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Product Life Cycle Management
A Guide to New Product Development

I.Komninos, D. Milossis, N. Komninos

URENIO
URBAN AND REGIONAL INNOVATION RESEARCH
ARISTOTLE UNIVERSITY OF THESSALONIKI

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The material of the New Product Development Guide has been collected from various sources, referred in the guide content. URENIO was only responsible for the organization and editing of the material included. The original owners of the material are clearly referred in all chapters of this New Product Development Guide. This guide is also presented and organized in web form in the web site of the project NPD-NET (http://www.urenio.org/npd-net).

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INTRODUCTION

The existence and the course of a business in the form of a company, enterprise or corporation is directly linked with the course of its products. A business unit exists to sell products and as far as the product sales go well so is the business unit. Products like everything else in life have a certain life cycle. Each product goes through this life cycle and eventually dies out. Products, which were once a household name, have disappeared from the market as they entered the decline phase of their life cycle. So due to this fact the long-term operation of a business depends on the on going development of new products.

The rapid development of new technologies, the shift change in customer needs and attributes, and the gradual increase of the competition has forced all business to adopt New Product Development (NPD) as a necessary and unavoidable business practice. NPD is a complex and time-consuming process, which cannot be taken lightly, since it holds more perils than first meets the eye.

According to David S. Hopkins and Earl L. Baily[1] research has shown that 40% of new consumer products, 20% of new industrial products and 18% of new services related products have failed completely as products. Further research has shown that the new product failure percentage is even greater in countries outside the US.

To avoid development of a new product that will not be a success in a market and to minimize the costs of such a development a NPD Roadmap can be used. Such a roadmap is a tool that can help companies and organizations to successfully develop new products or upgrade existing ones through a series of logical steps, starting from the process of idea generation and ending at the launch of the product into a market.

This process contains a series of activities called "Levels" and control points, called "Assessments". Each Level contains information and well-defined series of activities concerned with the particular Level of the development and each Assessment is a decision point where senior management can keep on or stop funding the process. In more detail, a **Level** contains all the information and tools that are needed to successfully complete the particular Level and an **Assessment** contains the required questions or specifications or mandates to which the results of the previous Level are compared to so that a go / kill or hold decision can be made. In the next chapters each Level is analysed further, and all relevant information or tools that can be used are presented. All Assessments are given in Appendices. In the final chapters of this report the complete roadmap is presented including all Levels and Assessments.

Each Level is split up in sections that include **a definition of the problem** that the Level is asked to tackle, a **possible solution** to the problem and an **analysis of the tools** available to tackle the problem. Each tool is properly defined, the references, on-line resources, software sources and consultancies or organizations that can help to use the tool are given and case studies of where and how the toll has been used are presented in separate sections. All Assessments are designed to work

1 fn. David S. Hopkins and Earl L. Bailey, "New Product Pressures", Conference Board Record, June 1971, p. 16-24, mentioned by Phillip Kotler, "Marketing Management", ch. 12, 7th Edition, EMI/Interbooks, 1991.

interactively with a potential roadmap user. Also tools and templates developed are given for the same reason.

The roadmap presented can be used not only as an informative tool but also as a complete guide of a NPD process. The tools, best practices and other relevant material presented, explained and analysed further down in the report are in most cases given in the form of files linked to this document so that a reader can use them to perform his own NPD process. The true purpose and final scope of this report is to provide the means for the development of a complete on-line NPD roadmap. One should note that the roadmap itself would not be able to answer all the questions or tackle all the problems of such a process unless the final user enters information whenever this is required and based on analysis results move forward into the process.

NPD Stage 1: Idea Generation

Every new product and every new product development process starts with the **idea generation**. Idea generation is a process in which creative thinking is used to produce large amount of ideas for new products. It is very important that all ideas no matter how ludicrous or extreme may sound, to be gathered.

The idea generation process should be on - going, have a specific purpose, involve the whole of the company including its clientele, use a variety of methods, have one person in charge and not evaluate the gathered ideas. During the idea generation - gathering process one should not criticize the ideas of others, should be freewheeling and generate as many ideas as possible. The management of ideas is also very important at this stage due to the large number of ideas to be selected and their diversity.

Based on what said above the problem of this level is to generate as many ideas as possible and manage them in such a way that it will be possible and easy for screening them later on.

1.1 Tools & Solutions

Ideas for new products can easily come from the very customers of the company. This can be accomplished by gathering information about their needs and preferences. Then when all data is collected a series of tools can help the company quantify these needs and translate them into new product ideas.

Gathering the customer needs can be done easily using questionnaires either upon the purchase of an existing product, or over the phone (telephone research based on a clientele list) or through the Internet (on-line questionnaires). The golden rule in either case is to ask the proper questions that can give a complete picture of the customer needs. This idea gathering process can also be done in conjunction with a market research. A market research can give a present picture of the market, that the new product is indented, and future market trends.

In the case that a market research is used to identify customer needs, a market plan must be formed beforehand that will keep the research in focus and identify target groups, sampling methods, possible ways of data evaluation, objectives of research etc.

Company suppliers, dealers, middlemen or partners can also be an invaluable source of new product ideas, since they are the ones that come face to face with customers on a daily basis and can draw from them information about company products. The way that they are communicating with the customers, which is usually informal, can show aspects of customer needs that cannot be shown in any market research. Furthermore, in the case of geographically dispersed customers, where the market is differentiated from place to place, dealers and suppliers or partners are the only ones that can give an accurate picture of the market and subsequently of the customer needs.

Fairs, seminars, expos and shows that competitors participate are a good place of obtaining new product ideas for either completely new products or supplements of existing products or upgrades of existing products. These events are places that competitor creativity is at a full-scale show and new innovation techniques or new technologies can be observed. (See Competitive Intelligence)

Once customer, suppliers, middlemen, users, etc have expressed their wishes in respect to needs of a new potential product, all data collected can be put into tools such as Conjoint Analysis (CA), so that all customer wishes can be transformed into new product ideas and these ideas can be managed properly. Some of the tools used such as QFD can also be used in creation of product concepts from product ideas and come up with a final product plan.

Furthermore there are techniques or methodologies such as Brainstorming, Competitive Intelligence, Think Tanks, the Delphi process, the Kano maps and Triz which can be used to generate ideas or manage them with or without the use of data collected.

1.1.1 Brainstorming

Brainstorming in general is a very good technique of developing many solutions to a problem. In the case of product idea generation, brainstorming can produce broad and odd ideas that can be developed extremely fast. During brainstorming sessions no idea is criticized since the process tries to open possibilities and break down assumptions about ones idea generation limitations. Also judgment and analysis of ideas generated will probably shut down the whole generation idea process.

There are two distinctive types of brainstorming: Individual and Group Brainstorming. Each has its characteristics, strengths and weaknesses and both are analysed further bellow.

- **Individual Brainstorming** tends to produce a wider range of ideas than the group one. In this type, one has not to worry about other people's opinions and views and therefore can be more creative. However sometimes ideas generated cannot be developed effectively because there is no group help or experience.
- **Group Brainstorming** can be very effective as it uses the experience of the whole group to generate ideas. When a member of the group reaches its limits then another can always pick up the idea generation to the next stage. In this way group brainstorming can develop and generate ideas in more depth than the individual one.

Group brainstorming can be very dangerous for the individuals involved in it. One's good idea can be another one's stupid idea. To avoid individual humiliation and to run brainstorming sessions effectively there should be always someone to run the session as a leader who must do the following.

- Define the problem needed solving clearly.
- Keep all members of the group focused on the problem in hand.
- Keep criticism and evaluation at bay.
- Encourage the participation of all members.
- Stop long dragging of ideas.
- Encourage members to further develop or follow up on other people ideas.
- Keep track of all ideas generated so that nothing discussed is missed.

To sum up, brainstorming can generate radical ideas that can be developed quickly. Individual brainstorming can produce more ideas than group but it is not as effective. And finally rules must be set to manage group brainstorming.

1.1.1.1 Brainstorming Methods

1.1.1.1A. Affinity diagrams

Affinity diagrams are a good way of organizing data coming from customers or users. It is a useful tool for sorting and managing of a lot of data from customer research and makes full use of team participation in the development of customer oriented product definition. Having this in mind the tool can be used in organizing the customer needs and wants in the process of idea generation in Level 1 but also in selecting and developing a product concept in Level 2.

Typically the tool is used with personal interviews. From each interview the team can usually identify 10 to 100 statements, which are connected to a product. Each statement can be identified, by pinpointing the customer requirement hidden behind it. The Affinity Diagram permits customer needs to be organized based on clustering and through group discussion. The method of constructing Affinity Diagrams consists of five simple steps. These are given bellow.

Step1: Team formation. The generation of Affinity Diagrams is a group activity. So a group of people must be gathered for that reason. It is useful to split the group in pairs so that people can discuss their insights and confirm their thinking.

Step 2: Customer statements notation. Customer statements collected from interviews, observation or customer research are written separately on a post-it note. One should have in mind that these could be a lot. One colour should be used for the post-it notes at this point. Numbers or other means of reference should be placed on the notes so that the origin of each note can be traced.

Step 3: Statements grouping. Statements on post-it notes should be grouped. There are no specific rules on how this must be done but it is useful for someone to have some pre-determined headings for each group of interest at the beginning of the process. Headings should not contain words that the team is familiar with such as "quality", "speed", "price", etc. Typically there should be 5 to 6 statements at each group at the end of the process.

Step 4: Naming the groups. Each group or cluster of statements should be given a name that relates to the statements that are contained in the specific group. A good name is such that when reading it the team will have the feeling that the customer is talking directly to them. It should be direct and using immediate language. The group names should be written in different colour post-it notes.

Step 5: Cluster the groups. Groups of statements should be clustered together to form higher-level groups of statements. Again each cluster should be named to define the specific function of each group.

The process of clustering and naming can go on until all members of the team are satisfied that a hierarchical structure of customer statements is formed. This structure should tell a story about the customer needs and wants.

Source: Better Product Design, Institute of Manufacturing, University of Cambridge, On-line http://www.betterproductdesign.net/tools/definition/affinity.htm

1.1.1.1B. Osborne's Checklist

Osborne's checklist is a simple tool that supports product idea or concept generation that can be used in a number of ways, brainstorming being the most popular one. The checklist contains a series of questions, which can be used either individually or in groups to encourage creative thinking concerning a specific issue.

In the case that the checklist is used in a brainstorming session, the questions are usually written in cards and these cards are randomly selected while discussing a certain problem. Alternative all questions are placed on a board that the group or the individual performing brainstorming can see.

A typical checklist is shown bellow.

Table 1: Typical Osborne's Checklist

Other uses?	New ways to use as is? Other uses if modified?
Adapt?	What else is like this? What other ideas does this suggest? What could I copy? Are there any past offers?
Modify?	New twist? Change colours, motion, odour, taste, form, and shape? Other changes?
Magnify?	What to add? More time? Greater frequency? Stronger? Higher? Larger? Thicker? Heavier? Extra value? Plus ingredient? Duplicate? Multiply?
Minify?	What to subtract? Smaller? Miniature? Lower? Shorter? Lighter? Split up? Understate? Less frequent?
Substitute?	Who else instead? What else instead? Other ingredient? Other material? Other process? Other approach? Other tone of voice? Other time?
Rearrange?	Interchange components? Other pattern? Other layout? Other sequence? Change place? Change schedule? Earlier? Later?
Reverse?	Opposite? Transpose positive and negative? Reverse roles? Upside down? Inside out?
Combine?	Blend? Alloy? Combine units? Assortment? Ensemble?

Source: Better Product Design, Institute of Manufacturing, University of Cambridge, On-line http://www.betterproductdesig.net/tools/comcept/osborne.htm

Osborne's checklist in the form above is also known as SCAMPER - Substitute, Combine, Adapt, Modify/Minify/Magnify, Put to other uses, Eliminate, Reverse/Rearrange.

Source: Better Product Design, Institute of Manufacturing, University of Cambridge, On-line http://www.betterproductdesig.net/tools/comcept/osborne.htm

1.1.1.1C. Multivoting

Multivoting as Affinity Diagrams and Osborn's Technique is another brainstorming method. In Multivoting a structured series of votes by a team are cast in order to narrow down a broad set of options to a few ones. The way that the method works is described as a series of steps bellow.

Step 1: A list of items is generated.
Step 2: Similar items are combined into groups that the participants of multivoting agree upon.
Step 3: Each item is then numbered.

Step 4: Each participant silently chooses one-third of the items.
Step 5: Votes are cast for each item.
Step 6: The items with the fewer votes are eliminated. This can be done easily having in mind the following table.

Group size (number of people)	Eliminate items with less than "x" votes
4 to 5	2
6 to 10	3
10 to 15	4
15 or more	5

Step 7: The process is repeated with the remaining items if it is required to have an outcome of a specific number of items.

Source: American Society for Quality, "Evaluation and Decision-Making Tools: Multivoting", On-line http://www.asq.org/learn-about-quality/decision-making-tools/overview/multivoting.html

1.1.1.2 Case Studies - Examples

Brainstorming Case Study 1: "Using brainstorming to test a new web-site"

One of the world's leading consulting firms wanted to redesign its Web site to align with a new marketing program. The firm needed to understand whether new concepts for the site successfully communicated that in addition to its core technology offerings, it offered a broad range of strategy consulting services.

Brainstorming was used with senior business executives to test the new site concepts. During the in-person sessions, a general discussion of consulting firms, led exposed executives to the new site concepts, and gathered reactions to various competitor sites.

Brainstorming exposed several aspects of the new site concepts that needed refinement before launch. Comments from executives showed the importance of clearly communicating the role of the Web site as a complement to the existing sales process. In addition, the sessions highlighted the need for industry specific content.

Brainstorming Case Study 2: "Using brainstorming to find out about low sales"

A national department store chain was seeking to understand why its private label brand of clothing wasn't selling well to teen boys. In order to achieve this, brainstorming sessions were conducted in-store.

Mini-groups of teens were recruited to meet in the store's conference room for a preliminary discussion of fashion preferences, shopping/purchase behaviours and brand/store preferences. Each group was then taken to the young men's department for a walk through where they were asked to browse the department making notes about their reactions to brand selection, displays, layout, overall appearance and feel of the department. In order to eliminate bias, the store's private label brand was never singled out as the focus of the research. Respondents were then convened for in-aisle focus groups to discuss their observations.

Results of the research led to a total revamping of the department's private label shop including aisle width, signage, product displays and merchandise offerings.

1.1.1.3 Brainstorming Tool from Urenio

Group brainstorming can be conducted using a file created by Urenio Research Unit.

Using this file one must note that it is really intended for use by the group leader and not only is a tool for gathering the ideas generated by the group but also has some means of preliminary selection of the best idea of the ones presented.

1.1.1.4 Consultants - Experts

- **Brainstorm network** (http://www.brainstormnetwork.org/consulting.html) Brainstorm Network & Associates are available to provide consulting in many areas of product innovation and marketing, including brainstorming training.

- **Agency Consulting Group Inc** (http://www.agencyconsulting.com/displayLink.asp?linkID=6)

- **Begley Consulting** (http://www.begleyconsulting.com/index.html)
The firm offers brainstorming sessions for generation of new ideas.

- **Turner consulting Group** (http://www.turnerconsulting.com/index.html)

Adventure Associates (http://www.adventureassoc.com/consulting.html)
The firm offers creative brainstorming sessions in house for idea generation purposes.

1.1.1.5 Software Tools

http://www.paramind.net/
ParaMind software is a serious yet fun program that operates on the principle of generating new text from text. It is totally configurable and can be used to logically expand any idea. It comes with a database of 500 related word chains, and more can added.

http://www.infinn.com/toolbox.html
Brainstorming Toolbox is a tool for better brainstorming, creative thinking, lateral thinking, creativity and problem solving. It improves ability to brainstorm either alone or in groups by bringing pro-active brainstorming and lateral techniques at one's computer. There is a free 30-day trial version of the software available.

http://www.mbaware.com/mbaware/min20staned.html
MindManager software is software that helps to organize and visually communicate ideas using a widely used technique called "Mind Mapping".

http://www.randomwordgenerator.com/
Random Word Generator software, is a software that allows the user to generate random words from a long list of common words called the "Brainstorming Toolbox". So it can be used to generate ideas by inserting a single word expressing the problem.

1.1.1.6 References

- "Idea Generation Tools: Brainstorming, Affinity Diagrams, and Multivoting" (http://www.qualityhealthcare.org), Institute for Healthcare Improvement, Boston, MA, USA, 2003
- "Osborne's Checklist" (http://www.betterproductdesign.net/tools/concept/osborne.htm), Good Design Practice Program, Institute for Manufacturing & Engineering Design Center, University of Cambridge, UK, 2004
- Mind Tools "Brainstorming: Generating Many Radical Ideas" (http://www.mindtools.com/index.html)
- Osborne A, "Applied Imagination: Principles and Procedures of Creative Problem Solving", Scribner, New York, 1957

1.1.2 Competitive Intelligence

A **Competitive Intelligence Program (CIP)** is *"a formalised, yet continuously evolving process by which the management team assesses the evolution of its industry and the capabilities and behaviour of its current and potential competitors to assist in maintaining or developing a competitive advantage"* (Prescott and Gibbons 1993).

Competitive intelligence uses public recourses to find and develop information on competition, competitors and market environments so that to produce new product ideas than can give an advantage against these competitors. Resources from which information about the competition can be drawn usually include the following.

- **Government Agencies.** They can produce valuable data, but getting the information is usually very time consuming.
- **Online databases.** Faster method for obtaining information but more expensive than others. Drawback is that databases do not contain information that has not been released or included in the on-line reports.
- **Companies and investment community resources.** Some information can be available from the competitive companies and can be obtained either by contacting the company directly or by contacting investment community sources.
- **Surveys and Interviews.** Surveys can produce large amount of data about the competition and interviews can give in - depth perspectives from small samples.
- **Drive - by and on - site observations.** Data can be collected from competition retail outlets, fairs and seminars where usually state of the art new products are on show.
- **Competitive benchmarking.** This kind of benchmarking can be used to compare one's company or business against the competition.

- **Defensive competitive intelligence.** It is used as a means to present one's company to the competition.
- **Reverse engineering.** Acquiring competition products and analysing their quality, features, costs, etc can yield invaluable information.

Effective implementation of a CIP requires not only information about the competitors products but also information about the market trends in existence, the technological advances available, the economic conditions in hand and the legal and regulatory mandates in force. Only when the above factors are taken into account, new product ideas can be generated from the information gathered on competitor products that can give a competition advantage against them.

It is important that all raw data is evaluated and screened for accuracy. Double-checking and cross - reference must always be in mind of those that perform a CIP. Miscalculations and assumptions made about the competitor's products can lead to false new product ideas that usually fail miserably after their full development.

The four main steps in designing an effective CIP are: Setting up the system, collecting the data, evaluating and analysing the data and disseminating information and responding to queries. These are described bellow.

1. **Setting up the system:** The first step requires the identification of the types of vital competitive information, identifying the best information sources and assigning someone to manage the system. In the case of SME's, which usually cannot afford a formal competitive intelligence officer, specific executives must be assigned to watch specific competitors. So when someone needs information on a particular competitor will be able to contact the executive assigned to him.
2. **Collecting the data:** Data must be collected on a continuous basis from the field i.e. from the sources mentioned above.
3. **Evaluating and analysing the data:** In this step, company managers check the data that they have collected for validity and reliability. Then they interpret the results organize them so users can find what they need more easily.
4. **Disseminating information and responding:** Key information is then sent to decision makers and managers. All inquiries are hopefully answered and all the people involved have adequate information about the competition whoever he is. Based on the information gathered, managers can also interpret the competition moves if any and his response to company moves.

Source: Malhorta Y. "Competitive Inteligence Programs: An Overview", 1996, Brint Institute, On-line: http://www.brint.com/papers/ciover.htm

1.1.2.1 Improving CI Capabilities

The way a company conducts competitive intelligence can always be improved so that the maximum results are obtained from such a process. Improvement can occur by following and implementing the five steps - methods that are given bellow.

1. A CI plan should be created. Such a plan should contain objectives, strategies and tactics and maybe a small roadmap on how to go about to conduct and manage CI.

2. Competitive Intelligence should be taken outside of product management. One must consult experts that the company already has. Help from sales, customer service, field operations and employees can be very valuable. In this way one can obtain information that can help on product development and form strong inner - company relationships.
3. One should be creative with external tactics. For someone to get as much information about his competition as possible, he must develop creative ways for obtaining it. Some of the ways that can be implemented are mentioned in the description of CI.
4. A Competitive Development Matrix should be created. Such a matrix can be of the form of a combination of the CI Tool and the CI File given. (See the two files for details)
5. One must conduct competitive intelligence ethically and legally. To do that one should follow the ten CI commandments.
    - I will not lie when presenting myself to the competition.
    - I will observe the company's legal guidelines set by the legal department.
    - I will not tape - record a conversation without the permission of the person - persons involved.
    - I will not bribe.
    - I will not plant listening - recording devices.
    - I will not deliberately mislead anyone in an interview.
    - I will neither give nor obtain price information to the competitor by unethical means.
    - I will not swap misinformation.
    - I will not steal a trade secret.
    - I will not press someone for information knowing that this action may jeopardise that parson's job or reputation.

1.1.2.2. Case Studies - Examples

Competitive Intelligence Case study 1: "Discovering the launch date of a competitive product".

A client of a competitive intelligence consultancy based in the UK wanted to know the date of the launch of a new competitive product. The client in question was not ready to launch his new product and did not want to lose his share of the market from a new emerging competitive product. Having the information of product launch, would allow the client to launch a counter - publicity campaign so that the effect of the new product advertising campaign would be much smaller and therefore his market share would not suffer as much. The consultancy discovered the new product launch date directly or otherwise and by interviewing the following group of people.

- Journalists: since they would have this kind of information for publicity reasons.
- Members of the competitors PR agency or advertising agency: since they undoubtedly have this kind of information since they are the ones managing the new product's promotion and advertising.
- Packaging suppliers: since they would have information on changes of production runs and so a new product launch date could have been estimated.
- Supermarket managers: since they would have been warned to reserve shelf space for the new product.

All of the above are people that they did not realize the sensitivity of the information involved and so did not compromise the competitive intelligence program that was under way.

Competitive intelligence Case Study 2: "Establishing a competitor's capabilities".

A big electronic parts manufacturer wanted to know about a competitor's warehouse handling capabilities, and from that, estimate the market demand for the competitor's product. The information needed was obtained by one of the manufacturer managers, who went on a Sunday morning to the competitor's warehouse and chatted with the security guard of the front gate. The manager used the following line of questions to discover the information needed plus a lot more.

- When does the warehouse open for deliveries?
- Are there enough bays to handle all the traffic?
- Out of curiosity how many are there?
- I wander, who else delivers to the warehouse?

By the answers that the manager got, not only he discovered that the demand exceeded the handling capabilities of the competitor and so a market opening was available to accommodate the extra demand by the manufacturer's products, but also that other companies, with different line of products that were using the same warehouse, were having problems of satisfying the market demand.

1.1.2.3 Consultants - Experts

- Competia Inc **(http://www.competia.com/home/)**

Competia is the world's premier community for professionals in CI and strategic planning. It offers everything, from news to custom coaching modules, to discounts on CI related material, to hosting the CI symposium.

- Aurora WDC **(http://www.aurorawdc.com/)**

The firm is a multi-faceted competitive intelligence outsourcing and support bureau. It serves people and companies in every industry covering every continent worldwide.

- Aware **(http://www.competitive-intelligence.co.uk/)**

A UK based competitive intelligence consultancy dedicated in helping a company gain and maintain competitive advantage.

- Richard Combes Associates Inc **(http://www.combsinc.com/)**

Leader in competitive intelligence consulting and research. Based in Chicago - USA.

- Cipher Systems Inc **(http://www.cipher-sys.com/)**

Leading worldwide consultancy and solution developer fro companies engaged in competitive intelligence or knowledge management.

- Phoenix Consulting Group Inc **(http://www.intellpros.com/)**

1.1.2.4 Online Resources

1.1.2.4A. On-line CI Sources

- US Patent and Trademark Office **(http://www.uspto.gov)**. It is a non-commercial federal entity of the US government, whose purpose is to promote the progress of science and to protect the copyrights of inventors and innovators.
- Search engine **(http://164.195.100.11/netahtml/search-bool.html)** of the US Patent image and text database.
- The European Patent Office website **(http://www.eurpopean-patent-office.org)**. Members of the EPO include all the EU member states plus some non - EU European countries.
- The UK Patent Office **(http://www.patent.gov.uk)** - An organization devoted to enhancing innovation and competitive advantage of British firms by granting intellectual property rights.
- Source for patent and invention documentation search **(http://www.frankilforge.com)**, market potential analysis and invention marketing to manufacturers. Specializing in consumer and leisure markets.
- Web site of the patent office **(http://www.jpo.go.jp)** of the Japanese government.
- Elsevier **(http://www.elsevier.com)** - Web site of the leading worldwide publisher of scientific, technological and medical information.
- Business Monitor International **(http://www.businessmonitor.com)** - publishing specialist business information on global emerging markets. Contains news, analysis, forecasts and data. Need to register and some information comes with a cost.
- KOMPASS **(http://www.kompass.com)** - excellent source of company data including management, turnover, address, employees, export sales, product types, trade names, etc. Some information must be purchased.
- The site of National Institute for Economic & Social Research **(http://www.niesr.ac.uk)** that contains information on microeconomic data in the UK. Also it is very good for establishing international market trends.

1.1.2.4B Tools from Urenio Research Unit

- Technology watch **(http://www.newventuretools.net/toolbox.html?toolwindow=http://193.92.80.99:8081/xeos/dynamic/onli/search.xsp)**: Easy and fast access to research results, and technology information, which can increase the potential innovation capabilities of a company.
- Website that helps SME's **(http://www.newventuretools.net/toolbox.html?toolwindow=http://services.oulutech.fi/vps/index_onli.html)** (Small and Medium Enterprises) to gain access of knowledge through consortiums or clusters of technological parks around the world.

1.1.2.5 References

- "Competitive Analysis"

(http://www.betterproductdesign.net/tools/market/comp_analysis.htm), Good Design Practice Program, Institute for Manufacturing & Engineering Design Center, University of Cambridge, UK, Online, 2004

- Malhorta, Y. "Competitive Intelligence Programs: An Overview" **(http://www.brint.com/papers/ciover.htm)**, Brint Research Institute, 1996
- Prescott, J. E. & Gibbons, P. T. "Global Competitive Intelligence: An Overview", Global Perspectives on Competitive Intelligence, Alexandria, Society of Competitive Intelligence Professionals, 1993

1.1.3 Conjoint Analysis

In the 1960s and 70s, organizations and academics were looking for a way to understand how people are taking decisions. They needed to know how people behaved during interviews. Did they say things on top of their mind or did they say what the interviewer wanted to hear? In their studies, academics, found that by looking at the ways people made decisions could predict which choices would be made between products and services. This is how Conjoint Analysis was born. The analysis produces market models for products and services, which enable companies to either improve existing products or find ideas for new ones.

To understand how the analysis works, one should describe products according to their attributes and features. For example a telephone device can be described by its weight, its appearance, its battery life in the case of cordless phones etc. The analysis takes these attributes or features and asks people to make a choice between same family products of different attributes. By asking for adequate number of attributes or features, the interviewer can work out a numerical representation of how valuable each attribute is to a customer.

Knowing the values of each attribute in respect to customer weight, one can compare one product to a competitor one and optimise attributes for a new one that the customer will embrace.

Developing a Conjoint Analysis involves the following steps:

1. Choose product attributes, for example, appearance, size or price.
2. Choose the values or options for each attribute. For example in the case of size one can choose the levels 5, 10, 15 and 20 cm. The more options one chooses for an attribute the more burden will be placed no the respondents.
3. Define products as a combination of attribute options. The set of combinations of attributes that will be used will be a subset of the possible set of products.
4. Choose the form in which the attributes and the options will be presented, for example, as a paragraph or as a picture.
5. Decide how the responses will be differentiated. For example responses can be split up depending on the preferences of the respondents or depending on other characteristics of the respondents such as age, location, etc.
6. Select the technique that will be used to analyse the data. There are different models that can be used such as the Part-Worth model, the Liner model or the Ideal-Point model. In either way special software written especially for conjoint analysis must be used to perform the statistics.

Source: QuickMBA, "Conjoint Analysis", On-line http://www.quickmba.com/marketing/research/conjoint/

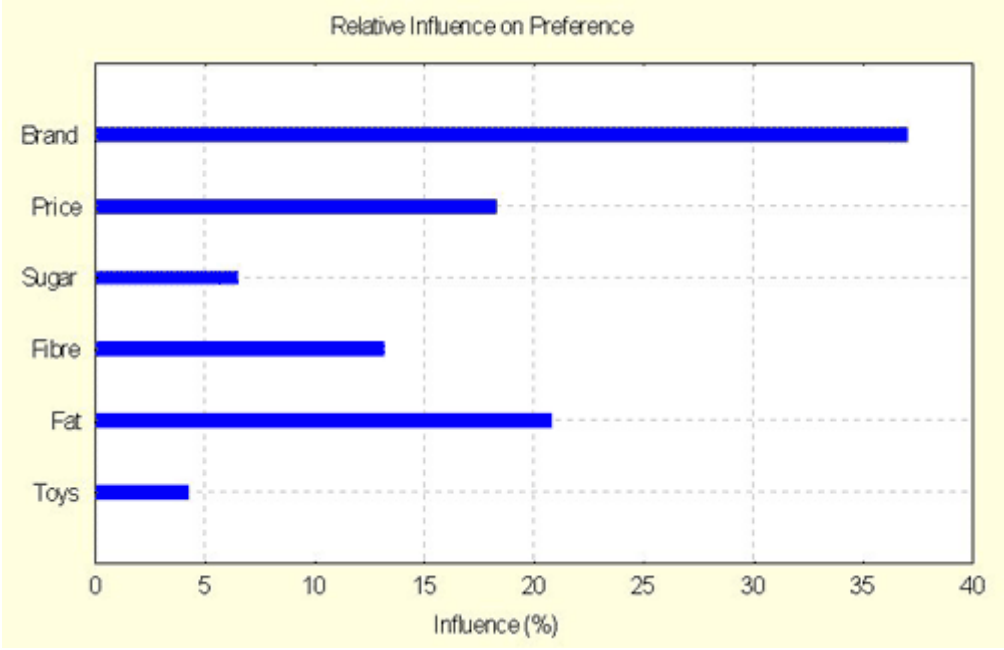
1.1.3.1 Case Studies - Examples

Conjoint Analysis Case Study 1: "Finding out which attribute of some of the breakfast cereals available in the market is more attractive to customers and therefore which attribute to optimize in a new cereal development"

The conjoint analysis study that focused on the problem described above was conducted by Sydney University in Australia, in behalf of a large food company that was considering entering into the breakfast foods market. The study was conducted using 90 people, randomly selected as interview respondents. The product attributes and the levels of each product attribute used are given bellow.

ATTRIBUTES	LEVELS
1. Brand	Kellogg, Sanitarium, Uncle Toby's, No Frills
2. Price (relative to market average)	-30%, -10%, +10%, +30%
3. Sugar content	High. Low
4. Fibre content	High. Low
5. Fat content	High. Low
6. Toys inside the pack	Yes, No

Using some kind of software that was purchased from an outside source and written especially for conjoint analysis, the interview questions were designed based on the attributes and levels given above and the result data were analysed to yield the following graph of "Relative Influence on Attribute Preference".



Also three scenarios were evaluated using the same software and data. In the first scenario brand market share was evaluated when everything else were equal, in the second brand market share was evaluated considering the realistic prices of the four brands and finally in the third scenario the potential of a low fat product in the market was evaluated. The results of the analysis are given bellow.

SCENARIO 1: ALL EQUAL

	No Frills	Uncle Toby's	Kellogg	Sanitarium
Sugar	High	High	High	High
Fibre	Low	Low	Low	Low
Fat	High	High	High	High
Toys	No	No	No	No
Price(0%=avg)	0%	0%	0%	0%
Market Shr	4%	25%	62%	9%

SCENARIO 2: REALISTIC PRICES

	No Frills	Uncle Toby's	Kellogg	Sanitarium
Sugar	High	High	High	High
Fibre	Low	Low	Low	Low
Fat	High	High	High	High
Toys	No	No	No	No
Price(0%=avg)	-15%	-5%	+5%	-5%
Market Shr	8%	35%	49%	8%

SCENARIO 3: SANITARIOUM WITH LOW FAT

	No Frills	Uncle Toby's	Kellogg	Sanitarium
Sugar	High	High	High	High
Fibre	Low	Low	Low	Low
Fat	High	High	High	Low
Toys	No	No	No	No
Price(0%=avg)	-15%	-5%	+5%	-5%
Market Shr	2%	19%	31%	48%

Using the information above the food company was not only able to pin point the attributes i.e. the characteristics that customers considered important to a breakfast cereal and therefore focus its product development on them but also made an estimate of the market share that the company would gain or lose depending on the attribute(s) that the company would decide to work on during development.

Conjoint Analysis Case Study 2: "Finding out which of the old products to cannibalise in favour of a new product"

An innovative medical device company had a strong position in their market, but was experiencing gradual market share erosion and had not launched a new product in years. As they prepared to

launch a new series of products, important marketing issues needed to be solved -- would the new products cannibalise their already strong position, should the new product series replace or supplement their current products, how should product options be bundled and priced for value, etc.

Using conjoint analysis as an integral piece of the market research, the strong position of the company's products was confirmed. Two of the new products offered tremendous value to a significant segment of customers and could command a premium price. Two other products were shown to be favoured primarily from their current customer base and, as proposed, did not attract current non-customers. By unbundling product features, and pricing them separately, a low-priced, low-feature product line could compete in the price-sensitive market segment, while not cannibalising their current products. The net effect was a multi-tiered product line, with value pricing, and a very successful new product launch.

Source: Nelson C, "Conjoint Analysis Case Study", Sydney University, On-line http://www.futuretoolkit.com/conjcase.htm

1.1.3.2 Consultants - Experts

- Brand Institute **(http://www.brandinstitute.com/index.htm)**

The institute utilizes statistical methods such as Adaptive Conjoint Analysis to facilitate optimal marketing decisions based on marketplace information.

- Mangen Research **(http://www.mrainc.com/conj_intro.html)**

- SpeedBack Market Research and Consulting **(http://www.speedback.com/)**

The firm is a full-time research agency specializing in Internet based and interactive market research methods including Conjoint Analysis, Qualitative Research and Quantitative Research.

1.1.3.3 Software Tools

http://www.tigris-software.com/tigris8.htm

TiCon 1.3 is the name of the Conjoint Analysis software that if offered by the company Tigris Software Systems. A demo is available that allows a complete set of the software features but it only works for up to 3 attributes and 2 options for each attribute.

http://www.sawtoothsoftware.com

ACA, CBC and CVA are the names of the different software programs for conjoint analysis offered by Sawtooth Software Inc. There is a demo version, which includes the capability of writing web-based surveys for conjoint analysis. One can build his own questionnaire and analyse the survey using the local web server installed with the demo program.

http://www.skim.nl/software/Ssd_ACA.html

Home of the **ACA (Adaptive Conjoint Analysis)** software offered by Skim Software Division. The software includes interviewing, analysis and scenario simulations capabilities. There is a demo available from the site.

http://www.palisade.com

The software offered by Palisade is called **@Risk** and it is really an add-on for MS Excel. It allows users to run probability distributions and Monte Carlo simulations for conjoint analysis data.

http://www.statease.inc
Design Ease 6 is the name of the software offered by Stat-Ease. With the software a user can run Design of Experiment simulations and it is intended for manufacturing, R&D and market research.

1.1.3.4 References

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1.1.4. Delphi Technique

The **Delphi Technique** was originally developed by Rand Corporation in the late 60's as a forecasting methodology. As the years passed its purpose was changed to the one of gathering information and judgments from participants to facilitate problem solving, planning and decision-making without physically assembling the contributors. Instead information is exchanged via mail, email or fax. The technique is designed to take advantage of participants' creativity as well as the facilitating effects of group involvement and interaction. It is structured to take full advantage on the merits of group problem solving and minimize its liabilities. It is a great tool for idea generation using external experts as well as product definition or product concept development.

The technique requires the presence of a coordinator whose job is to organize requests for information; information received and is responsible for the communication with the participants. Mail as means of communication can be used but email and fax can decrease the time required for the process to be completed considerably. For example for a process using 20 participants a total of 44 days is required for the process to be completed using common mail and only 3-4 days using email or fax.

The major steps of the technique are as follows:

1. The coordinator must identify the issue and prepare the first questionnaire which asks each participant to start individual brainstorming so that as many ideas as possible to be generated on the issue in hand.
2. Each participant must respond to the first questionnaire. His / hers ideas must be brief, concise, and not fully developed. The participant must not try to justify or evaluate his ideas. The first questionnaire must be returned to the coordinator anonymously.
3. The coordinator prepares and sends out a second questionnaire, which contains all the ideas gathered by the first one, and asks the participants to comment on each idea's strengths and weaknesses and to add some more if possible.
4. The participants respond to the second questionnaire and send it back to the coordinator.
5. The coordinator prepares and sends out a third questionnaire that sums up all the information gathered in the previous step and asks for additional information, clarifications, strengths, weaknesses and new ideas.
6. The participants respond to the third questionnaire and send it back to the coordinator.
7. The process can go on until no new ideas are emerging and all strengths, weaknesses and opinions concerning the ideas gathered are identified.

When all ideas that have been gathered and all their strengths and weaknesses are identified the exercise is declared finished. The end product is a list of highly evaluated ideas. If it is required the coordinator can at this point screen or assess the ideas gathered by using two methods. In the first method the coordinator prepares a questionnaire that lists all the ideas and asks the participants to scale each idea by a number of 0 to 10, 10 being the best. The participants send back to the coordinator rating forms and the coordinator compiles the results and finds the best idea that addresses the issue best. In the second method the coordinator asks each participant to vote for the top 5 ideas. The votes are returned to the coordinator who measures the results and prepares a report on the best five ideas.

Sources:

- Cline Alan, “Prioritization Process Using Delphi Technique”, White Paper, Carolla Development, 2000, On-Line http://www.carolla.com/wp-delph.htm
- Randall B Durham, “The Delphi Technique”, School of Business, University of Wisconsin, Sep 1998, On-line http://instruction.bus.wisc.edu/obdemo/readings/delphi.htm

1.1.4.1 Consultants - Experts

- Avant Consulting **(http://www.avantconsulting.com/services.asp?serv=SP&desc=36)**

1.1.4.2 References

- Cline A, "Prioritization Process Using the Delphi Technique" **(http://www.carolla.com/wp-delph.htm)**, Carolla Development, 2000
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(http://www.premier1.net/~barkonwd/school/DELPHI.HTM)

1.1.5 Morphological Charts

Morphological charts provide a well-structured approach to concept generation by widening the area of search for solutions to a defined design problem. It can help the design team to generate a complete set of alternative design solutions through a systematic analysis of the form, configuration or functionality of a product.

The chart is a visual way to capture the required product functionality and explore different ways and combinations to achieve that functionality. For each product function there may be a number of possible solutions. The chart enables these solutions to be expressed and provides the means for considering alternative combinations. This can help in the early visualization of the product architecture through the generation of different sub-solutions that no one has before thought about. When well used it can accommodate a user driven approach to product concept development.

The methodology behind the formation of such charts is simple. There are three main steps description of which is given bellow.

Step 1: List product functions or features that are needed to the product. The list should not be too long but should include the main product functions. Typically the list should not contain more than 10 items. It is useful to list the functions in an order of importance, putting the most important first and the least important last. Each function listed should be exclusive in regards to the others.

Step 2: List the potential solutions by which each function listed earlier can be achieved. One should think about new ideas as well as known solutions and all solution should be noted and expressed visually as well as using words. Any important characteristics of a solution should also be noted. Also a level of generality must be maintained.

Step 3: Draw up a chart containing all possible sub-solutions, which will represent the morphological chart. The chart will include the total solution for the product and will be made up from various sub-solutions. The total number of combinations can be large so the design team will need to select the ones that are feasible and producible. Also each solution or combination of solutions can be named so that it can be easily found and evaluated at a later time.

Source: Better Product Design, Institute of Manufacturing, University of Cambridge, On-line http://www.betterproductdesign.net/tools/concept/morph_charts.htm

1.1.5.1 Case Studies – Examples

Case Study 1: Mobile phone concept generation using a morphological chart.

For a widely used and available product as the one of a mobile phone, a morphological chart can be a very useful tool for finding a quick solution to new product concept generation. The possible functions of a mobile phone are easily recognized and include holding, storage, dialling, display, power supply, signal reception, signal processing, sound output, extra features, etc. Having these and more in mind one can easily find solutions. For example in the case of holding possible

solutions can be stopwatch-type grip, attached to clothing, gun grip, etc. Inserting all the possible functions and their solution into a table as the one shown bellow forms a morphological chart from which a total solution for concept development can be generated.

Table 1: Morphlogical Chart Example for a Mobile Phone

Morphological chart for a mobile phone				
Function	Options			
Holding	Stopwatch style	Calculator style	not held	
Storage	Pin badge	on sleeve	on belt	in pocket
Entering no	Keypad	Voice	Bar code	
Display	LED	LCD	None	
Power supply	Mains	Battery	Solar	
Signal reception	Internal aerial	External aerial	Cable aerial	
Sound output	Speaker	Earphone		
Sound input	Internal microphone	External microphone		
Extra features	Calculator	Memory bank	Alarm	Games

Source: Better Product Design, On-line http://www.betterproductdesign.net/tools/concept/morph_charts.htm

Considering the above morphological chart one possible solution could be a mobile phone that it is not held, can be stored as a pin badge, a keypad is used to dial the number, with no display, power by a battery, with an internal aerial, an internal microphone and with a large memory bank.

Source: Better Product Design, Institute of Manufacturing, University of Cambridge, On-line http://www.betterproductdesign.net/tools/concept/morph_charts.htm

Case Study 2: Forklift truck concept generation using a morphological chart.

In the case of generating a concept for a product such as a forklift truck to be used in a warehouse a morphological chart would look as the one shown bellow.

Table 1: Morphlogical Chart Example for a Forklift Truck

Morphological chart for a forklift truck				
Function	Options			
Support	Wheels	Tracks	Slides	Spheres
Steering	Wheels	Rails	Air thrust	
Stopping	Reverse power	Brakes	Blocks	
Moving	Air thrust	Power to wheels		
Power	Electric	Gas	Petrol	Steam
Lifting	Screw	Hydraulics		
Operator	Seat in front	Seat in back	Standing	Walking
Transmission	Hydraulic	Gears	Flexible cable	

Source: Kramer Steven, On-line http://www.mime.eng.utoledo.edu/design_clinic/An%20Overview%20of%20the%20Design%20Process/An%20Overview%20of%20the%20Design%20Process.PPT

Considering the above morphological chart a forklift truck can be designed to have wheels for support and steering, brakes for stopping, power to wheels for moving, be electric, use a hydraulic system for lifting things and a hydraulic system for transmission and having the operator walking behind the truck.

