

# Concepts in Engineering Design

Designing is about people planning and creating ways to produce things that achieve some known goals.

## Three types of Design – based on the product

*Novelty:* New tasks and problems that are realised by original designs incorporate new solution principles. These can be realised either by selecting and combining known principles and technology, or by inventing completely new technology. The term original design is also used when existing or slightly changed tasks are solved using new solution principles. Original designs usually proceed through all design phases, depend on physical and process fundamentals and require a careful technical and economic analysis of the task. Original designs can involve the whole product or just assemblies or components.

In *adaptive design*, one keeps to known and established solution principles and adapts the embodiment to changed requirements. It may be necessary to undertake original designs of individual assemblies or components. In this type of design the emphasis is on geometrical (strength, stiffness, etc.), production and material Issues.

## Three types of Design – based on the product

In *variant design*, the sizes and arrangements of parts and assemblies are varied within the limits set by previously designed product structures (e.g. size ranges and modular products). Variant design requires original design effort only once and does not present significant design problems for a particular order. It includes designs in which only the dimensions of individual parts are changed to meet a specific task. In [1 & 2] this type of design is referred to as *principle design or design with fixed principle*.

In practice it is often not possible to define precisely the boundaries between the three types of design, and this must be considered to be only a broad classification.

1. Opitz, H. und andere: Die Konstruktion – ein Schwerpunkt der Rationalisierung. Industrie Anzeiger 93 (1971) 1491–1503
2. Saling, K.-H.: Prinzip- und Variantenkonstruktion in der Auftragsabwicklung – Voraussetzungen und Grundlagen. VDI-Berichte Nr. 152. Dusseldorf: VDI-Verlag 1970

# Degree of Novelty of a Product

The tasks of designers can have different degrees of novelty. The majority of tasks are adaptations to and variations on existing designs. This does not imply that these tasks are less challenging for designers. For product planning, the following differentiation of design tasks is of interest:

- *Original design: New tasks and problems are solved using new or novel combinations of known solution principles.* Two different cases can be distinguished:
  1. An invention is something truly new and is often based on the application of the latest scientific knowledge and insights [1].
  2. An innovation is a product that realizes new functions and properties. This could be through novel or new combinations of existing solutions.

Pahl et al., Engineering Design: A systematic approach, Springer, 2007

# Degree of Novelty of a Product

*Adaptive design: The solution principle remains unchanged; only the embodiment is adapted to new requirements and constraints.*

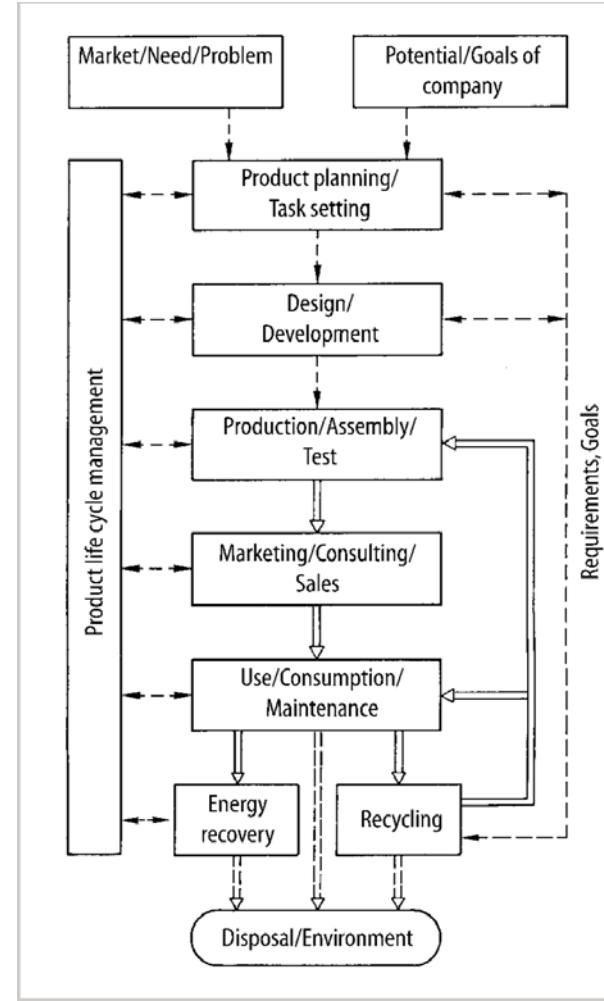
*Variant design: The sizes and arrangements of parts and assemblies are varied within the limits set by previously designed product structures, which is typical of size ranges and modular products .*

Pahl et al., Engineering Design: A systematic approach, Springer, 2007

# Life cycle of a Product:

In organisational respects, design is an essential part of the product life cycle. This cycle is triggered by a market need or a new idea. It starts with product planning and ends—when the product's useful life is over—with recycling or environmentally safe disposal. This cycle represents a process of converting raw materials into economic products of high added value. Designers must undertake their tasks in close cooperation with specialists in a wide range of disciplines and with different skills.

