
  - Integrate all players’ actions
- Set boundaries
  - Development process
  - Cycle time and milestones
  - Regulatory or financial requirements
Example of the product protocol: Power Nailer

Source: Ulrich / Eppinger 2011

Cordless electric roofing nailer
Example of the product protocol: Power Nailer

As stated before, the challenge was to “design a better hand-held roofing nailer.” The scope of the design problem could have been defined more generally (e.g., “fasten roofing materials”) or more specifically (e.g., “improve the speed of the existing pneumatic tool concept”). Some of the assumptions in the team’s mission statement were:

- The nailer will use nails (as opposed to adhesives, screws, etc.).
- The nailer will be compatible with nail magazines on existing tools.
- The nailer will nail through roofing shingles into wood.
- The nailer will be hand-held.

Based on the assumptions, the team had identified the customer needs for a hand-held nailer. These included:

- The nailer inserts nails in rapid succession.
- The nailer is lightweight.
- The nailer has no noticeable nailing delay after tripping the tool.

The team gathered supplemental information to clarify and quantify the needs, such as the approximate energy and speed of the nailing. These basic needs were subsequently translated into target product specifications. The target specifications included the following:

- Nail lengths from 25 millimeters to 38 millimeters.
- Maximum nailing energy of 40 joules per nail.
- Nailing forces of up to 2,000 newtons.
- Peak nailing rate of one nail per second.
- Average nailing rate of 12 nails per minute.
- Tool mass less than 4 kilograms.
- Maximum trigger delay of 0.25 second.

Source: Ulrich / Eppinger 2011
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Development Stage: Systematic problem solving
Tasks of the development stage

The underlying activity of technical product development (design) is "trial and error" learning, based on explicit or implicit experimentation of the development team.

Systematic problem solving

"Fail often in order to succeed sooner." – One of IDEO’s mottos

"Enlightened trial and error succeeds over the planning of the lone genius.”
Peter Skillman, 25 year veteran of creative product design, innovation and team leadership.

More general, design (with the result of the final concept or final prototype) should be a systematic process of internal and external search and the systematic exploration and combination of these inputs into a desired output.
Problem solving has two components:

1. **Search process** based on prior experience
2. **Trial-and-error-learning**

Five-Step-Process of Concept Development according to Ulrich & Eppinger

- **Step 1**: Clarify the Problem
- **Step 2**: External Search
- **Step 3**: Internal Search
- **Step 4**: Explore Systematically
- **Step 5**: Reflect on the Results and the Process

Systematic problem solving: Step 1
Step 1: Clarify the Problem

Input:
- Product Protocol
- Tested concepts and attributes

→ iterative process of further refinement

Decomposition of a complex problem into sub-problems by
- Function
- Sequence of user actions
- Key customer needs

Select sub-problems that are
- most critical to the success
- most likely to benefit from new and creative solutions

Functional decomposition into sub-functions
- Rule of thumb: 3-10
- Describe without technical specifications

Alternative problem decomposition by
- sequence of user activities
- classes of customer needs
Example: Designing a Coffee Maker

1. Understand the functions of the product

Overall Function

Supporting Sub-Functions

Auxiliary Functions

Source. T. Simpson & O. de Weck, MIT
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Systematic problem solving: Step 2
Step 2: External Search

Objective: Find **existing solutions** and get **background knowledge** for internal problem solving

**Sources of external input:**
- Idea database, internal experts
- Technical literature, databases
- Consult experts
- University cooperation
- Interview Lead Users, search in user forums (Netnography)
- Benchmark related products (reverse engineering)
- Search patents

**Open innovation**

A new focus on external search:
- Profit from external knowledge
- External actors, firm’s periphery
- Supplement (not substitute) conventional practices of internal search

**Absorptive capacity:** Firms need to **establish mechanisms** (*bridging strategies*) to **access input** from external actors and to **manage an interactive collaborative value creation process**.
2. External search for existing ideas and solutions

One of the most advanced innovations developed by coffee enthusiasts in online communities is called “PID’ing” of espresso machines.