Source: Kramer Steven, Naganathan Nagi, "An Overview of Design Process", MIME Department, University of Toledo, On-line
http://www.mime.eng.utoledo.edu/design_clinic/An%20Overview%20of%20the%20Design%20Process/An%20Overview%20of%20the%20Design%20Process.PPT

1.1.5.2 References

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- Kardos G, "The Morphological Method" **(http://www.carleton.ca/~gkardos/88403/CREAT/MORPHO.html)**, Dept of Mechanical and Aerospace Engineering, Carleton University, Ottawa, Canada, 1998

1.1.6. Six Thinking Hats

This technique is a very important one in the case of looking of project decisions from a number of different prospectives. Edward de Bono created the tool in his book "6 Thinking Hats. For someone to be creative in his decision-making especially in cases of large project management such as NPD projects, he must look at problems from 4 different points of views. He must look through the emotional point of view, the intuitive point of view, the creative point of view and the negative point of view. The tool helps people to do just that.

The tool can be used during team meetings or by a single person. In the case of team meetings can be very helpful since it can block confrontations of people with completely different points of views or thinking styles. The way the tool can be used is the following.

The thinking styles are divided and sorted according to different colored hats. In particular:

* The White Hat represents the thinking that is based on the raw data available. Information for example on competition, market place and others is taken into account to make decisions.
* The **Red Hat** represents people that look at problems using intuition, gut reaction and emotion. Also represents the activity of understanding other people's emotion (for example emotional customer reactions).
* The **Black Hat** represents the negative thinking. Bad points of a decision are considered. Also decisions are looked at cautiously and defensively. Black Hat thinking helps in making more tough and resilient plans.
* The **Yellow Hat**represents positive thinking. All the optimistic points of view are taken into account when making a decision. Also all the benefits and values of the decision are noted.
* The **Green Hat** represents creativity. Under this hat one can develop creative solutions to a given problem. The hat is surrounded by a lot of creativity tools that are available for use.

* The **Blue Hat** represents control. People assigned to this hat during meetings for example should be able to control planning. If for instance if ideas are scarce then the person assigned to the Blue Hat must direct the discussion towards the Green Hat thinking or in other words towards creative thinking.

Source: Mind Tools, "Six Thinking Hats – Looking at a Decision from all Points of View", On-line http://www.mindtools.com/pages/article/newTED_07.htm

1.1.6.1. Case Studies - Examples

Case Study: "Decision making about the construction of a new office building by a real estate - Property Company".

The directors of a property company are looking at whether they should construct a new office building. The economy is doing well, and the amount of vacant office space is reducing sharply. As part of their decision they decide to use the 6 Thinking Hats technique during a planning meeting.

Looking at the problem with the White Hat, they analyse the data they have. They examine the trend in vacant office space, which shows a sharp reduction. They anticipate that by the time the office block would be completed, that there would be a severe shortage of office space. Current government projections show steady economic growth for at least the construction period.

With **Red Hat** thinking, some of the directors think the proposed building looks quite ugly. While it would be highly cost-effective, they worry that people would not like to work in it.

When they think with the **Black Hat**, they worry that government projections may be wrong. The economy may be about to enter a 'cyclical downturn', in which case the office building may be empty for a long time. If the building is not attractive, then companies will choose to work in another better-looking building at the same rent.

With the **Yellow Hat**, however, if the economy holds up and their projections are correct, the company stands to make a great deal of money. If they are lucky, maybe they could sell the building before the next downturn, or rent to tenants on long-term leases that will last through any recession.

With **Green Hat** thinking they consider whether they should change the design to make the building more pleasant. Perhaps they could build prestige offices that people would want to rent in any economic climate. Alternatively, maybe they should invest the money in the short term to buy up property at a low cost when a recession comes.

The **Blue Hat** has been used by the meeting's Chair to move between the different thinking styles. He or she may have needed to keep other members of the team from switching styles, or from criticizing other peoples' points.

Source: Mind Tools, "Six Thinking Hats – Looking at a Decision from all Points of View", On-line http://www.mindtools.com/pages/article/newTED_07.htm

1.1.6.2. References

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- Mind Tools, "Six Thinking Hats: Looking at a Decision form all Points of View" **(http://www.mindtools.com/pages/article/newTED_07.htm)**, Mind Tools, 2004.

1.1.7 TRIZ - Idea generation using a problem-solving tool

"Idea generation for product development is an inventive problem. Until some years ago its solution was centered into the field of psychology where the links between the brain and insight and innovation are studied. Methods such as brainstorming and trial-and-error were commonly suggested and used. Depending on the complexity of the problem, the number of trials would vary. If the solution lied within one's experience or field, such as mechanical engineering, than the number of trials were fewer. If the solution was not forthcoming, then the person that performed idea generation would look beyond his experience and knowledge to new fields such as chemistry or electronics. Then the number of trials would grow large depending on how well the person could master psychological tools like brainstorming, intuition, and creativity.

Genrich S. Altshuller, born in the former Soviet Union in 1926, developed a better approach, relying not on psychology but on technology. Serving in the Soviet Navy as a patent expert in the 1940s, his job was to help inventors apply for patents. He found, however, that often he was asked to assist in solving problems as well. His curiosity about problem solving led him to search for standard methods. What he found were the psychological tools that did not meet the rigors of inventing in the 20th century. At a minimum, Altshuller felt a theory of invention should satisfy the following conditions:

- Be a systematic, step-by-step procedure
- Be a guide through a broad solution space to direct to the ideal solution
- Be repeatable and reliable and not dependent on psychological tools
- Be able to access the body of inventive knowledge
- Be able to add to the body of inventive knowledge
- Be familiar enough to inventors by following the general approach to problem solving.

In the next few years, Altshuller screened over 200,000 patents looking for inventive problems and how they were solved. Of these (over 1,500,000 patents have now been screened), only 40,000 had somewhat inventive solutions; the rest were straightforward improvements. Altshuller more clearly defined an inventive problem as one in which the solution causes another problem to appear, such as increasing the strength of a metal plate causing its weight to get heavier. Usually, inventors must resort to a trade-off and compromise between the features and thus do not achieve an ideal solution. In his study of patents, Altshuller found that many described a solution that eliminated or resolved the

contradiction and required no trade-off.
Altshuller categorized these patents in a novel way. Instead of classifying them by industry, such as automotive, aerospace, etc., he removed the subject matter to uncover the problem solving process. He found that often the same problems had been solved over and over again using one of only forty fundamental inventive principles. If only later inventors had knowledge of the work of earlier ones, solutions could have been discovered more quickly and efficiently.
In the 1960s and 1970s, he categorized the solutions into five levels.

- **Level one:** Routine design problems solved by methods well known within the specialty. No invention needed. About 32% of the solutions fell into this level.
- **Level two:** Minor improvements to an existing system, by methods known within the industry, usually with some compromise. About 45% of the solutions fell into this level.
- **Level three:** Fundamental improvement to an existing system, by methods known outside the industry. Contradictions resolved. About 18% of the solutions fell into this category.
- **Level four:** A new generation that uses a new principle to perform the primary functions of the system. Solution found more in science than in technology. About 4% of the solutions fell into this category.
- **Level five:** A rare scientific discovery or pioneering invention of essentially a new system. About 1% of the solutions fell into this category.

He also noted that with each succeeding level, the source of the solution required broader knowledge and more solutions to consider before an ideal one could be found.
What Altshuller tabulated was that over 90% of the problems engineers faced had been solved somewhere before. If engineers could follow a path to an ideal solution, starting with the lowest level, their personal knowledge and experience, and working their way to higher levels, most of the solutions could be derived from knowledge already present in the company, industry, or in another industry.
For example, a problem in using artificial diamonds for tool making is the existence of invisible fractures. Traditional diamond cutting methods often resulted in new fractures, which did not show up until the diamond was in use. What was needed was a way to split the diamond crystals along their natural fractures without causing additional damage. A method used in food canning to split green peppers and remove the seeds was used. In this process, peppers are placed in a hermetic chamber to which air pressure is increased to 8 atmospheres. The peppers shrink and fracture at the stem. Then the pressure is rapidly dropped causing the peppers to burst at the weakest point and the seedpod to be ejected. A similar technique applied to diamond cutting resulted in the crystals splitting along their natural fracture lines with no additional damage.
Altshuller distilled the problems, contradictions, and solutions in these patents into a theory of inventive problem solving which he named TRIZ. This theory can be applied to idea generation for product development or at the process of product development, as both are inventive processes."

Author: Glenn Mazur, Ideation International Inc., 23713 Riverside Drive, Southfield MI 48034 USA

Source: "Theory of Inventive Problem Solving", Ideation International Inc, On-line http://www.mazur.net/triz/

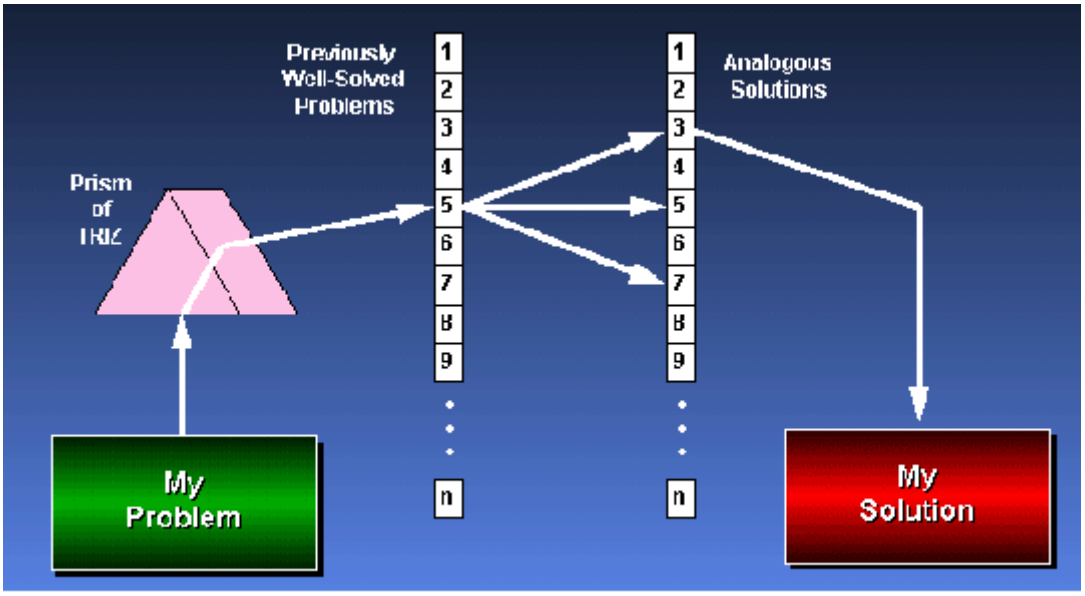
1.1.7.1 TRIZ Process Methodology

The TRIZ process as any process is governed by a simple and easy step-by-step methodology. This methodology is illustrated in the figure given below.

The main steps of the methodology are as follows.

Step 1: Identify the problem in hand. In the case of early product development that would be the generation of new product ideas according to already set criteria such as customer needs and desires. In later stages of product development the problem could be a technical, engineering or design issue that needs solving.

Figure 1: Graphical Representation of the TRIZ Methodology



Source: "Theory of Inventive Problem Solving", Ideation International Inc, On-line http://www.mazur.net/triz/

Step 2: Formulate the problem and create the prism of TRIZ. The problem is analyzed better and a full description of what is looked for is noted.

Step 3: Search for a previously solved problem. In the case of early product development this implies performing competitive analysis. Similar products that somewhat satisfy customer needs can be used as initiatives for new products by changing their characteristics or attributes to satisfy completely customer needs. In later stages of product development, a search in patent offices for example may reveal a solution to the problem in hand.

Step 4: Look out for similar solutions to the ones already found. Sometimes although a single solution may look to be the best by doing more research a new one could appear that would be even better one. One should carefully select the solution to the problem in hand carefully after serious consideration of all of the alternatives.

Source: "Theory of Inventive Problem Solving", Ideation International Inc, On-line http://www.mazur.net/triz/

1.1.7.2 Consultants - Experts

- Triz Chance Network **(http://www.triz-chance.ru/triz-chance_en.html)**
- INSYTEC (TRIZ training programs) **(http://www.insytec.com/about.htm)**
- Elite Consulting **(http://www.elite-consulting.com/problem_solving.htm)**
- Triz Consulting Inc **(http://www.trizconsulting.com/)**

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1.2 Level Assessment for Stage 1: Idea Generation

Assessment 1 evaluates the ideas generated in Level 1 and both the way and the tools used for idea generation.

According to the answers a user gives to the questions a GO, HOLD or KILL decision is provided for further progression in the roadmap and specifically to Level 2. In Appendix 1 the template for Level Assessment is included.

NPD Stage 2: Idea Screening

Once all viable ideas are gathered and managed, they must be further developed, examined, prioritised and evaluated so that a single product idea is selected for further development into a product concept. This whole process is called screening and is the main problem to solve in this Level using different tools and techniques.

2.1 Tools & Solutions

Once all viable ideas are gathered and managed, they must be further developed, examined, prioritised and evaluated so that a single product idea is selected for further development into a product concept. This whole process is called screening and is the main problem to solve in this Level using different tools and techniques.

There are many methods to screen ideas and select the best one for further development. Ideas can be screened against company's marketing strategies, against company sales and profitability minimum's, along with key customers and buyers etc. All screening processes should give adequate answers to key questions such as "Is it worth it", "Can the product win into the market", "Is it real". Further analysis of such questions is given bellow.

Table 1: Assessing New Product Feasibility

Is it real?	Is the market real?	Is there a need?
		Will the customers buy?
	Is the product real?	Will it satisfy the market?
		Can it be made?
Can we win?	Product competitive?	Differentiation?
		Low cost position?
	Company competitive?	Industry structure?
		Organizational effectiveness?
Is it worth it?	Will it be profitable?	Is the return adequate?
		Is the risk acceptable?
	Satisfy other needs?	Supports company's objectives?
		Other factors?

Source: Product Development Forum

The main idea screening methods are given bellow.

Screening Ideas Against Company's Marketing Strategies

Idea screening against new or pre-existing company marketing strategies will reinforce company focus and use of scare company resources. In this case the company's marketing strategy acts as a guideline for action. Such a strategy should consist of the following.

- A definition of the target customer group, either demographically, or by lifestyle or by using habits etc.
- A translation of the company's mission into a measurable annual objective.
- A set of product standards such as achievement of marketing goal, response to competition, profits, sales etc.
- A check list of accomplishments such as marketing spending, R&D spending, product quality, market positioning, etc.

If any of the product ideas that are screened are not compatible with the company's marketing strategies, then one can either consider altering these strategies or not pursuing at all a new product concept development.

Screening Ideas Against Company Sales and Profitability Minimums

Every new product must have the ability to generate a minimum amount of sales and subsequently profits. The number of sales and the profit margin depend on the size of the company. For example large consumer goods companies have an average profit margin of around 60%. This means that for every item they are selling, 60% of its price is profit and only 40% covers the development and production costs.

If a small company is competing with large ones, knowledge of profit margins and sales potentiality of the competing companies is essential so that to provide a successful business strategy. This strategy can be used to screen new product ideas that will be able to compete in a market.

Screening Ideas Against Key Customers and Buyers

Data, which can be collected along with new product ideas in the first stage of new product development, can be used to screen ideas. This means that input from customers cannot only provide new ideas but also the means to screen them.

Managers can get so committed to a product idea and subsequently to a product concept, that sometimes proceed to product development before all customer data is analysed and evaluated. To avoid this, Qualitative Research and Quantitative Research, can be invaluable tools in evaluating all data, screening ideas and producing feasible product concepts. Usually both tools are used after a product concept is selected, to evaluate it against the customers.

2.1.1. Qualitative Research

Qualitative Research is an original company research tool on a subject such as new product ideas or concepts, which is concerned with getting a "feel" for the research topic without doing a numerical and statistical measurement. One can think of Qualitative Research as an in - depth - interview or conversation with a target of potential users of the new product.

Qualitative Research might not accurately represent the whole of the market and consists of either focus groups or individual interviews. Focus groups can be a manageable number of potential buyers or users of products, to which a new product concept is presented. After the presentation they are encouraged to discuss their opinion of the new product concept with an interviewer and

with each other. A company can hire a research team to locate an adequate focus group, conduct such a session and present the results. Otherwise the marketing department of the company can conduct the whole process more economically. Individual interviews can be conducted with potential users or buyers of the new product concept or with users of competitive products.

The analysis of the data gathered from Qualitative Research is usually subject to large statistical errors and cannot predict the behaviour of a market accurately. False analysis of data can be disastrous for large companies that may invest large amounts of money and time to develop the wrong product concept. On the other hand, small companies that can recover quickly from actions taken based on such data can use the research since they have low product development budgets, they are closer to the market and the customers and they usually have small turnaround times.

Since Qualitative Research is based on interviewing a target group of potential users of a product about the product concept, it really is a market research tool. As a market research tool, using a market research plan and specially designed questionnaires can perform it. In the past Qualitative Research interviews were conducted in person and face to face. Nowadays there is a shift in on-line interviewing using the Internet.

2.1.1.1 Case Studies - Examples

Case Study: "Using Qualitative Research to identify market segments and new product solutions for customers"

Company X used Qualitative Marketing so that it could determine the unnerved high-priority opportunities for the company's technology, understand the priority segment, as well as its business and product requirements to provide direction for product development and marketing and establish the scope of opportunities for submission for next round funding.

Performance of Qualitative Marketing meant that the company conducted Qualitative Research of the company's beta sites and prospects, identified and interviewed the influencers, and analysed the findings and provided the results in report format.

The results of such an activity accomplished the following:

- Determined the best segment to target. Expanded the segment beyond a narrowly defined industry segment approach.
- Identified five applications that the target customer needs. This included finding 28 areas of problems that the company's product could solve.
- Established the trends that affect the target customers buying behaviour.
- Located seven influencer groups that reach the target audience.

2.1.1.2 Consultants - Experts

Association for Qualitative Research **(http://www.aqrp.co.uk/)**
The association represents people involved in qualitative research providing, help, tools and ways of communication for those that use the technique.

2.1.1.3 Software Tools

http://www.hostedsurvey.com/
The creators of the web site offer the creation of on-line surveys for every use.

http://www.myformsonline.com/
The web site offers the creation of survey forms that can be used for Qualitative Research or other market research and have them submitted for on-line filling for 30 days for free. After that period one can collect the results or it can install the software into a local server for a small fee and keep the research going.

http://www.surveymonkey.com/home.asp?bhcd2=1041881504
SurveyMoney.com offers low cost on-line software that allows a user to design a Qualitative Research survey and analyse the results based on the data collected during the survey.

2.1.1.4 References

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2.1.2 FMEA (Failure Modes and Effects Analysis)

Nowadays customers are placing increased demands on companies for cheap high quality and reliable products. As products become more and more complex, quality and reliability is getting very hard to be maintained by manufacturers. In previous years reliability and quality was achieved through extensive testing at the end of the product development process. The challenge was to design reliable and quality products from the beginning of product development and in particular at the early stages of product idea selection and product concept development.

FMEA (Failure Modes and Effects Analysis), is used by many companies as their central pillar of their design process, since it addresses in a big way the challenge mentioned above. FMEA can provide a structured approach to the analysis of route causes of product failure, the estimation of the severity of impact to the product, and the effectiveness of strategies for prevention. The output of the analysis is the generation of action plans to prevent, detect or reduce the impact of potential modes of product failure. When this analysis is conducted in the second Level of NPD i.e. the idea screening - product concept development, for each generated idea, the selection of the best idea that can result in a reliable and quality product can be achieved.

FMEA was firstly developed by the US military in the 1940's as a tool to improve the reliability of military equipment. It was quickly adopted by the aerospace industry and the automotive industry in the 70's. The analysis can be applied to address several issues such as organizational issues, strategy issues, product design issues, production processes and individual product components.

FMEA cannot only be used in the early stages of product development. During the design and product development processes updates are made to the product and its components. These changes can introduce new failure modes and it is therefore critical to review some or all of the FMEA analysis results by conducting an update to the analysis data.

Source: America Society for Quality, FMEA, On-line http://www.asq.org/learn-about-quality/process-analysis-tools/overview/fmea.html

2.1.2.1 References

- "Failure Modes and Effects Analysis Tool" **(http://www.ihi.org)**, Institute for Healthcare Improvement, 2004
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- Crow K, "Failure Modes and Effects Analysis, FMEA"

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2.1.3 Dot Sticking

Dot Sticking is a concept or idea selection tool that engages a wide number of people in the process. It is a simple tool and easy to administer but does not provide rich feedback on the reasons or motivations of the people involved in the process. It can be a powerful tool if the target customers are involved in the process. The tool is extremely useful when there are a lot of potential or competing ideas on the table. The tool is conducted by giving each person that it is involved a series of colored dots that can be used to indicate preference. The tool's approach can be defined in five simple steps.

Step 1. Each concept or idea must be presented in a similar way having the same amount of detail so that the persons involved in the process can make their choices without bias. Usually small drawings of each concept or idea are presented to the persons involved.

Step 2. The participants must be then selected. The participants can be an internal product design team or external stakeholders such as target customers or a combination of both.

Step 3. Dots are allocated to each of the participants. Depending on the number of concepts or ideas these can be 3 to 5. Different colored dots can be used to indicate different things such as performance, functionality, design etc. Participants can use his or her dots to indicate choice, by sticking them next to the concept or idea drawing.

Step 4. After all participants have used their corresponding dots, dots for each concept or idea are summed and the best concept is declared. Also a second round of dot sticking can take place by selecting the best 2 or 3 strongest concepts or ideas.

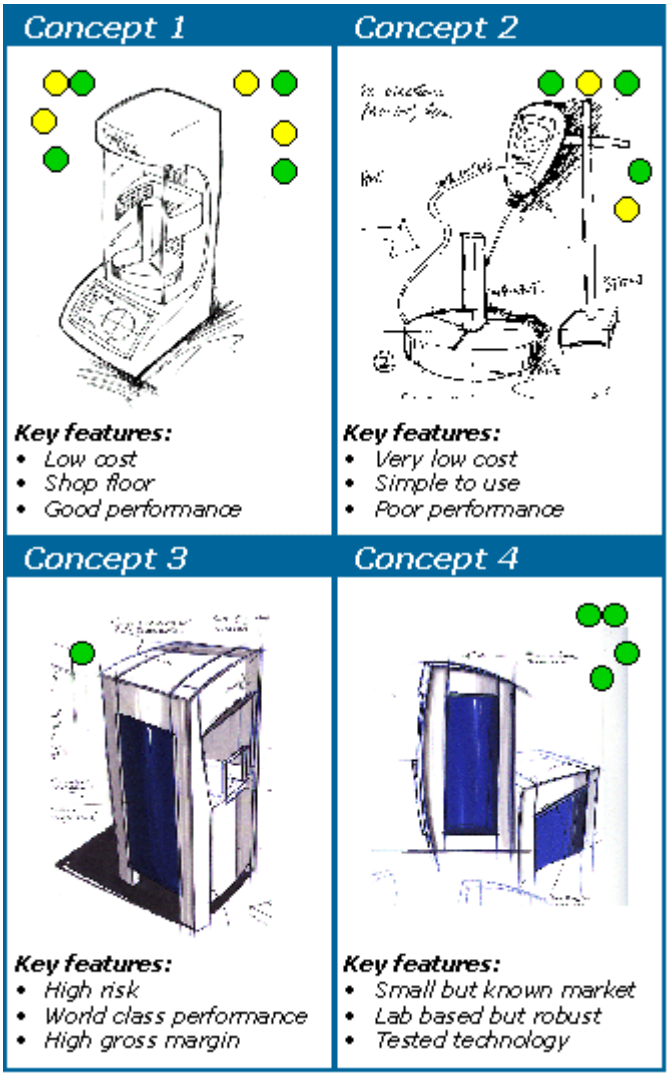
Step 5. It is sometimes helpful and necessary to understand the reason of the voting or dot sticking. In this case the participants are required to indicate or note likes and dislikes about the concepts by using post-it notes. This enables the design team to keep strong features of rejected concepts in mind.

Source: Better Product Design, Institute of Manufacturing, University of Cambridge, On-line http://www.betterproductdesign.net/tools/concept/dot.htm

2.1.3.1 Case Studies - Examples

The following 4 figures are typical examples of concept or product idea drawings to be used in a Dot Sticking process. As one can see each of the drawing has a number of dot that indicate the choice of the participants in respect to it. Bellow the drawings some strong or week features of each concept are noted for further study of participant motivations to be conducted by the design team. The concept with the largest number of dots is chosen to be the one that can be further developed.

Figure 1: Dot Sticking Example



Source: Better Product Design, Institute of Manufacturing, University of Cambridge, On-line http://www.betterproductdesign.net/tools/concept/dot.htm

2.1.4 SWOT Analysis

SWOT Analysis is a very effective way of identifying one's Strengths and Weaknesses, and of examining the Opportunities and Threats one can face. Carrying out an analysis using the SWOT framework can help focusing activities into areas where the company is strong, and where the greatest opportunities lie. By Performing a SWOT analysis, one can use the analysis results to screen new product ideas against the characteristics of one's company and ultimately its strategic goals.

The simplest way to carry out a SWOT Analysis one must write down answers to the following questions. Where appropriate, one must use similar questions:

Strengths:

- What are your advantages?

- What do you do well?
- What do other people see as your strengths?

One must consider this from his own point of view and from the point of view of the people he deals with. One mustn't be modest - be realistic. If there are any difficulties with doing this, one must try writing down a list of the company's characteristics. Some of these will hopefully be strengths!

Weaknesses:

- What could you improve?
- What do you do badly?
- What should you avoid?

Again, one must consider this from an internal and external basis - do other people seem to perceive weaknesses that you do not see? Are the competitors doing any better than the company? It is best to be realistic now, and face any unpleasant truths as soon as possible.

Opportunities:

- Where are the good opportunities facing you?
- What are the interesting trends you are aware of?
- Useful opportunities can come from such things as:
- Changes in technology and markets on both a broad and narrow scale
- Changes in government policy related to your field
- Changes in social patterns, population profiles, lifestyle changes, etc.
- Local Events

Threats:

- What obstacles do you face?
- What is your competition doing?
- Are the required specifications for your job, products or services changing?
- Is changing technology threatening your position?
- Do you have bad debt or cash-flow problems?

Carrying out this analysis will often be illuminating - both in terms of pointing out what needs to be done, and in putting problems into perspective. One can also apply SWOT analysis to one's competitors - this may produce some interesting insights!

Source: Manktelow James, "SWOT Analysis: Discover New Opoortunities. Manage and Eliminate Risks", Mind Tools, On-line: http://www.mindtools.com/pages/article/newTMC_o5.htm

2.1.4.1 Case Studies - Examples

Case Study: "SWOT Analysis on a starting up small consulting business"

A start-up small consultancy business might carry out the following SWOT analysis:

Strengths:

- We are able to respond very quickly as we have no red tape, no need for higher management approval, etc.
- We are able to give really good customer care, as the current small amount of work means we have plenty of time to devote to customers
- Our lead consultant has strong reputation within the market
- We can change direction quickly if we find that our marketing is not working
- We have small overheads; so can offer good value to customers

Weaknesses:

- Our company has no market presence or reputation
- We have a small staff with a shallow skills base in many areas
- We are vulnerable to vital staff being sick, leaving, etc.
- Our cash flow will be unreliable in the early stages

Opportunities:

- Our business sector is expanding, with many future opportunities for success
- Our local council wants to encourage local businesses with work where possible
- Our competitors may be slow to adopt new technologies

Threats:

- Will developments in technology change this market beyond our ability to adapt?
- A small change in focus of a large competitor might wipe out any market position we achieve
- The consultancy might therefore decide to specialise in rapid response, good value services to local businesses. Marketing would be in selected local publications, to get the greatest possible market presence for a set advertising budget. The consultancy should keep up-to-date with changes in technology where possible.

Source: Manktelow James, "SWOT Analysis: Discover New Opoortunities. Manage and Eliminate Risks", Mind Tools, On-line: http://www.mindtools.com/pages/article/newTMC_o5.htm

2.1.4.2 References

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2.1.5 PMI Analysis

PMI (Plus / Minus / Implications) analysis is an improvement of the weighting the pros and cons technique. When one has selected a course of action, PMI is a good method of evaluating this course. The method can be used in any case when decision-making plays a great role in the success of a project. In the case of NPD it can be used in any Level but can be extremely helpful during Level 2 where screening and evaluating new product ideas take place and a decision for the best one must be made.

For the technique to be used a table is drawn having three columns headed Plus, Minus and Implications. Within the table all the positive and negative points for following a given course of action are written. Also their implications and outcomes are noted. If the decision is not obvious then one can score the table and sum up the scores to see whether implementing the decision and taking the given course of action is worth the effort.

A simple example - case study of the PMI analysis is given.

Source: Mind Tools, "PMI – Weighting the Pros and Cons of a Decision", On-line http://www.mindtools.com/pages/article/newTED_05.htm

2.1.5.1 Case Studies - Examples

A young professional is deciding where to live. Her question is "should she move to the big city"?

She draws up the PMI table below:

Table 1: PMI Example Table

Plus	Minus	Implications
More going on (+5)	Have to sell house (-6)	Easier to find new job? (+1)
Easier to see friends (+5)	More pollution (-3)	Meet more people? (+2)
Easier to get places (+3)	Less space (-3)	More difficult to get own work done? (-4)
	No countryside (-2)	
	More difficult to get to work? (-4)	
+13	**-18**	**-1**

Source: Mind Tools, "PMI – Weighting the Pros and Cons of a Decision", On-line http://www.mindtools.com/pages/article/newTED_05.htm

She scores the table as 13 (Plus) - 18 (Minus) - 1 (Implications) = - 6

For her, the comforts of a settled rural existence outweigh the call of the 'bright lights' - it would be much better for her to live outside the city, but close enough to travel in if necessary.

Source: Mind Tools, "PMI – Weighting the Pros and Cons of a Decision", On-line http://www.mindtools.com/pages/article/newTED_05.htm

2.2. Level Assessment for Stage 2: Idea Screening

Assessment 2 evaluates the way the generated ideas of Level 1 were screened so that a single idea is produced for further development.
As in Assessment 1 a GO, Hold or KILL decision is issued for proceeding to the next level depending on the given answers to the questions. In Appendix 2 a template for Assessment of Level 2 is included.

NPD Stage 3: Concept Development & Testing

As soon as a single product idea is selected through the process described in Levels 1 and 2, a product concept has to be developed so that a complete product can emerge in later Levels of the NPD Roadmap. So the problem one is forced to face in this Level is the product concept development and its evaluation. The product concept must be the best from many and this is accomplished by examining all available concepts for a single product idea.

3.1 Concept Development

When a single idea is selected from many generated ones through a screening process as described in Level 1 and 2, a product concept must be developed based on this single idea. This product concept should be an innovative solution that will be sold in the marketplace and produce revenue for the business. The concept generation process involves the evaluation of several product concepts all based on a single product idea.

Product concept generation involves the following:

- Definition of target market and customers.
- Identification of the competition and formation of a competitive strategy.
- Early - preliminary product technical development and testing scheduling.
- Estimation of product development required resources.
- Creation of a preliminary business plan.

All of the above are tasks that are not necessarily performed during the concept development stage. For example competition analysis and competitive strategy formation should be already carried out during Level 1. Also in many cases some of the tasks performed in the Business Analysis Level are carried out now so that preliminary business plans are created. That is why in some cases this level incorporates the next one where business analysis is carried out.

3.1.1 Controlled Convergence

Controlled convergence is a non-numeric tool for concept development right after product idea evaluation and selection. It helps the designer team to pick a concept by use of a simple matrix. It was first developed in the 80's by Stuart Pugh. The matrix that is used enables the comparison of concepts against some pre-determined criteria and provides the structure for evaluation of alternatives and competing ideas.

The methodology behind the formation of the matrix and the data insertion in the matrix is base in a number of simple steps that can be easily be followed by no-specialized personal. These steps are given bellow.

Step 1: One should identify 5 to 10 different concepts for a given product idea. The concepts should be sketched and some words can be added describing them. If there are less than 5 concepts available it is advisable that some kind of creative method to be used so that more can be generated.

Each sketch representing a concept should be in the same detail as the rest and must communicate the idea behind it easily.

Step 2: The most crucial aspect of the matrix to be used is the selection of the criteria against which the different concepts will be screened. These should reflect deep understanding of the customer needs, desires and purchasing motivations. Also criteria that reflect internal company needs such as manufacturing, service, assembly, risk and maintenance issues should also be considered. The final list of criteria should be agreed by all of the persons that make up the design team. Listing the criteria in a vertical left hand axis and listing the concepts in a top horizontal axis sets the matrix.

Step 3: One should choose a concept as the predominant one. It helps if this concept already exists as a product. Then one should compare all concepts with the predominant one. If the concept is better or easier than the predominant one then it is marked with a "+", if it is worst or harder with a "-" and if it is similar or same with an "S". For each concept the total number of "+", "-" and "S" are added and the number of "-" is subtracted by the number of "+". Doing this gives each concept a score number.

step 4: It is possible that there are good concepts that suffer from one specific feature. These can be combined together so that a concept that has no drawbacks can be formed. In this way the matrix result for the combination of two or more concepts can be better than the one of the concepts on their own.

Step 5: The process should be repeated having the resulted from the previous process strongest concept as the predominant one. In this case new concepts can be added into the matrix.

Step 6: After the completion of the process one must consider the results carefully and ask for a team agreement of the outcome. One should look out for a solution that clearly stands out from the rest.

Source: Better Product Design, Institute of Manufacturing, University of Cambridge, On-line http://www.betterproductdesign.net/tools/concept/convergence.htm

3.1.1.1 References

- "Controlled Convergence" (http://www.betterproductdesign.net/tools/concept/convergence.htm), Good Design Practice Program, Institute for Manufacturing & Engineering Design Center, University of Cambridge, UK, 2004
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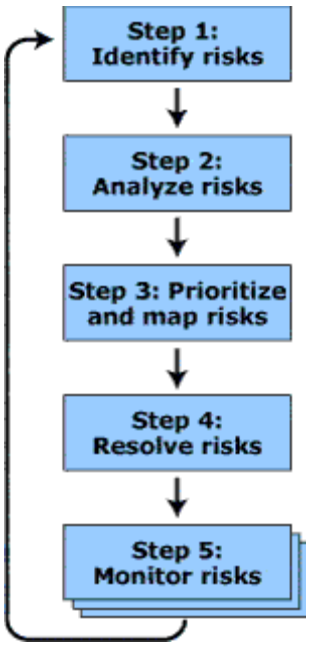
3.1.2 Risk Management

The product development process is an innovative process and as such it involves a large amount of risk. Much of this risk can be identified in advance and certain ways of dealing with that risk can be designed and implemented when the time comes. The new product development process as it is used nowadays in the form of a roadmap, consisting levels and assessment points, incorporates risk. The new product development roadmap process by itself does not facilitate ways of dealing this risk. Also sometimes the risk factors are so apparent that are not seen. Imagine looking for ones glasses that are right under ones nose. This is where risk management comes into play.

3.1.2.1 Risk Management Process

Managing the risk in a new product development process is about following a number of steps. These are graphically shown and discussed bellow.



Step1 & 2: Steps 1 and 2 are part of a planning process. During this process a cross-functional team consisting of people of as many different disciplines as possible think hard of potential development process problems. During this brainstorming session not only the risk factors must be identified but also possible solutions to the problems that might occur.

Step 3: During step 3 one must prioritize risks. For this to be done the following formulae can be used.

$$L_e = P_e * P_i * L_t$$

Where P_e is the probability of the risk event, P_i is the probability of impact, L_t is the total loss and L_e is the expected loss.

By evaluating the expected loss for all risk events that were identified and analyzed during steps 1 and 2 one can rank risks in order of severity. The larger the number of expected loss the most serious the risk is. By prioritizing the possible risks one can build solutions and plot courses of action that will if necessary address the most future serious problems first.

Step 4: During this step all risks are moved from the "risk list" that was created at steps 1, 2 and 3 and starting from the most serious ones one by one are dealt with using specific action plans. These actions plans must tackle the problems before they occur. They consist of preventive actions, which sometimes may require some time before they are truly effective. Also contingency plans must be formed and be ready to be implemented if the original action plans fail.

Step 5: All risks that were identified must be monitored. This must be done because one should know whether an action plan was successful or not in preventing a risk event from occurring. If an action plan was successful it should be retired, if not a new one or the contingency plan should be implemented.

3.1.2.2 Case Studies - Examples

Case Study: "Risk management for Intel's Corp dual processor server".

Using the 5-step process for risk management, which is discussed in "Risk management Process", the Intel Corp achieved to realize a dual processor server project having all customer requirements in place.

To begin with, during the **risk identification step** the Intel's cross-functional team identified three possible risk events: the inadequate product validation capacity, the high immortality of the new memory modules and the incomplete requirements of power management features.

Then the team during the **risk analysis step** examined the identified risk events in two steps:

- The team listed all the facts that led them to believe that the risk events and their impact will occur and examined each one to find an increased or decreased likelihood or severity of each of the risk event and its impact.
- Based on the facts the team estimated the probability of total loss for each event.

In the following **risk prioritization step**, the team, managed to prioritize the two main risk events that the project faced: The high immortality of the new memory modules and the incomplete requirements regarding power management features. For the third one, which was the product validation capacity, it was decided to be managed inactively by monitoring the risk event.

During the **fourth step** of the risk management process, the team formed action and contingency plans for each risk event. Such plans included the elevation of the importance and the priority of the whole project, the diversion of resources from other projects into this one and the possibility of planning a later product launch so that risk events could be dealt with as they occurred.

Finally during the **fifth step**, the team monitored all risk events so that if required the action plans would be implemented.

3.1.2.3 References

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- Smith G. P. Merritt G. M. "Using a Risk Model to Build Development Team Consensus", Project Management Innovations, Project Management Institution, Vol.6, Issue 4, Dec 2001.

3.1.3 Force Field Analysis

The Force Field Analysis is tool that uses a creative process for forcing agreement about all aspects of a desired change. The analysis is used for:

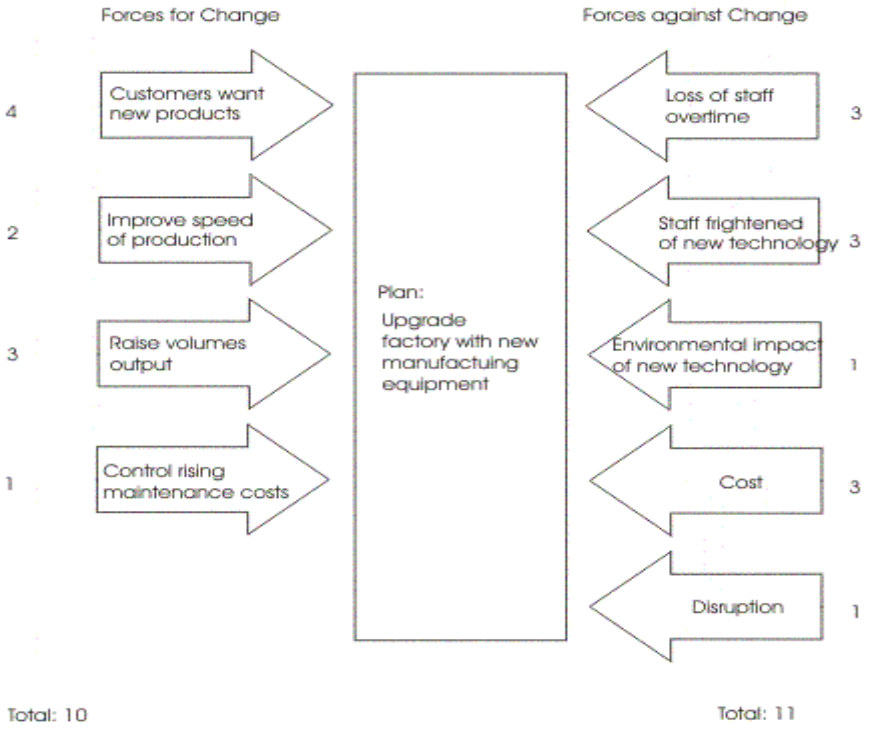
- Clarifying and strengthening the "driving forces" for change.
- Identifying obstacles or "restraining forces" to change.
- Encouraging agreement on relative priority of factors on each side of the balance sheet.

In the case of product development the analysis can show what path should be taken for a project to be feasible and can be manufactured. In this case the changes mentioned are the different characteristics of a path to be taken. To carry out such an analysis one should do the following.

- List all forces for change in one column and all forces against change in another.
- Assign a number to each force form 1 (being the weakest) to 5 (being the strongest).
- Draw a diagram showing the forces for and against change. Also note the size of each force by showing the assigned numbers next to them.
- Add up all the numbers in each column and compare the two numbers. If the number representing the total for change is bigger than the on against change then proceed with the project.

The above steps of performing the analysis can be easily illustrated by the following example.

Figure 1: Force Field Analysis Example



Source: Mind Tools, "Force Field Analysis – Understanding the Pressures for and Against Change", On-line http://www.mindtools.com/pages/article/newTED_06.htm

Because force-field analysis causes people to think together about what works for and against the status quo, it helps development team members to view each case as two sets of offsetting factors. It can be used to study existing problems, or to anticipate and plan more effectively for implementing change. When used in problem analysis, force-field analysis is especially helpful in defining more subjective issues, such as morale, management, effectiveness, and work climate.

Force-field analysis also helps keep team members grounded in reality when they start planning a change by making them systematically anticipate what kind of resistance they could meet. Conducting a force-field analysis can help build consensus by making it easy to discuss people's objections and by examining how to address these concerns.

Source: Mind Tools, "Force Field Analysis – Understanding the Pressures for and Against Change", On-line http://www.mindtools.com/pages/article/newTED_06.htm

3.1.3.1 References

- "Force Field Analysis: Understanding the Pressures For and Against Change" (http://www.mindtools.com/forcefld.html), Mind Tools, 2004
- "Force Field Analysis" (http://www.qaproject.org/methods/resforcefield.html), Quality Assurance Project, 2004
- "Force Field Analysis"

(http://www.skymark.com/resources/tools/force_field_diagram.asp), Sky Mark Corporation, 2003

3.1.4 Relevancy Concepting

"It's not exactly a secret -- efficiently managed brands frequently generate better than 80% of volume from 20% of users. But here's a lesser known info-bit. An astoundingly high proportion of healthy brands with low market penetration or an extended repurchase cycle -- or both -- track their success to the 80/20 Rule. Because the only way to succeed as a small brand is to run lean, efficient and focused.
Question: if 80% of $volume of a mature brand is generated by 20% of users...why would a volume minded manager allow the lightweights to drive the NPD process? It only takes third grade arithmetic to discover the volume contribution of a frequent user is sixteen times that of moderate/light users and therefore the only consumer needs, belief systems and product technologies that really impact volume are the ones relevant to the heavy-users of brands from which the new brand will draw its sales volume. Ultimately the new product concepts created by the 80/20 focus also should be evaluated by heavy-users and potential high volume prospects. Once again, who cares how the lightweights vote?