Figure 1: Life cycle of a product [Pahl et al., Engineering Design: A systematic approach, Springer, 2007]



## Product life cycle: economic view point

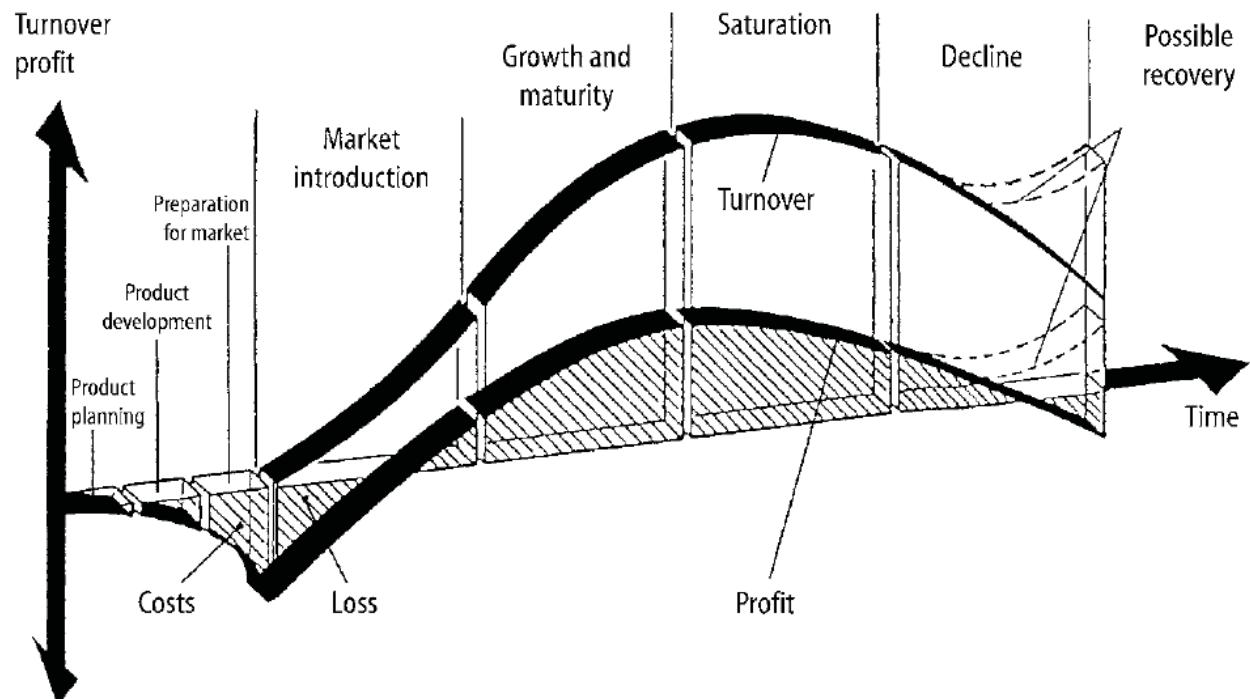


Figure 2: Product Life Cycle [Kramer, F.: Innovative Produktpolitik, Strategie – Planung – Entwicklung – Einführung. Berlin: Springer 1986]

# Product life cycle: economic view point

Every product has a life cycle (see Figure 1), as illustrated in Figure 2. This is based on an economic viewpoint showing turnover, as well as profit and loss.

The *cycle time depends strongly on the type of product and the branch of engineering*, but in general cycles times are becoming shorter. This trend is likely to continue. This has a large effect on work in the design and development department because the time allocated for tasks that are identical, or very similar, to previous ones is reduced. As a consequence, it is necessary to adapt the product development process.

Measures to reactivate the market or generate new products have to be introduced when the saturation phase has been reached, at the latest. The introduction of these measures is an important task of product monitoring. A related activity in this context is the development of market share.

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# Innovation

“Innovation is the successful exploitation of new ideas.”



<http://bgi.inventta.net/en/innovation/>

# Innovation

The concept of innovation is quite diverse, depending mainly on its application. Briefly, innovation is the successful exploitation of new ideas. And companies' success, for example, means increased revenues, access to new markets, increased profit margins, among other benefits.

Among the different possibilities to innovate, those related to product or process innovations are known as technological innovations. Other types of innovations can relate to new markets, new business models, new processes and organizational methods. Or even new sources of supply.

People often confuse innovation and innovation processes with continuous improvement and processes related to this topic. For an innovation to be characterized as such, it must cause a significant impact on the pricing structure, in the market share, in the company's revenue, etc.

Continuous improvements are not usually able to create competitive advantages of medium to long term, but they are able to maintain the competitiveness of the products in terms of cost.

# Types of Innovation – Focal object

The different forms of innovation can be classified in several ways.

Here we highlight two of these visions, as the innovation focal object and its impact.