For this innovation a digital screen is added as a control panel to the espresso machine, enabling to control machine temperature to the exact degree by the digital device.
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Systematic problem solving:
Step 3
Step 3: Internal Search

Objective: **Use of individual and team knowledge and creativity to create solution concepts**

**Activity of experimentation**

**Means to generate internal input:**
- Creativity techniques
- Methods of systematic problem solving (TRIZ, QFD)
- Consult internal experts
- Internal crowdsourcing
- Search internal databases
  - …

**Four guidelines of successful internal search (creation):**
- Suspend judgment
- Generate a lot of ideas, iterate often!
- Infeasible ideas are welcome
- Use graphical and physical media

**Basic rules of engaging in creative problem solving:**
- Make analogies
- Wish and wonder
- Use related stimuli
- Use unrelated stimuli
- Set quantitative goals
- Use the gallery method
- Trade ideas in a group
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Systematic problem solving: Step 4
Step 4: Explore Systematically

As a result of the internal and the external search activities, the team will have collected many concept fragments – each offering solutions to sub-problems. These fragments need to be organized and synthesized, in order to receive a complete concept.

**Concept Classification Tree** helps to divide the possible solutions into independent categories.

**Concept Combination Table** ("morphological matrix / box") supports process of selecting certain combinations of solution fragments.
4. Explore all identified technical solutions per (sub)function systematically

A way to capture this information is a “Morphological Matrix (Box)"

- Search for solution principles to fulfill sub-functions
  - Identify as many solutions for each sub-function and auxiliary functions as possible

- Combine solutions to embody physical concepts
  - Use morphological matrix to identify combinations of solutions
  - Each combination of solutions will fulfill overall function

- Use expertise and heuristics to eliminate infeasible solution combinations

Source. T. Simpson & O. de Weck, MIT
Step 4: Explore Systematically

As a result of the internal and the external search activities, the team will have collected many concept fragments – each offering solutions to sub-problems. These fragments need to be organized and synthesized, in order to receive a complete concept.

Guidelines to make concept combination easier:

- **Eliminate concept solution fragments** as they become infeasible to reduce complexity

- **Focus concept combination table on those sub-problems that are coupled** (whose solutions can be evaluated only in combination with solutions of other sub-problems)

- This often is the starting point for a modular product design
Modular product design and product family architecture

- **Modular design:** Subdividing a (product) system into smaller parts called **modules** (“chunks”), that can be independently created and then used in different systems.

- A modular system: **Functional partitioning the entire system (product)** into **discrete scalable, reusable modules**, rigorous use of well-defined **interfaces**, and making use of **industry standards** for interfaces.

- The objective is to better **meet demands for variety and to address heterogeneous customer or regulatory needs**.

- Designing a module-based product family involves defining multiple **product architectures** (Ulrich, 1995):
  - the arrangement of **functional elements** (function structure)
  - the mapping of **functional elements to physical components**
  - the specification of the **interfaces** among physical components

**Product family:** A group of related products that share common features, components, or subsystems (modules); and satisfy a variety of markets

**Product platform:** The module that remains constant from product to product within a given product family
Architecture of product
Scheme by which functional elements of product are arranged into physical chunks and by which chunks interact

Modular architecture:
- Chunks implement one or a few functional elements in its entirety
- Interactions between chunks are well defined and are generally fundamental to primary function of product

Integral architecture:
- Functional elements are implemented using more than one chunk
- Single chunk implements many functional elements
- Interactions between chunks are ill defined

Source: Robertson / Ulrich 1998
Creating a Module-Based Product Family

1. **Decompose products** into their representative functions

2. Develop modules with **one-to-one** (or many-to-one) correspondence with functions

3. Group common functional modules into a **common product platform**

4. **Standardize interfaces** to facilitate addition, removal, and substitution of modules

Source: T. Simpson & O. de Weck, MIT
Example: Designing a Coffee Maker

Source: T. Simpson & O. de Weck, MIT
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Systematic problem solving: Step 5
Step 5: Reflect on the Results and the Process

At the end, always reflect on what you did. Questions to ask are:

- Can we be confident that the solution space has been fully explored?
- Are there alternative function diagrams?
- Are there alternative ways to decompose the problem?
- Have all external sources been thoroughly pursued?
- Have ideas from everyone been accepted and integrated?
- Did we validate our sub-concepts by prototyping and testing with internal and external stakeholders?

Even though the reflection is placed at the end of this process, there should in fact be reflection throughout the whole process.

Also remember: In general, this is an iterative process!