NPD managers who know the new brand sales volume will -- from the introductory launch to the bitter end of the brand's life cycle -- never support the $24,000,000+ A&P spending levels required to maintain mass marketing efforts should design the brand to reflect that corporate reality. The consideration should influence every phase of the NPD process from the concept development phase onward.
The ultimate reality, for most managers of low budget brands, is the bottom line. For that materialistic but highly compelling reason, focusing concept development on the hi-volume 20% user base is the most effective way to maximize the productivity of every dollar invested in any new brand -- large or small. For low penetration or infrequently purchased brands it's the only way.
The tool concentrates the primary procedure -- for example, Re-Engineering Technology -- exclusively on the high-volume users within either the category...or...the competitor targeted as the primary source from which the new brand will draw its volume.

To ferret out heavy-user targets that may be as small as 1% of the US adult population, the tool uses a 200000-consumer database to identify the demographics, behaviour patterns and lifestyle characteristics of homogeneous clusters of the targeted 20% heavy-users. From mind-numbing arrays of data crosscuts, collections of best-bet cluster profiles are generated. Ultimately a half dozen are selected to generate the information that will drive the primary NPD tool selected by managers.
Interviews with respondents recruited to match the selected subsets of heavy users are conducted to execute the procedure involved in the preferred NPD tool. The effort pinpoints need gaps and perceived deficiencies in existing technology of competitive options. Ultimately the new product concepts created by the concept team are also evaluated by heavy-users and potential high volume prospects.
Most assuredly it's an elitist effort. For the last time, who cares how the lightweights feel? The addition of pre and post supplements to the standard procedure chosen by NPD managers nearly doubles the effort, completion time. And cost. Perhaps for that reason it's the last NPD Tool Polaris has added to an extensive array of procedures. But the process that suggested the potential -- the Management Tool called "Relevancy Marketing" -- has been a mainstay for re-staging small brands for years. Under its direction low penetration, small budget brands like Clorets, Certs, Vivarin, Campho-Phenique, Blossom Hill and MG Vallejo typically project payout of A&P investments in half the time required for traditional mass marketing programs.
Historically the profile of brands attracted to the process has run to low penetration... infrequent repeat purchase...low margin brands that must run lean and focus available promotional funds on high volume prospects. The definition runs from household cleaners to sparkling wines. From PC Notebooks to OTC drugs. Prospective users include financial, discount brokerage and Internet services. Perhaps travel cruises, gaming and recreational facilities."
Taken from: "Relevancy Concepting", Polaris Marketing, On-line http://www.polarismktg.com/senrelev.htm

3.1.5 New Tech Commercialization

Over the years some marketers have discovered that it is hopeless to use consumer input to transform commercial applications of breakthrough technology into appealing products. There were cases where high tech, first to launch, products based on consumer input were later on surpassed by more effective and appealing competitive ones that used the same technology. To avoid and predict this unpleasant phenomenon, marketers developed a simple tool that opened a window into the future. "**Commercializing New Technology**", became a good way for NPD managers to peer into a future world of opportunity and identify revolutionary new product technologies with great market appeal.

The tool screens the population into "innovation acceptors" and "wait and see" segments making it possible to work with a segment of the market that it is not rejecting a new product concept because it is based on a new technology. In order to forecast possible commercial applications of breakthrough technology, the concept development team first develops a series of presentations of the core technology. This can be done by using technology prototypes or digital simulators. In both cases a fully developed product positioning must exist.

Having the prototype applications presentations in hand the team can conduct a qualitative research by using two persons at a time groups. During the research, functionality and end-benefit utilities can be recognized, important commercial applications of the core technology and gaps or less important possible product - concept features can be identified. During the research the consumer must be perceived as a critic and not as a creator. This characteristic differentiates this kind of research from other consumer needs and wants product researches.

The results of the research is then put through a refinement process in which the benefits or pitfalls of the new technology and the possible product applications are demystified and decisions on concept development can be taken without bias by the concept development team. One must remember that the team always is biased towards the new technology that has been developed by their company or business.

Source: "Commercialising New Technology", Polaris Marketing, On-line http://www.polarismktg.com/sencomme.htm

3.1.6 Quicktime Workshop

"When cycle time is critical, interactive exchanges between users and NPD teams can significantly shorten the process of identifying "the next big thing"...improve the quality of the core concept...build cross-functional cooperation...and create an all-important proprietary commitment to subsequent product development efforts of the NPD team. It's the equivalent of a home run with the bases loaded.
The tool is typically selected for the wrong reason -- to save time up front. In the preliminary phases of identifying the NPD concept. And it does save time. Only later does it becomes apparent the process forced the NPD Team to work together to blueprint a concept that (1) places customers first and (2) inputs everyone's ideas into an concept that merits "universal buy-in." Between the two latent features of the process, NPD managers eradicate the unanticipated revise-rework-redirection problems that can easily

double product development time and cost -- a consideration that makes the 30 day delivery of the concept seem like small potatoes.
The tool is an updated and significantly more sophisticated version of qualitatively assisted efforts to generate new product concepts that most NPD managers know as "Focus Groups." The improvements add a new dimension to qualitative ideation efforts.

- Consumer respondents are truly focused on project-relevant issues by real-world assignments (i.e., keep a contact lens care log / diary, conduct a wardrobe inventory of casual wear apparel, videotape a software installation, test-drive a Toyota and a Suburu).
- Direct eyeball-to-eyeball interface between NPD manager (assisted by Polaris moderator) and paired consumers.
- Interviews of consumers conducted in "double dyads" -- pairs of interviewers interfacing with pairs of consumers -- to facilitate in-depth exploration and concurrently eliminate group bias and "me-too" response.
- Post interview debriefing objectives include efforts to construct theoretical models of consumer insights; objective is to encourage a broad-spectrum conceptual exploration of opportunity within which specific new product concepts occur.

Because the effort places the idea generation responsibilities primarily on individual members of the NPD Team and equips them with both consumer insights and coaching assistance in synthesizing the information into user-relevant concepts, the tool generates a wide variety of cross-functional perspectives. Which in turn generate a wider -- and deeper -- spectrum of new product concepts from which the team collectively can pick and choose.
The process can be completed in less than 30 days. For managers uninterested in rehashing shop-worn ideas and tacking frivolous gimmicks on existing technology platforms it's the fastest way to identify legitimately innovative new product concepts. It's unquestionably the quickest way to develop big ideas that reflect both consumer and corporate-wide perspectives.

The process is conducted in a three-phase effort where members of the NPD team define potential prospects, usage parameters and pre-interview assignments to focus respondents...individually participate in depth interviews with prospective users who have been pre-programmed to focus on NPD team issues...then reconvene in a workshop in which they share insights and synthesize acquired information into consumer-relevant new product concepts.
Members of the NPD Team assume primary responsibility for generating "the next-big-thing" concepts. Polaris contribution to the effort is that of a coach / facilitator and creative resource whose primary responsibility is to introduce and conduct the process, recruit & pre-program consumer respondents, co-host the consumer in-depth interviews, assist individual team members in modelling / mapping insights produced in the interviews in which they participated and moderate the ideation workshop in which models, need matrices and new concepts are shared and improved.
Toyota design engineers ride shotgun for target prospects and informally probe observed behaviour; Nike marketing and R&D managers interface with skateboarding mall rats to discuss the-next-big-thing in road footgear. A list of potential applications for productively mixing consumers and NPD managers would be only slightly shorter than the Yellow Pages. Particularly since the need to meet ever shortening windows of opportunity means every manager needs the NPD concept yesterday. And it's that urgency that adds a new dimension of risk to an already perilous journey.
Because ideas are fuzzy abstractions whose value is difficult to measure, there is an inclination to go with two or three interesting ideas that have been lurking in the back of your mind for some time. It's a seductive -- and dangerous -- temptation. But shun that devil, brothers and sisters. Take the 30 days it takes to generate a full range spectrum of consumer-comes-first NPD options. It's critical. Because surveys show it takes more than a dozen legitimately high potential NPD concepts to produce one successful new product launch for package goods. The way to shorten the ideation functions that drive the remainder of the NPD effort is to work together to shorten the conceptualisation time -- not short cut the quantity of ideas. Or their quality."

Taken from: "Quicktime Workshop", Polaris Marketing, On-line http://www.polarismktg.com/senquick.htm

3.2 Concept Testing

Concept testing is the process of using quantitative methods for evaluating consumer response to a product idea prior to the actual product development and product launch into a market. These quantitative methods are usually performed using specific tools, filed surveys, personal interviews or a combination of all three and aim to evaluate generated product concepts. Sometimes these methods are used to generate concepts as well.

Concept testing procedures fall into three main categories:

- **Concept evaluations**, where concepts representing product ideas are presented to customers or consumers in a verbal or visual way and then they are evaluated by quantitative methods by indicating degrees of purchase intent, likelihood of product trial etc.
- **Positioning**, which is concept evaluation where concepts are placed in the same environment with other similar concepts or actual similar products.
- **Product / concept trials**, where consumers evaluate a concept then the product and the results are compared.

Concept testing has been many times in the past inadequate as a way to identify and evaluate the criteria that consumer preferences are based. There are times when most of the concept testing methods or tools cannot identify the relative importance of the factors governing the way consumers; markets and market segments react differently to concepts or concept tests. So in these cases the people carrying the tests did not have all the information necessary to create successful products specifically tailored to the needs of the customers. For this reason one should be extra careful about how he conducts a concept way, what kind of tool or method he is using and how he is using the chosen tool or method.

3.2.1 Quantitative Research

Quantitative Research unlike *Qualitative Research* (1038) is based on reliable, numerical, statistical measurement of the total target population. Quantitative Research is distinguished from Qualitative Research by the large number of people who are questioned and the type of questions asked. Usually 100 people are required to give yes/no answers to a survey to get results that are 95% accurate. For higher accuracies in the order of 97% or 99% samples of 400 to 2000 are required. Quantitative Research is conducted after a product concept is developed and its features are explained to potential customers or buyers. This kind of research suits better large companies that have a lot of money to spent since it is usually quite expensive to implement. Smaller companies can do a small field-study test in the real market instead. For a successful quantitative research one needs the following three elements.

- A well-designed questionnaire.
- A randomly selected sample.
- A large sample.

The design of a good questionnaire depends upon the elements that will contain and the well-defined goals or questions to be answered by it. Questions can be set asked using the telephone, fax, or writing. The Quantitative Research questionnaires are similar to Qualitative Research ones, but more complex and more information demanding. All information gathered can be interpreted numerically so that a statistical measurement to be made afterwards. Typical style questions that can be asked and ultimate goals of the research are given in the table bellow.

Table 1: Quantitative Research Considerations and Questions

Research Considerations	Typical Research Questions
What decisions can be based on results?	Age? Sex? Occupation? Income range? Locality?
	Use of similar products?
What information is needed?	What competitive products are used?
Screening methods of sample?	Frequency of purchase of competitive products?
Size of sample?	Ranking of competitive products?
Results analysis method?	Competitive product price considerations?
	Competitive product features evaluation?
	Product advertising evaluation?
	Market positioning evaluation?
	New product concept evaluation?
	Purchase intent of new product concept?

All questions should be set in such a way that can be understood easily and encourage someone to be willing to answer them. One should avoid vague, non-useful background, trick and difficult to answer questions.

Once a good questionnaire is designed then the target sample of the research must be selected. This sample can be a probability one or a non-probability one. Probability sampling is when each customer sampled has an equal chance of being selected for testing. This means that results can represent equally of the entire target population. Non-probability sampling is exactly the opposite and that is why it can be biased. Small businesses use non-probability sampling due to budget constraints.

The same budget constraints can dictate and the size of the sample to be selected. The larger the size the more accurate the results will be. Also the more reliable the research will be.

3.2.1.1 References

- CCH, "Quantitative Research" (http://www.toolkit.cch.com/text/P03_3150.asp), CCH Business Owner's Toolkit, 2002
- Hopkins G H, "Quantitative Research Design" (http://www.sportsci.org/jour/0001/wghdesign.html), Dept of Physiology and School of Physical Education, University of Otego, New Zealand, 2000
- Joppe M, "Quantitative Research" (http://www.ryerson.ca/~mjoppe/ResearchProcess/QuantitativeResearch.htm), School of Hospitality and Tourism Management, University of Rayrson, Ontario, Canada

3.2.2 Quality Functional Deployment

Quality Functional Deployment (QFD) originated around 1985 by well-known Japanese firms as a tool of new product development or existing product refinement. Very soon it was adopted by most large firms worldwide and in the process acquired as many supporters as enemies.

A cross-functional team of individuals that are responsible of new product development usually carries out QFD. The process uses a series of matrices to document information about new product ideas collected or developed and through these matrices one can show a set of new product ideas and if needed a complete plan for new product. So QFD cannot only be an idea generation or idea management tool, but also a complete product development tool. This can be seen by careful examination of the following steps that make up QFD methodology.

- Acquisition of product characteristics or product customer requirements.
- Development of product concepts that can fulfil these requirements.
- Evaluation of each product concept.
- Derivation of low-level product requirements.
- Derivation of high-level product requirements.
- Determination of manufacturing process to meet both low and high-level product requirements.
- Development of process and quality controls.

As mentioned above a QFD analysis is made up from different matrices. The basic QFD methodology involves four basic steps containing the identification of customer needs or requirements and the use of those in the creation of three matrices. All four steps are analysed and explained bellow.

QFD requires that the basic customer needs or requirements are identified. This identification is the **first step** of designing and conducting a QFD analysis. It is important that these requirements are expressed in terms of "what" and not "how". For that reason it is important that marketing personnel should ask "why" until they truly understand the root requirement of a customer. QFD can also be used in such a way that the supplier requirements are identified and not the customer's. (Suppliers and middlemen can also generate product ideas).

Once these requirements are gathered, they have to be organized and prioritised so that it could be more simple and easy their insertion into the QFD matrices. Competitive products must be then identified by some means of a CIP program and along with the customer needs identified, be inserted into the first QFD matrix which is called "Product Specification Matrix". The filling up of the first QFD matrix is the second step of the QFD methodology and analysis. This matrix can be used to define customer needs in a mathematical way, analyse competitive products, plan a product to respond to needs and establish critical characteristic target values for each of the product requirements.

The **third step** of the QFD methodology helps to identify possible product design characteristics or specifications to meet the derived product requirements from the previous matrix. This helps to identify critical product parts or assemblies before product development. This second matrix is called "Product Design Specification Matrix".

The **fourth and final step** of the QFD methodology and analysis is used to identify critical processes in the product development. All the processes concerning the development of the critical product parts identified in the previous matrix are identified and target values are set as a measure during the development stage.

3.2.2.1 Case Studies - Examples

Case Study 1: "Product update due to changing customer needs"

A major supplier of medical implements needed to upgrade one of its products because of recent improvements in associated medications, an increased level of use, and for better infection control. They found they were losing business because their competitors were already a generation ahead of their current product.

The team decided to use QFD in order to better understand customer wants and needs. This data was gathered through numerous one on one interviews with their medical users. This really opened their eyes. They could easily tell, even this early in the project, that a product concept, which had been mandated by management, would not satisfy the customers. They decided to continue following the process and see where it led.

Only after completing the product-level QFD matrices, did they identify the alternative design concepts. These were documented, using CAD, to a level, which allowed them to choose one alternative as being clearly better than the others at satisfying the customer requirements in a cost effective way. The selected concept was significantly better than anyone had conceptualised before the study. It was truly a breakthrough.

The project was completed significantly faster than any previous, similar project. They were able to re-orient management's pre-conception of the product because they could prove that the selected product concept would satisfy all of the requirements whereas the management concept would not. Finally, the project manager states, "The new product was a revolutionary advancement in the existing technology. This breakthrough was largely due to the insight obtained by the project team as part of the QFD process." They credit the process with a lot of their success!

Case Study 2: "Differentiating from competitors"

A major bank was struggling with how to differentiate itself from its many competitors in a particular market segment. They wanted to either change the way they were performing their current business or add an innovative new service, which would be difficult for their competitors to copy.

The team, consisting of the regional manager and his direct reports, was brought together to define in strategic terms what direction their bank should go. Market research was performed and a number of niches were identified which wanted very specialized services.

After a particularly attractive niche was selected, the team used QFD to convert the benefits desired by the customers into measurable characteristics of a service offering. Alternative services were brainstormed using a structured brainstorming process. These concepts were defined in enough

detail that they could be objectively analysed. The team used the characteristics of the service offering to select the concept that would best satisfy the user and business requirements.

The team was able to identify, define, and develop a brand new concept in personal banking. While the bottom-line results are not yet available, the team expects the new service to be a dramatic success.

3.2.2.2 QFD Tool from Urenio

There are two files available that are created by the Urenio Research Unit to be used as a tool and examples of the QFD matrices. The files can be used not only to see what QFD matrices look like but also to perform QFD following the instructions given. The first file can be used to gather customer requirements for QFD use and the second has three of the most important QFD matrices ready for filling up. Also instructions are given in the second file. The names of the files are given bellow.

3.2.2.3 Consultants - Experts

- QFD Institute (http://www.qfdi.org/)

Non-profit organization that researches and develops state of the art market research tools such as Quality functional deployment.

- QFD Consultants Inc (http://www.qfd.bc.ca/)

Private sector consultancy that is made up by 14 engineers based in Vancouver - Canada. The firm provides design, engineering and experience for QFD development.

- QFD Insitut Deutschland EV (http://www.qfd-id.de/en/index.html)

The German QFD Institute is a non-profit organization whose purpose is the distribution and the understanding of engineering technique known as QFD.

- Quality Associates International Inc (http://www.quality-one.com/services/qfd.cfm)
- QAI is an international full service quality and reliability-consulting firm. Among the services it provides is QFD as a facilitation quality tool.

3.2.2.4 Software Tools

http://www.qfd2000.co.uk/introductionqfd2000.htm

QFD2000 software is a complete software solution for Quality Functional Deployment. The QFD2000 software offers easily customisable matrices but also goes beyond this to provide the extra tools one will need to understand customer requirements and develop products and services to delight them.

http://www.qfdcapture.com/

QFD Capture software is a complete QFD software tool available from the above website. Along with the software there are tutorials, case studies and an explanation of the QFD process available.

3.2.2.5 References

- Crow, K. "Performing QFD Step By Step" (http://www.npd-solutions.com/index.html), NPD Solutions Inc, 2002
- Katz, G. M. "After QFD: Now What" (http://www.pdma.org/visions/apr01/after_qfd.html), Visions Magazine

3.2.3 Decision Tree Analysis

Decision Trees are very good tools for helping someone to chose between several courses of action. They can provide an effective structure, which one can lay options and investigate possible outcomes of choosing these options. Also Decisions Trees can help in the formation of a complete picture of the risks and rewards associated with a particular project and each course of action related to it.

Decision Trees provide an effective method of decision making due to the following characteristics.

- Clearly lay out a problem so that all options can be challenged.
- Allow to analyze fully the possible consequences of a decision.
- Provide a framework to quantify the values of outcomes and the probabilities of achieving them.
- Help making the best decisions on the basis of existing information and best guesses.

A complete example of a Decision Tree, which is used to investigate the perils and rewards of developing a new product or upgrading an existing one, is given. One can study the example - case study for deeper understanding of the way Decision Trees work.

Source: Mind Tools, "Decision Tree Analysis - Choosing Between Options by Projecting Likely Outcomes", On-line http://www.mindtools.com/dectree.html

Case Studies – Examples: Drawing a Decision Tree

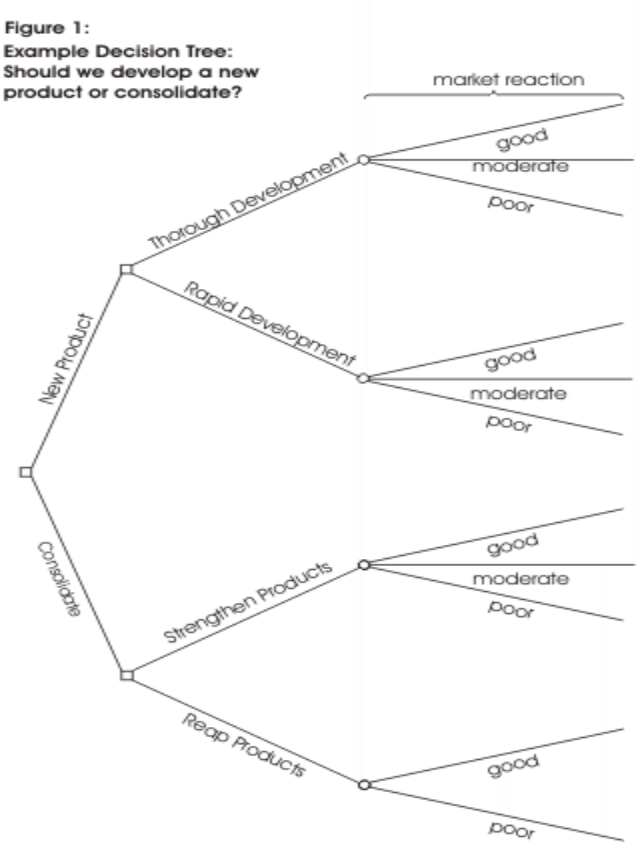
One can start a Decision Tree with a decision that one needs to make. The first step is to draw a small square to represent the decision on the left of a large piece of paper. From this squere one then should draw out lines towards the right of the paper for each possible solution, and note that solution along each line. One should keep the lines apart as far as possible so that one can expand all possible thoughts.

At the end of each drawn line, one should think about the different outcomes. If the outcome of taking a particular decision is uncertain, then a small circle should be drawn. If the outcome is another decision, another square should be drawn. Squares always represent decisions, and circles always represent outcomes. One should write the decision the square or circle. If one has completed the solution at the end of a particular line, then this should be left blank.

Beggining from the new decision squares on a diagram, one should draw out lines representing options. From the circles lines should be drawn representing possible outcomes. Again a brief note

should be made on each line explaining what it means. This exercise should be made until one has drawn out as many as possible outcomes and decisions.

An example of the resulting procedure is shown in Figure 1:



Source: Mind Tools, "Decision Tree Analysis - Choosing Between Options by Projecting Likely Outcomes", On-line http://www.mindtools.com/dectree.html

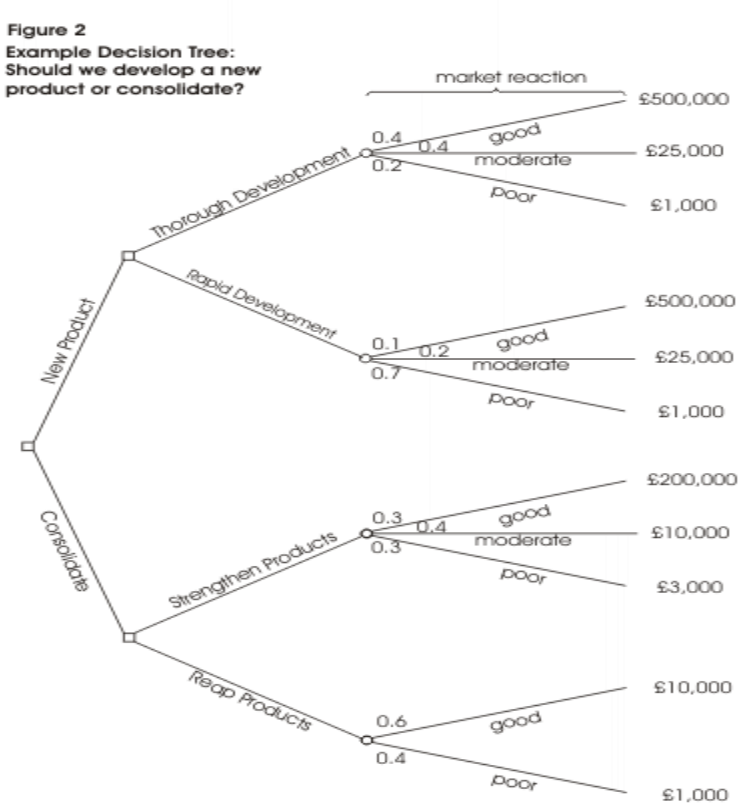
Once this procedure is finished, one should review the tree diagram. Each square and circle should be chalenged so that any solutions or outcomes that were not apparent can be identified. If there are such outcomes or solutions, they must be drawn. If necessary, the tree must be redrawn if there are parts of it that are too congested or untidy. One should now have identified all the possible outcomes of ones decisions.

Evaluating Your Decision Tree

Evaluating the tree is where one can work out which outcome has the greatest value. One should begin by assigning a cash value or score to each possible outcome. The estimation should be made based upon the value of each outcome.

Next one should take a look at each circle and calculate the probability of each outcome. If percentages are used, the total must come to 100% at each circle. If fractions are used, these must add up to 1. If one has data on past events, one may be able to make calculations of the probabilities. Otherwise one should write down ones best estimates.

This exercise will provide a tree like the one shown in Figure 2:



Source: Mind Tools, "Decision Tree Analysis - Choosing Between Options by Projecting Likely Outcomes", On-line http://www.mindtools.com/dectree.html

h2. Calculating Tree Values

Since one has worked out the value of the outcomes, and assessed the probability of the outcomes of uncertainty, it is time to start calculating the values that will help to make ones decision.

One should begin on the right hand side of the tree, and work back towards the left. As one completes a set of calculations all one needs to do is to note the result. One can ignore all the calculations that lead to that result from that point and onwards.

Calculating The Value of Uncertain Outcome Nodes

Where one is calculating the value of uncertain outcomes, this must be done, by multiplying the value of the outcomes by their probability. The total for that node of the tree is the total of these values.

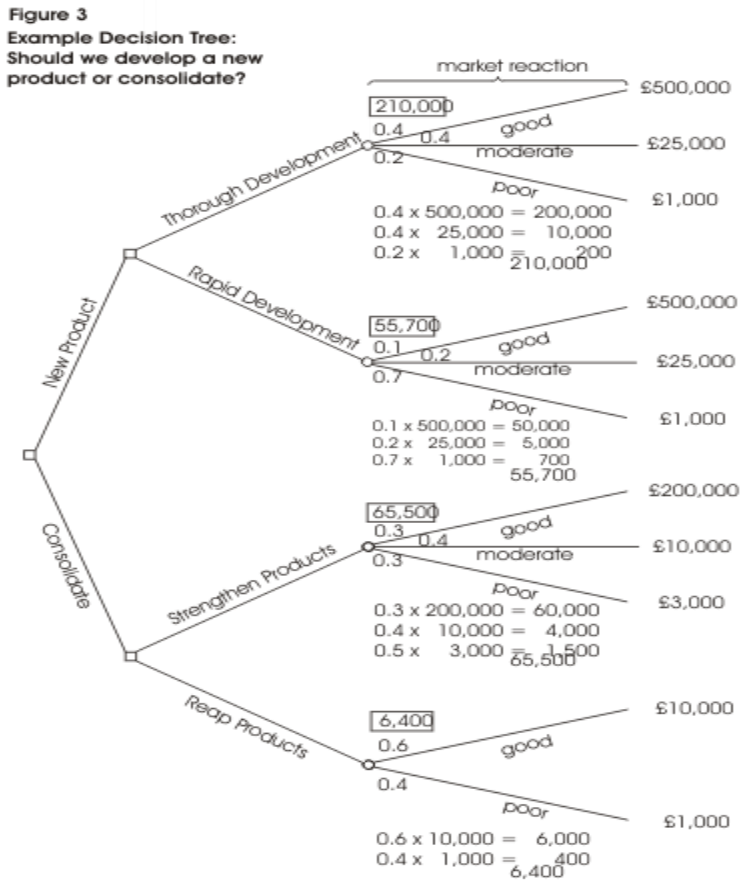
For the example in Figure 2, the value for 'new product, thorough development' is:

Table 1: Calculating The Value of Uncertain Outcome Nodes

0.4 (probability good outcome) x £500,000 (value) =	£200,000
0.4 (probability moderate outcome) x £25,000 (value) =	£10,000
0.2 (probability poor outcome) x £1,000 (value) =	£200
TOTAL	£210,200

Source: Mind Tools, "Decision Tree Analysis - Choosing Between Options by Projecting Likely Outcomes", On-line http://www.mindtools.com/dectree.html

Figure 3 shows the calculation of uncertain outcome nodes:



Source: Mind Tools, "Decision Tree Analysis - Choosing Between Options by Projecting Likely Outcomes", On-line http://www.mindtools.com/dectree.html

Calculating The Value of Decision Nodes

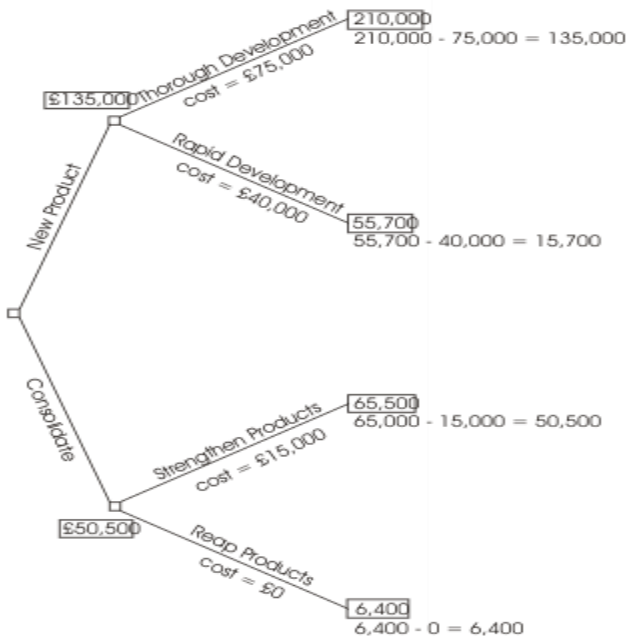
When one is calculating a decision node, one should write down the cost of each option along each decision line. Then by subtracting the cost from the outcome value that one has already calculated, will give a value that represents the benefit of that decision.

One should note that amounts already spent do not count for this analysis and should not be taken into making the decision.

When one has calculated these decision benefits, one ought to choose the option that has the largest benefit, and take that as the decision. This is the value of that decision point.

Figure 4 shows this calculation of decision nodes in our example:

Figure 4:
Example Decision Tree:
Should we develop a new product or consolidate?



Source: Mind Tools, "Decision Tree Analysis - Choosing Between Options by Projecting Likely Outcomes", On-line http://www.mindtools.com/dectree.html

In the example above, the benefit previously calculated for 'new product, thorough development' was £210,000. The estimation of the future cost of this approach is £75,000. This gives a net benefit of £135,000.

The net benefit of 'new product, rapid development' was £15,700. On this branch therefore it was chosen the most valuable option, 'new product, thorough development', and allocated this value to the decision node.

Source: "Decision Tree Analysis: Choosing Between Options By Projecting Likely Outcomes" (http://www.mindtools.com/dectree.html), Mind Tools

3.2.4 KANO Model

The KANO Model, which was developed in the 80's by Professor Noriaki Kano, offers to its users some insight into the new product attributes, which are perceived to be important to customers. For

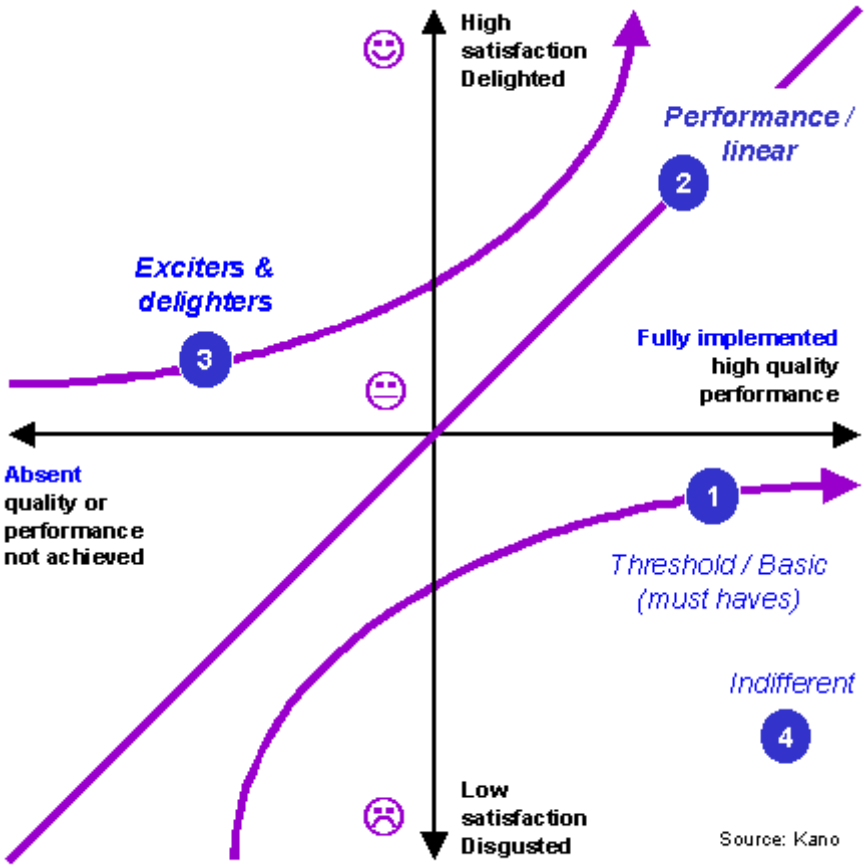
this reason it is a very helpful tool for idea evaluation and extremely helpful for product concept development. It focuses the attention of the user on differentiating features. It can be a very powerful tool if all the methodology is followed and a very useful one as a visualization tool.

As mentioned above the tool is a very useful visualization tool. The model can visualize product attributes or characteristics and stimulate discussion within the product design team. The model offers a strong methodology for mapping consumer responses. This is done by classifying product characteristics into three basic types:

- **Threshold / Basic Attributes.** Characteristics, which must be present for the product to be successful. One must note that a customer will most probably remain neutral towards the product even when improved versions of these characteristics exist.
- **One-dimensional attributes (Performance / linear).** These product characteristics are directly related to customer satisfaction. As these are improved or their number increases in a new product, the customer will be more satisfied. In the other hand if these are decreased in functionality or quality the customer will be dissatisfied.
- **Attractive attributes.** Product characteristics that offer great satisfaction to a customer. The difference between them and the One- dimensional ones is that a decrease in quality, functionality or number of these characteristics will not result in customer dissatisfaction. These product features are difficult to be identified since they are considered as unexpected by customers and basic customer needs usually are identified first. Sometimes these product characteristics are called customer latent needs.

Successful product concept development can either be achieved by a high level of execution of performance / liner attributes or by the inclusion of attractive attributes into a new product concept. One should note that today's customer needs might become tomorrow's expected features as customer expectations vary over time. The following figure shows the Kano Model in the form of customer attributes combined with customer satisfaction.

Figure Kano Model



Source: Better Product Design, Institute of Manufacturing, University of Cambridge, On-line http://www.betterproductdesign.net/tools/definition/kano.htm

3.2.4.1 KANO Model Methodology

The Model uses a structured user questioning methodology to characterize different features - attributes and remove any doubts or misunderstood points by making certain that the categorization of attributes is based on user research. The methodology is more or less straightforward can it sis given in the form of five basic steps bellow.

Step 1. One must determine the main features of interest that are to be classified later on. This can be done by the product design team.

Step 2. A questionnaire must be set up. The questionnaire must be designed in such a way that the design team can understand exactly how the customer feels about a certain attribute. This can be accomplished by asking two questions about a specific feature, a functional one and a non-functional one (i.e. the feature is and it is not present).

Step 3. As with most interviews, a sufficient number of responses must be gathered and an average response must be found.

Step 4. Based upon the responses gathered a type of feature can be determined from a simple look up table that should be set up. In this case one should note that apart from the attributes that were described earlier, one could have one or two additional attributes. These can be the "Indifferent responses" and the "Contradiction responses".

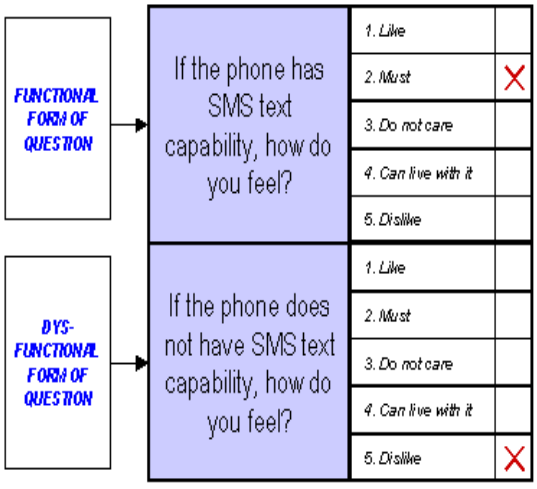
Step 5. All features must be plotted into the Kano graph to provide a visual guide to the relative importance of each attribute to the customers.

The model can be difficult for someone to grasp but it provides useful information about additional product features apart from those that satisfy the customer wants and needs. As QFD it requires team involvement since it relates product features with user perceptions.

Source: Better Product Design, Institute of Manufacturing, University of Cambridge, On-line http://www.betterproductdesign.net/tools/definition/kano.htm

3.2.4.2 Case Studies - Examples

The following tables show an example of how a questionnaire can be set-up for gathering customer product needed features for use in the Kano Model and an example of a simple look up table. The first one includes a functional and a non-functional question about a mobile phone characteristic. In the second one the user can see that SMS text is a must for a mobile phone.



Customer requirements		DYS-FUNCTIONAL: 1. Like	2. Must	3. Do not care	4. Can live with it	5. Dislike
FUNCTIONAL	1. Like	Q	A	A	A	O
	2. Must	R	I	I	I	X
	3. Do not care	R	I	I	I	E
	4. Can live with it	R	I	I	I	E
	5. Dislike	R	R	R	I	Q

O = One dimensional or linear features
I = Indifferent response
A = Attractive features
E = Expected features
R = reversal (inconsistent response)
Q = Questionable response

Source: Better Product Design, Institute of Manufacturing, University of Cambridge, On-line http://www.betterproductdesign.net/tools/definition/kano.htm

3.2.4.3 References

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3.2.5 Weighting and Rating

Weighting and Rating (W&R) is the simplest and most commonly used method or tool for concept selection or product idea selection. The tool is very easy to understand and apply but it demands very reliable information to be truly effective. The tool can be very good to show front runners in terms of concepts or ideas, but since it is numerical it is very dangerous if someone is not open minded because it tends to show only one right solution to a given problem. Also the tool is very sensitive to small changes and can be easily be used in the wrong way since it is very easy to "cook the books". The tool can be conducted if one follows the next four steps.

Step 1. One should list all the important features of the product that have been determined during the product definition phase and from any other criteria against which competitive solutions can be judged.

Step 2. Some of the features that are listed in Step 1 are more important in respect to others. So weights must be assigned to each of the features indicating their importance. Ideally weights must be considered and assigned in partnership with target customers.

Step 3. Each feature must be scored. Customers and not the design team must do the scoring. This is done to remove bias.

Step 4. Each score is must then be multiplied by the feature's weight and all the totals must be summed. The product option or concept with the highest score is the winner of the process.

Source: Better Product Design, Institute of Manufacturing, University of Cambridge, On-line http://www.betterproductdesign.net/tools/concept/weight-rate.htm

3.2.5.1 Case Studies - Examples

The table bellow is a typical example of how Weighting and Rating tool can be used in selecting the best concept for a new car.

Table 1: Weighting & Rating Example

FEATURE / ATTRIBUTE		Option 1 New Mini		Option 2 VW Passat		Option 3 Rover 45		Option 4 Fiesta		Option 5 Focus	
	WEIGHT (0-10)	Score (0-10)	Total Sx W	Score (0-10)	Total Sx W	Score (0-10)	Total Sx W	Score (0-10)	Total Sx W	Score (0-10)	Total Sx W
CAPACITY											
Passengers	2	3	6	9	18	7	14	3	6	4	8
Luggage	3	2	6	9	27	7	21	4	12	6	18
Bulky items	2	1	2	6	12	8	16	8	16	7	14
PERFORMANCE											
Fuel efficiency	4	7	28	4	16	6	24	8	32	6	24
Top speed	8	7	56	7	56	5	40	4	32	6	48
0-60	8	8	64	5	40	4	32	3	24	5	40
COMFORT											
Interior trim	7	7	49	9	49	6	42	4	28	5	35
Noise	2	5	10	8	16	6	12	4	8	5	10
Drinks holders	2	5	10	9	18	4	8	3	6	5	10
Radio - CD	9	5	45	5	45	5	45	5	45	5	45
Derivability	9	9	81	6	54	7	63	3	27	6	54
SAFETY											
Airbags	8	5	40	10	80	5	40	5	40	10	80
ABS	7	10	70	10	70	10	70	0	0	10	70
Crach worthiness	8	5	40	9	72	8	64	3	24	6	48
MISC											
Colour	6	6	36	3	18	3	18	4	24	4	24
Affordability	2	6	12	3	6	6	12	8	16	6	12
Depreciation	1	9	9	2	2	5	5	6	6	5	5
		Weighted total	564	Weighted total	599	Weighted total	526	Weighted total	346	Weighted total	545

Source: Better Product Design, Institute of Manufacturing, University of Cambridge, On-line http://www.betterproductdesign.net/tools/concept/weight-rate.htm

As one can see all the features are listed in left hand side of the table and weights are assigned to each of them. Then scores for each feature is noted and this score is multiplied by the weight to give a total number. All numbers are then summed to give the grand total for each product option. In the case of selecting a car the VW Passat is the winner and so the best product concept.

Source: Better Product Design, Institute of Manufacturing, University of Cambridge, On-line http://www.betterproductdesign.net/tools/concept/weight-rate.htm

3.2.6 Communications Check

A developed new product concept is not the product by itself. It's simply a general representation of a product technology and its end-benefits. Sooner or later this idea, fuzzy thought or generalized notion must be translated using a certain way so that potential consumers can evaluate it. Typically this translation is performed in a strategically oriented product positioning statement. The problem is, if a product concept is talking "apples" and the target consumer is hearing "oranges," any evaluation of that particular product concept is surely going straight for disaster. One could discard what could have been the best idea in the lot during the idea screening process. Even worse, one could develop an unwanted apple -- not the required orange that the consumer thought one was promising.

Since communication is an art it's easy for a product concept to be the wrong one or, more likely, have less than optimal perceptions. Especially if the concept involves general benefits new technology or ideas driven by emotional forms of logic. Over the years testing showed that out of eight concepts, one absolutely fails to give out the intended message and/or strategic content and another two will be significantly less than the best. Murphy's Law states that one of the three miscommunications would have been the "great idea."