## Focal Objectives of Innovation

### Product innovation:

It consists of changes in product attributes with a change in how the product is noticed by consumers.

Example: car with automatic transmission compared to “conventional” one.

### Process innovation:

It consists of changes regarding the product or the service production process. It does not necessarily have an impact on the final product but produces benefits in the production process, generally increasing the productivity and reducing costs.

Example: automobile produced by robots compared to that produced by human workers.

## Innovation of business model:

It consists of changes in the business model which means the way the product or the service is offered to the market. It does not necessarily imply changes in the product or even in the production process but in the way as it is brought to the market.

Example: the consumer rents a car paying a monthly fee to use the vehicle, including insurance, maintenance and replacement by newer model every year, compared to the traditional business model where the vehicle is sold.

# Types of Innovation – impact

## Innovation Impact

### Incremental Innovation:

It reflects small continuous improvements in products or product lines. It generally represents small improvements in benefits noticed by the consumer and it does not change significantly the business model or the way the product is consumed.

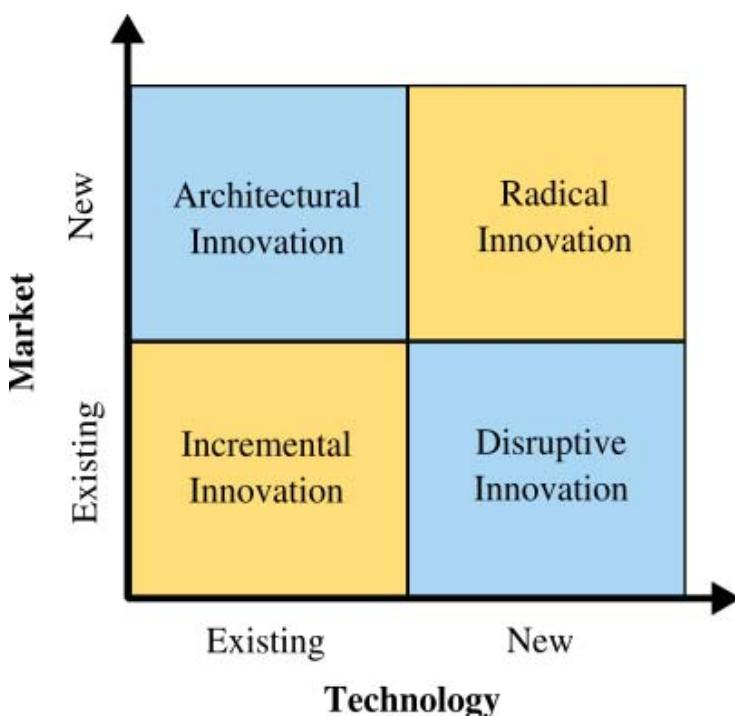
Example: the evolution of common CD to double CD, capable of storing twice as many tracks.

### Radical Innovation:

It represents a drastic change in the way that the product or the service is consumed. It generally, brings a new paradigm to the market segment that modifies the existing business model,

Example: the evolution of the music CD to digital files in MP3 extension.

# Types of Innovation – Technology and Market



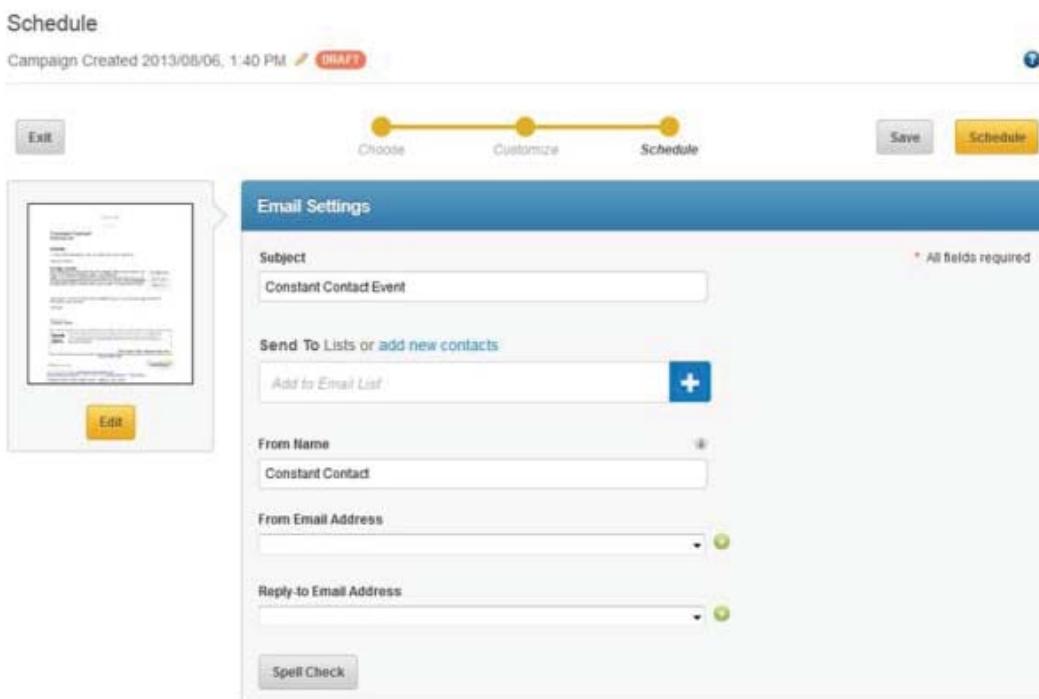
# Types of Innovation

## Incremental Innovation

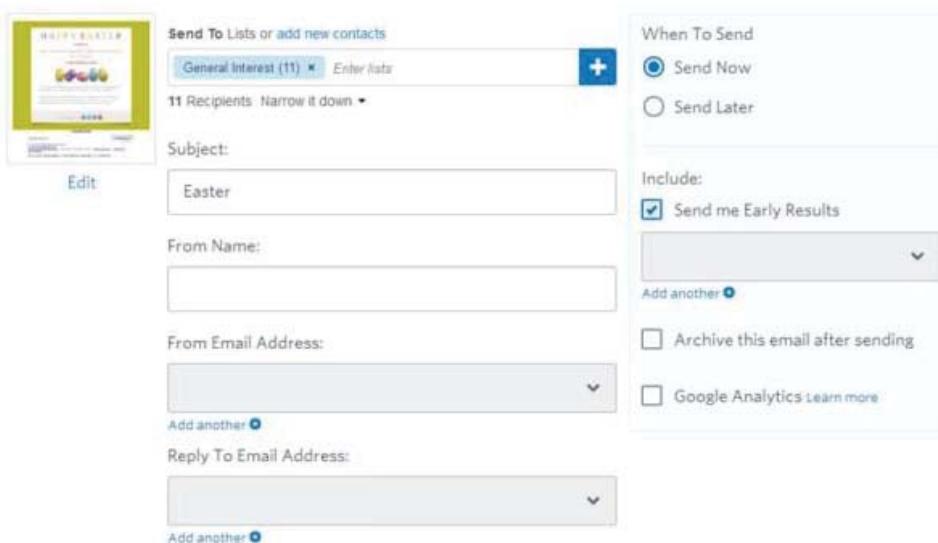
Incremental Innovation is the most common form of innovation. It utilizes your existing technology and increases value to the customer (features, design changes, etc.) within your existing market. Almost all companies engage in incremental innovation in one form or another.

Examples include adding new features to existing products or services or even removing features (value through simplification). Even small updates to user experience can add value, for example below is an older version of Constant Contact's email schedule page:

JUNE 29, 2015 BY [JORGE LOPEZ](#) FILED UNDER: [SOFTWARE DEVELOPMENT](#), [TECH TALK](#)  
[file:///D:/Courses/Design%20courses/Concepts%20in%20Engineering%20Design/Types%20of%20Innovation%20\\_%20Constant%20Contact%20Tech%20Blog.html](file:///D:/Courses/Design%20courses/Concepts%20in%20Engineering%20Design/Types%20of%20Innovation%20_%20Constant%20Contact%20Tech%20Blog.html)



There is nothing majorly wrong with this page, however it is easy to see that the page title is "Schedule", yet there are no schedule settings anywhere to be seen. In fact, in this version, you have to click on the yellow schedule button on the upper right-hand corner to actually pop up the schedule settings. In addition, there is a huge empty space on the right side of the page that does not contribute much value to the user. Below is a more current version of the same page:



The screenshot shows a user interface for creating an email campaign. At the top, it displays 'Campaign Created 2014/06/25, 8:48 AM' and a 'DRAFT' status with a save date of 'Last saved 8:48am on 6/25/14'. There are 'Save as Draft' and 'Schedule' buttons. The main area includes a preview of an 'EASTER' email template, a 'Send To' section with 'General Interest (11)' selected, a 'When To Send' section with 'Send Now' chosen, and various other campaign settings like 'Include' (checkbox for 'Send me Early Results'), 'Archive this email after sending', and 'Google Analytics'.

This updated version replaces the “Schedule” title with the title of the email campaign. This makes it easier for the user to see which campaign they are working on. Actual schedule settings have replaced the awfully huge empty space on the right-hand side, which makes it possible for the big yellow “Schedule” button to actually schedule. Also, larger sized form fields have been introduced to allow easy clicking on those elements. All these changes, which may seem as just updates, are actually small incremental changes focused on adding more value to an existing product. They will prove to be incrementally innovative if customers have a better experience with the product and are able to schedule email campaigns much easier.