"The tool, in its simplest configuration, troubleshoots communication efforts of candidates prior to concept testing to determine if the intended selling proposition registered, was understood and accomplished key strategic objectives. Communications that missed the strategic mark are revised and advanced to the next step in the NPD effort. The effort is qualitative. Quick. Inexpensive. And can avoid costly downstream mistakes."[2]

The communication procedure can start at the beginning, developing the communications necessary to pinpoint and transfer the concept as it was thought by the NPD team. The procedure uses whatever means are necessary to express, in consumer terminology and graphics, the strategic elements of the product benefit, supporting technology, tangible features & attributes, performance characteristics, pragmatic proof-of-performance and abstract benefits. Typically the communication procedure depicts a fully developed product concept and this way may take the form of a poster, an image or a set of storyboards. In some cases even the concept itself may serve as the format conveying its message to the consumer. Animation, videotape or CD presentations may be appropriate, but in no instance does the communication employ tactical or executional variables.

In instances where the communication must be developed, members of the concept team are briefed by NPD managers who top line product technology, tangible features & attributes, performance characteristics, pragmatic proof-of-performance, abstract benefits. Plus profiles and need matrices of the target prospect.

In other situations the concept components have already been consolidated by managers into a finished positioning statement that has been communicated in a poster board, frame-by-frame storyboard or videotape. Working with these positioning materials, Two-On-One interviews probe concept communication efforts to confirm target prospects "got it" at all four levels: registration of plain text message...comprehension of strategic content... internalization of personally relevant benefits/utility...rationalization of purchase decision (economic or coherence with personal value system). No attempt to evaluate the concept's impact on purchase intent is made; the effort would be both premature and statistically unreliable.

Necessary revisions are recommended to NPD managers and, with their approval, final versions of the concept are advanced to the next phase of the project.

Source / Taken from: "Comm Check", Polaris Marketing, On-line http://www.polarismktg.com/sencommc.htm

[2] Polaris Marketing

3.2.7 Concept Screen Software

Once a number of ideas are collected, the next step is to screen these ideas so that to identify which one to pursue. **Concept Screen®** is an Internet based screening system provided by Decision Analyst Inc, which can do exactly that.

Concept Screen® inserts all possible product ideas into a database and then a total of 50 - 70 target audience consumers are asked to review and evaluate these ideas. The outcome of such a review then goes through a market test called Conceptor to evaluate the market strength of the resulting product concept and finally, a name and a packaging research is done to define the optimum name and package for the new product concept.

Concept Screen® can be found on-line at the Decision Analyst Inc web site at the address: http://www.decisionanalyst.com/Services/concept.asp

3.3 Level Assessment for Stage 3: Concept Development

Assessment 3 evaluates the way the selected product idea of Level 3 was turned into a product concept so that a new product is produced for further development and how this concept was evaluated.

As in Assessment 2 a GO, Hold or KILL decision is issued for proceeding to the next level depending on the given answers to the questions.

In Appendix 3 the template for Level Assessment is included.

NPD Stage 4: Business Analysis

Since the company has a great idea for a new product chosen, the product concept has been developed and the marketing strategy seems feasible, the next step is to check whether the finances are there to back up such a project. The business analysis level looks more deeply into the cash flow the product could generate, what the cost will be, how much market shares the product may achieve and the expected life of the product. So in this Level the business situation surrounding a proposed project is checked.

4.1 Tools & Solutions

The evaluation of the necessary financial resources for development of a concept into a new product can be done using specific tools such as "Cost - Benefit Analysis" for the calculation of expected costs and return of investment, "Gannt Charts" for the scheduling of the whole project from now until product launch, "Critical Path Analysis & PERT" for the management and relocation of resources if necessary and "Stakeholder Analysis" for the evaluation of support from the companies executives, the investors and all the people that can influence the NPD project.

Also in this Level the new product life cycle must be evaluated since this factor will greatly affect all above factors of the business analysis.

4.1.1 Cost Benefit Analysis

One of the tools available to select an idea for further development is Cost Benefit Analysis. Such an analysis can show whether there are the economics to back up the development of the product concept into a physical product. CBA is really the creation of a so-called Business Plan (BP). A BP has the following structure.

- The executive summary.
- The business.
- The marketing plan.
- The organizational plan.
- The production plan.
- The financial plan.

The purpose of creating a business plan is to find and secure financing internal or external for the product development process or more general for the start up or expansion of a business venture. Since up to product idea screening and product concept development no real money was spend, it is crucial that a BP is formed before going into development. A BP requires information from different persons coming from different principles of a company. There is no way that a single person can provide with all the answers needed for the creation of it. The result of a BP is usually an estimate of whether there will be a profitable return, in this case, to the product development investment.

Source: Financing Innovation, "Basic Business Plan", On-line http://www.newventuretools.net/toolbox.html?toolwindow=http://onlibrowser.pt/financing-innovation-tool

4.1.1.1 Cost Benefit Analysis Tool: "Financing Innovation"

A Business Plan (BP) can be formed on-line using a tool, which can be found under the heading "Financing Innovation" on the following web site.

http://www.newventuretools.net

4.1.2 Product Life Cycle

All products and services have certain life cycles. The life cycle refers to the period from the product's first launch into the market until its final withdrawal and it is split up in phases. During this period significant changes are made in the way that the product is behaving into the market i.e. its reflection in respect of sales to the company that introduced it into the market. Since an increase in profits is the major goal of a company that introduces a product into a market, the product's life cycle management is very important.

The product's life cycle - period usually consists of five major steps or phases: Product development, Product introduction, Product growth, Product maturity and finally Product decline. These phases exist and are applicable to all products or services from a certain make of automobile to a multimillion-dollar lithography tool to a one-cent capacitor. These phases can be split up into smaller ones depending on the product and must be considered when a new product is to be introduced into a market since they dictate the product's sales performance.

Product development phase begins when a company finds and develops a new product idea. This involves translating various pieces of information and incorporating them into a new product. A product is usually undergoing several changes involving a lot of money and time during development, before it is exposed to target customers via test markets. Those products that survive the test market are then introduced into a real marketplace and the introduction phase of the product begins. During the product development phase, sales are zero and revenues are negative. It is the time of spending with absolute no return.

The introduction phase of a product includes the product launch with its requirements to getting it launch in such a way so that it will have maximum impact at the moment of sale. This period can be described as a money sinkhole compared to the maturity phase of a product. Large expenditure on promotion and advertising is common, and quick but costly service requirements are introduced.

The growth phase offers the satisfaction of seeing the product take-off in the marketplace. This is the appropriate timing to focus on increasing the market share. If the product has been introduced first into the market, (introduction into a "virgin" market or into an existing market) then it is in a position to gain market share relatively easily. A new growing market alerts the competition's attention.

When the market becomes saturated with variations of the basic product, and all competitors are represented in terms of an alternative product, the maturity phase arrives. In this phase market share growth is at the expense of someone else's business, rather than the growth of the market itself. This period is the period of the highest returns from the product. A company that has achieved its market share goal enjoys the most profitable period, while a company that falls behind its market share goal, must reconsider its marketing positioning into the marketplace.

The decision for withdrawing a product seems to be a complex task and there a lot of issues to be resolved before with decide to move it out of the market. Dilemmas such as maintenance, spare part availability, service competitions reaction in filling the market gap are some issues that increase the complexity of the decision process to withdraw a product from the market. Often companies retain a high price policy for the declining products that increase the profit margin and gradually discourage the "few" loyal remaining customers from buying it. Such an example is telegraph submission over facsimile or email.

4.1.2.1 PLC Quick Reference

INTRODUCTION PHASE	
PRICE	High, customers willing to pay premium for new product. Early adopters.
PROMOTION	Limited. Highly targeted promotional efforts aimed at specific customers
DISTRIBUTION	Direct (factory to customer) or limited distribution through specific strategic partners.
SALES	Small team of highly skilled salesmen with good knowledge of the market.
DEVELOPMENT	Focus on time to market and uniqueness.
MANUFACTURING	High expenditure for new production capacity.
SERVICE	High level of service for targeted customers.
SUPPORT	Direct factory support. Engineering involvement is required.
TRAINING	Focused on new product features, benefits, differentiation, pricing and functionality.
TECHNOLOGY	New and innovative.
COMPETITION	Limited. May be offering different solution for the same problem or application.
MARKET SHARE	Low overall.
GROWTH PHASE	
PRICE	10% of market level. – 10% if the brand name is weak and competition is severe, + 10% if sales are good and competition does not have similar product to offer.
PROMOTION	Heavy. Targeted promotions, trade shows, direct mail, sales seminars, articles and press releases.
DISTRIBUTION	Highly skilled. Focused channels with strong technical skills if needed, complementary products and services.
SALES	Everywhere possible. Retail shops, telephone, internet.
DEVELOPMENT	Complete development. Market penetration is sustained with variations and improvements of the product.

MANUFACTURING	Addition of capacity and automation.
SERVICE	Local and regional, fully staffed.
SUPPORT	Phone support.
TRAINING	Transition to newer version of product.
TECHNOLOGY	Newer and leading edge.
COMPETITION	New appearing worldwide.
MARKET SHARE	High growth. All out market warfare with competitors.
MATURITY PHASE	
PRICE	Stable.
PROMOTION	Focused on reliability, quality, predictability, new enhancements.
DISTRIBUTION	Many distributors, alternative channels, offshore sales.
SALES	Direct sales focused on hi-volume, high profit.
DEVELOPMENT	Focused on cost reductions.
MANUFACTURING	Focused on increasing yield and productivity.
SERVICE	Distributors take over the service efforts.
SUPPORT	Local channels lead support.
TRAINING	Competition differentiation.
TECHNOLOGY	Aging
COMPETITION	Well established.
MARKET SHARE	Predictable market share every year. Limited opportunities for quick gains.
DECLINE PHASE	
PRICE	High compared to the demand.
PROMOTION	Limited – no promotion or advertising efforts.
DISTRIBUTION	Use of existing channels.
SALES	Maintenance and repair orientated for high-tech products.
DEVELOPMENT	Focused on cost reduction.
MANUFACTURING	No capital expenditures, outsourcing.
SERVICE	High prices on spare parts.
SUPPORT	Phone support.
TRAINING	None
TECHNOLOGY	Old and outdated.
COMPETITION	Limited.
MARKET SHARE	Shrinking fast.

4.1.2.2 References

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4.1.3 Gantt Charts

Gantt Charts are used to analyze and plan complex projects. Specifically they can be used to plan the tasks ahead, to schedule all the tasks, to allocate resources and work out the critical path of a project in terms of its required completion date. In this way Gantt Charts can be used to monitor the progress of a project. All activities sequential or parallel can be at any time checked and remedy actions can be taken if a project or a specific activity has fallen behind.

The most common software tool that is used by managers to build and manage Gantt Charts is Microsoft Project. The steps that are needed for the Gantt Chart to be built are the following.

- Listing all the project activities or tasks and their duration.
- Plotting the tasks onto a graph paper.
- Scheduling all the activities.
- Presenting the analysis.

A case study of the creation of a Gantt Chart for the development of a custom written computer project is available.

Source: “Gannt Charts: Planning and Scheduling More Complex Projects”, Mind Tools, On-line http://www.mindtools.com

4.1.3.1 Case Studies - Examples

Case Study: "Planning a custom written computer project".

Step 1: All the required tasks or activities are noted. Information of their duration, potential beginning and whether they are parallel or sequential is noted as well.

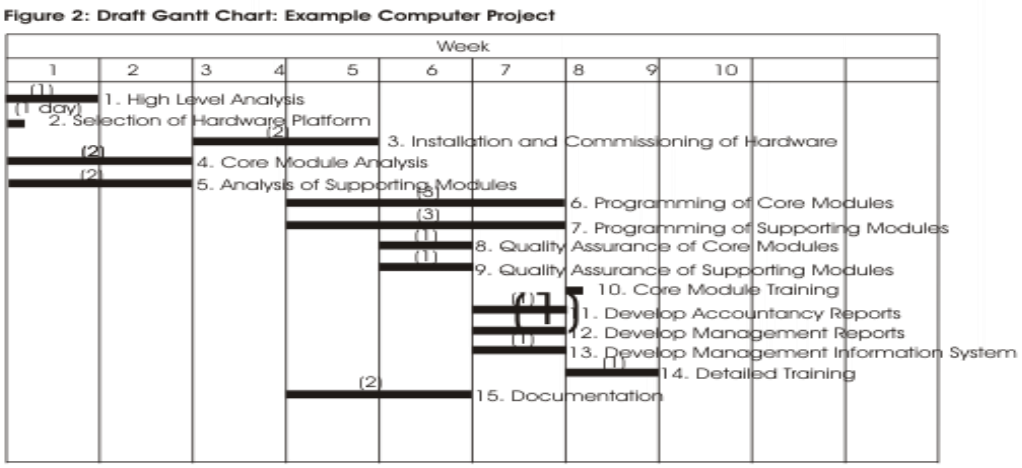
Table 1: Activities List

TASK	START	LENGTH	TYPE	DEPENDS ON
1. High level analysis	Week 1	5 days	Sequential	
2. Selection of hardware	Week 1	1 day	Sequential	1
3. Installation of hardware	Week 3	2 weeks	Parallel	2
4. Analysis of core modules	Week 1	2 weeks	Sequential	1
5. Analysis of supporting modules	Week 1	2 weeks	Sequential	4
6. Programming of core modules	Week 4	3 weeks	Sequential	4
7. Programming of supporting modules	Week 4	3 weeks	Sequential	5
8. Quality assurance of core modules	Week 5	1 week	Sequential	6
9. Quality assurance of supporting modules	Week 5	1 week	Sequential	7
10. Core module training	Week 7	1 day	Parallel	6
11. Development of accounting reporting	Week 6	1 week	Parallel	5
12. Development of management reporting	Week 6	1 week	Parallel	5
13. Development of management analysis	Week 6	2 weeks	Sequential	5
14. Detailed training	Week 7	1 week	Sequential	1-13
15. Documentation	Week 4	2 weeks	Parallel	13

Source: Mind Tools, "Gantt Charts – Planning and Scheduling More Complex Projects", On-line http://www.mindtools.com/pages/article/newPPM_03.htm

Step 2: The tasks are plotted onto graph paper. This will produce an untidy diagram as the one shown bellow.

Figure 1: Plotting the Tasks

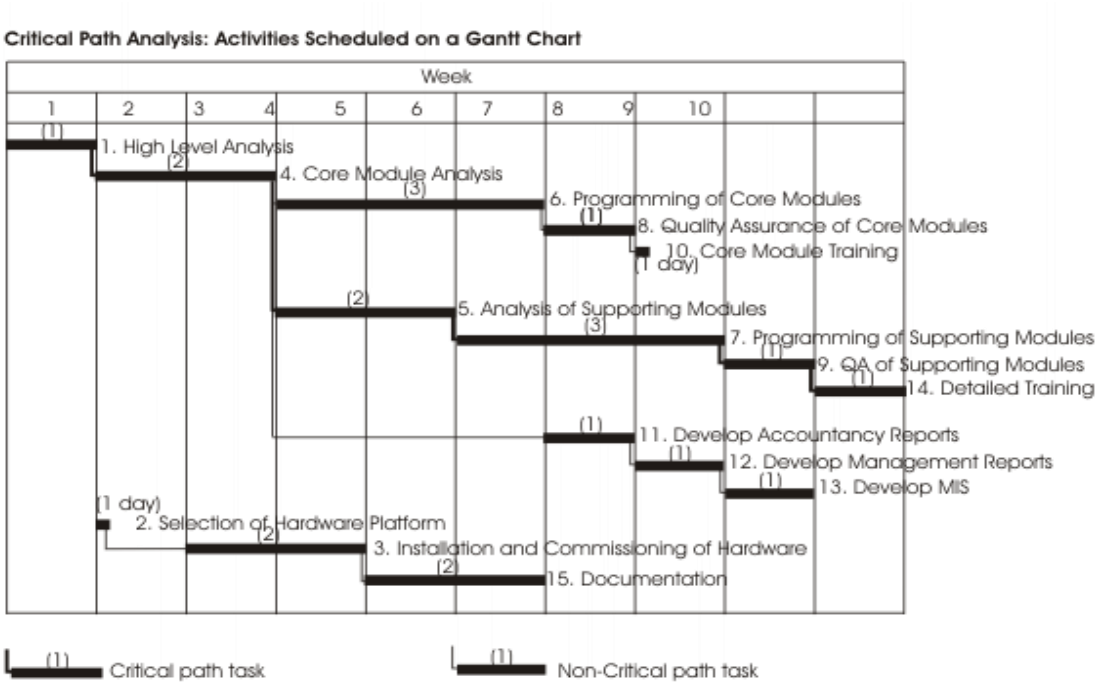


Source: Mind Tools, "Gantt Charts – Planning and Scheduling More Complex Projects", On-line http://www.mindtools.com/pages/article/newPPM_03.htm

Step 3: All activities are scheduled in such a way that the sequential activities are carried out in the required sequence. Parallel tasks are scheduled in such a way that they do not interfere with sequential ones.

Step 4: The analysis is presented. This can look something like the chart shown bellow.

Figure 2: Analysis Presentation



Source: Mind Tools, "Gantt Charts – Planning and Scheduling More Complex Projects", On-line http://www.mindtools.com/pages/article/newPPM_03.htm

4.1.3.2 References

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4.1.4 Critical Path Analysis & PERT

Critical Path Analysis and PERT charts are two very powerful tools that can help a company or a person to schedule and manage large complex projects. Both tools were developed in the 50's to manage large defense projects and are used ever since. Critical Path Analysis is similar to Gantt charts. It can help schedule large complex projects in a way that is familiar to Gantt Charts. The benefit of using Critical Path Analysis instead of Gantt Charts is that CPA can identify the reason behind the delay of a task or activity and very easily relocate resources so that the task can catch up and be completed on time. Also CPA allows the user to know the minimum time required for a task to be completed. This is very handy in the case of accelerated projects since CPA can identify which tasks can be moved along faster. The main disadvantage of CPA is that the relation of tasks is not so apparent as with Gantt Charts.

PERT (Program Evaluation and Review Technique) Chart is a variation of CPA. PERT Charts tend to have a more sceptical approach than CPA in terms of scheduling tasks. For the tool to be used, an estimation of the shortest possible time each task will take, the most likely length of time each task will take and the longest time each time will take must be taken into account. A formula is then used to calculate the time to use for each task. This is given bellow.

$$\text{Task time} = (\text{Shortest time} + 4 \times \text{Likely time} + \text{Longest time}) / 6$$

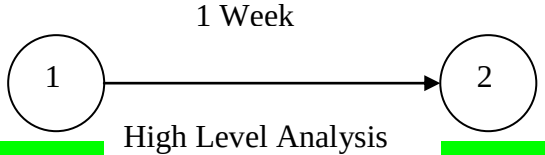
This is very helpful for getting realistic estimates of time.

Both tools can be used in a series of steps that are described bellow.

Step 1: All the activities of a project are noted along with their respective duration, starting point, type and dependency as with Gantt Charts.

Step 2: The activities are plotted as a circle and arrow diagram. For example a very simple diagram for the case study presented for Gantt Charts is shown bellow.

Figure 1: Simple Circle and Arrow Diagram



Source: Mind Tools, "Critical Path Analysis & PERT Charts", On-line: http://www.mindtools.com/critpath.html

Step 3: All the activities sequential or parallel are interconnected using arrows. And the complete CPA Chart is formed.

Step 4: Using the CPA Chart the steps or activities, which are required so that a goal is achieved, are identified.

Source: Mind Tools, "Critical Path Analysis & PERT Charts", On-line: http://www.mindtools.com/critpath.html

4.1.5 Stakeholder Analysis

The first step in **stakeholder analysis** is to identify who are the major stakeholders that can affect positively or negatively a project. For this to be done one should consider the people that are affected by the work done, the people that have some kind of influence or power over it and the people that have a specific interest in the successful conclusion of the project. One can see in the table bellow some of the stakeholders that usually influence a major project.

Table 1: Major Stakeholders Identification

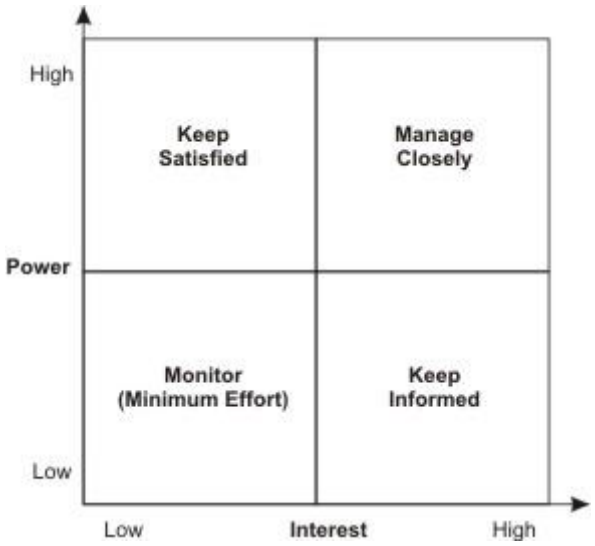
INTERNAL BUSSINESS	EXTERNAL BUSSINESS	EXTERNAL GENERAL
The boss	Shareholders	Government
Senior executives	Business partners	Trade associations
Coworkers	Suppliers	The press
Project team	Lenders	Interest groups
Customers	Analysts	The public in general
Potential customers	Future recruits	The community

Source: Mankyelow Rachel, "Stakeholder Analysis & Stakeholder Management - Winnig Support for Your Products", Mind Tools, On-line: http://www.mindtools.com/pages/article/newPPM_07.htm

One should note that although stakeholders can sometimes be organizations or group of people one must identify the single person from an organization or a group with whom one can communicate.

The second step in stakeholder analysis is the prioritization of the identified stakeholders. Some of the stakeholders may have the power to block or advance a project. Others may be interested or not. All the stakeholders must be mapped using a Power / Interest Grid as the one shown bellow.

Figure 1: Power / Interest Grid for Stakeholder Prioritization



Source: Mankyelow Rachel, "Stakeholder Analysis & Stakeholder Management - Winnig Support for Your Products", Mind Tools, On-line: http://www.mindtools.com/pages/article/newPPM_07.htm

The position of each stakeholder in the grid can reveal the way one can handle him and what kind of actions to be taken for him. Specifically:

- High power / interested people: These are the people that one should keep satisfied and be engaged with.
- High power / less interested people: An effort should be made to keep these people satisfied but one should not over do it since they tend to be easily bored.
- Low power / interested people: These must be kept inform about the progress of the project. They can be very helpful in difficult times.
- Low power / less interested people: These should be kept in a close watch. One must keep communications with them at a minimum.

The next step in the analysis is for the person conducting the analysis to try to understand the key stakeholders. In respect to that one must know how to approach them, how to communicate with them, what are their likes and dislikes. The key questions that one should ask himself when he tries to understand his stakeholders are:

- What financial or emotional interest does the stakeholder concerning the completion of the project?
- What are his motivations?
- What kind of information will he need?
- What is the best way of communicating with him?
- What is his opinion about the project?
- Who or what can influence his opinion about the project?
- If the stakeholder is negative about the project what will win him around?
- If the stakeholder is negative about the project and cannot be won around how one can manage his opposition?

One can manage the understanding he has gained on the stakeholder map by color-coding. For example green could be used for supporters, red for critics and orange for neutrals.

Source: Mind Tools, "Stakeholder analysis & Stakeholder Management – Winning Support for you Projects", On-line http://www.mindtools.com/pages/article/newPPM_07.htm

4.1.5.1 Stakeholder Analysis Management

In every company small or large projects such as new product development tend to become more important as time goes by and people, are more and more affected by them. Some of these people have the power to get in the way of such projects and others can support them in a big way. Stakeholder management is a process by which one can identify key stakeholders and win their support. Stakeholder analysis is the first stage of stakeholder management. The analysis helps in the identification and the visualization of the most important stakeholders. During the analysis one must brainstorm so that to identify the main stakeholders, he must then prioritize them by power and interest, and finally plot a Power / Interest Grid. Also the motivation that drives the stakeholders and the way one can win them is also analyzed.

Once stakeholder analysis is completed a stakeholder planning must be performed. This is a process where one can plan how to manage the stakeholders and gain their support for the project or projects in hand. Stakeholder planning can be conducted by using a planning sheet by going through the following steps.

- Insertion of information from the Power / Interest Grid.
- Management approach planning.
- Identification of what it is required from each stakeholder.
- Identification of the messages that need to be conveyed.
- Identification of the actions that need to be carried out and the way communications should be performed.

Good stakeholder management can help a company to manage the politics that sometimes can come with major projects.

Source: Mankyelow Rachel, "Stakeholder Analysis & Stakeholder Management - Winnig Support for Your Products", Mind Tools, On-line: http://www.mindtools.com/pages/article/newPPM_07.htm

4.1.5.2 Stakeholder Analysis Planning

Once a stakeholder analysis is complete, one will have the needed information to plan stakeholder communication. Stakeholder communication is crucial because communication will be the means for successful stakeholder management. To start off the stakeholder planning process one must set-up or draw a table such as the one shown bellow.

Power			
Interest			
Stakeholder name			
Key interests and issues			
Current status			
Desired support			
Desired project role			
Actions desired			
Messages needed			
Actions and communications			

Using the table one can go through the process using the following steps.

- **Update the planning sheet using the information in the Power / Interest Grid.** Based on the information gathered during the stakeholder analysis, one should enter the stakeholder name, his influence, and his current status (advocate - supporter - neutral - critic - blocker).
- **Plan the approach to stakeholder management.** One should think about what kind of help would he need during the course of the project, the time necessary to obtain it and the way to manage communications and the help provided. Help wit a project could include sponsorship, advice, expert input, material, quality control etc.
- **Think of what is needed from each stakeholder.** One should think about the levels of support required from each stakeholder, the roles that the stakeholders should perform, and the actions they should perform. This information should be entered in the "Desired support", the "Desired project role" and the "Actions desired" lines of the planning table.
- **Identify the messages you want to get through.** All the messages that need to be conveyed to the stakeholders to win their support should be noted. Typical messages should include the benefits in increasing profitability and delivering improvements.
- **Identify actions and communications.** Finally one should identify all the actions needed for the messages to be conveyed to the stakeholders and the means or ways of communicating these messages to them.

Source: Mind Tools, "Stakeholder Planning – Planning Stakeholder Communications", On-line Source: Manktelow Rachel, "Stakeholder Planning – Planning Stakeholder Communications", Mind Tools, On-line http://www.mindtools.com/pages/article/newPPM_08.htm

4.1.5.3 References

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4.2 Level Assessment for Stage 4: Business Analysis

Assessment 4 evaluates the way or ways of financing the development of the selected concept into a new product and the way the whole project is scheduled in respect to time limitations and how the required resources are located, used or reallocated to fit the project needs.

As in Assessment 3 a GO, Hold or KILL decision is issued for proceeding to the next level depending on the given answers to the questions.

NPD Stage 5: Beta & Market Testing

Product testing can occur in all levels of the NPD process. It can take the form of concept testing at the end of concept development, of prototype and beta testing at the end of the prototype development or of final product testing at the end of the technical implementation.

Regardless of the level or phase of the NPD process, the product testing process consists of three components: the creation of a testing strategy (which often includes the creation of test cases), the creation of a test plan (which includes test cases and test procedures and the execution of the tests.

The test strategy is a formal description of how a product will be tested. For the creation of such a strategy the testing team must analyze all the product requirements, write the test strategy and review the plan. The test plan may include test cases, conditions, the test environment, a list of related tasks, pass / fail criteria and some kind of risk assessment.

The test plan is prepared by reviewing all the functional requirements of the product. These requirements can be easily broken down into specific test procedures. The test procedures can define the test conditions, data to be used for testing and the expected results. The test plan should include tests cases or scenarios, which should be designed to represent typical and extreme situations that may occur during the product's life.

Tests execution is completed, by following the test documents in a methodical manner. Test documents are the results of the test strategy creation and the test plan development. As each test is executed a record of the test result must be kept in a test execution log. All test results noted in the execution log must be evaluated by engineers and screened against the pass / fail criteria set in the test plan. Any faults or bugs in the operation of the product should be fixed before the product goes through the technical implementation and manufacturing phase. There are cases where faults are not fixed since they are noted as low importance in the risk assessment prepared in earlier levels of development. After all tests are completed a summary is prepared and delivered to the project manager, the quality assurance manager and the leader of the test team. When all tests in the test summary are certified then the product takes the go ahead to the next level of development.

5.1 Tools & Solutions

The solution or solutions that deal with beta and market product testing vary and cover a lot of different aspects and issues. One should look into product development testing and the tests that must be carried out during this stage, he must give extra notice into major market research issues and he must know what kind of tests are available. Also some basic or in some cases specialized knowledge of prototyping techniques and testing must be in hand.

All the above are discussed in this Level as tools or methods or techniques and the Level aims to give a spherical informative point of view of what is available and what can be done to solve the problem of testing. Apart from that, the most important testing techniques are given bellow.

Unit testing. Unit testing occurs when all product components are tested and the expected test results are met or their differences are explained and accepted. It involves the testing of the product as a whole.

Functional testing. It is a black-box testing procedure designed to examine the functionality of the product. It is performed by specialized test engineers.

Usability testing. During this test the user-friendliness of the product is examined. This product characteristic is purely subjective and depends on the targeted product end-user or consumer. User interviews, surveys, market research results and other techniques can be used to define and analyze the test procedure and the test results.

Integration testing. Integration testing is the continuous testing of an application as new functionality is recommended. Programmers, engineers and testing personnel usually perform this type of testing.

System testing. System testing is a black box testing performed by the test team as the complete product is configured in a controlled environment. The purpose of the system testing is the validation of the products or application accuracy, its ability to perform all the tasks designed for and the simulation of real life scenarios.

End-to-End testing. This kind of testing is very similar to system testing since during the test situations that mimic real life are used. During this test the product or service or application is put to interact with other components that it will usually be connected to or incorporated with in real life.

Performance testing. This kind of testing verifies possible loads, volumes and response times that the product may be specified to have.

Installation testing. This test examines the way a new product or service can be installed, uninstalled, upgraded or changed.

Alpha testing. This test takes place when development is near completion. End-users or customers usually perform it and its results can only be used for minor design changes to be made.

Beta testing. As with alpha testing this test is performed by end-users or customers. The test is performed when all development is completed and just before the product or service is launched into a market.

Source: Better Product Design, Institute of Manufacturing, University of Cambridge, On-line http://www.betterproductdesign.net/tools/concept/testing.htm

5.1.1 Rapid Prototyping

Rapid Prototyping (RP) is widely used in many industries such as aerospace, medical and consumer products industries and as the name suggests its use is to quickly make prototypes for communication and testing purposes. RP really refers to a set of technologies that can automatically construct models from CAD data. These models allow developers and R&D teams to quickly make three-dimensional designs of developing products. These models are used to simplify complex products and can lead to early tooling for manufacturing or production and early packaging planning. In this way substantial amounts of time and money are saved since manufacture, production and preparation of product launch can be developed before the product reaches its final

form. In addition RP models can do a few things that usual metal or plastic prototypes cannot. Simulations on the performance of the product can be run using the RP model and the CAD data.

A very important feature of Rapid Prototyping is Rapid Tooling (RT). RT is the automatic fabrication of production quality machine tools. Tooling for the production of new products is one of the most expensive steps in a manufacturing process since high quality is required. Tools often have complex geometries with dimensions of extremely low tolerances. Also they must be hard, wear - resistant and have extremely smooth surfaces. To meet these requirements tool mold construction can be very expensive and time consuming. So RP techniques are used to speed up the process. It is said that RP techniques can reduce tooling costs and subsequently product developing times up to 75%. Rapid tooling can be divided into two main categories: Direct and Indirect RT.

- **Direct Rapid Tooling** is when CAD data are used to construct models of tools in the same way as they it happens in the case of Rapid Prototyping for products. This technique is today in the development process.
- **Indirect Rapid Tooling** is when RP parts are used to construct molds and dies that are used to construct the tools.

A usual result of Rapid Prototyping is Rapid Manufacturing (RM). RM is the automated production of products direct from CAD data. Today only a small amount of products are produced in this way. As new materials and technologies become available, the RM technique will become more and more used.

RM can be expensive compared to traditional manufacturing processes especially compared with large mass production runs. For short runs, however, RM can be cheaper since it does not require tooling. RM is also the best technique for producing custom parts or products, which are tailored to the customer's specifications. Finally RM can be used when the product geometry is too complex, or contains internal voids and layered structures.

5.1.1.1 Prototyping Testing

When prototypes are ready, they must go through vigorous tests, which are divided into Functional Tests, Customer Tests and Market Tests. Functional tests are divided into two sequential types of tests: Alpha testing and Beta Testing. A brief description of each is given bellow.

- **Alpha Testing** means testing the product prototype within the company to see how it performs in different applications. Engineers or scientists do this usually within the R&D department and if all tests are successful the product prototype moves into Beta Testing.
- **Beta testing**, is a set of tests that are carried out using potential customers. These customers test the product prototype and provide feedback to the company of their experience using the product. The marketing department of a company usually supervises beta testing, although the results go back to the R&D department for possible refinements of the product prototype. It is most successful if the potential customers used are heterogeneous, if the potential application(s) is not fully known, if several decision makers, such as high executives or managers, are involved in purchasing the product and if the opinion leadership of early adopters is sought.

Customer Testing can take a variety of forms. One can bring customers into a lab and encourage them to test the prototype or giving them samples of the product prototype to take back into their homes and test it. In home placement are common for products ranging from ice cream flavours to home appliances. For example when "DuPont" developed its new synthetic carpeting, it installed free carpeting into several homes in exchange for the homeowners promise to report back to the company, after a certain period of time, their likes and dislikes about the carpeting.

After management is satisfied that Functional and Customer Testing provided enough feedback, then the product prototype is given a brand name and packaging and it is put through a Market Test. During a Market Test, the new product is introduced into an authentic setting to learn how big the market is and how consumers and dealers react to handling, using and purchasing the product. In this way not only the product is tested but also the hypothesis, market research and work done in the early stages of the NPD (mainly the first two stages). A good example of Market Testing is "IdeaLab", which is a company that introduced new Internet based ventures such as EToys. When the company decided to launch into the Internet a web-based car buying service called "Cars Direct", a web site was created as a prototype to test the market for such a service. This web site was a live one and monitored on-line market reactions. Through the site four cars were sold in one evening, a fact that showed the product's potential for strong market acceptance.

In testing consumer products, a company should focus on the estimation of four variables: trial, first repeat purchase, adoption and purchase frequency. A company by testing wants to see whether these variables exist at high levels. For example one can see that many consumers trying a product for the first time but few re-buying it. In another case one can see high adoption but very low purchase frequency (good example of this are frozen foods). The major methods of consumer goods market testing, from the least to the most costly are given bellow.

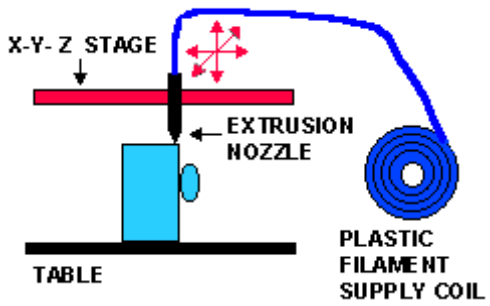
- **Sales - Wave Research.** Consumers that initially try the product at no cost are offered the product or a competitive one for up to five times at a slightly reduced price. The number of customers that select the product again and their satisfaction towards the product is noted.
- **Simulated Test Marketing.** 40 buyers are asked to answer questions about brand familiarity and product preferences. Then they are asked to see commercials of both competitive products and of the new product and they are given money and brought to a store to make a purchase. The company then notes how many customers have bought the new product and how many the competitive ones. This is a test of the advertisement's effectiveness against competitive ones in a simulated trial. Also customers receive a free sample of the product and then are asked to report on product attributes, usage, satisfaction and purchase intention.
- **Controlled Test Marketing.** In this kind of test a research company manages a panel of outlets that will carry the new product for a fee. The new product company selects the number of stores and their geographical location. The research company delivers the new product to the selected stores and controls the positioning of the product into each store and it's pricing. Sales are recorded through electronic means and evaluated. Also local advertising and promotions during the test is evaluated.
- **Test Markets.** In this case the company chooses few cities and through full advertising and promotion, the company's sales force tries to carry the product into full exposure and large-scale sales. Here the people involved with the test must decide on the number and location of the cities, the length of the test, what to track and what action to take. Nowadays Market Tests become more and more scarce since they cost too mush and companies prefer more economical test methods with smaller test areas and shorter test periods.

Business goods can also benefit from market testing and there are several methods available to do just that. Expensive industrial goods usually undergo just Alpha and Beta Testing. But it is better to undergo and some form of market test as well. So these goods usually are market tested in trade shows. Trade shows draw large number of customers who view many products in a few concentrated days. The company that wants to test its new product, can observe how much interest customers show for the product, how they react to its various features and how many express purchase intentions and place orders. The disadvantage of trade shows is that the new product is revealed to the competition and so the company must be prepared to launch the new product into the market soon after the trade show.

5.1.1.2 Prototyping Techniques

5.1.1.2A Fused Deposition Modelling (FDM)

Figure 1: Diagram of FDM



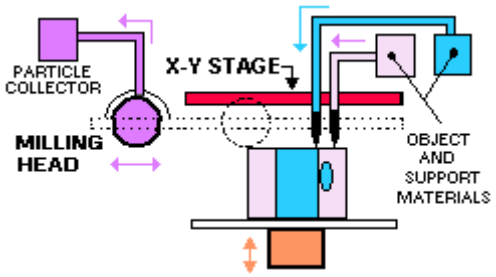
Source: "Fused Deposition Modeling", Worldwide Guide for Rapid Prototyping, On-line: http://home.att.net/~castleisland/fdm_int.htm

"FDM is the second most widely used rapid prototyping technology, after stereolithography. A plastic filament is unwound from a coil and supplies material to an extrusion nozzle. The nozzle is heated to melt the plastic and has a mechanism, which allows the flow of the melted plastic to be turned on and off. The nozzle is mounted to a mechanical stage, which can be moved in both horizontal and vertical directions.
As the nozzle is moved over the table in the required geometry, it deposits a thin bead of extruded plastic to form each layer. The plastic hardens immediately after being squirted from the nozzle and bonds to the layer below. The entire system is contained within a chamber, which is held at a temperature just below the melting point of the plastic.
Several materials are available for the process including ABS and investment casting wax. ABS offers good strength, and more recently polycarbonate and polysulfone materials have been introduced which extend the capabilities of the method further in terms of strength and temperature range. Support structures are fabricated for overhanging geometries and are later removed by breaking them away from the object. A water-soluble support material, which can simply be washed away, is also available.
The method is office-friendly and quiet. FDM is fairly fast for small parts on the order of a few cubic inches, or those that have tall, thin form-factors. It can be very slow for parts with wide cross sections, however. The finish of parts produced with the method have been greatly improved over the years, but aren't quite on a par with stereolithography. The closest competitor to the FDM process is probably three-dimensional printing."

Source / Taken from: "Fused Deposition Modeling", Worldwide Guide for Rapid Prototyping, On-line: http://home.att.net/~castleisland/fdm_int.htm

5.1.1.2B Inkjets

Figure 1: Inkjets Diagram



Source: "Inkjets", Worldwide Guide for Rapid Prototyping, On-line: http://home.att.net/~castleisland/ink_int.htm

Thermal Phase Change Inkjets

"Solidscape, Inc.'s inkjet method is illustrated, but others are also available. This machine uses a single jet each for a plastic build material and a wax-like support material, which are held in a melted liquid state in reservoirs. The liquids are fed to individual jetting heads, which squirt tiny droplets of the materials as they are moved in X-Y fashion in the required pattern to form a layer of the object. The materials harden by rapidly dropping in temperature as they are deposited.
After an entire layer of the object is formed by jetting, a milling head is passed over the layer to make it a uniform thickness. Particles are vacuumed away as the milling head cuts and are captured in a filter. The process is repeated to form the entire object. After the object is completed, the wax support material is either melted or dissolved away.
The most outstanding characteristic of the Solidscape system is the ability to produce extremely fine resolution and surface finishes, essentially equivalent to CNC machines. However, the technique is very slow for large objects. While the size of the machine and materials are office-friendly, the use of a milling head creates noise, which may be objectionable in an office environment. Materials selection also is very limited.
Other manufacturers use considerably different inkjet techniques, but all rely on squirting a build material in a liquid or melted state, which cools or otherwise hardens to form a solid on impact. 3D Systems produces an inkjet machine called the **ThermoJet Modeller(tm)**, which utilizes several hundred nozzles in a wide head configuration. It uses a hair-like matrix of build material to provide support for overhangs, which can be easily brushed off once the object, is complete. This machine is much faster than the Solidscape approach, but doesn't offer as good a surface finish or resolution.
All thermal phase change inkjets have material limitations and make fragile parts. The applications range from concept models to precise casting patterns for industry and the arts, particularly jewellery."

Photopolymer Phase Change Inkjets

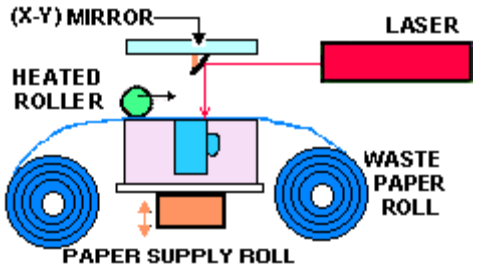
"Objet Geometries Ltd., an Israeli company, announced the **Quadra(tm)** system in early 2000. It's potentially a promising replacement for stereolithography. The process is based on photopolymers, but uses a wide area inkjet head to layer wise deposit both build and support materials. It subsequently completely cures each layer after it is deposited with a UV flood lamp mounted on the print head. The support material, which is also a photopolymer, is removed by washing it away in a secondary operation. The low price, approximately $65K, and specifications that are similar to laser-based stereolithography systems costing ten

times as much make this an important technology to watch.
In July 2002, 3D Systems introduced a similar photopolymer-based system called the **InVision(tm)**. It uses the technology originally developed for the **ThermoJet Modeller(tm)**."

Source / Taken from: "Inkjets", Worldwide Guide for Rapid Prototyping, On-line: http://home.att.net/~castleisland/ink_int.htm

5.1.1.2C Laminated Object Manufacturing

Figure 1: Laminated Object Manufacturing Diagram



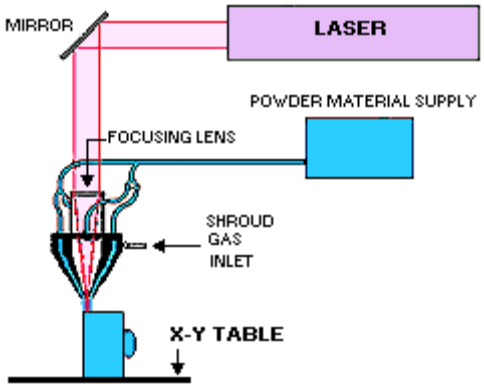
Source: "Laminated Object Manufacturing", Worldwide Guide for Rapid Prototyping, On-line: http://home.att.net/~castleisland/lom_int.htm

"Profiles of object cross sections are cut from paper or other web material using a laser. The paper is unwound from a feed roll onto the stack and first bonded to the previous layer using a heated roller, which melts a plastic coating on the bottom side of the paper. The profiles are then traced by an optics system that is mounted to an X-Y stage.
After cutting of the layer is complete, excess paper is cut away to separate the layer from the web. Waste paper is wound on a take-up roll. The method is self-supporting for overhangs and undercuts. Areas of cross-sections, which are to be removed in the final object, are heavily crosshatched with the laser to facilitate removal. It can be time consuming to remove extra material for some geometries, however.
Many companies and research groups have developed variations on this method. For example, Kira's Paper Lamination Technology (PLT) uses a knife to cut each layer instead of a laser and applies adhesive to bond layers using the xerographic process. There are also variations, which seek to increase speed and/or material versatility by cutting the edges of thick layers diagonally to avoid stair stepping.
In general, the finish, accuracy and stability of paper objects are not as good as for materials used with other RP methods. However, material costs are very low, and objects have the look and feel of wood and can be worked and finished in the same manner. This has fostered applications such as patterns for sand castings. While there are limitations on materials, work has been done with plastics, composites, ceramics and metals. Some of these materials are available on a limited commercial basis.
The principal commercial provider of LOM systems, Helisys, ceased operation in 2000. However, there are several other companies with either similar LOM technology, or in early commercial stages. These companies are addressing market segments ranging from concept modelling to very large objects for architectural applications."