## Types of Innovation

### Disruptive Innovation

Disruptive innovation, also known as stealth innovation, involves applying new technology or processes to your company’s current market. It is stealthy in nature since newer tech will often be inferior to existing market technology. This newer technology is often more expensive, has fewer features, is harder to use, and is not as aesthetically pleasing. It is only after a few iterations that the newer technology surpasses the old and disrupts all existing companies. By then, it might be too late for the established companies to quickly compete with the newer technology.

There are quite a few examples of disruptive innovation, one of the more prominent being Apple’s iPhone disruption of the mobile phone market. Prior to the iPhone, most popular phones relied on buttons, keypads or scroll wheels for user input. The iPhone was the result of a technological movement that was years in making, mostly iterated by Palm Treo phones and personal digital assistants (PDAs). Frequently you will find that it is not the first mover who ends up disrupting the existing market. In order to disrupt the mobile phone market, Apple had to cobble together an amazing touch screen that had a simple to use interface, and provide users access to a large assortment of built-in and third-party mobile applications.

# Types of Innovation

## Architectural Innovation

Architectural innovation is simply taking the lessons, skills and overall technology and applying them within a different market. This innovation is amazing at increasing new customers as long as the new market is receptive. Most of the time, the risk involved in architectural innovation is low due to the reliance and reintroduction of proven technology. Though most of the time it requires tweaking to match the requirements of the new market.

In 1966, NASA's Ames Research Center attempted to improve the safety of aircraft cushions. They succeeded by creating a new type of foam, which reacts to the pressure applied to it, yet magically forms back to its original shape. Originally it was commercially marketed as medical equipment table pads and sports equipment, before having larger success as use in mattresses. This “slow spring back foam” technology falls under architectural innovation. It is commonly known as memory foam.

# Types of Innovation

## Radical innovation

Radical innovation is what we think of mostly when considering innovation. It gives birth to new industries (or swallows existing ones) and involves creating revolutionary technology. The airplane, for example, was not the first mode of transportation, but it is revolutionary as it allowed commercialized air travel to develop and prosper.

The four different types of innovation mentioned here – Incremental, Disruptive, Architectural and Radical – help illustrate the various ways that companies can innovate. There are more ways to innovate than these four. The important thing is to find the type(s) that suit a particular company and turn those into success.

# Importance to Innovate



## Importance to Innovate

Whereas innovations are able to generate competitive advantages in the medium and long term, innovate is essential for the sustainability of the companies and the countries in the future.

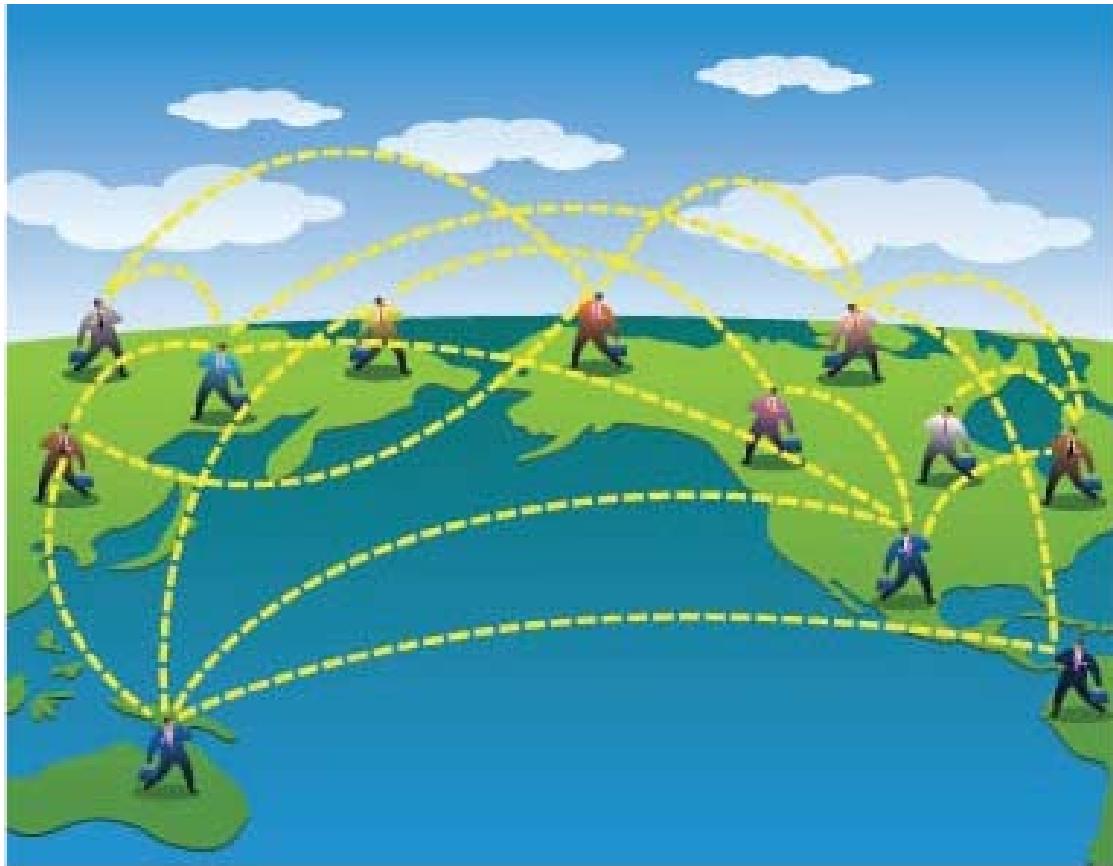
**“Those who innovate are at an advantage over the others.”**