Source / Taken from: "Laminated Object Manufacturing", Worldwide Guide for Rapid Prototyping, On-line: http://home.att.net/~castleisland/lom_int.htm

5.1.1.2D Laser Engineered Net Shaping

Figure 1: Laser Engineered Net Shaping Diagram



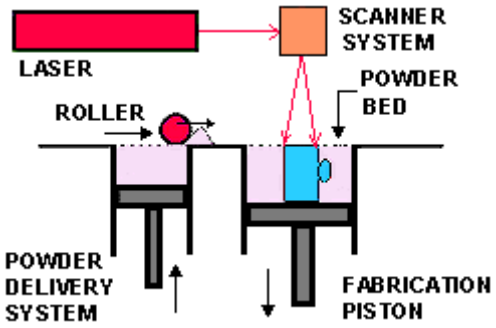
Source: "Laser Engineered Net Shaping", Worldwide Guide for Rapid Prototyping, On-line: http://home.att.net/~castleisland/len_int.htm

"Laser Engineered Net Shaping (LENS) is a technology that is gaining in importance and in early stages of commercialisation. A high power laser is used to melt metal powder supplied coaxially to the focus of the laser beam through a deposition head.
The laser beam typically travels through the centre of the head and is focused to a small spot by one or more lenses. The X-Y table is moved in raster fashion to fabricate each layer of the object. The head is moved up vertically as each layer is completed. Metal powders are delivered and distributed around the circumference of the head either by gravity, or by using a pressurized carrier gas. An inert shroud gas is often used to shield the melt pool from atmospheric oxygen for better control of properties, and to promote layer-to-layer adhesion by providing better surface wetting.
A variety of materials can be used such as stainless steel, Inconel, copper, aluminium etc. Of particular interest are reactive materials such as titanium. Materials composition can be changed dynamically and continuously, leading to objects with properties that might be mutually exclusive using classical fabrication methods.
The strength of the process lies in the ability to fabricate fully dense metal parts with good metallurgical properties at reasonable speeds. Objects fabricated are near net shape, but generally will require finish machining. They have good grain structure, and have properties similar to, or even better than the intrinsic materials. Selective laser sintering is at present the only other commercialised RP process that can produce metal parts directly. LENS has fewer material limitations than SLS and doesn't require secondary firing operations as some of those processes do, however."

Source / Taken from: "Laser Engineered Net Shaping", Worldwide Guide for Rapid Prototyping, On-line: http://home.att.net/~castleisland/len_int.htm

5.1.1.2E Selective Laser Sintering

Figure 1: Selective Laser Sintering Diagram



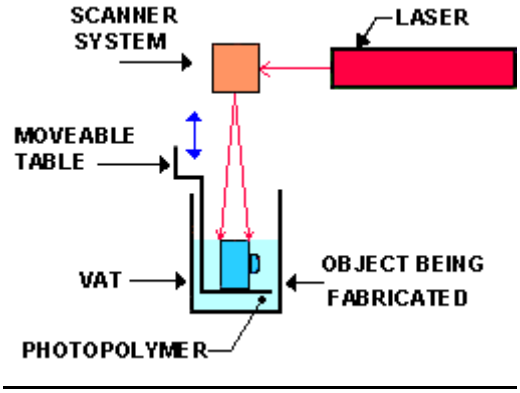
Source: "Selective Laser Sintering", Worldwide Guide for Rapid Prototyping, On-line: http://home.att.net/~castleisland/sls_int.htm

"A roller spreads thermoplastic powder over the surface of a build cylinder. The piston in the cylinder moves down one object layer thickness to accommodate the new layer of powder. The powder delivery system is similar in function to the build cylinder. Here, a piston moves upward incrementally to supply a measured quantity of powder for each layer.
A laser beam is then traced over the surface of this tightly compacted powder to selectively melt and bond it to form a layer of the object. The fabrication chamber is maintained at a temperature just below the melting point of the powder so that heat from the laser need only elevate the temperature slightly to cause sintering. This greatly speeds up the process. The process is repeated until the entire object is fabricated.
After the object is fully formed, the piston is raised to elevate it. Excess powder is simply brushed away and final manual finishing may be carried out. No supports are required with this method, since overhangs and undercuts are supported by the solid powder bed.
SLS offers the key advantage of making functional parts in essentially final materials. However, the system is mechanically more complex than stereolithography and most other technologies. A variety of thermoplastic materials such as nylon, glass filled nylon, and polystyrene are available. Surface finishes and accuracy are not quite as good as with stereolithography, but material properties can be quite close to those of the intrinsic materials. The method has also been extended to provide direct fabrication of metal and ceramic objects and tools.
Since the objects are sintered they are porous. It may be necessary to infiltrate the part, especially metals, with another material to improve mechanical characteristics."

Source / Taken from: "Selective Laser Sintering", Worldwide Guide for Rapid Prototyping, On-line: http://home.att.net/~castleisland/sls_int.htm

5.1.1.2F Stereolithography

Figure 1: Stereolithography Diagram



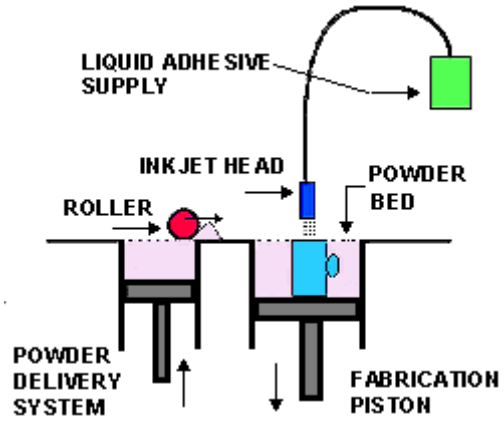
Source: "Stereolithography", Worldwide Guide for Rapid Prototyping, On-line: http://home.att.net/~castleisland/sla_int.htm

"Stereolithography is the most widely used rapid prototyping technology. Stereolithography builds plastic parts or objects a layer at a time by tracing a laser beam on the surface of a vat of liquid photopolymer. This class of materials, originally developed for the printing and packaging industries, quickly solidifies wherever the laser beam strikes the surface of the liquid. Once one layer is completely traced, it's lowered a small distance into the vat and a second layer is traced right on top of the first. The self-adhesive property of the material causes the layers to bond to one another and eventually form a complete, three-dimensional object after many such layers are formed.
Some objects have overhangs or undercuts, which must be supported during the fabrication process by support structures. These are either manually or automatically designed, and fabricated right along with the object. Upon completion of the fabrication process, the object is elevated from the vat and the supports are cut off.
Stereolithography generally is considered to provide the greatest accuracy and best surface finish of any rapid prototyping technology. Over the years, a wide range of materials with properties mimicking those of several engineering thermoplastics, have been developed. Limited selectively colour-changing materials for biomedical and other applications are available, and ceramic materials are currently being developed.
The technology is also notable for the large object sizes that are possible."

Source / Taken from: "Stereolithography", Worldwide Guide for Rapid Prototyping, On-line: http://home.att.net/~castleisland/sla_int.htm

5.1.1.2G Three Dimensional Printing

Figure 1: Three Dimensional Printing Diagram



Source: "Three Dimensional Printing", Worldwide Guide for Rapid Prototyping, On-line: http://home.att.net/~castleisland/3dp_int.htm

"Three-dimensional printing was developed at MIT. It's often used as a direct manufacturing process as well as for rapid prototyping.
The process starts by depositing a layer of powder object material at the top of a fabrication chamber. To accomplish this, a measured quantity of powder is first dispensed from a similar supply chamber by moving a piston upward incrementally. The roller then distributes and compresses the powder at the top of the fabrication chamber. The multi-channel jetting head subsequently deposits a liquid adhesive in a two dimensional pattern onto the layer of the powder which becomes bonded in the areas where the adhesive is deposited, to form a layer of the object.
Once a layer is completed, the fabrication piston moves down by the thickness of a layer, and the process is repeated until the entire object is formed within the powder bed. After completion, the object is elevated and the extra powder brushed away leaving a "green" object. No external supports are required during fabrication since the powder bed supports overhangs.
Three-dimensional printing offers the advantages of speedy fabrication and low materials cost. In fact, it's probably the fastest of all RP methods. Recently colour output has also become available. However, there are limitations on resolution, surface finish, part fragility and available materials. The closest competitor to this process is probably fused deposition modelling".

Source / Taken from: "Three Dimensional Printing", Worldwide Guide for Rapid Prototyping, On-line: http://home.att.net/~castleisland/3dp_int.htm

5.1.1.3 Case Studies - Examples

Case study: "Rapid Prototyping in the ceramics industry"

A study by the Royal Doulton Company has shown that, although Stereolithography may be too expensive for use in the development of new tableware designs, there are specialist applications, in particular, airline tableware, where the technology could be of great value. The study, which was undertaken by Royal Doulton designer Richard Delaney as part of his Postgraduate Diploma in

Design, compared the cost of developing a new teapot design by using conventional prototyping methods and by using Stereolithography.

The concept design for the new pot was produced using Royal Doulton's concept visualisation software. Before the design could be converted into the computer file needed to produce the Stereolithography model, all the information was transferred into Delcam's Power Solution software. Power Solution is a much more precise modelling and machining package that was initially acquired by the company for the design and manufacture of dies for the granulate pressing of tableware. One of the reasons for using Power Solution to generate the data needed for the Stereolithography equipment was to ensure that all the surface fillets and intersections were precisely closed. This is essential for successful operation of the rapid prototyping process. A second reason for using Power Solution was to recreate the handle as the concept design software gave a slightly inaccurate result, not always giving a constant thickness throughout the handle. Thirdly, the Power Solution data used to produce the prototype can also be used to generate NC data for machining production moulds or models.

The Stereolithography model was produced by the rapid prototyping bureaux at Rover Group in four parts - the main body of the teapot, a plug to fit in the hole in the base that is required to allow excess polymer to drain away, the spout and the lid. The parts were also assembled by the bureaux and bead blasted to give a superior finish. The resulting prototype had a sufficiently good appearance for use as a presentation model. In a genuine project, the prototype would be sprayed white and lacquered to give an appearance closer to china. For this study, the surface was left in the state that it was delivered to the Royal Doulton Company, so it could be used to help explain the Stereolithography process.

The main advantage of the rapid prototyping approach was the speed of preparation of the model. With this example, which is of average complexity, the prototype was produced in about a third of the time taken using conventional modelling. Richard Delaney estimated that simple round designs could be modelled conventionally in less time than would be needed for Stereolithography. Equally, the gains with more complex shapes, including relief modelled decoration, would be even greater. In the same way, the speed of modification of the design would depend on its complexity.

With conventional modelling, the item involved is usually completely remodelled, with each modification taking almost as long as the production of the first prototype. Using CAD, any adjustments can be made to the design relatively quickly. For pieces like the teapot, Stereolithography also gives the ability to use the model as a china piece would be used. The prototype has an exact wall thickness throughout the model so giving the same internal appearance. This allows an accurate check to be made of its pouring capability, which is not possible with a conventional solid prototype. In addition, the model can be supported by its handle, enabling the feel and balance of the pot in use to be tested.

Despite these advantages, Peter Allen, Director of Design Development & Technology at Royal Doulton, felt that the additional cost of Stereolithography, which totalled around one third more than conventional techniques, could only be justified in special circumstances. Most new designs for tableware are launched at a small number of key exhibitions. Since these dates are known well in advance, the design development and prototyping work can be scheduled in plenty of time. One area where time is more critical is in the supply of airline tableware. Royal Doulton has become one of the world's largest suppliers of fine and bone china to the airline industry, supplying carriers such as British Airways, All Nippon and Air Canada. Additionally, through its partnership with De

Ster, the Dutch manufacturers of rotable plastics for airline use, the company's client base now numbers around seventy airlines. The introduction of new shape designs for this market is usually associated with a complete re-design of the aircraft interior, and always requires a rapid response. "Customers from the airlines are not always sure what they want until they see our ideas visualised on the computer" explained Mr. Allen. "Once a new design concept has been selected, we need to make prototypes for approval as quickly as possible so that we can move into full-scale production fast enough to meet the airline's deadline. In such cases, the additional cost of Stereolithography could easily be justified.

Having built up the leading position in this market, we are keen to use any new technology that will complement our traditional skills and allow us to offer an even better service to our customers." The Royal Doulton Company The Royal Doulton Company is the world's leading manufacturer and distributor in the premium ceramic tableware and giftware market. The company employs over 5,500 people on ten manufacturing sites, mainly based in Stoke-on Trent. In addition to the Royal Doulton brand, the company manufactures other major brand names, including Royal Albert, Royal Crown Derby and Minton. Around 50 % of the company's sales are made outside the UK.

Source: Programming Plus Inc, "Rapid Prototyping in the Ceramics Industry", On-line: http://www.programmingplus.com/Roi_web/Demos/Delcam_web/info/case/doulton.htm

5.1.1.4 Software Tools

http://www.materialise.com/mt.asp?mp=hm_main
Materialise Software develops innovative applications enabling advanced use of the rapid prototyping and tooling techniques. The Materialise software products provide a variety of solutions for data handling in product communication, rapid prototyping and rapid tooling. Besides this, the Materialise Software Development Services offer professional software solutions, tuned to your needs. For this, Materialise has the largest software development team in the RP sector with locations in Belgium and Kiev (Ukraine).

http://www.biba.uni-bremen.de/groups/rp/rp_soft.html
The currently available **RP Workbench** is a graphical data preparation tool for the verification and conversion of geometric model data sets for Rapid Prototyping Applications. The system allows creating error-free and build-ready RP data sets from various modelling sources and formats within a consistent software environment. Their leading edge body healing technology is able to handle and fix all kinds of incorrect model data. The powerful OpenGL-based visualisation together with the easy-to-use and adaptable interface gives permanent and fast control of the Rapid Prototyping data preparation process.

5.1.1.5 References

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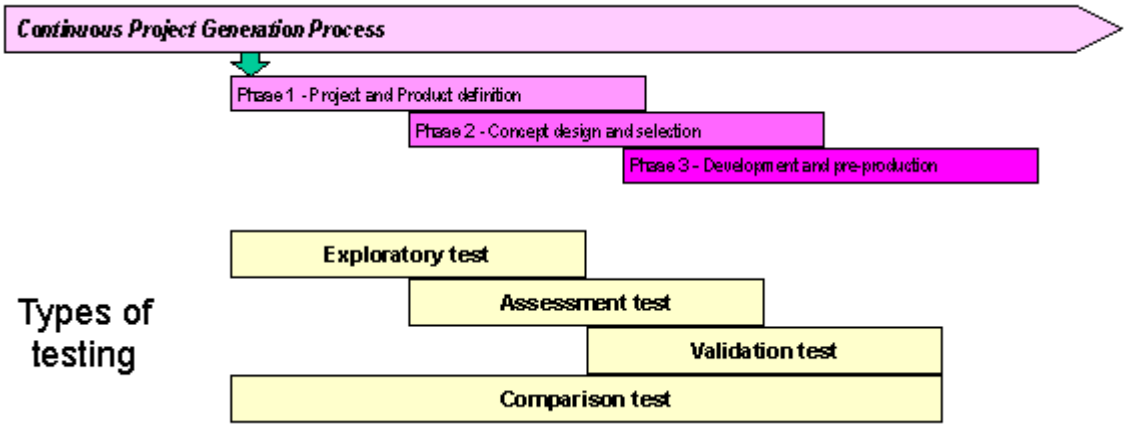
5.1.2 Product Development Testing

Product development testing is a testing process that starts at the front end of product development and ends at the very end of it. It includes different types of tests that can be applied at different levels of product development. These tests help the development team to fully understand what exactly is going on and if whether things are on track. Also the different ways that data are captured can sometimes reveal aspects of the development process that the tests on their own cannot identify.

As mentioned product development testing consists of different tests that can be applied to different levels of product development. These test are carried out to examine different objectives, approaches and types of modelling. There are five main types of testing that can be described in more detail and these are:

1. **The Exploratory Tests**
2. **The Assessment Tests**
3. **The Validation Tests**
4. **The Comparison Tests**
5. **ISO 9000 Tests**

In respect to the development process the timing of these different tests can be visualized using the following figure.



Source: Better Product Design, Institute of Manufacturing, University of Cambridge, On-line http://www.betterproductdesign.net/tools/concept/testing.htm

5.1.2.1 Exploratory Tests

Exploratory tests are those that are carried out early in the development process during Levels 1 and 2. This is when the problem of NPD is still being defined and different solutions are being considered. They usually take place after the team has a clear understanding of user profile or customer needs. Their objective is to examine and to explore the preliminary design concepts and answer some basic questions that include:

- What to customers think about using the product concept?
- Does the basic product functionality have value to the user or customer?
- Is the product's user interface appropriate and easy to operate?
- How does the user feel about the product concept?
- Are the team's assumptions about the customer needs correct?
- Has the team misunderstood any customer wants or needs?

This kind of early analysis of concepts and how are these fit into the user or customer profile or specific wants and needs is very critical. It is the most critical one compared to all prototyping or product evaluation analysis tests that can be performed later on. This due to the act that faulty assumptions at this stage will most certainly be the root of a lot of problems further down the development process.

Data collection at this point is usually qualitative and is based on observation, interview and discussion with the target audience. The ideal scenario for this kind of tests is for the customer to test the product concept without training or prompting so that he can assess freely all the controls and instructions. Some metrics can be applied such as time to perform tasks or number of errors or failures allowed.

Source: Better Product Design, Institute of Manufacturing, University of Cambridge, On-line http://www.betterproductdesign.net/tools/concept/testing.htm

5.1.2.2. Assessment Tests

Unlike to the exploratory tests that are designed to explore all potentially solutions for new product development, the Assessment Tests are designed to look with more detail into the preferred single solution. This is why they are usually performed at a later stage of development than the exploratory ones.

The aim of the assessment tests is to ensure that all assumptions are relevant to the preferred solution and that specific design choices are appropriate for that solution. These tests focus on usability and functionality that is offered by the solution in hand. This in some cases can be considered as an early new product evaluation. Assuming that the right product concept is chosen the assessment tests tend to seek answers to questions like the following:

- Is the product concept usable?
- Does the product concept satisfy all user needs?
- How does the user use the product and could it be more effective?
- How will the product be assembled and tested and could this be achieved in a better way?
- Can the user complete all the product tasks as intended?

Assessment tests require complex product modelling, analytical methods of testing, simulations and working product replicas. The evaluation of the tests results can be informal using both internal and external evaluation panels or teams. Data collection as in the case of the exploratory tests can be qualitative and based on observation, interviews and discussions.

Source: Better Product Design, Institute of Manufacturing, University of Cambridge, On-line http://www.betterproductdesign.net/tools/concept/testing.htm

5.1.2.3 Validation Tests

Validation tests are conducted at the late stages of new product development process and are designed to examine that all design goals have been met. These kinds of tests may examine the product's functionality, reliability, usability, performance, maintainability, assembly methods, robustness and others. Validation tests examine the product as if it was just out of the production line. So product activities should and are expected to be working in full.

A performed validation test is the first opportunity to examine product components altogether. Single component testing can be performed at this point. During validation tests the product must have its final form including packaging, documentation and labels. Included in the validation tests are all formal test that are required for certification for safety or environmental purposes. Compared to the assessment tests, validation ones focus on experimental rigor and consistency. Sometimes it is preferable for the testing to be carried out by an external team and away from the original design team.

Data collection is usually quantitative based on measures of performance. This is done by benchmarking the new product against some kind of expected performance or pre-set standards. Any failures on product performance must be noted and errors should be corrected before the product reaches the manufacturing process.

Source: Better Product Design, Institute of Manufacturing, University of Cambridge, On-line http://www.betterproductdesign.net/tools/concept/testing.htm

5.1.2.4 Comparison Tests

A **comparison test** can be conducted at any point of the product development process. These tests aim to compare companies, practices, concepts, products, or product elements against some existing alternative. For example "Benchmarking", as it is offered by Urenio Research Unit, is a comparison test that can be carried out at the beginning or the end of the process. The alternatives against any of the above can be compared against could be either a existing solution or a competitive one.

Comparison testing can include the examination of data from both product performance and product preference. The tests are used to examine performance, to test superiority, or to understand product advantages and disadvantages of different product designs.

Source: Better Product Design, Institute of Manufacturing, University of Cambridge, On-line http://www.betterproductdesign.net/tools/concept/testing.htm

5.1.2.5. ISO 9000 Tests

ISO 9000 defines a series of test activities such as design review, design verification, design validation, quality control, safety etc. Some of these activities are further discussed bellow.

- **Design review.** A design review is a set of tests activities that aim to test the product design against pre-determined quality requirements. During the tests it is imperative that all problems must be identified and all the necessary action should be proposed to the design team.
- **Design verification.** Design verification tests are tests whose purpose is to examine product design and development outputs and to use objective evidence to confirm that these outputs meet the product design and development initial specifications.
- **Design validation.** Design validation tests are tests that are performed to examine whether the resulting product meets all user needs or wants.

Source: Better Product Design, Institute of Manufacturing, University of Cambridge, On-line http://www.betterproductdesign.net/tools/concept/testing.htm

5.1.3 Market Research Issues

5.1.3.1 Market Targeting Strategy

Market targeting strategy sometimes is confused with marketing strategy since it can be a part of it. It is a completely different thing. The marketing strategy is the creation of a market plan which is described in Level 7 and which is used in product commercialization. Market target strategy is used in market testing and it relates with the selection of the customers that will participate in the tests.

Also sometimes market target strategy is used in the final selection of the market during product concept development or marketing plan creation. In that case the same apply.

The targeting strategy must include the number of market segments to target, the number of product to offer and a plan of which product to be offered where. There are three main steps of targeting: the market segmentation, the target choice and the product positioning.

Target strategy is influenced by the market maturity, the diversity of customer needs and preferences, the company's size, the strength of the competition and the volume of products required for the tests.

5.1.3.1A Market segmentation

A very important issue related to market research and to market testing is **market segmentation**. Market segmentation is the process of selecting a group or groups of consumers or customers having similar characteristics for the market testing to be performed. Its purpose is to determine specific segments of the market upon which to concentrate marketing efforts, research and testing, to adopt a customer-oriented philosophy, to divide a large market into small sub-segments and to develop a dominant position in a specialized market segments.

The most important requirements of market segmentation are three:

- **Market measurements:** Identification and measurement of the characteristics and of the size of the market segment.
- **Economic opportunity:** The segment that is selected must have the income and the size so that to make a specific product profitable.
- **Market access:** The segment must be reachable i.e. must be easily handled, approached and manipulated by marketing methods.

A market can be segmented using the following steps:

Step 1: A demographic profile must be created. For example a typical profile of a customer of a specific market segment is given in the table bellow.

Market Segment Characteristics	Consumer Profile
Age:	45-50
Income level:	€ 30.000 +
Education level:	Post secondary education

Step 2: Identification of high concentrations of potential customers that fit the market segment characteristics. Usually people with similar characteristics such as income level are located in specific places. This information is very handy for the placement of products.

Step 3: Determination of consumer habits. How, where, when, and what potential consumers prefer to buy should be identified and noted.

Assessment 1 evaluates the ideas generated in Level 1 and both the way and the tools used for idea generation.

According to the answers a user gives to the questions a GO, HOLD or KILL decision is provided for further progression in the roadmap and specifically to Level 2.

Source: Better Product Design, Institute of Manufacturing, University of Cambridge, On-line http://www.betterproductdesign.net/tools/market/segmentation.htm

5.2 Level Assessment

Assessment 5 evaluates the way a product prototype is build and how that prototype is tested in respect to its functionality and market requirements as set in previous levels of the NPD Roadmap. Also ways of testing the development process are looked into and the results of such tests are evaluated.

Once again at the end of the assessment a Go, Kill or Hold recommendation is given to proceed into Level 6 of the Roadmap.

NPD Stage 6: Technical Implementation

As soon as all the market and beta testing of the new product prototype is concluded then the new product must enter into the technical implementation Level. In this Level the product is manufactured in large quantities so that it can be released into the selected market or market segment. The problems one could face in this Level are manufacturing, production or manufacturing management related. Tools and methods are provided in this Level to tackle some of the most occurring problems.

6.1 Tools & Solutions

Issues that need to be looked at and solved in this Level are things to do with manufacturing and the ways this can be done easily and effectively inside the cost and time limits set, and according to the specifications that have been laid out during the previous levels of development.

Also this Level deals and gives some insight solutions with some major manufacturing issues such as mass manufacturing, bill of materials management, quality assurance and value engineering and major tools that can be a great help for engineers and production personnel are discussed. These include CAD/CAM, Design for X, Industrial Design, Reengineering, Reverse Engineering and others.

Solutions for specific industry related issues are not given since the Level contents are set to give general directions in solving management problems that can arise in all industries and to provide some insight of the situations that must be dealt in product production.

6.1.1 Design for X

The term "Design for Manufacture" was used in the past to describe a design approach that ensured that a product is both manufacturable and simple to assemble. Nowadays the term "Design for X" is used to include activities such as the design for manufacture that express product design using a collection of tools, techniques and philosophies to link customer requirements and quality criteria such as robustness, serviceability and others.

There are dozens of Design for X methodologies; tools and techniques, each of them have impact on specific markets and for specific types of products. Some of the Design for X methodologies are given bellow

- Design for manufacture.
- Design for assembly.
- Design for disassembly.
- Design for life cycle.
- Design for ease of use.
- Design for installation.
- Design for maintenance.
- Design for validation.

- Design for reliability.
- Design for reuse.
- Design for cost.
- Design for the environment.
- Design for quality.
- Design for speed.

The most important of all the design approaches that are given above are the Design for Manufacture and the Design for Assembly since they have direct and recognizable impact on product costs.

Source: Better Product Design, Institute of Manufacturing, University of Cambridge, On-line http://www.betterproductdesign.net/guide/design4X.htm

6.1.1.1 Design for Manufacture

Design for Manufacture (DfM) is more than a philosophy than a practice. It is a way of thinking, which can be applied to any product component, product or product family tree. Its purpose is to minimize the overall component count and to optimize the remaining components so that the manufacturing costs to be reduced. For this to be accomplished the product design team must have deep understanding of the things that contribute to the overall product cost and the relative trade-offs between manufacturing processes, production volume and fixed and variable costs. The design for manufacture is defined by three key elements: the process selection, the reduction of process stages and the design of the process.

Process selection involves the selection of both material and methods for manufacturing the individual product components and it is based on the following:

- Performance criteria such as conductivity, strength, friction or thermal properties.
- Tolerance specifications.
- Component complexity requirements.
- Set up and tooling costs.
- Production volume.
- Expertise required and capability.

The reduction of the manufacturing process stages can be achieved by eliminating the unnecessary stages through a combination of alternative strategies. Such strategies can be the component minimization (method that is used widely in the electronics industry), the elimination of finishing processes (for components that may not be visible to the customer), the combining of manufacturing processes and the single direction processing or machining (this helps to reduce set up requirements).

The design of the process is defined by certain guidelines, which aim to ensure optimum design of components to satisfy any constraints that govern the manufacturing process. These guidelines help designers - engineers to avoid errors, recognize pitfalls and take advantage of benefits. Sometimes they are identified as good practices for certain manufacturing processes. Many guidelines are available for all, others are well kept company secrets. They can cover almost all industry segments

but sometimes they can be difficult to use since one should expect the unexpected when it comes in producing a new product.

Source: Better Product Design, Institute of Manufacturing, University of Cambridge, On-line http://www.betterproductdesign.net/guide/design4X.htm

6.1.1.2 Design of Assembly

The **Design of Assembly (DfA)** can be considered as part of DfM since it also supports the minimization of the total number of product components. In addition DfA focuses on the optimisation of how product components can be moved, held, located and joint during the manufacturing process.

Like DfM, there are certain guidelines that can be used for DfA. These guidelines are nothing more than rules that govern part count, how wires and cables are set, how adjustments should be made, how parts are inserted, and how components can be assembled in closed spaces. Like DfM, DfA guidelines can also be difficult to implement since there are always unexpected issues that can appear during the manufacturing - assembly process.

Systematic approaches can provide a unique environment for decision-making process for DfA. These are many methods for someone to follow a systematic approach for DfA. The two best-known ones are the one that was developed in the 70's by Boothroyd and Dewhurst, and the one developed in the 80's by Lucas Engineering Systems. For the record a systematic approach for DfA begins with an analysis of the assembly to determine if products components can be eliminated based upon the following simple rules:

* Determine the relative movement between one part and another.
* Determine whether a material must be different from another.
* Determine whether a specific part needs to be altered or replaced.

The approach ends with mapping of the assembly sequence to determine matters such as the design and setting up of the feeding for automated assembly, the setting up of the insertion order of components and the setting up of fitting, securing and locating components.

Source: Better Product Design, Institute of Manufacturing, University of Cambridge, On-line http://www.betterproductdesign.net/guide/design4X.htm

6.1.1.3 Design for Life Cycle

For many durable goods, there are a variety of other design considerations related to the total product life cycle. For consumable products, some of these life cycle factors may be of lesser importance. Life cycle factors that may need to be addressed during product design include: Testability / Inspectability, Reliability / Availability, Maintainability / Serviceability, Design for the Environment, Upgradeability, Installability, Safety and Product Liability and Human Factors.

The relative importance of these factors and their orientation will vary from industry to industry and product to product. However, there are general design principles for these life cycle

requirements that will be generally applicable to many items. A basic integrated product development concept is the parallel design of support processes with the design of the product. This parallel design requires early involvement and early consideration of life cycle factors (as appropriate) in the design process. However, in many organizations, consideration or design of the support processes is an after-thought and many of these developmental activities are started after the design of the product is well under way if not essentially complete.

Source: Crow Kenneth, "Design for the Life Cycle", DRM Associates, On-line http://www.npd-solutions.com/lifecycle.html

6.1.1.3A Design for Testability / Inspectability

Test and inspection processes can consume a significant amount of effort and the development or acquisition of test equipment can require considerable time and expense with some products. Early involvement of the test engineering or quality assurance functions can lead to design choices that can minimize the cost of developing or acquiring necessary equipment and the effort to test or inspect the product at the various stages of production. A starting point is to establish a common understanding between Engineering, their customers, and other functional departments regarding the requirements for product qualification, product acceptance after manufacture, and product diagnosis in the field. With this understanding, a design team can begin to effectively design products and test and inspection processes in parallel.

Increasingly complex and sophisticated products require capabilities and features to facilitate test and acceptance of products and diagnosis products if a defect is identified. Specific principles, which need to be understood and applied in the design of products, are:

- Use of Geometric Dimensioning and Tolerancing (GD&T) to provide unambiguous representation of design intent.
- Specification of product parameters and tolerances that are within the natural capabilities of the manufacturing process (process capability index Cp and Cpk)
- Provision of test points, access to test points and connections, and sufficient real estate to support test points, connections, and built-in test capabilities
- Standard connections and interfaces to facilitate use of standard test equipment and connectors and to reduce effort to set-up and connect the product during testing.
- Automated test equipment compatibility.
- Built-in test and diagnosis capability to provide self-test and self-diagnosis in the factory and in the field.
- Physical and electrical partitioning to facilitate test and isolation of faults.

In addition, test engineering should be involved at an early stage to define test requirements and design the test approach. This will lead to the design or specification of test equipment that better optimizes test requirements, production volumes, equipment cost, equipment utilization, and testing effort/cost. Higher production volumes and standardized test approaches can justify development, acquisition, or use of automated test equipment. The design and acquisition of test equipment and procedures can be done in parallel with the design of the product, which will reduce lead-time. Design of products to use standardized equipment can further reduce the costs of test equipment and reduce the lead-time to acquire, fabricate, and set-up test equipment for both qualification testing and product acceptance testing.

6.1.1.3B Design for Reliability

Reliability consideration has tended to be more of an after-thought in the development of many new products. Many companies' reliability activities have been performed primarily to satisfy internal procedures or customer requirements. Where reliability is actively considered in product design, it tends to be done relatively late in the development process. Some companies focus their efforts on developing reliability predictions when this effort instead could be better-utilized understanding and mitigating failure modes. And so developing improved product reliability. Organizations will go through repeated (and planned) design/build/test iterations to develop higher reliability products. Overall, this focus is reactive in nature, and the time pressures to bring a product to market limit the reliability improvements that might be made.

In an integrated product development environment, the orientation toward reliability must be changed and a more proactive approach utilized. Reliability engineers need to be involved in product design at an early point to identify reliability issues and concerns and begin assessing reliability implications as the design concept emerges.

Use of computer-aided engineering (CAE) analysis and simulation tools at an early stage in the design can improve product reliability more inexpensively and in a shorter time than building and testing physical prototypes. Tools such as finite element analysis, fluid flow, thermal analysis, integrated reliability prediction models, etc., are becoming more widely used, more user friendly and less expensive. Design of Experiments techniques can provide a structured, proactive approach to improving reliability and robustness as compared to unstructured, reactive design/build/test approaches. Further, these techniques consider the effect of both product and process parameters on the reliability of the product and address the effect of interactions between parameters. Finally, the company should begin establishing a mechanism to accumulate and apply "lessons learned" from the past related to reliability problems as well as other producibility and maintainability issues. These lessons learned can be very useful in avoiding making the same mistakes twice.

Specific Design for Reliability guidelines include the following:

- Design based on the expected range of the operating environment.
- Design to minimize or balance stresses and thermal loads and/or reduce sensitivity to these stresses or loads.
- De-rate components for added margin.
- Provide subsystem redundancy.
- Use proven component parts & materials with well-characterized reliability.
- Reduce parts count & interconnections (and their failure opportunities).
- Improve process capabilities to deliver more reliable components and assemblies.

6.1.1.3C Design for Maintainability / Serviceability

Consideration of product maintainability/serviceability tends to be an after-thought in the design of many products. Personnel responsible for maintenance and service need to be involved early to share their concerns and requirements. The design of the support processes needs to be developed

in parallel with the design of the product. This can lead to lower overall life cycle costs and a product design that is optimized to its support processes.

When designing for maintainability/serviceability, there needs to be consideration of the trade-offs involved. In high reliability and low cost products or with consumable products, designing for maintainability/serviceability is not important. In the case of a durable good with a long life cycle or a product with parts subject to wear, maintainability/serviceability may be more important than initial product acquisition cost, and the product must be designed for easy maintenance. In these situations, basic design rules need to be considered such as:

- Identify modules subject to wear or greater probability of replacement. Design these modules, assemblies or parts so that they can be easily accessed, removed and replaced.
- Use quick fastening and unfastening mechanisms for service items.
- Use common hand tools and a minimum number of hand tools for disassembly and re-assembly.
- Minimize serviceable items by placing the most likely items to fail, wear-out or need replacement in a small number of modules or assemblies. Design so that they require simple procedures to replace.
- Use built-in self-test and indicators to quickly isolate faults and problems.
- Eliminate or reduce the need for adjustment.
- Use common, standard replacement parts.
- Mistake-proof fasteners so that only the correct fastener can be used in re-assembly. Mistake-proof electrical connectors by using unique connectors to avoid connectors being mis-connected.

In addition, service and support policies and procedures need to be developed, service training developed and conducted, maintenance manuals written, and spare parts levels established. As these tasks are done in parallel with the design of the product, it reduces the time to market and will result in a more satisfied customer when inevitable problems arise with the first delivery of a new product.

Source: DRM Associates (http://www.npd-solutions.com/lifecycle.html)

6.1.1.4. Design for the Environment

There are three major elements of design for the environment: design for environmental manufacturing, design for environmental packaging, and design for disposal and recycle ability. Design for environmental manufacturing involves the following considerations:

- Non-toxic processes & production materials.
- Minimum energy utilization.
- Minimize emissions.
- Minimize waste, scrap & by-products.

Design for environmental packaging involves the following considerations:

- Minimum of packaging materials.

- Reusable pallets, totes and packaging.
- Recyclable packaging materials.
- Bio-degradable packaging materials.

Design for disposal & recycle ability involves the following considerations:

- Re-use / refurbishment of components & assemblies.
- Material selection to enable re-use (e.g., thermo set plastics vs. thermoplastics) and minimize toxicity.
- Avoids filler material in plastics such as fibreglass and graphite.
- Minimum number of materials / colors to facilitate separating materials and re-use.
- Material identification to facilitate re-use.
- Design to enable materials to be easily separated.
- Design for disassembly (e.g., fracture points, fastening vs. bonding).
- Avoid use of adhesives.
- Limit contaminants - additives, coatings, metal plating of plastics, etc.
- Maximize use of recycled or ground material with virgin material.
- Design for serviceability to minimize disposal of non-working products

To support design for recycle ability, design for dis-assembly needs to be addressed. Design for disassembly enhances maintainability or serviceability of a product, and it enables recycling of materials, component parts, assemblies, and modules. There are a number of principles to facilitate disassembly:

- Provide ready access to parts, fasteners, etc. to support disassembly.
- Design modular products to enable modules to be disassembled for service or re-use.
- Minimize weight of individual parts and modules to facilitate disassembly
- Use joining and fastening techniques to facilitate disassembly (e.g., fasteners instead of adhesives)
- Minimize fragile parts and leads to enable re-use and re-assembly.
- Use connectors instead of hard-wired connections.
- Design to enable use of common hand tools for disassembly.

Source: DRM Associates (http://www.npd-solutions.com/dfe.html)

6.1.1.5 References

- "Design for Manufacturability Handbook", Bralla.
- "Design for X" (http://www.betterproductdesign.net), Good Design Practice Program, Institute for Manufacturing & Engineering Design Center, University of Cambridge, UK, 2004
- Buxter M, "Product Design: Practical Methods for the Systematic Development of New Products", Stanley Thormes, UK, 1999.
- Crow K.A. "Design for the Environments" (http://www.npd-solutions.com/dfe.html), DRM Associates, 2002
- Crow K.A. "Design for the Life Cycle"

(http://www.npd-solutions.com/lifecycle.html), DRM Associates, 2002

6.1.2 Industrial Design

> "When someone chooses to buy a product, he takes for granted that the product will perform the function or functions it is intended for. The customer is usually attracted by the products appearance, specification and price. But he is also attracted by less obvious product characteristics, such as sound, smell and feel. These subjective characteristics of a product make the product a joy to use since they satisfy customer senses and so form a bond between the customer and the product beyond rational purchasing criteria. By paying more attention to these characteristics, manufacturers stand to benefit.
>
> The work of Industrial Design has shown the importance of the quality of user experience when interacting with product. For example, the balance of a wine glass or the action of a hinge is qualities, which are often taken for granted until they are found to be lacking. A company should consider these issues when designing from the users perspective.
>
> The aim to develop guidelines to ensure that the subjective characteristics mentioned above, is for industrial design to become a recognised part of the design cycle in the same way that sophisticated procedures are used by some manufacturers to evaluate and refine the visual aesthetics.
>
> Whilst some quite ordinary products already possess many of these sensory attributes, it would appear that manufacturing industry does not sufficiently recognize and prioritize them. Even in more expensive consumer goods they are often missed."

Author: Bailey Mark, ", The Center for Industrial Design, NorthCumbria University, UK

Source: Bailey Mark, "Sense Matter", The Center for Industrial Design, NorthCumbria University, On-line: http://www.cfid.co.uk/portfolio/research/pdf/senses_matter.pdf

6.1.2.1 Industrial Design Management

Industrial Design as any of the design methods and processes available for NPD needs to be well planed and managed. Also the need to locate and select the proper designer for a specific job is crucial. Before embarking into a industrial design project one should give a little bit of thought to the need of working with an industrial designer, the gains or potential benefits for such a partnership and the ways to plan such an engagement.

To pinpoint the value of such engagement one should consider the following.

- What are the customer requirements?
- What elements of the design are crucial to the success of the product?
- What skills are available and what do we need?
- What are the financial benefits?
- How do we compare to our competition?

To identify the type of industrial design involvement one should consider the following.

- How important are human factors or ser interface issues in the new product?
- How important is creativity and innovation?
- Is the work primarily styling?

Lastly to plan the engagement one should consider the following.

- What is the scope of the project?
- What form an initial brief on the engagement should have?

When all the above are answered i.e. the need for industrial design is established, the type of design involvement is identified, and the relationship is planed, then the selection criteria should be set. Their identification is crucial since they will be used later to evaluate the pros and cons of different possible suppliers. These criteria can differ from company to company and can include elements such as price, location, specific skills, IT and communication, track record and personality.

Often designers are selected based on word of mouth or previous experience. It can be very difficult to locate the right person with the right skills. Alternative approaches include location using design directories, web links, and local business links. If all fail one should seek out examples of products that one likes and contact the manufacturer to identify the industrial designer(s) involved.

As a rule one must select 5 suppliers and contact 3 of them asking them to respond to a short brief prepared with the involvement of all team members. All the members must agree on the form and contents of the brief. An effective brief must have the following.

- Exactly what is required from the industrial designer: all usability issues, potential form and feel and technical and quality aspects.
- All the critical constraints such as timescales, budget, resources, manufacturing process, scope of project and specific technical requirements.
- Some company information such as background, market information, user requirements (if any) and expected sales volume.

Depending on the responses the right supplier with the skills needed is selected.

The relationship between engineers and industrial designers becomes increasingly important. It is vital that all concepts are supported and are feasible and producible. Managing such relationship requires a joint appreciation of the following issues.

- Knowing who is responsible to deliver which aspects and when.
- Breaking the project into discrete phases.
- Having an agreed approach regarding management changes during the process.
- Identifying the system architect.
- Partitioning each task base on a understanding of interfaces between components.
- Identifying the commercial, technical and market risks.
- Ensuring IT compatibility and effective data transfer.
- Identifying the modes of informal and formal communication between members.

6.1.2.2 Industrial Design Activity Map

For someone to perform industrial design needs some kind of methodology and actions plan that will guide him through the whole process. Such a guide is the design map that follows. The map is basically a series of actions that one should take to be able successfully perform industrial design. The main actions are four and each of them is split up depending if they are internal or external. Each of the internal or external actions is made up by smaller activities that are described bellow.