Innovation has the ability to add value to company's products, differentiating it, even momentarily, in the competitive environment. Innovation is even more important in markets with plenty of commodities, such as the ones presenting a high level of competition and whose products are roughly equivalent between competitors. Those who innovate in this context, either doing incremental or radical, product, process or business model innovations, are at an advantage over the others.

Innovations are important because they allow companies to access new markets, increase revenues, perform new partnerships, learn new knowledge and increase the value of their brands.

Obviously, the benefits of innovation are not limited to the companies. Innovations enable countries and regions to increase the level of employment and income, as well as the access to the globalized world. Innovations offer new products that now have more benefits of the products offered.

# The dynamics of innovation



## The dynamics of innovation

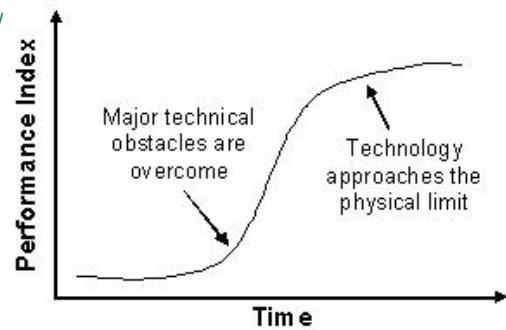
In general, companies are at the center of innovation. It is through them that technologies, inventions, products, finally, ideas come to the market. The vast majority of large companies have entire areas dedicated to innovation, presenting research and development (R&D) laboratories that have several researchers. Despite this central role played by the companies, the interaction between partners is essential. Without it, the innovations are hampered.

These partners have diverse functions, from conducting external research and development of products and processes, to the implementation of investments or subsidies, going through prototype development, market research and production scheduling.

Thus, a set of institutions form what are known as innovation system: universities, research centers, fostering agencies, investors, government, companies' customers, suppliers, competitors or other partners.

A trend that is becoming stronger is the open innovation model (or open innovation), where companies look outside of their R&D centers for ideas and projects that can help them add competitive advantages.

# The S-Curve Framework



In the innovation management field the S-Curve illustrates the introduction, growth and maturation of innovations as well as the technological cycles that most industries experience.

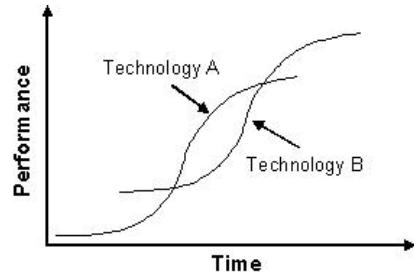
In the early stages large amounts of money, effort and other resources are expended on the new technology but small performance improvements are observed.

Then, as the knowledge about the technology accumulates, progress becomes more rapid.

As soon as major technical obstacles are overcome and the innovation reaches a certain adoption level an exponential growth will take place. During this phase relatively small increments of effort and resources will result in large performance gains.

Finally, as the technology starts to approach its physical limit, further pushing the performance becomes increasingly difficult, as the figure below shows.

# The S-Curve Framework



Consider the supercomputer industry, where the traditional architecture involved single microprocessors.

In the early stages of this technology a huge amount of money was spent in research and development, and it required several years to produce the first commercial prototype.

Once the technology reached a certain level of development the know-how and expertise behind supercomputers started to spread, boosting dramatically the speed at which those systems evolved.

After some time, however, microprocessors started to yield lower and lower performance gains for a given time/effort span, suggesting that the technology was close to its physical limit (based on the ability to squeeze transistors in the silicon wafer).

In order to solve the problem supercomputer producers adopted a new architecture composed of many microprocessors working in parallel.

This innovation created a new S-curve, shifted to the right of the original one, with a higher performance limit (based instead on the capacity to co-ordinate the work of the single processors).

# The S-Curve Framework

Usually the S-curve is represented as the variation of performance in function of the time/effort. Probably that is the most used metric because it is also the easiest to collect data for.

This fact does not imply, however, that performance is more accurate than the other possible metrics, for instance the number of inventions, the level of the overall research, or the profitability associated with the innovation.

One must be careful with the fact that different performance parameters tend to be used over different phases of the innovation, as a result the outcomes may get mixed together, or one parameter will end up influencing the outcome of another.