Figure 1: Diagram of the Design Map

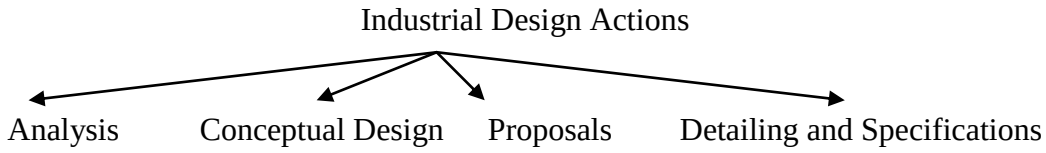


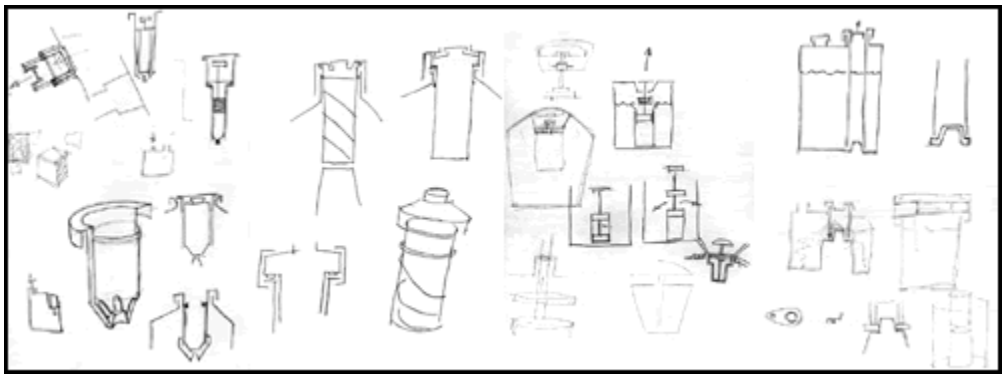
Table 1. Activities of Industrial Design Actions (Some activities are the same in different actions and may be repeated internally or externally depending on the action)

Activities	**Actions**			
	Analysis	**Conceptual design**	**Proposals**	**Detailing & Specification**
Internal	Sketch & Draw	Sketch & Draw	Sketch Model	Sketch & Draw
	Sketch Model	2D Technical Drawing	3D Digital Model (Constrained)	Sketch Model
	Prototype	3D Digital Model (Constrained)	3D Digital Model (Unconstrained)	2D Technical Drawing
		3D Digital Model (Unconstrained)		Prototype
External	Sketch & Draw	2D Technical Drawing	Sketch & Draw	Sketch Model
	2D Technical Drawing	3D Digital Model (Constrained)	Sketch Model	2D Technical Drawing
	3D Technical Drawing	3D Digital Model (Unconstrained)	2D Technical Drawing	3D Digital Model (Constrained)
	3D Digital Model (Constrained)	Prototype	Presentation	3D Digital Model (Unconstrained)
	3D Digital Model (Unconstrained)		Appearance Model	Prototype
	Prototype		Prototype	

6.1.2.2A Sketch & Draw

This activity is used to explore design issues. The activity by itself must be exploratory, quick and descriptive. Sketches are used to explore issues raised by the brief. Sketches may be used to establish in very approximate terms an outline of the issues posed by the brief, they enable us to 'shape' the problem and to understand it. Sketches are quick and loose and help to externalise thoughts. They can be used to communicate and think through ideas with oneself or with others in a team. They are often used in conjunction with words, written or spoken. They often serve as illustrations to early conversations or thinking processes and although potentially may not mean much to a 3rd party, often serve as markers for ideas, which can be returned to later.

Figure 1: Examples of sketch & draw activity results.



Source: "Sketch & Draw", The Center for Industrial Design, NorthCumbria University, On-line: http://www.cfid.com/portfolio/research/Nina/HTML-files/media-types/analysis-internal-sketch & draw.htm

In the examples shown above sketches were used at a very early stage to establish the extent of the problem posed by the brief and to brainstorm some potential solutions to give confidence that the problem could be solved. In this case study this was done prior to the project proposal being written.

Source: The Center for Industrial Design, Northcumbria University, On-line **Source:** "Sketch & Draw", The Center for Industrial Design, NorthCumbria University, On-line: http://www.cfid.com/portfolio/research/Nina/HTML-files/media-types/analysis-internal-sketch & draw.htm

6.1.2.2B Sketch Models

Sketch models are used to explore scale, volume, proportion and spatial issues. Sketch models must be informative, exploratory and may take many forms: foam models, rough test rigs etc. In the analysis action they might be used to establish & test configuration options, explore volume and spatial issues. They are exploratory and as such they should always be moving in parallel with the thinking process, and therefore need to be relatively quick to create. Sketch models can be seen as a form of '3D sketching'. As with sketches they can assist personal thinking or be used as part of a team process. Early configurations and volume studies can also be carried out within a 3D modelling system which might be more accurate but has the disadvantage in that it cannot be

touched, held or walked round. Sketch models are often not to scale and are often made in materials, which bear no resemblance to the final product.

Figure 1: Example of a sketch full-scale model.

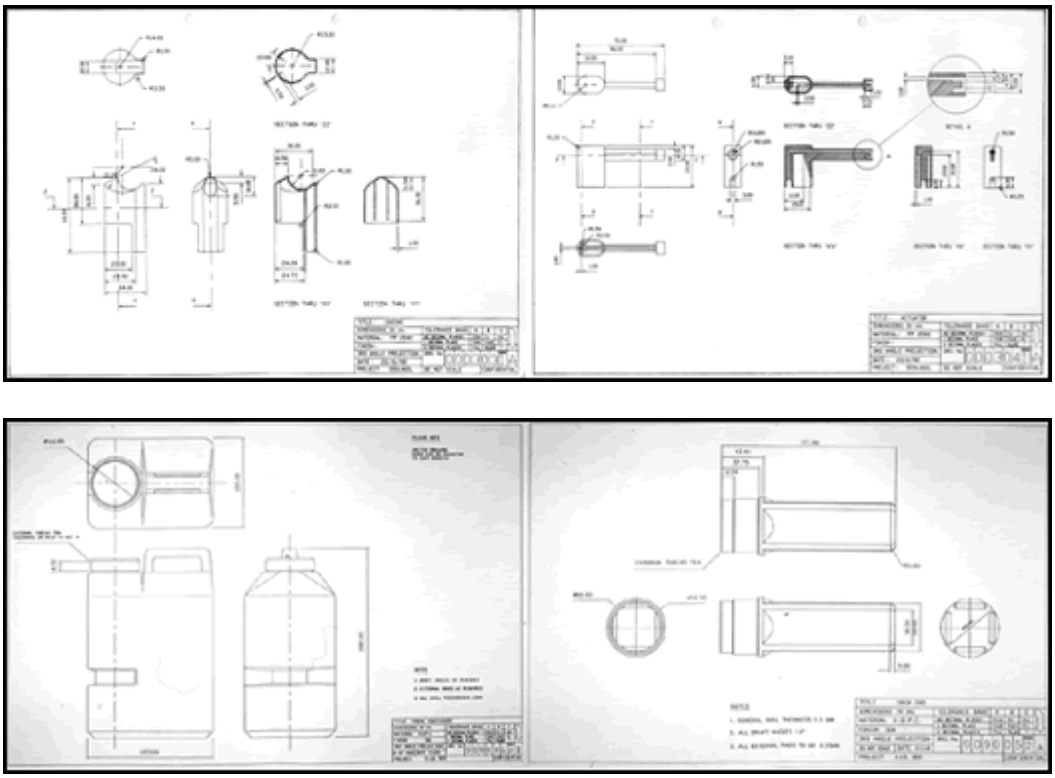
Source: The Center for Industrial Design, Northcumbria University, On-line Source: "Sketch Models", The Center for Industrial Design, NorthCumbria University, On-line: http://www.cfid.com/portfolio/research/Nina/HTML-files/media-types/analysis-internal-sketch models.htm

6.1.2.2C 2D Technical Drawing

These drawings are used to discuss manufacturing details and issues. They must be detailed, accurate, and informative and can be duplicated. Technical drawings, both hand drawn or digital are an extremely useful means of communicating to third parties when researching issues such as feasibility & cost. They can be used to describe a potential design in a way that can be understood by suppliers and can provide enough detail & information to enable them to make some form of considered feedback.

They are often used to obtain a range of castings, from ballpark to final. However, all 2D technical drawings suffer the same drawbacks, they are an impression of a 3D shape, and for their creation require a significant amount of skill in order to represent the 3D shape correctly. Further, they require interpretation by the person reading the drawing in order that the 3D shape can be. Earlier in the process this may not constitute a major problem, but if one is relying on a 2D specification for manufacture, then the success of the end result depends heavily on the skill of both the creator and the interpreter of the information. Although suffering the same drawbacks, digitally created 2D technical drawings (2D CAD) are much more flexible and useful than their hand drawn cousins. They can be edited and modified at will and can be printed as many times as needed. For the best possible accuracy they can also incorporate 2D snapshots of 3D data, enabling the addition of dimensions or notes, which can assist in the evaluation of the design or in the manufacturing process.

Figure 1: Examples of hand - made and digital 2D technical models.



Source: The Center for Industrial Design, Northcumbria University, On-line Source: "2D Technical Drawing", The Center for Industrial Design, NorthCumbria University, On-line: http://www.cfid.com/portfolio/research/Nina/HTML-files/media-types/analysis-external-techdraw-digi.htm

6.1.2.2D 3D Digital Model (Constrained)

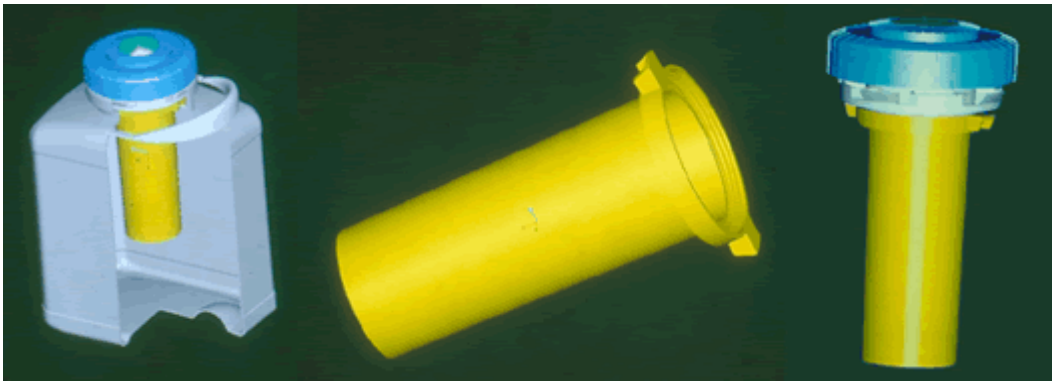
3D digital models, both unconstrained and constrained, can be used to support the analysis process. They can be used to discuss design feasibility and costing issues with a range of suppliers. 3D models provide what might be called a '360 degree' view of the design, enabling interrogation of every modelled element. In comparison to 2D representations of the design, such as 2D technical drawings, they require no representation of the 3D shape by the creator, and no interpretation by the client or supplier. They are significantly superior in their ability to communicate the design and avoid ambiguity. Digital models can be viewed in a number of ways, on screen, where they can be moved around and interrogated, or snapshots can be taken and imported into a digital presentation or printed onto hard copy. Constrained digital models provide a complete '360 degree' view where all aspects of the design are communicated and can be interrogated, including the ability to carry out mould flow and other engineering analysis. This complete picture enables accurate assessment of design feasibility as well as costs.

Figure 1: 3D digital models example

Source: "3D Digital Model", The Center for Industrial Design, NorthCumbria University, On-line: http://www.cfid.com/portfolio/research/Nina/HTML-files/media-types/analysis-external_s_digimodel.htm

Constrained models can be used to support the detailing and specification process. It is during this stage of the process that they are at their most useful. Constrained models are ideal for this action in that they have access to dimensioning, draft and FEA tools. Further, constrained models have direct access to 2D drawing output, what is known here as a 3D technical drawing. Constrained 3D digital models can be used to fully define the design and detailing of all aspects of the product, including internal and external detailing. By the time this action is undertaken the designer should have a very good idea as to the general configuration and form language of the design, it is therefore ideal that 3D should be employed at this stage to create the model, which will be used to define all aspects of the design.

Figure 2: Constrained 3D digital models example



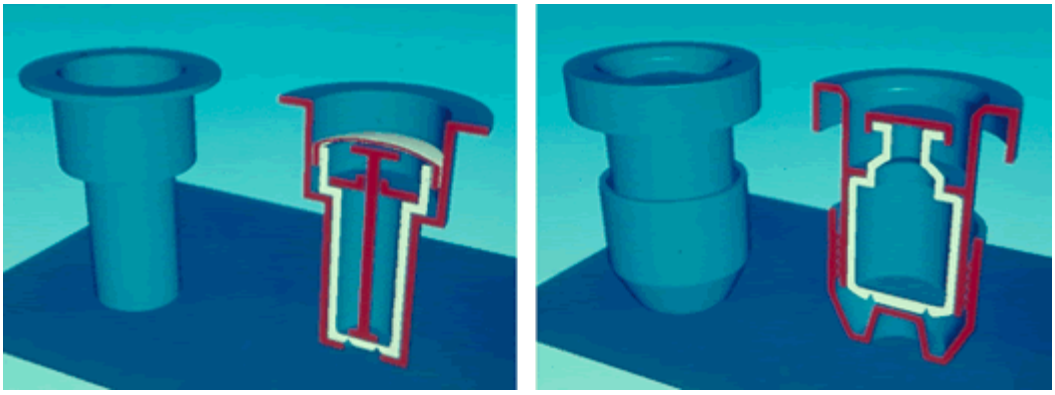
Source: "3D Digital Model", The Center for Industrial Design, NorthCumbria University, On-line: http://www.cfid.com/portfolio/research/Nina/HTML-files/media-types/analysis-external_s_digimodel.htm

6.1.2.2E 3D Digital Model (Unconstrained)

3D unconstrained digital models can be used to support the analysis process. They can be used to discuss design feasibility and costing issues with a range of suppliers. 3D models provide what might be called a '360 degree' view of the design, enabling interrogation of every modelled element. In comparison to 2D representations of the design, such as 2D technical drawings, they require no representation of the 3D shape by the creator, and no interpretation by the client or supplier. They are significantly superior in their ability to communicate the design and avoid ambiguity. Digital models can be viewed in a number of ways, on screen, where they can be moved around and interrogated, or snapshots can be taken and imported into a digital presentation or printed onto hard copy. Unconstrained 3D digital models provide this '360 degree' view but cannot be interrogated to the same extent as a constrained model and therefore provide more in the way of visual information than hard data. By their very nature unconstrained models are not modelled to hard specifications and are therefore not as accurate as their constrained cousins. Unconstrained models can also be used to support the creation of rapid prototypes although often-additional work has to be done to the model to make it suitable.

They can also be used to support the conceptual design process. They are used much in the same way as a physical 3D sketch model to provide the feedback necessary in order to progress the design. Compared to a sketch model they are significantly superior in their ability to communicate the design and avoid ambiguity. Unconstrained models are more likely to be used earlier in the process due to their more 'sketchy' nature, 3D form, which may be difficult to visualise in sketches or foam, can be created digitally providing a high level of feedback. The drawbacks are that digital models take longer to create than a sketch or a sketch model, using a digital model too early in the process may cause the designer to 'lock in' the design too early, perhaps being reluctant to change the model radically once it has been created. Further, it has been found that problems can arise if designers attempt to 'design' on CAD, digital modelling tools are such that progress is much better if the designer knows, even approximately, what the design will be like before he/she sits down in front of the screen. This is less so with unconstrained models, which have the opportunity to be 'pushed and pulled' into shape, however it is still advisable to have an approximate idea of the design before sitting down at a blank screen.

Figure 1: Unconstrained 3D digital model example

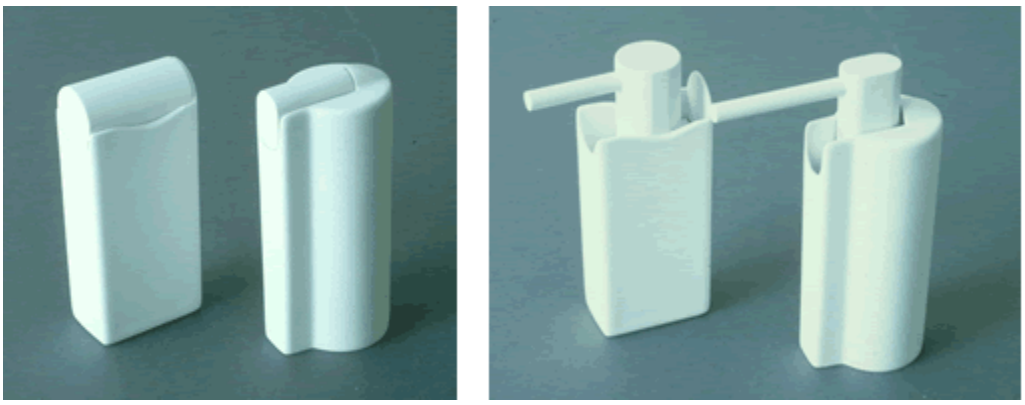


Source: "3D Digital Model (Unconstrained)", The Center for Industrial Design, NorthCumbria University, On-line: http://www.cfid.com/portfolio/research/Nina/HTML-files/media-types/analysis-internal_ns_digimodel.htm

6.1.2.2F Appearance Model

Appearance models might be created in order to present the concept to third parties outside the immediate client/supplier sphere. Such models might be used in market research, or as part of a company review process. The response to them may shape project funding or continuation decisions. Appearance model are just that however, unlike prototypes, they would not have any 'working' aspects; they would merely be 3D 'pictures' of the proposed design. Despite having little or no functionality, appearance models would look like real things and are therefore able to inspire strong emotional reactions in viewers.

Figure 1: Example of appearance models



Source: "3D Digital Model", The Center for Industrial Design, NorthCumbria University, On-line: http://www.cfid.com/portfolio/research/Nina/HTML-files/media-types/proposal-ex-external_app_model_trad.htm

Digital appearance models differ from non-digital in that the main shape for the model is created directly from data provided by the 3D digital model. The digital model provides data to drive machinery such as a CNC milling machine. Non-digital models can be created in number of ways, perhaps via the supply of 2D technical drawings, supported by a 3D sketch model. The key difference is that the digitally driven model is accurate to the 3D digital model, whereas the non-digital model requires interpretation by the model maker of the information provided.

Source: "3D Digital Model", The Center for Industrial Design, NorthCumbria University, On-line: http://www.cfid.com/portfolio/research/Nina/HTML-files/media-types/proposal-ex-external_app_model_trad.htm

6.1.2.2G Computer Visualisation

The pre-existence of 3D digital models supports the creation of computer visualisations and/or animations to support presentation of the concept outside of the immediate external client/supplier audience. These more glamorous representations of the proposed design might be used for market research, or perhaps to communicate the design to client peers or affiliates in order to maintain confidence or just to communicate as part of a company wide project review process. Such forms of communication are glamorous and can be informative and exciting, but are more of a surface view of the product. They let the viewer see what the presenter wants them to see. Animations in particular are highly time consuming and should not be undertaken lightly.

Figure 1: Example of a computer visualisation model

Source: The Center for Industrial Design, Northcumbria University, On-line Source: "Computer Visualisation", The Center for Industrial Design, NorthCumbria University, On-line: http://www.cfid.com/portfolio/research/Nina/HTML-files/media-types/proposal-ex-external_comp_vis.htm

6.1.2.2H Presentation - Illustration

Presentation illustrations, created digitally or non-digitally, can be used to support design presentations. The Non Digital versions are a development of sketch & draw and are a richer method of communicating design intent. In some instances they try to suggest what the design might look like once made, this is usually done via a process of rendering, using tools such as markers or coloured pencils. They help add life to a design concept, giving it an extra dimension, perhaps an element of 3D-ness. They are less coherent than a 3D representation; this may be appropriate in some situations where only a gut reaction to a range of ideas is required. Often, if less detail is available, viewers find it easier to focus on the idea as a whole, rather than on the way the design looks. Although they might be seen to hold less value than a 3D representation of a design, they are much quicker to create potentially allowing the creation of a much larger range of

concepts. They can be used to make the product look very glamorous, and it is easy to hide the fact that design issues have not been resolved behind this glamour.

Figure 1: Example of model presentation

Source: The Center for Industrial Design, Northcumbria University, On-line Source: "Presentation - Illustration", The Center for Industrial Design, NorthCumbria University, On-line: http://www.cfid.com/portfolio/research/Nina/HTML-files/media-types/proposal-external_presillus_trad.htm

6.1.2.2I Prototype

Prototypes can be used to develop the design detailing and specification either as a personal experimentation process or as part of a team. Hand built prototypes invite continual modification until the design is acceptable. At this stage realistic materials should be used to reduce inaccuracies as much as possible. Prototypes can be used to completely simulate the finished product, incorporating working components etc.

Figure 1: Example of prototypes

Source: "Prototype", The Center for Industrial Design, NorthCumbria University, On-line: http://www.cfid.com/portfolio/research/Nina/HTML-files/media-types/proposal-external_prot_trad.htm

A prototype might exist as a support to the final specification, illustrating it and showing how the product should look and function. A digital prototype could illustrate form, fit & assembly issues as well as issues such as mechanistic behaviour. A digital prototype requires the pre-existence of a digital model.

Figure 2: Example of a digital prototype

Source: "Prototype", The Center for Industrial Design, NorthCumbria University, On-line: http://www.cfid.com/portfolio/research/Nina/HTML-files/media-types/proposal-external_prot_trad.htm

6.1.2.3 Consultants - Experts

- Industrial Design & Construction (IDC) (http://www.idc-ch2m.com)

Industrial design and construction company based in the US, which supplies and facilitates planning, designing and construction of products for process intensive technology industries.

- Institute of Design of Ume University (http://www.dh.umu.se)

Institute of Design of Ume University was founded in 1989 and it is organized solely for the purpose of teaching industrial design. The institute is collaborating with the EU through the Mal1 Norra Norland Program.

- Sowden Design (http://www.sowdendesign.com/english/index.cfm)

Sowden Design is a company that designs and constructs computer peripherals and other electronics using 3D computer models, which are used for prototyping.

- Center for Industrial Design (http://www.cfid.co.uk/)

The Center for Industrial Design is a research led design consultancy, which functions as a commercial enterprise within the University of Nothcumbria at Newcastle, UK.

- Transform Design (http://www.transformdesign.com)

Transform Design is an industrial design firm servicing both industry and consumer oriented manufacturers since 1991. Transform Design services include all phases of bringing a product to a market, from analysis to manufacturing.

- Teams Design (http://www.teamsdesign.com)

Teams Design in an international industrial design consultant, which provides complete product design and development services.

- Creative Design (http://www.creative-design.co.uk)

Creative Design is an award winning product design consultant based in the UK.

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6.1.3 Lean Manufacturing

Lean manufacturing is a business tactic whose aim is to reduce waste in manufactured products and can be applied during the manufacturing process. Most product costs are assigned when a product is first designed. It is typical for engineers to assign or specify materials and manufacturing processes that are reliable but in most cases expensive. This tactic reduces the reliability risk but increases the manufacturing costs of a product. Instead of doing a lot of companies have adopted some kind of checklists that are designed to review product designs and cut manufacturing costs.

Techniques have been developed for all levels of product design namely system engineering, mechanical engineering, electrical engineering and software engineering. Also tactics such as the "Just In Time" technique are applied to reduce waste of the form of unused inventory of product components.

6.1.3.1 Electrical Engineering Level

At the electrical engineering level, lean manufacturing is the process of identifying the product components or processes that add cost and replace them or completely eliminate them. Usually what happens is that expensive mechanical processes are replaced with cheap electrical or software ones and expensive electrical or electronic components eliminated or replaced with cheaper ones.

An important factor in electronic and electrical engineering is the way tolerances are treated. Usually components have different tolerances and the small tolerances are found in expensive components. So a solution based on lean manufacturing is to replace these components with other ones of larger tolerances but in the same case the product functionality remain the same or close to the one achieved with the small tolerance components.

Another lean manufacturing solution that can be applied to the electrical engineering level is the integration of mechanical and electrical parts in such a way to reduce count of cables, connectors and other electro-mechanical material.

6.1.3.2 Mechanical Engineering Level

In the case of the mechanical engineering level, lean manufacturing is the process of reviewing the materials and processes to be used in product manufacturing. A review team made of an accountant, a product design engineer and a manufacturing engineer, should identify the materials and processes that add costs into manufacturing and try to eliminate or reduce them. For example the use of die casts or moulds instead of machining in the case of metal part production is a cost cutting solution.

The tooling costs and any production machinery costs are also estimated and alternative solutions should be identified by the review team. For example the reuse of machinery for completing different tasks can be a cost cutting solution.

In many cases it is crucial to identify materials that require less time to form or less time to be machined due to their characteristic properties. Again the review team should identify such possibilities.

6.1.3.3 System Engineering Level

At the system engineering level, product requirements must be reviewed with marketing and customer representatives to eliminate or reduce costly product requirements. Product requirements are assigned to the cheapest discipline. For example product adjustments and measurements may be moved to software rather than a electrical or mechanical solution that may be more expensive.

6.1.3.4 Just In Time (JIT)

The Just In Time (JIT) technique is a lean manufacturing tactic designed to reduce manufacturing costs by reducing and eventually eliminating the product parts or components in a company inventory. The idea behind the technique is to have enough product parts or components in

inventory (in a warehouse) to achieve production of a specific number of product units. Usually this specific number being the number of ordered units by the customers.

This tactic or technique which, was first tried and developed by Toyota Motor Corporation, has the advantage of cutting costs by reducing or eliminating the stocked pilled unsold products or product parts. But in the same time has the risk of stopping or even slowing down the production line in the case of a bad or faulty part since there are usually no replacement parts as the product parts or components are just the ones required to have a certain number of product units. Also ones of the tactics main characteristics is the one of been able to plan an exact production timetable based on the available product orders and save money on labor.

6.1.4 CAD/CAM

Computer Aided Design-CAD is defined the use of information technology (IT) in the Design process. A CAD system consists of IT hardware (H/W), specialized software (S/W) (depending on the particular area of application) and peripherals, which in certain applications are quite specialized. The core of a CAD system is the S/W, which makes use of graphics for product representation; databases for storing the product model and drives the peripherals for product presentation. Its use does not change the nature of the design process but as the name states it aids the product designer. The designer is the main actor in the process, in all phases from problem identification to the implementation phase. The role of the CAD is in aiding him/her by providing:

- Accurately generated and easily modifiable graphical representation of the product. The user can nearly view the actual product on screen, make any modifications to it, and present his/her ideas on screen without any prototype, especially during the early stages of the design process.
- Perform complex design analysis in short time. Implementing Finite Elements Analysis methods the user can perform: Static, Dynamic and Natural Frequency analysis, Heat transfer analysis, Plastic analysis, Fluid flow analysis, Motion analysis, Tolerance analysis and Design optimization.
- Record and recall information with consistency and speed. In particular the use of Product Data Management (PDM) systems can store the whole design and processing history of a certain product, for future reuse and upgrade.

The technique initiated in the MIT from Ian Sutherland, when the first system the Sketchpad was created within the SAGE (Semi-Automatic Ground Environment) research project. The automotive and aerospace industries were the first users and the forerunners of development of CAD technology.

The first system was very expensive, the computer graphics technology was not so advanced at that time and using the system required specialized H/W and S/W, which was provided mainly by the CAD vendors. The first CAD systems were mainframe computer supported systems, while today the technology is for networked but stand alone operating workstations (UNIX or WINDOWS

based systems). AUTODESK was the first vendor to offer a PC based CAD system the AUTOCAD (beginning of 1980). Today WINDOWS is the main operating system for CAD systems.

The first applications were for 2D Drafting and the systems were also capable of performing only 2D modelling. Even today 2D-drafting is still the main area of application (in terms of number of workplaces). Later, (mid-1980), following the progress in 3D modelling technology and the growth in the IT H/W, 3D modelling systems are becoming very popular. 3D modelling was at the beginning wire frame based. Aerospace and automotive industries were using surface modelling systems for exact representation of the body of the product. At the same time solid modelling was recognized as the only system, which could provide an unambiguous representation of the product, but it was lacking adequate support for complex part representations.

Today we are experiencing a merge of solid and surface modelling technology. Most solid modelling systems are capable of modelling most of industrial products. Systems sold today (especially for mechanical applications, which are the majority of systems sold world-wide) are characterized as NURBS (Non Uniform Rational B-Sline) based systems, employing solid modelling technology, and they are parametric and feature based systems.

The use of CAD systems has also been expanded to all industrial sectors, such AEC, Electronics, Textiles, Packaging, Clothing, Leather and Shoe, etc. Today, numerous CAD systems are offered by several vendors, in various countries.

Source: Computer Aided Design - CAD, by Dr N. Bilalis, Technical University of Crete, On-line at http://www.urenio.org under the heading Innovation Reports.

6.1.4.1 References

* Bilalis N. "Computer Aided Design - CAD" (http://www.urenio.org/rsi.htm), Urenio, Technical University of Crete

6.1.5 Re-engineering

Product development practices can create many opportunities to reengineer and improve the process as a whole and reduce development time. Whether a product is developed in an R&D environment or not, it is very easy to improve the development process by perceiving problems, brainstorming opportunities, analyzing and redesigning.

To reengineer the development process one needs to fully understand the development process itself since the development of a new product can redefine a company's development process. Also benchmarking of the process can identify any changes and pinpoint improvement opportunities. Brainstorming can be also used to look for new improvement opportunities. In either case, knowledgeable personnel, to the appropriate level of management, must present all opportunities.

To be effective, any action that results to the improvement of the way that people work and subsequently the way business is done, leads to better processes and practices. In reengineering these actions must at all times lead to evolutionary change, which can stimulate morale and

imagination (hence innovation) and can create the opportunities for the appearance of creative ways for dealing with adversary and competitive challenges.

In many cases as companies fight competition and severe economic situation; they tend to find solutions in extreme actions such as downsizing. This is a very good short-term solution but a very poor long term one. By reengineering the business processes of a company, especially its product development practices, the company can benefit a great deal in the long term. Reengineering can mobilize employee commitment and imaginative cooperation and hence its product innovative development ability and not only that.

6.1.5.1 Case Studies - Examples

A hypothetical government agency charges $10 per employee paycheck issued due to layers upon layers of bureaucracy. By comparison a private sector commercial services agency with the same number of employees charges only $1,5. The government agency management decided to bring the $10 figure down to the one of the private sector agency by reengineering its payroll processes. To accomplish this, management asked all employees to write down workflow diagrams that showed who does what, how and when. When these diagrams were entered into a computer for data analysis, it became apparent that the charges were that high because the paycheck had to go through typically, the controller, then the personnel department, then the regional processing center and then the auditors.

Next the management made out a diagram showing how much money would have been saved if say the controller or the regional processing center or the personnel department were removed from the chain. By removing one of them and by reengineering the actual business practices that ordinarily take place in the remaining elements of the chain, so that to be more effective, the charges were reduced to those of the private sector agency.

6.1.5.2 Software Tools

http://www.semdesigns.com/Products/DMS/DMSToolkit.html

Semantic designs Inc is a company that has developed software package called **DMS Software Reengineering Toolkit**. The DMS Software Reengineering Toolkit is a set of tools for automating customized source program analysis and modification of large scale software systems and therefore reengineer the whole systems.

6.1.5.3 Consultants - Experts

Reengineering Forum (http://reengineer.org/)

The forum is an industry related association that encourages the combined industry - research review of the practice of reengineering of software, systems and business processes.

6.1.5.4 References

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6.1.6 Reverse Engineering

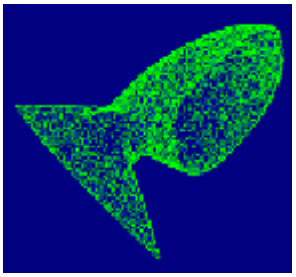
Reverse engineering is defined as the process of analysing a system or an object to identify its components and their inter-relationships and create representations of the system or the object in another form or at a higher level of abstraction. In the case of product development this is translated into the process in which an existing competitive product is analysed and documented so that its development process is understood. In this case the tricky part is to avoid copying it or stepping into copyright laws while doing so. This process can help companies that have no product development experiences and although have the resources to conduct product development do not know where and how to start.

The process is a practice that nowadays is often used by almost everyone in industry related companies such as computer hardware and software manufacturers, automobile industries, pharmaceutical firms etc. It provides a fairly cheap way in developing a new or a better offering of a product without the hassle of going through a complete development process. For example an automobile industry can purchase car of a competitive firm, disassemble it, examine the welds, seals and other components of the car for the purpose of enhancing their vehicles of similar components.

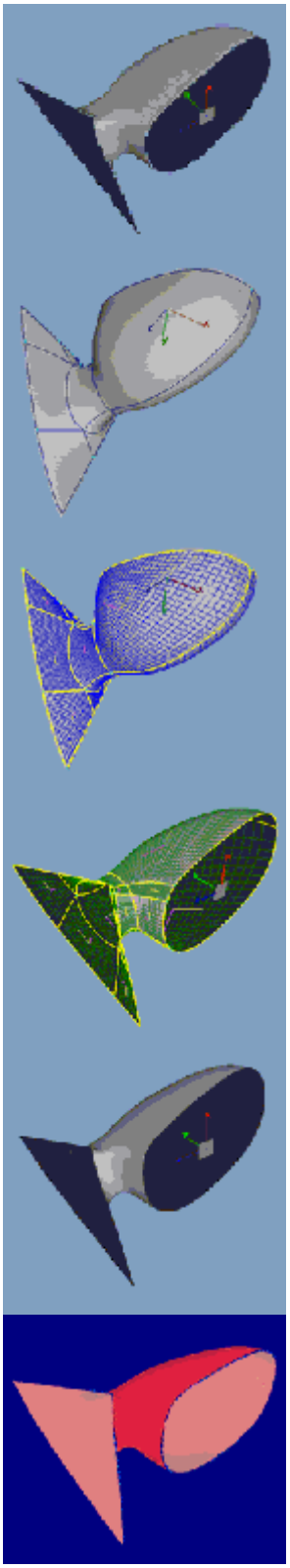
Source: Crow Kenneth, “A Methodology for Reverse Engineering”, On-line http://www.npd-solutions.com/remethod.html

6.1.6.1 Reverse Engineering Methodology

A typical workflow in reverse engineering could involve scanning an object and recreating it. This process comes in a series of steps, which are discussed and illustrated bellow.



Step 1: A cloud of points is taken from scanned data using a digitizer such as a laser scanner, a computed tomography or faro arms.



Step 2: The cloud of points is converted to a polygonal model. The result is cleaned up, smoothed and sculptured to the required shape and accuracy.

Step 3: Curves are drawn or created on the mesh using automated tools such as feature detection tools or dynamic templates.

Step 4: A restructured spring mesh is created using semi-automatic tools.

Step 5: NURBS surfaces are fitted using surface fitting and editing tools.

Step 6: The final resulting NURBS surface, which satisfies accuracy and smoothness requirements, is exported to a CAD package for generating toll paths for machining.

Step 7: The part is manufactured and then analyzed for physical, thermal, electric or other properties.

Source: Crow Kenneth, "A Methodology for Reverse Engineering", On-line http://www.npd-solutions.com/remethod.html

6.1.6.2 Major Applications

6.1.6.2A Reverse Engineering of Business

Reverse engineering is not used only in cases of products or product components. It can also be used in the case of a business. The most common application of business reverse engineering is competitor product analysis. Reverse engineering can be used to analyse how a competitor product works, what it does, who manufactures it, what kind of components consists of, how much does it cost to be produced, what kind of patents protects it etc.

Value engineering is a related activity which involves the deconstruction and the analysis of products and whose objective is to find opportunities for cost cutting.

6.1.6.2B Reverse Engineering of Electronic Components

Reverse engineering of electronic components is very much used nowadays since manufacturers of new electronic products need to solve interoperability problems. This means that new electronic components or new electronic in nature products need to be compatible with others so that information and services can be exchanged between them directly and satisfactory. Reverse engineering is used for competitive or otherwise electronic equipment functionality analysis so that a new product can be 100% compatible with them.

Coordinate - Measuring Machines (CMM) is one of the reverse engineering techniques that are used for electronic equipment. CMM can be used to digitize a circuit and the information to be used in computer-aided modelling. Another new and improved technique is laser scanning. The technique uses a laser beam o scan across the surface of components of any shape and display the results in real time in a computer screen.

6.1.6.2C Reverse Engineering of Software

Reverse engineering is applied to software in a big way. One of the most famous cases of reverse engineering of software is the case of the first non-IBM implementation of BIOS. In the US the "Digital Millennium Copyright Act" exempts from the circumvention ban some acts of reverse engineering aimed at interoperability of file formats and protocols and judges in key cases have ignored the law since it is possible to be acceptable to circumvent restrictions for use but not for access.

A typical example of software reverse engineering is the "Samba Software". The software allows systems that are not using or running Microsoft Windows to share files with systems that are. The Samba project had to reverse engineer the way Windows file shared worked which was unpublished and restricted Microsoft Corp information, so that a computer that did not use windows could emulate the procedure.

Reverse engineering of software can be accomplished by various methods. The two main ones is analysis through observation of information exchange and decompilation or disassembly using a disassmbler.

6.1.6.3 Case Studies - Examples

Reverse Engineering Case Study

Although the use of reverse engineering as means to duplicate or copy a software program constitutes a copyright violation and it is illegal, an example of how can be done is very useful in understanding the process and act as a case study of reverse engineering use.

Software reverse engineering involves in reversing a program's machine code (the binary string of 0's and 1's that are send to the processor) back into the source code that it was written in, using programming language commands. To do this, in the case of a complicated program, someone can use for example a hexadecimal dumper, which prints or displays the binary numbers of a program in hexadecimal format (which is easier to read). Knowing the hex words that make up the processor instructions, as well as the instructions length, a reverse engineer can identify certain portions of the program and see how it works. Also besides the dumper, a disassembler can be used to read the binary code and transform it into text displaying each executable command. A disassembler usually cannot tell the difference between an executable instruction and data send to the processor. So in this case the reverse engineer can use a debugger that does exactly that. So in any case using different tools a software program can be analyzed to the point that it is understood completely and can be copied or its source code altered to create a new software product through reverse engineering.

6.1.6.4 Consultants - Experts

- Future Technology Systems Consultancy (http://www.fts.gr/fts/ftsprduk.htm), Greece
- Industrial Center, Hong Kong Polytechnic University (http://www.ic.polyu.edu.hk/services/consultancy.htm)

- Liveware Software Engineering, Reverse Engineering Services (http://www.liveware.com/english/services/reengineering.htm)

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6.1.7 Major Manufacturing Issues

6.1.7.1 Bill of Material (BOM)

A bill of material is a formally structured list for an object (semi-finished or finished product), which lists all the component parts of the object with the name, reference number, quantity, and unit of measure of each component. A bill of material can only refer to a quantity greater than or equal to one of an object. It is a product data structure, which captures the end products, its assemblies, their quantities and relationships.

There are usually two kinds of bills of materials needed for a product: engineering and manufacturing BOM. The engineering BOM normally lists items according to their relationships with parent product as represented on assembly drawings. But this may not be sufficient to show the grouping of parts at each stage of the production process nor include all of the data needed to support manufacturing or procurement. These requirements may force the arrangement of the product structure to be different in order to assure manufacturability. Thus, engineering and manufacturing will usually have different valid views for the same product.

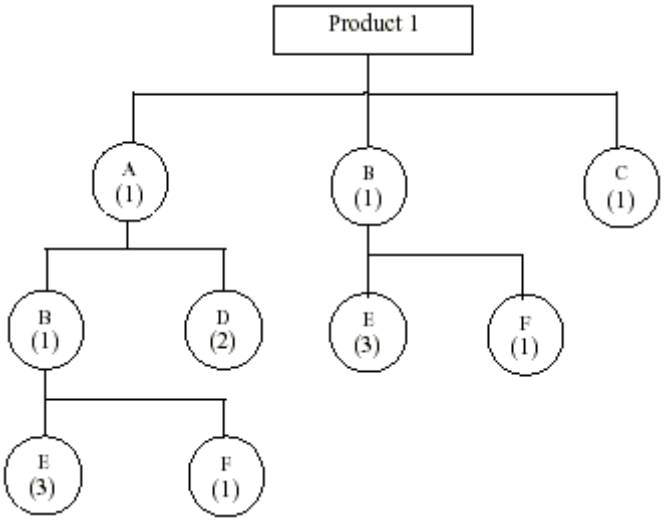
Manufacturing Requirements Planning (MRP) systems typically rely on a Bill of Materials (BOM) and the product structure for their information. In theory, the BOM can and should be produced automatically by the CAD system but in practice there is usually human intervention or even re-entry. The main reasons are: The difficulty of tracking changes to the BOM (product structure) and affectivity dates and transferring this data back to the design system. Many changes, such as different suppliers for fasteners, do not affect the design form, fit and function and are therefore only made and stored in the manufacturing systems. The need in manufacturing to view the product structure differently. It is often necessary to batch similar components from different products together for mass production or efficient purchasing.

Product Data Management (PDM) technology enables changes to be tracked and implemented through the design and engineering change process and then passed over to the MRP system when approved. Therefore PDM systems use BOM to represent configuration management of the product.

A Bill of Materials is a product data structure, which captures the end products, its assemblies, their quantities and relationships. The structure of a part's list determines the accessibility of the part's information by various departments in a company. It also helps to determine the level of burden put on the computational device in searching for product information. In many companies the BOM is structured for the convenience of individual departments. This, however, engenders problems in other departments.

In Figure 1, a product named Product 1 is shown graphically with the summarized products structure and the number of all items that are needed to make the parent products are enclosed in brackets.

Figure 1: Graphical Representation of Product 1 Structure



Source: Crow Kenneth, "Product structure and Bills of Material", DRM Associates, On-line http://www.npd-solutions.com/bom.html

Table 1 contains a bill of materials for Product 1 in which the total usage of each item is collected into a single list for the product. This kind of list is convenient for the master production schedule but results in the duplication assemblies. This implies that each product bill that uses assembly must be changed whenever there is a change in assembly. Furthermore, since lead times of intermediate assemblies cannot be determined, parts are ordered too early the first time they are encountered in the product structure.

Table 1: BOM for Product 1.

Part	Qty
A	1
B	2
C	1
D	2
E	6
F	2

Source: Crow Kenneth, "Product structure and Bills of Material", DRM Associates, On-line http://www.npd-solutions.com/bom.html

Other arrangements used in arranging the bill of materials is by indenting the product data as shown in Table 2. One disadvantage of this method is that all components of an assembly are repeated each time the assembly is used, resulting in massive duplication of data.

Table 2: Intended BOM

Product 1	Qty
A	1
B	1
E	3
F	1
D	2
B	1
E	3
F	1
C	1

Source: Crow Kenneth, "Product structure and Bills of Material", DRM Associates, On-line http://www.npd-solutions.com/bom.html

One solution to the duplication problem is by holding each assembly only once in 'single level' bill of materials as shown in Table 3. In this approach it identifies only the components used by one level and a required subassembly. This means that engineering changes can be made in only one place.

Table 3: Single-level bill of materials

Level 1

Part/Product 1	Qty	Pointer to level
A	1	A
B	2	B
C	1	

Level 2

Part/A	Qty	Pointer to
B	1	B
D	2	

Level 3

Part/B	Qty	Pointer to
E	3	
F	1	

Source: Crow Kenneth, "Product structure and Bills of Material", DRM Associates, On-line http://www.npd-solutions.com/bom.html

'Where used' lists give an easy overview of the products where a given material is contained. This happens by displaying of all BOM's, which contain this component.
Below is given the typical information, which can be found in a bill of materials:

Product or Higher-Level Assembly

- Product/Assembly Item Number
- Product/Assembly Name
- Product/Assembly Description
- Unit of Measure
- Revision Level

Each Component/Item

- Item Number

- Item Name
- Item Description
- Revision Level
- Unit of Measure
- Quantity per (each higher level assembly)
- Effectivity (date in and date out or serial number in and serial number out)

Source: DRM Associates (http://www.npd-solutions.com/bom.html)

6.1.7.2 Mass production

Mass production is the process of manufacturing large amounts of standardized products is a production line. The process permits very high rates of production per person and so it provides very inexpensive products. The aim of the process is the reduction of non-productive effort of any kind.

In craft production a single person must get all the necessary parts and assemble them to produce a product with the help of all kind of tools which are used many times. In mass production each worker repeats one or few related tasks and uses the same tool to perform almost identical operations in a stream of products. The tool and the parts required are always there and no time is spent getting them or finding them.

Mass production systems are usually organized in assembly lines. A factory may have more than one assembly lines in the cases of complex products. A diagram of typical mass production factory looks like the skeleton of a fish. Different sub-assembly lines are used to produce different parts of a product and all finished parts are joint together at the end.

Nowadays managers choose which part or which product to put in a assembly line based on the return of investment (ROI) that a specific assembly line can produce. Assembly lines that are considered to have bad ROI are usually outsourced.

Source: This article is licensed under the GNU Free Documentation License, On-line http://www.gnu.org/copyleft/fdl.html. It uses material from http://en.wikipedia.org/wiki/Mass_production
For more information please see: http://en.wikipedia.org/wiki/Wikipedia:Copyrights

6.1.7.3 Producibility

Sometimes manufactured products have unnecessary precision, production operations or parts. Simple redesign of the product can eliminate these so that costs are lowered and manufacturability, reliability and profits are increased. There are a lot of examples in different industries where this is common practice.

Some Japanese disc brakes have parts with tolerances of three mm an easy to meet precision. This fact combined with some basic statistical process controls assures that less than one in a million will fail. Also many vehicle manufacturers have programs of reducing the number of types of fasteners in their product so that their inventory, tooling and assembly costs are reduced.

Another reducibility technique is "near net shape" forming. A forming process can eliminate many low precision machining or drilling steps. Also precision transfer stamping can produce hundreds of high quality parts fast from generic rolls of steel and aluminium. Die-casting is used to produce metal parts from aluminium or tin alloys. Plastic injection molding is a handy technique in cases where the part is supplemented with inserts of brass or steel.

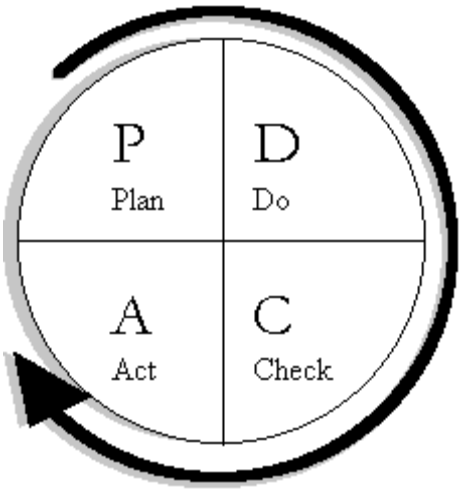
In the case of computer manufacturing, parts can be replaced with software that fits into a single lightweight low power memory part or micro-controller. In the electronics industry some PCB's (Printed Circuit Boards) contain parts that are leadless. This reduces the count of holes (Via) and clipping off the leads after soldering and therefore the cost of manufacturing.

6.1.7.4 Quality Assurance

Quality assurance covers all the activities from design, development, production, installation, servicing and documentation. But it also includes the management of raw materials, assemblies, products and product components; services related to production and all the inspection processes. That is why it is vary important to the product manufacturing process. One of the most widely used quality assurance tool is the Plan - Do - Check - Act (PDCA) cycle that is also known as the "Shewhart Cycle".

The PDCA cycle is really nothing more than a four-stage checklist that one must go through to get from "problem faced" to "problem solved". The cycle was originally developed by Walter Shewhart. He was a pioneer statistician who was working in the Bell laboratories in the 1930's in the US. The cycle can be graphically presented as shown bellow.

Figure 1: The PDCA Cycle.



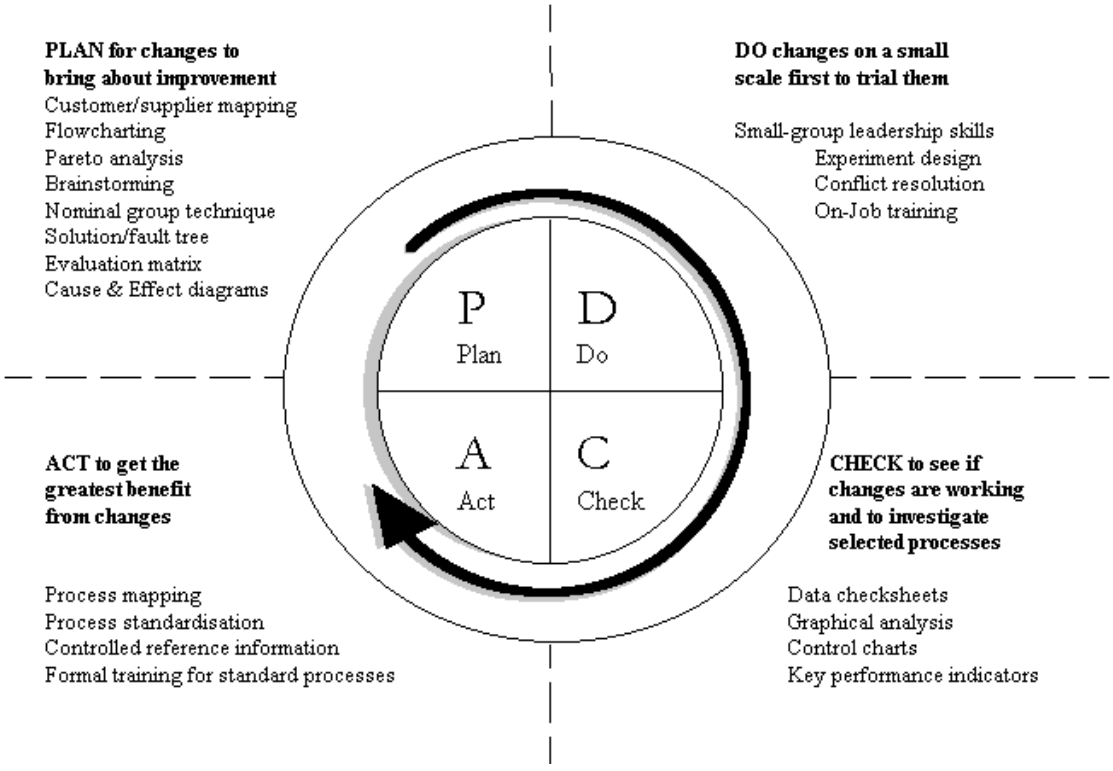
Source: HCI Professional Services, "The PDCA Cycle", On-line http://www.hci.com.au/hcisite2/toolkit/pdcacycl.htm

Here is what one must do for each stage of the Cycle:

- Plan to improve your operations first by finding out what things are going wrong (that is identify the problems faced), and come up with ideas for solving these problems.
- Do changes designed to solve the problems on a small or experimental scale first. This minimises disruption to routine activity while testing whether the changes will work or not.
- Check whether the small scale or experimental changes are achieving the desired result or not. Also, continuously Check nominated key activities (regardless of any experimentation going on) to ensure that you know what the quality of the output is at all times to identify any new problems when they crop up.
- Act to implement changes on a larger scale if the experiment is successful. This means making the changes a routine part of your activity. Also Act to involve other persons (other departments, suppliers, or customers) affected by the changes and whose cooperation you need to implement them on a larger scale, or those who may simply benefit from what you have learned (you may, of course, already have involved these people in the Do or trial stage).

The next figure illustrates some of the tools or techniques that can be used. One must note that these are not to be strictly applied but one can use any or all of them.

Figure 2: Tools - Techniques That Can be Used in the PDCA Cycle



Source: HCI Professional Services, "The PDCA Cycle", On-line http://www.hci.com.au/hcisite2/toolkit/pdcacycl.htm

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6.1.7.5 Value Engineering

Value engineering is a branch of industrial - manufacturing engineering in which the output of a system is optimized. The optimization process consists of two components: the optimization of performance and the optimization of cost.

Usually cost and performance optimization within value engineering involves the reduction of product quality and thus the reduction of cost. But this should not to be the case. Cost optimization should reduce cost by eliminating wasteful practices. This can be done by several ways, which are discussed bellow.

- **Material substitutions.** Some materials that are used in a product can sometimes be substituted by less expensive ones. For example if a product has a life cycle expectancy of 10 years and it consists of materials with life expectancy of 15 or 20 years then these can be substituted since keeping them is a wasteful practice.
- **Process efficiency.** Sometimes manufacturing or production processes can be redesigned so that they are more efficient and therefore more cost effective. Process engineering can help a lot in this case.
- **Modularity.** Modules that are designed once and are used in many different products can reduce cost a great deal. By using the same modules in different products or applications reduces development costs, production costs and product complexity.
- **Energy efficiency.** A product can be designed to be energy efficient. This adds value to the product and although it does not necessarily reduces production costs may increase profits by increased sales. This is applied to heating and air-conditioning, transportation, and industrial equipment products.

Value engineering usually is performed in four stages:

1. **Information gathering stage.** This stage is really a product function analysis stage where all required product functions are determined.
2. **Alternatives generation stage.** In this stage all possible alternatives in respect to product functionality are identified.
3. **Analysis stage.** A thorough analysis of both the product functions and their alternatives is carried out during this stage.

4. **The decision stage.** Finally in this stage, decisions are made in respect to which functions can be altered and which can be replaced so that cost and performance are optimized.

6.2 Level Assessment

Assessment 6 evaluates the way the selected concept and the resulting product prototype is finally produced, manufactured in large quantities so that it can be launched into a market at the end of Level 7.

The use of CAD/CAM techniques, of industrial design techniques, of reverse engineering and of re-engineering techniques is examined and the whole work in Level 6 is judged so that again a GO, KILL or HOLD decision to be issued for progression into Level 7 of the roadmap.

NPD Stage 7: Product Commercialisation

If a company decides to go ahead with the commercialisation of a new product, it will face the largest costs to date. The company would have already spent much on product idea generation, product idea selection, product development, prototype development and product prototype testing and validation, but the amount of money that commercialisation requires is far more. The company will have to built, rent a large full-scale manufacture facility if it has none or outsource the manufacturing process, it will have to spend a bundle on promotion and advertising, it will have to decide upon and rent or contract a large distribution and delivery system, and it will have to take some very difficult and important decisions about the commercialisation process in general.

7.1 Tools & Solutions

Due to the nature of the NPD-NET Roadmap matters concerning manufacturing related issues are dealt in >Level 6< (1123). So in this Level the solution to the commercialising problem are related to all the marketing aspects of product distribution, product pricing and product promotion. These aspects include product advertising, product publicity and public relations, product pricing methodologies and product personal selling and selling promotion.

7.1.1 Marketing Plan

Marketing planning is a very complex and cross - functional process. It contains all the marketing activities and tasks that should reflect the company's strategies. Ideally all levels of an organization should understand such strategies so that each level can carry out its part. Since markets today are highly competitive, marketing strategies and marketing planning must have a big understanding of customer needs and market behaviour. Successful companies are those that have acute awareness of such issues and form their strategies accordingly.

The market plan is a document that focuses on bringing such strategies into life. It can be considered as a roadmap for performing marketing activities and tasks such as sales, advertising, promotion, and others having the successful product launch always in mind. Forming a market plan is a step-by-step process, which includes the following.

1. Understanding the strategy of one's company and taking steps for the establishment of links between company strategy and marketing planning.
2. Analyzing the environment within the company does business. This includes the market, the industry, the competitors and other issues.
3. Understanding the market segmentation so that the right customers can be targeted. These customers are the ones whose needs a new product will satisfy.
4. Knowing how and where to position the product so that its key features and values are shown to the target audience.
5. Forming the "marketing mix" which consists of a combination of activities which are used to bring the product into a market and sustaining it into this market for as long as possible. These activities include:

- Deciding which products meet the needs of the pre - identified target customers.

- Pricing those products so that their competitive value price is recognized by the market targets.
- Defining promotional programs to reach those target customers. Such programs include advertising and communications programs.
- Creating channels of distribution so that the new product or products are at the right time close to the target customers.

6. Determining the person or team that will bring the product into the market. That includes the sales team.
7. Launching product line extensions if this is considered necessary.
8. Training the sales team to competitive position the product.
9. Budgeting the marketing program so that all goals and strategies are satisfied.
10. Describing operational difficulties an dependencies of other organizations.

7.1.2 The Elevator Speech

The Elevator speech is a tool that can be used in Level 7 just prior to product launch into the market. The tool helps the developing team to focus on how the product will be sold and what the selling message will be. The aim of the tool is to drive the team's attention towards the target market, critical product characteristics and important product features that differentiate it from the other competitive products.

The tool's name is derived form an imaginary scenario in which one finds him in an elevator where he has to describe the product in 30 seconds (time to get from ground floor to the top floor). The Elevator Speech should be produced by a large team that includes sales, marketing, production and design personnel, so that contribution and support is ensured.

The tool approach or methodology is very simple. The team tries to focus upon and answer to the following key questions or statements in a small amount of time.

- For... (Identification of target customer).
- Who... (Statement of product need or opportunity).
- The... (Product name) is a... (Product category).
- That... (Key feature, compelling reason to buy).
- Unlike... (Main competitive product).
- Our product... (Statement of primary differentiation).

Source: Better Product Design, Institute of Manufacturing, University of Cambridge, On-line http://www.betterproductdesign.net/tools/definition/elevator.htm

7.1.3 Product on a Page - Advert

As with The Elevator Speech, The Product on a Page is another tool that helps the product developing team to think about how the product will be sold and what the selling message will be. Unlike with the Elevator Speech, the use of the tool drivers the team's attention, only toward the important product features and its main differences from the competitive products.

Usually a product specification sheet is a detailed and lengthy document. A single page advert that is well structured can give more or less the same information as the product specification sheet. The team by creating such an advert can focus easily on the crucial product characteristics and visualize the product proposition from a customer's point of view. For such an advert to be created the whole developing team must be included. In some cases it is useful to have a customer present. Also such an advert can be a draft of the advertising or promotion campaign during product launch.

The methodology of creating such an advert is very easy to grasp and to follow. It consists of six simple steps.

Step 1: Who is the adverts target and where it should be placed? (Statement or description of the profile of the target customers or users. At this point it is decided whether one type of advert is sufficient to cover all potential customer segments).

Step 2: Purpose of advert? (Statement of the reason behind the advert. In this step it is decided how the advert will raise customer interest. For example will the advert compare the product against competitive ones or will the advert try to change purchase customer behaviour?).

Step 3: Issues to address? (At this step all key product features are identified and noted. Sometimes a bullet system is used. Also customer needs are noted).

Step 4: Catch phrase? (At this point the team must come with a phrase that catches the full selling product message and product mission).

Step 5: Images? (The team must decide what kind of product or other images will be used. Typical examples include the product in use, the potential customers, the place of use or some abstract image that carries a certain message).

Step 6: Product brochure or handbook development. (In step 6 as all elements of the advert are in place, the team can build a brochure or handbook outline that can be used in conjunction with the advert during the advertising or promotion campaign).

Source: Better Product Design, Institute of Manufacturing, University of Cambridge, On-line http://www.betterproductdesign.net/tools/definition/pop-advert.htm

7.1.4 Distribution Channels

7.1.4.1 Distribution Definition and Considerations

The definition of a distribution channel was first given by Buclin in his book "Theory of Distribution Channel Structure" (1966). He wrote "Channel of distribution comprises a set of institutions which perform all of the activities utilized to move a product and its title from production to consumption". But in reality a distribution channel is not as simple as it is presented above. Many factors must be taken into consideration and a lot of things to be decided for a product to be moved from manufacture into the market.

First of all for successful distribution channel set up there are six basic decisions that must be made by the marketing team beforehand. These decisions are related to the questions that are given below.

- Use of direct or indirect channels?
- Use of single or multiple channels?
- What will be the cumulative length of the multiple channels if those are used?
- What types of intermediaries will be used?
- What will be the potential number of intermediaries if those are used?
- Which companies will be used so that to avoid "inter-channel" conflict?

When all the above questions are answered then the marketing team should select the distributor taking into account the following considerations.

- Market segment: the distributor must be familiar with the target consumer and segment.
- Changes during the product life cycle: different channels can be exploited at different points of the product's life cycle.
- Producer - distributor fit: there must be a match concerning policies, strategies and image between the producer and the distributor.
- Qualification assessment: the experience and the track record of all potential distributors must be established and assessed.
- Training and support: the amount of training and support that a distributor will require to have the job done must be taken into account.

7.1.4.2 Distribution Channel Strategy

A distribution channel strategy is influenced by many factors that fall into three main categories: market, producer and product. These factors influence the way a product distribution channel is set up and their consideration is crucial on the decisions that must be made by the marketing team to accomplish a successful product launch. All major factors are analyzed and discussed bellow.

Market factors. An important market factor is "buyer behaviour". This factor describes the way customers prefer to buy a product. For example do customers prefer to buy a product from a retailer, locally, via mail or perhaps from the Internet? Another one is "buyer needs" which describes what customers would like to have in regards to technical product assistance, product installation or product servicing. Both factors contain information that can be easily gathered during the early stages of NPD process by a market research when the product or the product concept is designed. The willingness and cost of channel intermediaries to the product are also a market factors. An intermediary could either charge a high commission that would be unacceptable by the producer or he could decide not to support a specific product if it requires a heavy investment.

Producer factors. Sometimes a producer will not have the resources that are necessary for all the distribution channel activities to be performed. If that is the case the use of agents or outside contractors is the only way that a product can reach a market. Also producers may not have the required customer approaching skills to sell their products. Channel intermediaries that invest heavily in customer relations are the only people that can create a competitive advantage for a given product. Another producer factor is the price and location of product sale. For example in the

case when a producer sells via a retailer it is common that he loses control of the final product price due to retailer discounts, promotional offers.

Product factors. The way that products reach customers depend on what kind of products they are. For example complex equipment such as medical, aerospace or electronic components are sold directly to customers without the intervention of intermediaries, retailers or agents.

Another thing that influences the formation of a distribution channel strategy is distribution intensity. This can be intensive, selective or exclusive. Intensive distribution is focused on the complete saturation of the market by using all available methods to sell a product. Selective distribution on the other hand aims at the use of a limited number of outlets to sell a product. It can work very well when customers are willing to "shop-around". Finally exclusive distribution is an extreme form of selective distribution in which only one wholesaler, retailer or distributor in a specific geographical area is allowed to sell a particular product.

Source: Tutor2u Ltd, "Distribution Channel Strategy", On-line http://www.tutor2u.net/business/marketing/distribution_channel_strategy.asp

7.1.4.3 Types of Distribution Channels

There are many types of distribution channels. The most important ones are wholesalers, agents, retailers, the Internet and overseas distributors and direct sales. A description of each is given bellow.

Wholesalers. These usually buy products from producers in large quantities and sell these to retailers. They take ownership or title of goods. Most of the times they provide storage facilities and sometimes take some of the product marketing responsibilities. The wholesaler provides minimum contact between the producer and the customer.

Agents. They are used mostly in international markets. They will typically secure orders for products and take commissions from the producer. Agents usually do not tie capital to goods but sometimes they can stockpile products in cases when products need to get into a market as soon as they are produced. They are very expensive to train and keeping them under control is a difficult task due to the distances involved. Also they are difficult to be motivated due to the nature of their payment.

Retailers. Retailers have a strong relationship with the customers. They will hold a lot of different products and brands in stock and they will usually offer credit or discounts to the customers. All products are promoted and merchandised by them. Also the retailers will have the final say on price.

The Internet. E-commerce is a distribution channel that is growing steadily in the past years. The Internet offers a large dispersed market to producers. Set up costs can be low and all the e-commerce technology is easily attainable. Also in recent years there is a shift in commerce and consumption habits that benefits distribution through the Internet.

Direct sales. Direct sales involve the supply of customers directly from the producer's factory. The marketing or sales in-house department looks after all contacts. Usually direct sales involve international sales and require sales personnel or office away from home base.

In some cases one of the above alternatives is sufficient by one's company to bring a new product into a market. But in other cases a combination of some or all of the above alternatives will bring the desired result.

Sources:

- Marketing Teacher, "Place, Distribution, Channel or Intermediary", On-line http://www.marketingteacher.com/Lessons/lesson_place.htm
- ICT USA, "ICT Channels of Distribution", On-line http://www.emich.edu/ict_usa/CHANNELS_OF_DISTRIBUTION.htm

7.1.5 Product Pricing

Pricing is one of the product commercialization components along with promotion and distribution. A well-chosen price for a product should focus on three things: achieve the financial goals of the business i.e. profitability, fit with the reality of the market and support a products positioning that is aligned with the other aspects of product commercialization.

Price can be influenced by the distribution channel, the type of promotion used for the product and the quality of the product. It can be high if manufacturing is expensive, distribution is exclusive and the product is heavily supported by advertising and promotional campaigns. A low product price can balance product characteristics such as low quality and light advertising. From the marketers point of view the best price is the one that it is very close to the maximum customers are willing to pay.

Product pricing can have different characteristics and involve different strategies. Some of the strategies that are used in product pricing are:

- "Premium Pricing" is a pricing strategy that involves pricing of a product at or near its possible range. Consumers will buy Premium Priced products because they believe that are of high quality (a high price is a sign of self worth) and they require best product performance.
- "Demand Pricing" is a pricing method that uses consumer demand as the central element.
- "Promotional Pricing" is a pricing strategy that sets price as the key element of product commercialization i.e. is used in conjunction with advertising and promotion to get the product quickly known.

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7.1.5.1 Product Pricing Objectives

A pricing strategy must be always focused on specific pricing objectives or goals. For someone to set up a pricing strategy must first determine the pricing objectives. To do this one should consider the overall financial, marketing and economic objectives of the company, the objectives of the product, the consumer price elasticity and price points and the resources that are available. Some of the most common pricing objectives are given in the table bellow.

Table 1: Pricing Objectives

Maximize long –run profit
Maximize short-run profit
Increase sales volumes
Increase market share
Achieve the target of Return of Investment (ROI) set
Maintain price leadership
Maintain company growth
Discourage competitive entrances into the market
Match competitor prices
Create interest about the product
Create competitive advantage
Help promote the company
Help obtain and maintain distributor and sales personnel loyalty

7.1.5.2 Pricing Methods

7.1.5.2A Competitor Indexing

Competitor indexing is a pricing method that is used by marketers. It involves the use of the price of competitor products to set one's own product price. This strategy is typically used by companies, which belong to an industry with 2 or more dominant companies. It has the advantage of being easy to use and extensive marketing and statistical analysis are not required. But it has the disadvantage of being purely reactive. Typical pricing decisions based on this method are given bellow.

- Matching of competitor price.
- Setting price 5% above or bellow the competitor one.
- Setting price at a specific amount bellow or above the competitor one.
- Setting price within a range from the competitor one.

7.1.5.2B Cost-plus Pricing

Cost-plus pricing is a pricing method that is often used by companies because it is very easy to calculate product price with little information. There are several varieties of the method and the most common one is the one that uses the following formulae.

$$P = (AVC + FC\%) * (1 + MK\%)$$

Where P = price, AVC = average variable cost, FC% = percentage allocation of fixed costs, MK% = percentage markup. For example if variable costs are €30, the allocation to cover fixed costs is €10, and a 50% markup is needed then one should charge €60 for the product.

To make things even easier and simpler, some retailers ignore fixed costs and just use the price that they have paid to their suppliers as the cost term of the equation. This way they "insert" the fixed cost into the markup percentage. To simplify things even more sometimes a percentage for the markup is not used. Instead a fixed amount is set by the head office to make it easy to retailers and store managers to set price for products.

Cost-plus pricing is easy to calculate, it requires minimum amount of information, it is easy to administer and has the ability to stabilize markets (it is not affected by factors such as demand variations, competitive forces and ethical advantages). In the same time cost-plus pricing ignores the role of the customers, ignores the role of the competitors, uses historical accounting costs rather than real-time ones, uses a standard output level to allocate fixed costs, ignores the opportunity costs and ignores possible incremental costs.

7.1.5.2C Price Skimming

Price skimming is a pricing method in which a marketer set a high price for the product at first and then gradually lowers this price over a period of time. This pricing strategy allows the company to recover production and other product costs quickly before competition steps using the high product price in and then profit and work against the competition by lowering the product price. The strategy is often referred as "riding down the demand curve". This is because marketers try to lower product price following the decrease in consumer demand as time goes by and competition steps into the market.

There are some drawbacks of the strategy that must be considered before embarking into price skimming. Firstly the method encourages the introduction of competitors that see an opportunity and step in very quickly. This often has the result of using the pricing method for defensive purposes and not for goal achieving ones. Secondly negative publicity can result from fast price lowering. This is because some early consumers or customers will feel ripped-off since they would have paid a high price for a product that will have a low price in a short period of time. Thirdly cost may not be recovered and the objective of the price strategy not achieved. And last but not least

lowering the price of a product may have legal implications depending on the laws that apply to a specific market.

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For more information please see: http://en.wikipedia.org/wiki/Wikipedia:Copyrights

7.1.5.2D Target Rate of Return Pricing

Target rate of return pricing is a pricing method used almost only by market leaders or companies that have product monopolies. The idea behind the method is to start-off with a rate of return objective, for example 5% of invested capital or 10% of sales revenue, and then arrange the price structure so that to achieve the target rates of return. The idea and the pricing method are best illustrated using the simple example that is given bellow.

- A company invests €100 million to produce and market designer woman's shoes.
- They estimate that the European demand is such that they can sell 2 million shoes per year.
- From preliminary production cost evaluation they know that each pair of shoes will cost €50. So the annual production cost will be €100 million.
- Management decides that a 20% return of investment is needed. So the return of investment must be €20 million.
- So the price for a pair of woman's designer shoes must be set to €60.

A typical but often unseen consequence of this pricing method is the fact that price should be altered often to match consumer demand. Since a fixed rate of return of investment is used in the price calculations, as demand falls, price must be increased to keep the desired rate. As demand falls the profit margin can be decreased to keep the price steady but this will decrease the profit objectives set by the company. This is the reason why this pricing method is used only by market leaders and product monopolists. Only they are in the position to change rates of ROI or profit margins without much effect for their businesses.

Source: This article is licensed under the GNU Free Documentation License, On-line http://www.gnu.org/copyleft/fdl.html. It uses material from http://en.wikipedia.org/wiki/Rate_of_return_pricing.
For more information please see: http://en.wikipedia.org/wiki/Wikipedia:Copyrights

7.1.6 Product Promotion

Product promotion involves the disseminating of information about the product. It consists of four subcategories: advertising, personal selling, sales promotion and publicity and public relations. These four subcategories create the promotional mix or the promotional plan of a product. The promotional plan has to do with how much attention one must pay to each of the four promotional subcategories and includes a set of objectives, which are given bellow.

- Sales increase.
- New product acceptance.

- Creation of brand.
- Product positioning.
- Competitive retaliations if required.
- Creation of a company image.

7.1.6.1 Advertising

In the early years of mankind and until printing was discovered advertising only existed in the form of word-of-mouth. As printing was developed in the 15th and 16th century the first steps towards modern advertising were taken. In the 17th century advertisements started to appear in weekly newspapers in England and a century later advertising had become a popular and common thing. As the economy grew and mankind entered the industrial age in the 19th century advertising grew as well. The first advertising agency was created in 1843 in Philadelphia by Volney Palmer and this agency and the ones that followed were just brokers for space in newspapers. Only in the 20th century advertising agencies started to take over the responsibility of the advertisement content as well.

From the early 20th century until now the purpose of advertising was to stimulate the consumer demand for a product, service or idea. The way this is achieved is by creating a brand franchise for a product. A brand franchise is created by the ability of the product to draw buyers. This ability is established in small or large degree depending on the product and the market. There are many advertising methods and techniques available which are presented and discussed in a separate section.

7.1.6.1A Advertising Channels

Brochures or flyers. Nowadays one of the most common methods of advertising is the use of brochures or flyers. Brochures can contain a great deal of information if they are well designed and written. Production of brochures can be done either in-house by using some kind of desk - top publishing or word processor software or they can be outsourced using an advertising agency. In the case of in-house production a attractive tri-fold brochure can be made by using a 8.5-inch by 11-inch sheet folded in thirds.

Direct mail. Direct mail can be used if one needs to convey product information directly to his customers. Direct mail can be customized so that the material sent is focused on customer specific needs and wants. Addresses can be collected either from customers by asking them to fill out information cards when they purchase a product or by collecting customer addresses from checks or invoices. A direct mail list must be kept updated. An easy way for someone to do this is to notice all returning mail.

Email messages. Emails can be a very easy way of informing people about your business. For this to be done a signature line can be inserted to every outgoing mail. One should note that this is much

appreciated and noted by the recipients. One should be careful about inserting advertisements into outgoing mails since nowadays this can be perceived as Spam.

Magazines. Magazines advertisements can be very expensive but they can get your message out in a very powerful way. One should be careful to choose magazines that address issue in specific industries that interest you and your customers. A short article about one's business can be an alternative to an advertisement and can provide more information to potential customers. One way of keeping the cost at a low level is to contact a magazine reporter and arrange for a short interview. Most of the times reporters are looking for new stories or sources and do not charge for their services.

Newsletters. Newsletters can be an inexpensive way of advertising one's business or products. Unlike emails customers usually sign up for these when visiting a business website. The best way to go about introducing newsletters is to hire a consultant for the initial design and layout and then use the in-house Webmaster for web insertion or Internet set-up.

Newspapers (major or neighbourhood). One can get his/hers business known to the public using the newspapers by placing ads, writing a letter to the editor or working with a reporter to get a story written about the business. Advertising can get very expensive especially in the case of the major (large circulation) newspapers. Newspapers can sometimes provide advice about what and how to advertise. For small or medium size companies the best way of reaching the public is local or neighbourhood newspapers that are closest to the target customer interests.

Posters and bulletin boards. Posters can be a very powerful way of advertising when placed in places that the public can notice them easily. The best places to post advertisements are places that customers frequently use such as buses, the metro, by the road etc. One should make sure that advertisements in posters or bulletin boards contain vivid colors so that a customer's eye is easily attracted to.

Radio announcements or advertisements. One of the main advantages of radio ads is that they are cheaper than the television ones and reach almost the same audience in respect to size. Timing is very important factor concerning radio ads. These should be placed at times when customers can listen to the radio such as in the morning or afternoon rush hour when they go or return from work.

Television advertisements. Most companies do not consider television ads at all due to their high cost. But nowadays, new television networks or station emerge at a very fast rate and competition can sometimes drop prices. So a company can place a television ad at a relative cheap rate. One should note that television ads are priced depending on their length, the time of showing and the number of ads per month or week or day.

Web pages. Nowadays advertising in the World Wide Web is commonplace for most businesses. Using the web for advertising requires some expertise, equipment and some kind of software so that ads can be designed, written and placed under a domain name. Also maintenance is required so that the advertisements are kept up to date in respect to new products and services. In the case that web advertisements are linked to some kind of ?-commerce then things can be complicated in terms of extensive functions and graphics and so a consultant or a web designer may be required.

7.1.6.1B Ways to get Free Advertising

Promotion and advertising can be a heavy expense for a business that either it is new and wants to be known in a market or has a new product that is going to be launched into a market. In the case of a small or tight budget, such as the budgets of typical small or medium size businesses, there are some low cost advertising techniques that can be used. A number of such methods are described bellow.

- **Giveaways.** People always like to receive free items and especially items that can be used to increase their knowledge or improve their way of living. One can build an entire advertising and promotion campaign based on this customer desire. For example a furniture business can give away free planning guides or free repair instruction manuals. Both items can be very attractive to customers or the public in general and giving them away can produce positive comments about the business. Also giving away such specific items can have the result of the business being perceived as an expert in the field of furniture planning or repairing.
- **News Creation.** Publicity about one's business in the newspapers (local or national) can be a very easy thing for someone to accomplish without the cost of having an advertisement inserted in the newspaper. The recruiting of a new associate, the selling of an unusual product, a free advice column concerning the sector that the business is in, the announcement of receiving an award or a grant, can be news that a newspaper will be interested in and that would attract the attention to many potential customers.
- **Events.** One can easily attract the attention of media or a crowd by staging a promotional event. For instance a business that manufactures children's food can arrange a lunch with a "Easter Bunny" during the Easter holidays.
- **Charities.** In the case of launching a new product and when the business is targeting a specific market segment it would be a great idea to offer the product to a charity as a raffle price at a fund raising event. Not only the product will be known but also the business.
- **Contests.** As with the case of charities one can use contests to promote his / hers product. The business must choose a contest that is relevant to the products that is manufacturing or selling. For example an eating contest will be a great promotion activity for a food manufacturing business.
- **Couponing.** This method can be applied after the launch of a new product. Giving away discount coupons can increase both the sales and the company publicity. Coupons can be handed out through magazines, newspapers, store counters, door-to-door mail, or hand by hand at locations where big crowds are gathering such as shopping malls, athletic events, social events etc.
- **Badges and Novelties.** One can easily and inexpensive produce badges, bumper stickers, book covers and other novelties that bear the company name or a smart slogan that is related to one's business. These can be distributed free by the same methods that are described above in the case of coupons.
- **Parties.** Everyone enjoy and attend parties. These can be held at the company's premises and celebrate the anniversary of the company or some special holiday. This is great way of getting publicity not only about one's company and its products but also its facilities and employees.

7.1.6.1C Product Placement

Product or brand placement is a form of advertising in which a product or a brand name is inserted intentionally in motion pictures and television programs. The product or the brand name can be mentioned in the dialogues, can appear in the set, can be used by a character or can be seen in vehicles or billboards. The product or the brand name can also appear in commercials inserted in the motion film. These commercials usually are made for use in the specific motion picture. This kind of advertising is also known as stealth advertising.

Brand placement usually begins with the studio representatives contacting brand marketers or their advertising agencies and informing them of the film's potential for product placement. If the marketers or the advertising agencies are interested then the film's scripts are sent to them for review and for placement strategy formation. If everything goes well some negotiations take place regarding cost, availability, merchandising opportunities and promotion of the product, brand name or film.

Brand or product placement offers marketers some great advantages over other kind of advertising methods. The greatest of all is cost efficient communication. Over the life cycle of a film, a film will be shown in theatres for a period of time, then maybe on television and then released on DVD or VHS. As time goes by the cost of advertising per viewer or viewing decreases. So product or brand placement maybe thought expensive at start but is very cheap in the long run. Also another great advantage is that the product advertising through placement lacks competition since it is run in an environment that is clean from other advertisements of competitive products.

Sometimes marketers require guarantees of audience attendance and always prefer lengthy theatrical viewings. This is due to the fact that in the dark environment of a theatre the advertising through product or brand placement has the maximum effect on viewers.

Brand or product placement is commonly directed to large corporations or companies since they are usually the ones with the money available to embark in such an advertising adventure. Nowadays the method is also used in the case of video games and music videos.

7.1.6.2 Personal Selling

Sales, or the activity of selling, forms an integral part of commercial activity. The primary function of sales is to find and close leads, turning prospective customers into actual ones. Forms of selling include:

Direct Sales - involving face-to-face contact
1. Retail or consumer
2. Door-to-door or travelling
3. Business-to-business

Indirect - human-mediated but with direct contact
1. Telephone or telesales
2. Mail-order

Electronic
1. Web B2B, B2C
2. EDI

Agency-based
1. Consignment
2. Multi-level.
3. Sales agents (real estate, manufacturing)

7.1.6.3 Publicity & Public relations

Public relations (PR) is the practice of conveying messages to the public through the media on behalf of a client, with the intention of changing the public's actions by influencing their opinions. PR practitioners usually target only certain segments of the public ("audiences"), since similar opinions tend to be shared by a group of people rather than an entire society. Communication is more regarded as an instrument and the "media" as one of the possible channels. The rather simplistic view in the first sentences doesn't explain internal relationship management and communication activities carried out by public relations practitioners. Nor does it explain community relations and activities.

Many people criticize the PR industry for its influence on the public, and for its sometimes unethical actions in pursuing a preferred message over the facts. However, to say that of all PR practitioners would be inaccurate. Most do not work for the large, multinational agencies, but are rather in-house employees of organizations, like companies, nonprofit organizations, and federal and local governments. Most are concerned with gaining any publicity for their clients or employers in the first place rather than "spinning" a controversial issue over a prolonged period. The "spinning" that the industry's critics complain of generally occurs in the service of large corporations and prominent issue advocates rather than the rank-and-file of the PR industry, though the amount of "spin" that can be bought with either financial or political capital does have a strong influence on public discourse

Publicity is closely related to public relations. Whereas public relations is the management of all communications between the firm and the general public, publicity is the management of product or brand related communications between the firm and the general public. It is primarily an informative activity (as opposed to a persuasive one), but its ultimate goal is to promote the companies products, services, or brands. A publicity plan is a planned program aimed at obtaining favourable press coverage for a companies products.

The most basic tool of the publicist is the press release, but other techniques include telephone press conferences, in-studio media tours, multi-component video news releases (VNR's), newswire stories, and internet releases. For these releases to be used by the media, they must be of interest to the public (or at least to the market segment that the media outlet is targeted to). The releases are often customized to match the media vehicle that they are being sent to. Getting noticed by the press is all about saying the right thing at the right time. A publicist is continuously asking what

about you or your company will pique the reader's curiosity and make a good story? The most successful publicity releases are related to topics of current interest. These are referred to as news pegs. An example is if three people die of water poisoning, an alert publicist would release stories about the technology embodied in a water purification product.

But the publicist cannot wait around for the news to present opportunities. They must also try to create their own news. Examples of this include:

- Contests
- Walkathons
- Art exhibitions
- Event sponsorship
- Arrange a speech or talk
- Make an analysis or prediction
- Conduct a poll or survey
- Issue a report
- Take a stand on a controversial subject
- Arrange for a testimonial
- Announce an appointment
- Celebrate an anniversary
- Invent then present an award
- Stage a debate
- Organize a tour of your business or projects
- Issue a commendation

The advantages of publicity are low cost, and credibility (particularly if the publicity is aired in between news stories like on evening TV news casts). The disadvantages are lack of control over how your releases will be used, and frustration over the low percentage of releases that are taken up by the media.

7.1.6.4 Sales Promotion

Sales promotions are non-personal promotional efforts that are designed to have an immediate impact on sales. Sales promotion is media and non-media marketing communications employed for a pre-determined, limited time to increase consumer demand, stimulate market demand or improve product availability. Examples include:

- Coupons
- Discounts and sales contests
- Point of purchase displays
- Rebates

Sales promotions can be directed at either the customer, sales staff, or distribution channel members (such as retailers). Sales promotions targeted at the consumer are called consumer sales promotions. Sales promotions targeted at retailers and wholesalers are called trade sales promotions. Some sale promotions, particularly ones with unusual methods, are considered gimmicks by many.

7.1.6.4A Consumer Promotion Techniques

The most known and used techniques of consumer sales promotional techniques are given bellow. These are mostly used in large retailer establishments such as super markets and shopping malls.

NAME	DESCRIPTION
Price deal	A temporary reduction in the price. For example "happy hour".
Cents-off deal	Offers a brand at a lower price. Price reduction may be percentage marked on the package.
Price-pack deal	The packaging offers a certain percentage more of the product for the same price.
Coupons	Coupons that offer reduced price on a product or even a free product are common practice today.
Free standing insert	A coupon booklet that is offered inside newspapers or magazines containing price reductions on selected products.
Rebates	Consumers are offered money back if the receipt or the bar codes of a product are mailed back to the manufacturing or promotion company.
Contests / Games	The consumer is automatically inserted into a game or a contest with a high value price by purchasing a specific product.

7.1.6.4B Trade Promotion Techniques

The most known and used techniques of trade sales promotional techniques are given bellow.

NAME	DESCRIPTION
Trade allowances	A short-term incentive offered to make a retailer to stock up on a product.
Dealer loader	An incentive offered to make a retailer to purchase and display a product.
Trade contest	A contest to reward retailers that sell the most of a specific product.
Point of purchase displays	Extra sales tools given to retailers to boost sales.

Training programs	Dealer employees are trained in selling a specific product.
Push money	An extra commission paid to the retailer employees to push a specific product.

7.2 Level Assessment

Assessment 7, which is the last assessment before the product is launched into a market, evaluates the marketing aspects of product launch. Although the assessment is not obligatory since the product is already by now produced and market insertion is one way or the other imminent, it is advisable to be considered so that the product is as much successful as possible and maximum returns of investment and profits are achieved. Also the detail of the assessment questioning is low since the assessment is only for advisory purposes and serves the role of a checklist.

8. General Purpose Tools

8.1 Benchmarking Tool, Urenio Research Unit

Benchmarking is the process in which a company's practices, technology, production process, and its actual products are evaluated comparative with other companies of the same filed of activities.

In the case of this NPD roadmap a tool can be used to evaluate the entire above characteristics comparative to European best organizations in the same field. The performance of a company is evaluated through financial data, administration and management, strategy, R&D, manufacturing, engineering, products and marketing, quality and customer satisfaction and warehousing and distribution.

Benchmarking as a tool can be used either at the beginning or at the end of the NPD process. It can reveal strengths and weaknesses of the company when used at the beginning of the process and evaluate the result of the process when used at its end.

URENIO Research Unit offers benchmarking in this form online at http://www.urenio.org/benchmark/index.asp.

8.2 Business Process Reengineering

Business Process Reengineering or Redesign (BPR) is a method of finding the optimum processes or tasks that result in cost cutting, efficiency and productivity optimization and better work - business performing. Companies on the brink of disaster to cut costs and return to profitability often use it. Also it can be used to optimize resources in complex projects so that efficiency is optimized.

BPR must be accompanied by strategic planning, must be "owned" throughout the organization, must include the IT section of a business, must be sponsored by top executives, must have projects with strict timetables of the range of six months and must not ignore corporate culture and emphasize constant communication and feedback.