Civil aircraft provides a good example, on early stages of the industry fuel burn was a negligible parameter, and all the emphasis was on the speed aircrafts could achieve and if they would thus be able to get off the ground safely.

Over the time, with the improvement of the aircrafts almost everyone was able to reach the minimum speed and to take off, which made fuel burn the main parameter for assessing performance of civil aircrafts.

Overall we can say that the S-Curve is a robust yet flexible framework to analyze the introduction, growth and maturation of innovations and to understand the technological cycles.

The model also has plenty of empirical evidence, it was exhaustively studied within many industries including semiconductors, telecommunications, hard drives, photocopiers, jet engines and so on.

CUSTOMER NEEDS AND WANTS



# CONSUMER NEEDS AND WANTS

Sometimes a business is started to satisfy consumer needs.

Needs are things that are necessary for survival.

You *need* food, clothing.

# CONSUMER NEEDS AND WANTS

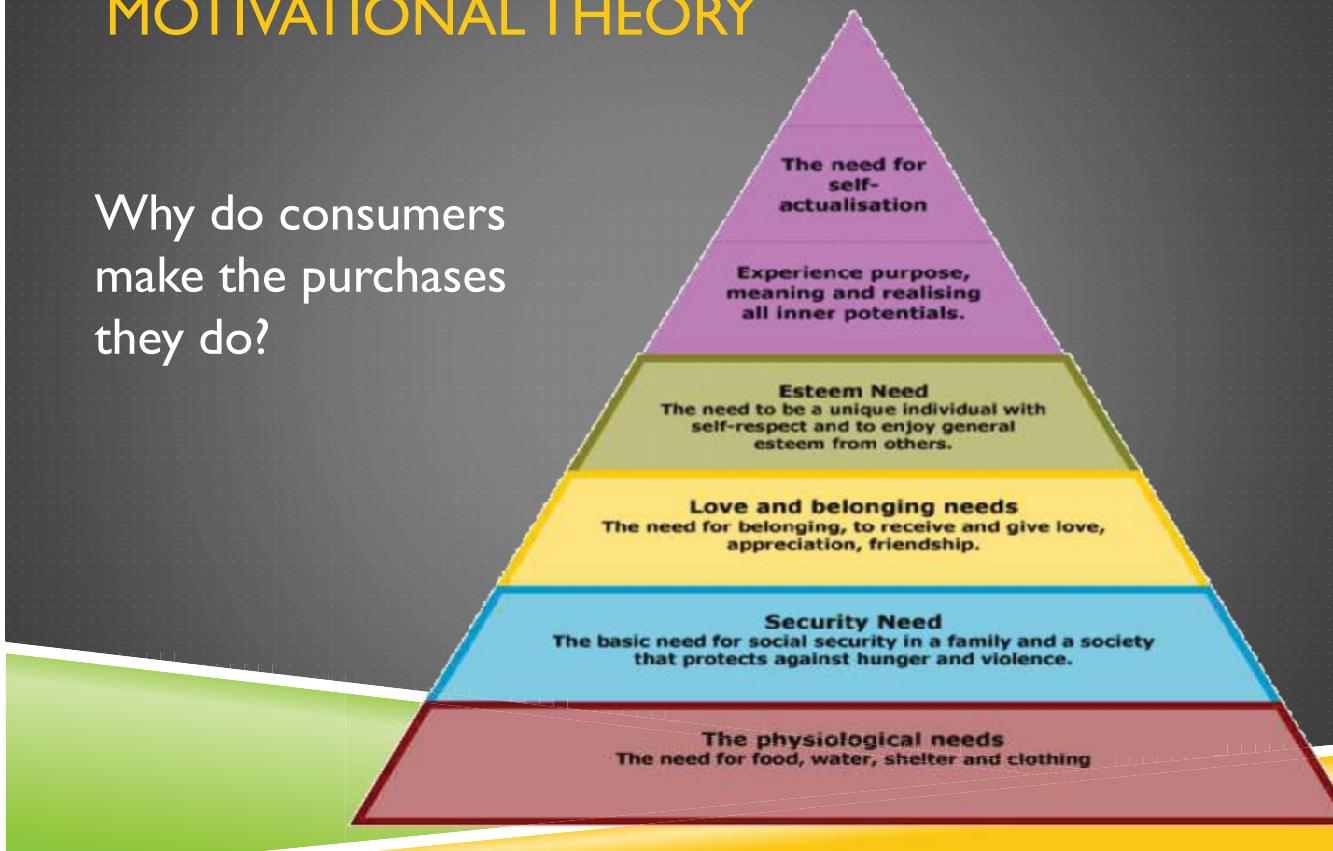
**Wants** are things that are not necessary for survival, but add comfort and pleasure to our lives.

You *want* a pizza, or new computer

# MASLOW'S HIERARCHY OF NEEDS

## MOTIVATIONAL THEORY

Why do consumers make the purchases they do?