It can be applied to literally all sections or departments of a business: from human resources to research and development, from marketing to sales and from production to quality control.

8.2.1 Business Process Reengineering Methodology

There is a 5-step general methodology for BPR. This is described bellow.

- **Development of business vision and process objectives:** BPR is driven by a business vision, which implies specific business objectives such as cost reduction, time reduction and output quality improvement.

- **Identification of the processes to be redesigned:** Most businesses or firms try to identify these processes that have the most impact on the business vision. Other firms try to identify all the processes within the organization and then prioritize them in order of redesign urgency.
- **Understanding and measurement of the existing processes:** All processes must be fully understood and measured so that mistakes are not repeated during redesign and a baseline for redesign is provided.
- **Identification of IT Levers:** IT capabilities that influence or that may have an impact on the processes redesign must be identified.
- **Designing and building a prototype of the new process:** A process should not be altered immediately but a prototype of the new process should be designed and build so that the new process can be accessed before implementation. This allows the quick delivery of results without mishaps and bugs.

8.2.2 References

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8.3 Collaborative product development

A very few firms or businesses nowadays have the resources to undertake a complex new product development project. Usually they tend to concentrate on core technologies required for product development and rely on outside sources for complementary skills and resources. Also as markets become more and more competitive, downsizing has led a lot of companies in outsourcing to get the skills needed for product development. The following figure shows typical NPD operations and the way collaboration with outside sources can be achieved.

A typical co-operation NPD project must go through a number of stages to be successful. Usually the stages that are used are: Preparation, Formation, Management, Evolution and Conclusion. Each stage activities and the problems that may arise are given in the following table.

Table 1. Collaboration Stages, Activities and Problems

STAGE	ACTIVITY	PROBLEMS
Preparation	Product development strategy. Product design.	Not enough information exists on in-house potentials.

	Deciding what to do in-house. Identifying partners. Performing partner selection.	Partner may have a hidden agenda. Partner is not fully accessed.
Formation	Setting ground rules. Agreeing commercial terms. Setting copyright issues. Definition of communication channels.	Overestimating partner's capabilities. Very strict or rigid rules may slow down partners and the entire process. Being too cautious and mistrustful may have the effect of not achieving a win-win solution.
Management	Open and regular communications. Identification of risks. Adequate resources allocation.	Sometimes managers that run the project are not advised in forming it so renegotiations are required. Incompatible metric systems, time zones, file formats and software tools may be a problem. Incompatible business practices and cultural differences may also be a problem.
Evolution	Adapting to new facts and problems quickly.	Process required to be resourced due to partner inability to achieve goal.
Conclusion	Planning for long-term production and support. Learning from any mistakes that have been made.	Support agreements must be in place. Uncertainty over joint assets, materials or inventory.

Very few small and medium size companies have experience in dealing with collaborative projects. The table bellow illustrates the levels of collaborative maturity of companies and the problems that exist in each level for each NPD activity.

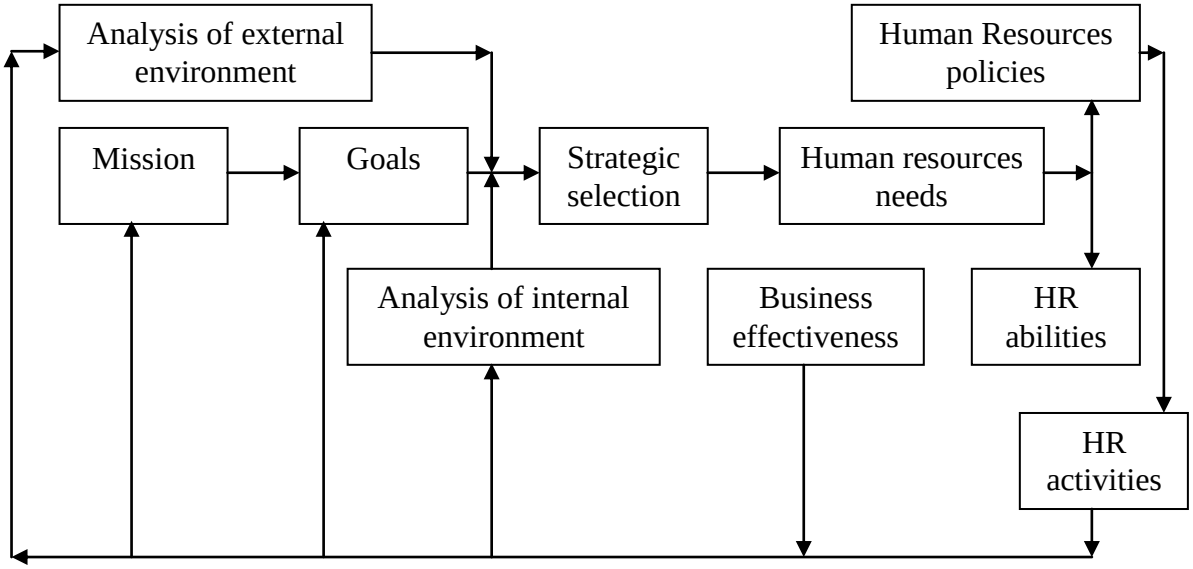
8.4 Human Resources Management

In the last decade the human factor and the human resources in general are taking center stage in the operations of a business or a company. Globalization and the development of new products demand personnel with new skills and expertise and force companies to adopt flexible methods of managing this personnel. Especially in R&D environments where there are fast technological changes and the need for innovation is continuous, Human Resources Management (HRM) is thought to be a valuable and flexible tool.

Effective HRM requires good knowledge of the external and internal environment it is operated i.e. the R&D department and the market as a whole and a good understanding of the strategic orientation of the company (in this case the product concept to be developed). HRM has two

distinctive and separate phases: the strategic planning and the strategy implementation. The effect of these on the formation of HRM strategies is shown at the figure bellow.

Fig 1. Formation of Human Resources Strategies



Source: Xirotiri - Koufidou S.

HRM Strategies

By interpreting the external and internal environment of a company and with good knowledge of company goals and mission, Human Resources Management strategies or tasks can be developed and used to recruit new personnel, to evaluate, motivate and train existing personnel and explore new management practices and strategies.

The simplest HRM task is recruitment of new personnel. A typical recruitment process has specific steps as the ones shown in the table bellow.

Table 1: Recruitment Process

1. Job definition as a result of HRM strategy	
2. Evaluation and selection of recruitment sources	
2.1 External recruitment sources	2.2 Internal recruitment sources
Job announcements in the press	Formal job announcement
Personal recommendations	Informal job announcement
Universities and educational institutions	
Data banks	
Institutes of professionals	
3. Preparation and job vacancy announcement	
4. Candidate selection	
5. Hiring	

Source: Xirotiri - Koufidou S.

Another HRM task is the evaluation, motivation and training of existing or new personnel. Evaluation of personnel can be done by several ways. Job analysis, successful task or goal achievement measurement and productivity measurement are some of these ways. Evaluation can also be done using qualitative, quantitative or absolute standards methods, which require a more in depth analysis and sometimes, personal interviews. Evaluation results can show how motivated as well as how well trained an employee is. Also they can show the level of employee commitment and the need if any for personal achievements award granting.

Finally HRM strategy formation can help explore new ways of operating a business or company depending on the market situation. Such ways of operations can be downsizing, re-engineering and Total Quality Management (TQM). Downsizing is the planed reduction of personnel to compact negative economic and market trends. HRM is the only management tool that can successful conduct such a process, since downsizing also means the re-arrangement of human resources so that the company stays competitive and flexible with reduced personnel. Re-engineering requires the redesign of the company's processes and operations. Again HRM can help, since such a redesign means the reposition of personnel and their retraining according to their new positions and tasks. Total quality management is the nothing but an effort to provide better and more quality products to customers. The business of producing quality products sometimes requires the re-organization of departments and processes. HRM can help in this case as well, since departments and processes are nothing without the people that works in them.

8.5 Market Research Tools

<table>
<tr><td colspan="5">Business Objective
(What is to be decided, what is to be learned)</td></tr>
<tr><td colspan="5">Research Objective
(What do you want to know from the research)</td></tr>
<tr><td>What information is needed?
(Key measures? Relationships?)</td><td>Whom would you like to talk to?</td><td>Capable?</td><td>Willing?</td><td>Accurate?</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="5">Data Collection Plan
(Who will collect the data? Focus groups or one-to-one interviews? Sampling methods? Procedures? Experience, cost and timing of data collectors?)</td></tr>
<tr><td colspan="5">Analysis Plan
(What methods are going to be used to quantify the importance of customer needs?)</td></tr>
</table>

Questionnaires: In the Appendix we include some questionnaires for Market Research

8.6 Product Outsourcing

Developing a new product concept to a reliable and feasible new product can require resources and time commitment that a company cannot spare. It may also require engineering tools and expertise that may not be available or too expensive to acquire. To overcome these problems and many more that could surface during new product development many companies turn to Product or Process Outsourcing.

Outsourcing is really the situation when a company or business gives a task to someone else that can do it more effectively. In the case of product development, outsourcing means the hiring or external contractors to develop a product concept into a product. It allows the company to take risks, reduce operating costs, free-up resources, improve its market focus, and be flexible to sudden market changes. Although outsourcing can be used in most of the major business functions of a company, such as payroll, market research and logistics, its use can be vary successful in R&D processes due to the very complexity of such processes.

Outsourcing must be careful designed, the outsourcer - company relationship must be very well managed and the outsourcing results must be thoroughly benchmarked. Also the outsourcing process must be assessed beforehand so that one would not embark in a process that it is not useful.

Table 1: Outsourcing Assessment and Possible Results.

Outsourcing Assessment	Assessment Results
Identification of outsourcing costs	Pint point unexpected costs that are not explicitly in the scope of outsourcing such as personnel related costs, costs of additional resources and costs due to confidential information leaks that can lead in legal liabilities or competitive disadvantage.
Determination of Service Levels Agreements (SLA's)	Determine what is needed and expected though each stage of the outsourcing process and set levels of commitment of the outsourcer.
Flexibility check	Determine outsourcer flexibility and remove inflexible work practices.
Investigation of the form of penalties	Pre-set standards that an outsourcer must uphold and penalties that may imposed to the outsourcer in the case of no compliance of those standards.

Source: Australian Quennsland Government

Managing the outsourcing process is a task difficult by itself. The essence of outsourcing is to transfer the company's focus from managing resources and processes to managing results. So outsourcing management centers on the management of the outsourcer performance. Careful contracting, well-defined result benchmarking and quick resolution of disputes can do just this. Also the creation of a scoreboard of the behaviour of the outsourcer and of the end result may appear extremely helpful. Such a scoreboard is shown bellow.

Table 2: Possible Outsourcing Scoreboard

Criteria Evaluated	Sub Criteria	Possible Metrics
Experience	Specialized Knowledge	
	Technology know-how	
Communication	Presentations	Number / Month
	Frequent updates	Number / Month
Contract uphold	On-time delivery	% Above time set
	Budget keep	% Above budget set
	Contract terms uphold	No of penalties imposed
Efficiency	Completion on schedule	
	Quality end result	
	Goal achievement	

Source: Avlonitis G.

Most companies decide to outsource the development of a product concept or the development of a part of the product concept, feeling very confident that this action will save them money and time. The main mistake a company is bound to make is the impression that outsourcing is a good deal just because the outsourcer's product developing cost is lower than the company's. This can many times lead to poor quality products and subsequently dissatisfaction and grief. So benchmarking is required to provide a baseline of costs and service levels. Also benchmarking can be used for contract refinement and contract negotiations.

What to do and what don't for successful outsourcing

Five do's of successful outsourcing

- One must outsource the "bottlenecks", the things that are really keeping the company from growing profitably.
- One must pick great partners, check them out and speak to their customers.
- Once outsourcing is done, the outsourcer must be regarded as part of the company and treated as such.
- One must demand excellence, since outsourcing is what the outsourcer does for a living.
- Outsourcing might scare employees. One must communicate honestly with them.

Six mistakes in outsourcing

- Not really defining the desired results and they could be measured.
- Not talking to the outsourcer current and past clients.
- Failing to consider long-term relationship dynamics.
- Not planning up-front on how the company-outsourcer relationship will end.
- Treating the outsourcer as an outsider.

Four inhibitors to outsourcing

- Fear of loss of control.
- Work viewed as too strategic.
- Company's unique culture.
- Measuring the value.

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8.7 Portfolio Management

Portfolio management has to do with how a person or a company invests his product development resources, how project are prioritized and how resources are allocated across development projects. Portfolio management treats R&D investments much like a manager treats his investments in a stock market.

There are four goals in portfolio management: maximizing the value of the portfolio, looking for the right balance of projects, making sure that all the projects are aligned and making sure that one does not have too many projects for his given resources. There are a number of tools that can help someone to choose the right portfolio. These can be quantitative, graphical and strategic. Each of the portfolio goals is analyzed bellow.

Goal 1: Maximizing the value of ones portfolio. The goal in this case is to select a new product project so that to maximize the sum of commercial worth of all active projects in terms of some strategic objective. Tools that can be used in this case are:

- Net Present Value (NPV). One could calculate the net present value of each project and then rank all by the outcome of NPV divided to a constrained predetermined value. For example a predetermined value could be remaining - unspent R&D costs. Projects can be ranked according to this index until out of resources. This way the value of the portfolio is maximized for a given limited resource expenditure.
- Expected Commercial Value (ECV). This method uses decision tree analysis i.e. breaking the project into decision stages for example R&D, prototyping, testing, commercialization. All possible outcomes of the project combined with the probability of each of them occurring are defined. The resulting ECV is divided by a pre determined constrained resource as in the case of NPV and projects are ranked according to the resulting index.

- Scoring Model. During this method decision makers rate projects according to a number of questions. Depending on the answers given projects are ranked in a 1 to 5 or 0 to 10 scale. Addition of these rating makes up the quantified Project Attractiveness Score, which incorporates strategic, financial and other considerations. The projects are ranked according to the PAS until resources run out.

Goal 2: Balancing ones portfolio. In this case the goal is to balance all projects according to a set of parameters. These parameters can be time, risk factors, product types, different markets, project types etc. The techniques used to achieve this goal are mainly graphical. The most used ones include bubble diagrams and pie charts.

Goal 3: Portfolio Alignment. Portfolio alignment means that all the projects should be on target in terms of the strategy and all spending should reflect ones strategic priorities. Several tools have been designed to align ones portfolio. Such tools are the "Top-down Strategic Buckets", "Top-down Product Roadmaps" and the "Bottom-up".

Goal 4: Picking the Right Number of Projects. Many companies have too many projects running at the same time and limited resources. The result is that projects end up in a queue and products make too much time to reach a market. So an over-riding goal is required so that a balance is maintained between projects and resources available. This can be done in several ways, some of which are given bellow.

* Resource limits. Using the tools that are mentioned in the case of the 1st goal one can build a resource limitation and projects can be ranked until the company is out of resources. The same occurs if the Bubble Diagrams are used.

- Resource Capacity Analysis. In this case one should calculate the resource demand, prioritize projects from best to worst, and add up the resources required by the R&D department for all projects. Using then some kind of software toll such as MS Project the available resources per project per month can be determined. The outcome of this exercise is the identification of the projects or departmental groups that are hold back due to the lack of resources.

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8.8 Supply Chain Management

Supply chain management is a powerful tool that brings together all activities of a company that bring a product into a market. It contains activities from different departments of a company such as manufacturing, purchasing and transportation, and links external partners of a company such as vendors, carriers, distributors and information providers to the company. In the case of product development process related activities in general; supply chain management can be an even more powerful tool. Using it correctly the development process can be completed smoothly as key departmental and external activities can be integrated and used in parallel and in conjunction to one another.

Supply chain management today focus on inventory management, transportation service procurement, materials handling, inbound / outbound transportation, warehousing management and transportation operations management. All of the above are critical factors in the product development process although sometimes tend to be considered as secondary activities. Future trends in supply chain management include customer service focus and information technology.

The main goal of supply chain management is to help accomplish corporate strategic objectives (one of which is NPD) through reducing working capital, taking assets off the balance sheet, accelerating cash to cash cycles and increasing inventory turns. To make these happen supply chain management uses the following principles.

- Segmentation of customers based on service needs.
- Customization of the supply chain management network.
- Listening to market demand and planning accordingly.
- Differentiation of product close to the customer.
- Strategic management of supply sources.
- Development of a supply chain wide technology strategy.
- Adaptation of channel spanning performance measures.

Supply chain management benefits include:

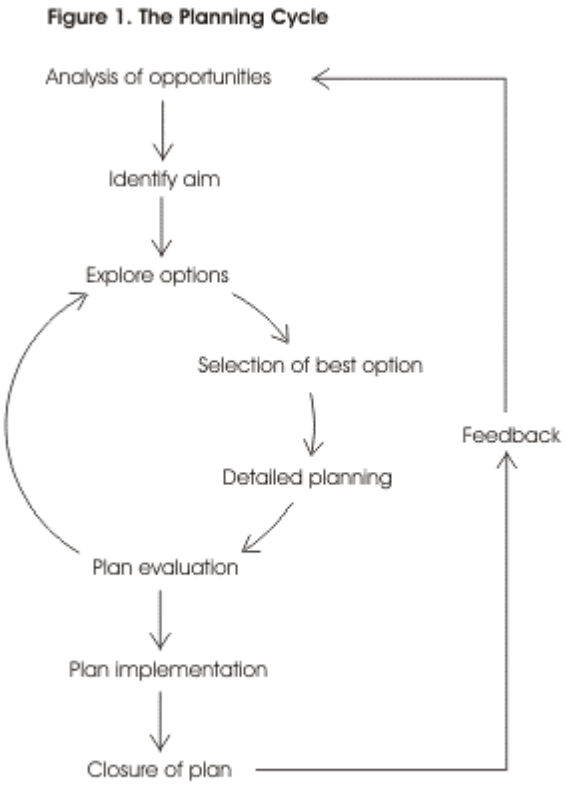
- Profitable growth.
- Working capital reduction.
- Fixed capital efficiency.
- Global tax minimization.
- Cost minimization.

Source: Zigiaris S.

8.9 The Planning Cycle

The Planning Cycle is a tool that can be used to bring all the aspects of a project into a single process. The tool can be used for projects up to a certain level of complexity and this makes it very handy to small or medium size companies that usually undertake simple development projects. For projects that involve a lot of people over a long period of time other methodologies are necessary.

Fig 1. A Typical Planning Cycle



Source: Mind Tools (http://www.mindtools.com)

The first step of the planning cycle is the analysis of opportunities, which can help to have a well reality based plan. The identification of aim follows which helps to focus the plan to a certain goal. The third step is the exploration of all option available to achieve the goal set at the previous step. Then the best approach is selected, a more detailed planning is generated and the final plan is evaluated. Then as all planning is finished and evaluated, the plan is implemented. Finally as the plan reaches its goal all information, conclusions and results are fed back into future planning. Each of these steps are described in more detailed in the section Planning Cycle Steps.

APPENDICES

APPENDIX 1: LEVEL ASSESSMENT FOR NPD STAGE 1: IDEA GENERATION

Assessment 1 evaluates the ideas generated in Level 1 and the both the way and the tools used for idea generation.
According to the answers a user gives to the following questions a GO, HOLD or KILL decision is provided for further progression in the roadmap and specifically to Level 2.

Methods used for idea generation	
Tick all that applies	
a. Conjoint analysis	☐
b. Delphi technique	☐
c. Competitive intelligence analysis	☐
d. Brainstorming (Group or individual)	☐
e. Morphological charts	☐
f. Six thinking hats technique	☐
g. Triz	☐
h. None of the above	☐

Please state method if option (h) is selected in the above question

Ideas generated are	
Tick all that applies	
a. Less than 10	☐
b. Less than 25	☐
c. Less than 50	☐
d. Less than 100	☐
e. None	☐

Ideas generated information (general)
Ideas generated have (rated description)
Ideas generated are possibly (feasibility)
They have
Ideas Documentation

Ideas generated information (specific)		
Their description contains a possible target market	Yes ☐	No ☐
Ideas are based on a competitive product or an existing product	Yes ☐	No ☐
Idea description contain customer needs	Yes ☐	No ☐

The people used in idea generation were	
a. Customers - Consumers	☐
b. Employees - Business partners	☐
c. Competitors	☐

d. None of the above	☐
e. Other from the above	☐
Idea generation method was performed	
a. Internally (Inside the company by for example the marketing dept)	☐
b. Externally (Outsourced using a private firm or organization)	☐

If the process was performed internally, was it supervised by	
Tick all that applies	
a. Upper management	☐
b. Lower management	☐
c. Specialized personnel	☐
d. Single employee	☐
e. Not supervised	☐
If the process was outsourced, who did the idea generation ?	
a. Private firm	☐
b. Non-profit organization	☐
c. Consultancy	☐
Were there any problems encountered during the process ?	
Please state	

This assessment is filled by	
Tick all that applies	
a. Upper management	☐
b. People that conducted the idea generation process	☐
c. Lower management	☐
d. Single individual	☐

Decision - recommendation is	
GO to LEVEL 2	☐
HOLD or Repeat the Level	☐
KILL the process	☐

APPENDIX 2: LEVEL ASSESSMENT FOR NPD STAGE 2: IDEA SCREENING

Assessment 2 evaluates the way the generated ideas of Level 1were screened so that a single idea is produced for further development. As in Assessment 1 a GO, Hold or KILL decision is issued for proceeding to the next level depending on the given answers to the following questions.

Idea screening was done against	
Tick all that applies	
a. Company's marketing strategies	☐
b. Company sales and profitability minimums	☐
c. Key customers and buyers	☐
d. None	☐

Tools that were used for screening were	
Tick all that applies	
a. Dot sticking technique	☐
b. Failure mode and effects analysis	☐
c. PMI analysis	☐
d. Qualitative research	☐
e. SWOT analysis	☐
f. Roadmap provided screening tool	☐
g. None	☐

Please give a YES or NO answer to the following questions		
Was there an idea selected for further development?	Yes ☐	No ☐
According to the SWOT analysis are the strengths more than the others?	Yes ☐	No ☐
If qualitative research was used, were there any specific focus groups in the research?	Yes ☐	No ☐
If PMI analysis was used, was the number of pluses more than the minuses?	Yes ☐	No ☐
Was the FMEA worksheet used in the FMEA analysis?	Yes ☐	No ☐

Decision - recommendation is	
GO to LEVEL 3	☐
HOLD or Repeat the Level	☐
KILL the process	☐

APPENDIX 3: LEVEL ASSESSMENT FOR NPD STAGE 3: CONCEPT DEVELOPMENT

Assessment 3 evaluates the way the selected product idea of Level 3 was turned into a product concept so that a new product is produced for further development and how this concept was evaluated. As in Assessment 2 a GO, Hold or KILL decision is issued for proceeding to the next level depending on the given answers to the following questions.

Tools that were used for concept development	
Tick all that applies	
a. Controlled convergence technique	☐
b. Force field analysis	☐
c. New technology commercialization technique	☐
d. QuickTime workshop technique	☐
e. Relevancy concepting technique	☐
f. Risk management and analysis	☐
g. None	☐

Tools that were used for concept evaluation	
Tick all that applies	
a. Communications check technique	☐
b. Decision tree analysis	
c. Kano model technique	
d. Quality functional deployment	
e. Quantitative technique	
f. Weighting and rating technique	
e. None	

Please give a YES or NO answer to the following questions		
Was there a product concept developed based on the idea?	Yes ☐	No ☐
Has the concept consumer appeal?	Yes ☐	No ☐
Has the concept competitive advantage? (Based on the competitive intelligence analysis of Level 1)	Yes ☐	No ☐
Is there a clear and viable market position for the product?	Yes ☐	No ☐
Is the concept development technical feasible?	Yes ☐	No ☐
Does the concept has international appeal?	Yes ☐	No ☐

Is the market big enough for enough sales and hence profits?	Yes ☐	No ☐
Are there any known killer variables that might crop up during development?	Yes ☐	No ☐
Does the concept fit into the strategic planning of the company?	Yes ☐	No ☐
Is the concept complex and hence its development?	Yes ☐	No ☐
Does the concept offer value for money to a potential customer?	Yes ☐	No ☐

Decision - recommendation is	
GO to LEVEL 4	☐
HOLD or Repeat the Level	☐
KILL the process	☐

APPENDIX 4: LEVEL ASSESSMENT FOR NPD STAGE 4: BUSINESS ANALYSIS

Assessment 4 evaluates the way or ways of financing the development of the selected concept into a new product and the way the whole project is scheduled in respect to time limitations and how the required resources are located, used or reallocated to fit the project needs. As in Assessment 3 a GO, Hold or KILL decision is issued for proceeding to the next level depending on the given answers to the following questions.

Tools that were used for project management	
Tick all that applies	
a. Cost benefit analysis	☐
b. Gannt charts	☐
c. Critical path analysis & PERT	☐
d. Stakeholder analysis	☐
e. None	☐

Project financing	
Tick all that applies	
a. Were there adequate funds available for the development?	☐
b. Was the funding external?	☐
c. Was there any use of the BIC (Business and Innovation Centers)?	☐
d. Was there any use of the EIC (Euro Info Centers)?	☐
e. If CBA was used were the benefits more than the costs?	☐

Project scheduling and life cycle issues		
Was there a product life cycle evaluation performed that included development times as well?	Yes ☐	No ☐
According to Gantt charts (if any), were all the tasks scheduled?	Yes ☐	No ☐
According to the critical path analysis (if any) were the tasks times evaluated?	Yes ☐	No ☐
If critical path analysis was used were any potential delays identified so that resources can be easily relocated?	Yes ☐	No ☐

Project support issues		
If a stakeholder analysis was performed, will the project have the necessary support?	Yes ☐	No ☐
If the necessary support is lacking, did the analysis reveal ways of motivating such support?	Yes ☐	No ☐

	Decision - recommendation is	
	GO to LEVEL 5	☐
	HOLD or Repeat the Level	☐
	KILL the process	☐

APPENDIX 5: LEVEL ASSESSMENT FOR NPD STAGE 5: PRODUCT TESTING

Assessment 5 evaluates the way a product prototype is build and how that prototype is tested in respect to its functionality and market requirements as set in previous levels of the NPD Roadmap. Also ways of testing the development process are looked into and the results of such tests are evaluated. Once again at the end of the assessment a Go, Kill or Hold recommendation is given to proceed into Level 6 of the Roadmap.

Product prototyping construction		
Was there a product prototype build?	Yes ☐	No ☐
Were there rapid prototyping methods used?	Yes ☐	No ☐
Did the prototype undergo extensive testing?	Yes ☐	No ☐
Was the prototype developed adequate according to		
a. Customer expressed needs	Yes ☐	No ☐
b. Company strategic planning	Yes ☐	No ☐
c. CBA analysis	Yes ☐	No ☐
d. Competitive analysis	Yes ☐	No ☐
e. Product concept specifications	Yes ☐	No ☐

Specific prototype tests that were carried out	
Tick all that applies	
a. Alpha tests	☐
b. Beta tests	☐
c. Functionality tests	☐
d. Usability tests	☐
e. End-to-end tests	☐
f. System tests	☐

g. Customer tests		☐
h. Market tests		☐
Product development tests		
a. At this time were there any other tests carried out such as product development tests?	Yes ☐	No ☐
b. Were there any product development tests scheduled to be carried out in the future during the next Levels of development?	Yes ☐	No ☐

Product development tests carried out or to be carried out	
Tick all that applies	
a. Assessment tests	☐
b. Validation tests	☐
c. Comparison tests	☐
d. Exploratory tests	☐
e. ISO 9000 tests	☐
f. None of the above	☐

Decision - recommendation is	
GO to LEVEL 6	☐
HOLD or Repeat the Level	☐
KILL the process	☐

APPENDIX 6: LEVEL ASSESSMENT FOR NPD STAGE 6: TECHNICAL IMPLEMENTATION

Assessment 6 evaluates the way the selected concept and the resulting product prototype is finally produced, manufactured in large quantities so that it can be launched into a market at the end of Level 7. The use of CAD/CAM techniques, of industrial design techniques, of reverse engineering and of re-engineering techniques is examined and the whole work in Level 6 is judged so that again a GO, KILL or HOLD decision to be issued for progression into Level 7 of the roadmap.

Production - manufacturing		
Was there any of the following tools used?		
a. CAD/CAM	☐	
b. Industrial design	☐	
c. Reverse engineering	☐	
d. Re-engineering	☐	
e. Lean manufacturing	☐	
f. Design for X	☐	
g. None of the above	☐	
Was value engineering used?	Yes ☐	No ☐
Were BOM files used in the manufacturing process?	Yes ☐	No ☐
Was there an assembly line used for mass production?	Yes ☐	No ☐
Were there any producibility techniques used to cut manufacturing costs and increase product reliability?	Yes ☐	No ☐
Was quality assurance used for the management of materials and production processes?	Yes ☐	No ☐
Were data from rapid prototyping used for rapid manufacturing and rapid tooling to cut production costs?	Yes ☐	No ☐

	Were there any other techniques or methods used to make the manufacturing process easier and more reliable?	Yes ☐	No ☐

	Decision - recommendation is	
	GO to LEVEL 7	☐
	HOLD or Repeat the Level	☐
	KILL the process	☐

APPENDIX 7: LEVEL ASSESSMENT FOR NPD STAGE 7: COMMERCIALISATION

Assessment 7, which is the last assessment before the product is launched into a market, evaluates the marketing aspects of product launch. Although the assessment is not obligatory since the product is already by now produced and market insertion is one way or the other imminent, it is advisable to be considered so that the product is as much successful as possible and maximum returns of investment and profits are achieved. Also the detail of the assessment questioning is low since the assessment is only for advisory purposes and serves the role of a checklist.

Issues considered	
Tick all that applies	
a. Distribution	☐
b. Pricing	☐
c. Promotion	☐
Distribution issues	
Was there a distribution strategy developed?	Yes ☐ No ☐
Were the distribution channels selected and agreed upon?	Yes ☐ No ☐
Pricing issues	
Was there a pricing strategy developed?	Yes ☐ No ☐
Tick the pricing methods that were used	
a. Competitor indexing	☐
b. Cost plus pricing	☐
c. Price skimming	☐
d. Target rate of return pricing	☐

e. None of the above	☐

Promotion issues	
Tick all the promotion activities that were carried out	
a. Advertising	☐
b. Personal selling	☐
c. Publicity and public relations	☐
d. Sales promotion	☐
e. None of the above	☐
f. Other	☐

Decision - recommendation is	
LAUNCH THE PRODUCT	☐
HOLD or Repeat the Level	☐

APPENDIX 8: Questionnaires for Market Research

Questionnaire 1: Consumer Satisfaction (How satisfied are customers from a Generic Product)

Q1. When did you last buy Generic Product?
In the past month □
2-3 months ago □
4-6 months ago □
7-12 months ago □
1-2 years ago □
More than 2 years ago □

Q2. Whereabouts do you buy Generic Product?
Outlet 1 □
Outlet 2 □
Outlet 3 □
Outlet 4 □
Outlet 5 □
Outlet 6 □
Other (PLEASE WRITE IN)_____ □

Q3. How satisfied are you overall with Primary Brand of the Generic Product?
Very satisfied □
Quite satisfied □
Neither satisfied nor dissatisfied □
Quite dissatisfied □
Very dissatisfied □

Q4. How satisfied are you with the Value for Money of Primary Brand?
Very satisfied □
Quite satisfied □
Neither satisfied nor dissatisfied □
Quite dissatisfied □
Very dissatisfied □

Q5. How satisfied are you with the Service and Delivery of Primary Brand?
Very satisfied □
Quite satisfied □
Neither satisfied nor dissatisfied □
Quite dissatisfied □
Very dissatisfied □

Q6. How satisfied are you with the After-Sales Support of Primary Brand?
Very satisfied □
Quite satisfied □
Neither satisfied nor dissatisfied □
Quite dissatisfied □

Very dissatisfied □

Q7. How satisfied are you with the Design and Durability of Primary Brand?
Very satisfied □
Quite satisfied □
Neither satisfied nor dissatisfied □
Quite dissatisfied □
Very dissatisfied □

Q8. How satisfied are you with the Quality of Primary Brand?
Very satisfied □
Quite satisfied □
Neither satisfied nor dissatisfied □
Quite dissatisfied □
Very dissatisfied □

Q9. How satisfied are you with the Ease of use of Primary Brand?
Very satisfied □
Quite satisfied □
Neither satisfied nor dissatisfied □
Quite dissatisfied □
Very dissatisfied □

Q10. How would you rate Primary Brand compared to Competitive Brand overall?
Primary Brand is a lot better □
Primary Brand is a little better □
They are about the same □
Competitive Brand is a little better □
Competitive Brand is a lot better □

Q11. How would you rate Primary Brand compared to Competitive Brand on Value for money?
Primary Brand is a lot better □
Primary Brand is a little better □
They are about the same □
Competitive Brand is a little better □
Competitive Brand is a lot better □

Q12. How would you rate Primary Brand compared to Competitive Brand on Service and Delivery?
Primary Brand is a lot better □
Primary Brand is a little better □
They are about the same □
Competitive Brand is a little better □
Competitive Brand is a lot better □

Q13. How would you rate Primary Brand compared to Competitive Brand on After sales support?
Primary Brand is a lot better □
Primary Brand is a little better □
They are about the same □

Competitive Brand is a little better □
Competitive Brand is a lot better □

Q14. How would you rate Primary Brand compared to Competitive Brand on Design and Durability?
Primary Brand is a lot better □
Primary Brand is a little better □
They are about the same □
Competitive Brand is a little better □
Competitive Brand is a lot better □

Q15. How would you rate Primary Brand compared to Competitive Brand on Quality?
Primary Brand is a lot better □
Primary Brand is a little better □
They are about the same □
Competitive Brand is a little better □
Competitive Brand is a lot better □

Q16. How would you rate Primary Brand compared to Competitive Brand on Ease of use?
Primary Brand is a lot better □
Primary Brand is a little better □
They are about the same □
Competitive Brand is a little better □
Competitive Brand is a lot better □

We would like to know a little more about you to help us understand how different people like different products and services

Q17. Are you...?
Male □
Female □

Q18. How old are you?
15-19 □
20-24 □
25-34 □
35-44 □
45-54 □
55-64 □
65+ □

Q19. Which of these best describes your job?
Managerial □
Professional □
Clerical □
Skilled Trades □
Manual worker □
Student □
Retired □

Unemployed □
Home maker □
Other PLEASE WRITE IN _____ □

Q20. Which of these best describes you
Married/Living with partner □
Single/Widowed/Divorced □

Q21. Which of these best describes your home?
Owned □
Privately rented □
Share parent/relative's home □

Questionnaire 2: Usage and Attributes (Understand how a Generic Product is used and how)

Q1 When did you last buy Generic Product?
In the past month □
2-3 months ago □
4-6 months ago □
7-12 months ago □
1-2 years ago □
More than 2 years ago □

Q2 Which is your favourite Generic Product?
Primary Brand of Generic Product □
Competitive Product 1 □
Competitive Product 2 □
Competitive Product 3 □
Competitive Product 4 □
Competitive Product 5 □
Competitive Product 6 □
Other (PLEASE WRITE IN)_____ □

Q3 Whereabouts do you buy Generic Product?
Outlet 1 □
Outlet 2 □
Outlet 3 □
Outlet 4 □
Outlet 5 □
Outlet 6 □
Other (PLEASE WRITE IN)_____ □

Q4 Why is that?
_____
_____

Q5 How do you find out information about Generic Product?
TV □
Radio □
General newspapers or magazines □
Specialist magazines □
Direct mail □
Leaflets □
In my local outlet □
From friends or colleagues □
From sales reps □
From special exhibitions or seminars □
Other (PLEASE WRITE IN)_____ □
None of these □

Q6 How would you rate the Primary Brand of Generic Product compared to Competitive Product 1 overall?

Primary Brand of Generic Product is a lot better □
Primary Brand of Generic Product is a little better □
They are about the same □
Competitive Product 1 is a little better □
Competitive Product 1 is a lot better □

Q7 How would you rate the Primary Brand of Generic Product compared to Competitive Product 1 on Quality?
Primary Brand of Generic Product is a lot better □
Primary Brand of Generic Product is a little better □
They are about the same □
Competitive Product 1 is a little better □
Competitive Product 1 is a lot better □

Q8 How would you rate the Primary Brand of Generic Product compared to Competitive Product 1 on Ease of Use?
Primary Brand of Generic Product is a lot better □
Primary Brand of Generic Product is a little better □
They are about the same □
Competitive Product 1 is a little better □
Competitive Product 1 is a lot better □

Q9 How would you rate the Primary Brand of Generic Product compared to Competitive Product 1 on Value for Money?
Primary Brand of Generic Product is a lot better □
Primary Brand of Generic Product is a little better □
They are about the same □
Competitive Product 1 is a little better □
Competitive Product 1 is a lot better □

Q10 How would you rate the Primary Brand of Generic Product compared to Competitive Product 1 on After-Sales Support?
Primary Brand of Generic Product is a lot better □
Primary Brand of Generic Product is a little better □
They are about the same □
Competitive Product 1 is a little better □
Competitive Product 1 is a lot better □

Q11 How would you rate the Primary Brand of Generic Product compared to Competitive Product 1 on Service and/or Delivery?
Primary Brand of Generic Product is a lot better □
Primary Brand of Generic Product is a little better □
They are about the same □
Competitive Product 1 is a little better □
Competitive Product 1 is a lot better □

Q12 How would you rate the Primary Brand of Generic Product compared to Competitive Product 1 on Design and/or Durability?
Primary Brand of Generic Product is a lot better □

Primary Brand of Generic Product is a little better □
They are about the same □
Competitive Product 1 is a little better □
Competitive Product 1 is a lot better □

Here are a number of statements that people have made. For each one please say how much you agree or disagree with the statement.

Q13 I like to have a routine that I stick to
Agree strongly□
Agree a little □
Neither Agree nor Disagree □
Disagree a little □
Disagree a lot □

Q14 I tend to spend most evenings at home
Agree strongly□
Agree a little □
Neither Agree nor Disagree □
Disagree a little □
Disagree a lot □

Q15 I like to keep up with new technology
Agree strongly□
Agree a little □
Neither Agree nor Disagree □
Disagree a little □
Disagree a lot □

Q16 My friends would describe me as someone who likes talking
Agree strongly□
Agree a little □
Neither Agree nor Disagree □
Disagree a little □
Disagree a lot □

Q17 I often find myself helping in organising clubs or community groups
Agree strongly□
Agree a little □
Neither Agree nor Disagree □
Disagree a little □
Disagree a lot □

Q18 It's important to me to keep up appearances and to look good
Agree strongly□
Agree a little □
Neither Agree nor Disagree □
Disagree a little □
Disagree a lot □

We would like to know a little more about you to help us understand how different people like different products and services

Q19 Which of these television services do you have?
Digital Television □
Satellite/Cable Television □
Don't have digital or satellite, but have a TV □
Don't have a TV □

Q20 Do you have access to the Internet at home or at work?
Yes - at home □
Yes-at work □
Yes-both □
No □

Q21 Which of the following, if any, have you bought on the Internet?
Computer software □
Computer hardware □
Books □
Music □
Travel/Holidays □
Food/Groceries □
Household appliances □
Financial services □
Other products □
Haven't shopped via Internet □

Q22 Are you...?
Male □
Female □

Q23 How old are you?
15-19 □
20-24 □
25-34 □
35-44 □
45-54 □
55-64 □
65+ □

Q24 Which of these best describes your job?
Managerial □
Professional □
Clerical □
Skilled Trades □
Manual worker □
Student □
Retired □

Unemployed □
Other PLEASE WRITE IN _____ □

Q25 Which of these best describes you
Married/Living with partner □
Single/Widowed/Divorced □

Q26 Which of these best describes your home?
Owned □
Privately rented □

Questionnaire 3: Segmentation (Understand how customers are segmented)

Q1 Which is your favourite Generic Product?
Primary Brand of Generic Product □
Brand 1 □
Brand 2 □
Brand 3 □
Brand 4 □
Brand 5 □
Brand 6 □
Other (PLEASE WRITE IN)_____ □

Q2 Whereabouts do you buy Generic Product?
Outlet 1 □
Outlet 2 □
Outlet 3 □
Outlet 4 □
Outlet 5 □
Outlet 6 □
Other (PLEASE WRITE IN)_____ □

Q3 Why is that?
_____
_____

Q4 How do you find out information about Generic Product?
TV □
Radio □
General newspapers or magazines □
Specialist magazines □
Direct mail □
Leaflets □
In my local outlet □
From friends or colleagues □
From sales reps □
From special exhibitions or seminars □
Other (PLEASE WRITE IN)_____ □
None of these □

Here are a number of statements that people have made. For each one please say how much you agree or disagree with the statement.

Q5 I like to have a routine that I stick to
Agree strongly □
Agree a little □
Neither Agree nor Disagree □
Disagree a little □
Disagree a lot □

Q6 I tend to spend most evenings at home
Agree strongly □
Agree a little □
Neither Agree nor Disagree □
Disagree a little □
Disagree a lot □

Q7 I like to keep up with new technology
Agree strongly □
Agree a little □
Neither Agree nor Disagree □
Disagree a little □
Disagree a lot □

Q8 My friends would describe me as someone who likes talking
Agree strongly □
Agree a little □
Neither Agree nor Disagree □
Disagree a little □
Disagree a lot □

Q9 I often find myself helping in organising clubs or community groups
Agree strongly □
Agree a little □
Neither Agree nor Disagree □
Disagree a little □
Disagree a lot □

Q10 It's important to me to keep up appearances and to look good
Agree strongly □
Agree a little □
Neither Agree nor Disagree □
Disagree a little □
Disagree a lot □

We would like to know a little more about you to help us understand how different people like different products and services

Q11 How frequently do you read a paid-for local newspaper?
Daily □
Once or twice a week □
Once or twice month □
Less than once a month □
Don't read paid-for local newspapers □

Q12 How often do you listen to your local commercial radio station?
More than 2 hours a day □
About an hour a day □
A few times a week □

Less than a few times a week □
Don't listen to local commercial radio □

Q13 Do you have access to the Internet at home or at work?
Yes - at home □
Yes-at work □
Yes-both □
No □

Q14 Which of the following, if any, have you bought on the Internet?
Computer software □
Computer hardware □
Books □
Music □
Travel/Holidays □
Food/Groceries □
Household appliances □
Financial services □
Other products □
Haven't shopped via Internet □

Q15 Are you...?
Male □
Female □

Q16 How old are you?
15-19 □
20-24 □
25-34 □
35-44 □
45-54 □
55-64 □
65+ □

Q17 Which of these best describes your job?
Managerial □
Professional □
Clerical □
Skilled Trades □
Manual worker □
Student □
Retired □
Unemployed □
Other PLEASE WRITE IN _____ □

Q18 Which of these best describes you
Married/Living with partner □
Single/Widowed/Divorced □

Q19 Which of these best describes your home?

Owned □

Privately rented □

Share parent/relative's home □