## MASLOW'S HIERARCHY OF NEEDS

### ► **Physiological Needs**

The most basic needs that are vital to survival, such as the need for water, air, food, and sleep

### ► **Security Needs**

These include needs for safety and security. Examples: steady employment, health insurance, safe neighbourhoods, and shelter from the environment.

### ► **Social Needs**

Belonging, love, acceptance and affection. Example: friendships, romantic companionship, involvement in social, community, or religious groups.

# MASLOW'S HIERARCHY OF NEEDS

## ► **Esteem Needs**

The need for things that reflect on self-esteem, personal worth, social recognition, and accomplishment.

## ► **Self-actualizing Needs**

The need for personal growth without recognition or the opinions of others. Interest in fulfilling ones potential.

## MASLOW'S HIERARCHY AND CONSUMERS

### ► Consumers fit into one level of the pyramid

- The level you are at determines and influences your consumer habits

### ► Businesses need to recognize these needs and use them to identify their target market.

- Which stage is the consumer trying to achieve?
- Better able to advertise to satisfy those needs.
- Create products to satisfy needs.

## MASLOW'S HIERARCHY WHERE ARE YOU?

- ▶ Lets take a quick test to see where you fit on Maslow's hierarchy. *Don't worry you won't need to share your results.*
- ▶ Go to Blackboard and click on the link
- ▶ Take the quiz
- ▶ Think about these questions when you're done?
  - ▶ Do you think it is accurate?
  - ▶ How do you think this influences what you want/need?
  - ▶ How do you think this influences your consumer habits?

## BUSINESS AND THE CONSUMER

# BUSINESSES RELY ON CONSUMERS

- ▶ Many aspects of business depend on the role of the consumer
  - ▶ Supply and Demand
  - ▶ Pricing
  - ▶ Marketing
  - ▶ Production
  - ▶ Service

## ATTRACTING CONSUMER INTEREST

It is important to understand how consumers make buying decisions. This will help decide what to make, how to market and distribute the product.

Businesses need to listen to what the consumer wants or what they think they need.

The challenge is then to get those customers to buy your product.

# CUSTOMERS VERSUS CONSUMERS

- ▶ Customers **buy** products or services
- ▶ Consumers **use** the product or service
- ▶ It is a very small difference and often these terms are used interchangeably.

## FACTORS THAT INFLUENCE BUYING

# FACTORS THAT INFLUENCE BUYING INCOME

The amount of money consumers have to spend has a big influence on what they buy.

## Example: 4 Member Families Spending on Groceries

	Family #1	Family #2
Income	\$30,000	\$125,000
Amount Spent on Groceries per Year	\$4,800	\$9,600
Percent of Income Spent on Groceries	16%	7.7%

# FACTORS THAT INFLUENCE BUYING PRICE

Price is the most important consideration for consumers

- ▶ Consumers want good value for their money and won't spend more than what they believe an item is worth
- ▶ *What other factors do you look for in your purchase?*
  - ▶ Quality
  - ▶ Convenience
  - ▶ Service
  - ▶ Variety
  - ▶ Warranty

## FACTORS THAT INFLUENCE BUYING STATUS

- ▶ Some people buy goods because neighbours or friends have
- ▶ Some consumers purchase expensive items even when they can't afford them
- ▶ **Conspicuous consumption:** the desire to flaunt purchases to impress others

## FACTORS THAT INFLUENCE BUYING CURRENT TRENDS

- ▶ Usually applies to clothing
- ▶ Clothing creates an image is often seen as an indicator of status or popularity
- ▶ **Peer Pressure:** Being influenced by friends to buy something you don't really want

## FACTORS THAT INFLUENCE BUYING CUSTOMS AND HABITS

- ▶ Special occasions and holidays increase consumer spending
- ▶ People may also buy things due to habit:
  - ▶ Friday night dinner out
  - ▶ Saturday movie night
  - ▶ playing lottery
  - ▶ smoker vs. non-smoker

## FACTORS THAT INFLUENCE BUYING SAFETY

- ▶ Product safety has become a major issue to the public especially for cars, appliances, and children's items (cribs)
- ▶ The Canadian Standards Association (CSA) develops the standards for safety and certifies products

# FACTORS THAT INFLUENCE BUYING PROMOTION

- ▶ Advertising and promotion are designed to influence consumer spending
- ▶ **Lifestyle advertising:** showing attractive, healthy, successful and appealing people using the product or service that is being promoted. It is suggested that if you use the product your lifestyle will improve.

## FINAL THOUGHTS ATTRACTING CONSUMERS

- ▶ In Business and Marketing the task is to come up with a product the consumer needs or wants, at a price they're willing to pay, in a place that is convenient, and promote it so they know about it.
- ▶ Maslow's Hierarchy of Needs helps businesses identify their target market and understand peoples buying motivation.
- ▶ Income, Price, Status, Trends, Safety, Promotion, Customs and Habits are the most common factors that influence buying.