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A Company-led Methodology for the Specification of Product Design Capabilities in Small and Medium Sized Electronics Companies

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A Company-led Methodology for the Specification of Product Design Capabilities in Small and Medium Sized Electronics Companies

Volume 2

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AGILITY

A Company–led Methodology for the Specification of Product Design Capabilities in Small and Medium Size Electronics Companies

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The *AGILITY* Methodology

INTRODUCTION

AGILITY is a company-led methodology for achieving design excellence which draws extensively on the lessons of international electronics design best practice. The methodology utilises well proven tools and techniques to guide companies through the entire process of creating a flexible electronics design capability.

It differs markedly from existing consultancy approaches which attempt to "lock" clients into costly and potentially open-ended relationships. Consultants generally do not involve personnel in the client companies in devising solutions, nor do they typically attempt to develop the skills of client staff by passing on their knowledge and expertise. In such circumstances, lack of client ownership of, and hence commitment to, an implemented solution is almost inevitable.

Revitalisation of the design to manufacture operations of any firm, large or small, requires commitment right from the top and it is a key aspect of *AGILITY* that it empowers senior management by insisting that the managers themselves, with appropriate assistance, make the critical decisions affecting the future of their businesses and control the overall improvement process.

The methodology enables managers to identify cost-effective and appropriate design system solutions which can readily be translated into action plans for improvement and, crucially, it ensures that key skills are transferred to company personnel.

What *AGILITY* delivers

AGILITY delivers an agreed corporate mission statement to place the investigation in context, a set of product and design process improvement opportunities, an agreed set of design capability solutions and a prioritised action plan for creating a flexible design capability.

Origins of *AGILITY*

The methodology is the product of 6 man-years of development and is based on a detailed investigation into the design methods used in a number of leading electronics firms in the U.K., Europe, the United States, Japan and Korea.

Detailed examination of the electronics product design process demonstrated that there was a pattern for success - a process which could be followed by any company - to achieve similar success.

The *AGILITY* methodology has been developed independently of any hardware or software vendor. It's impartiality in this respect ensures that the solutions developed are appropriate to the client company - and not to the vendors and consultants who provide the service.

THE METHODOLOGY

Figure 1 below presents an overview of the methodology, showing each of the steps involved in the methodology's three stages: Strategic Analysis, Design Resource Analysis and Design Capability Solution. It should be noted that feedback occurs throughout the methodology but, for the purposes of clarity on the diagrams, feedback loops have not been described.

How the methodology is applied

AGILITY achieves results by involving company personnel, at all levels, in the improvement process. At all times the company retains ownership and control so that the actions identified are fully supported and can be implemented successfully.

Despite the fact that the road to electronics design excellence has been successfully navigated by many Japanese, U.S. and, indeed, British companies, it is unlikely that all firms will have the necessary skills and capabilities to undertake such a major task.

In such circumstances, a facilitator may be required to provide the necessary guidance and direction. The presence on the Top Team of someone with wide design, manufacturing and consultancy experience will ensure that the improvement process is handled competently and with sensitivity.

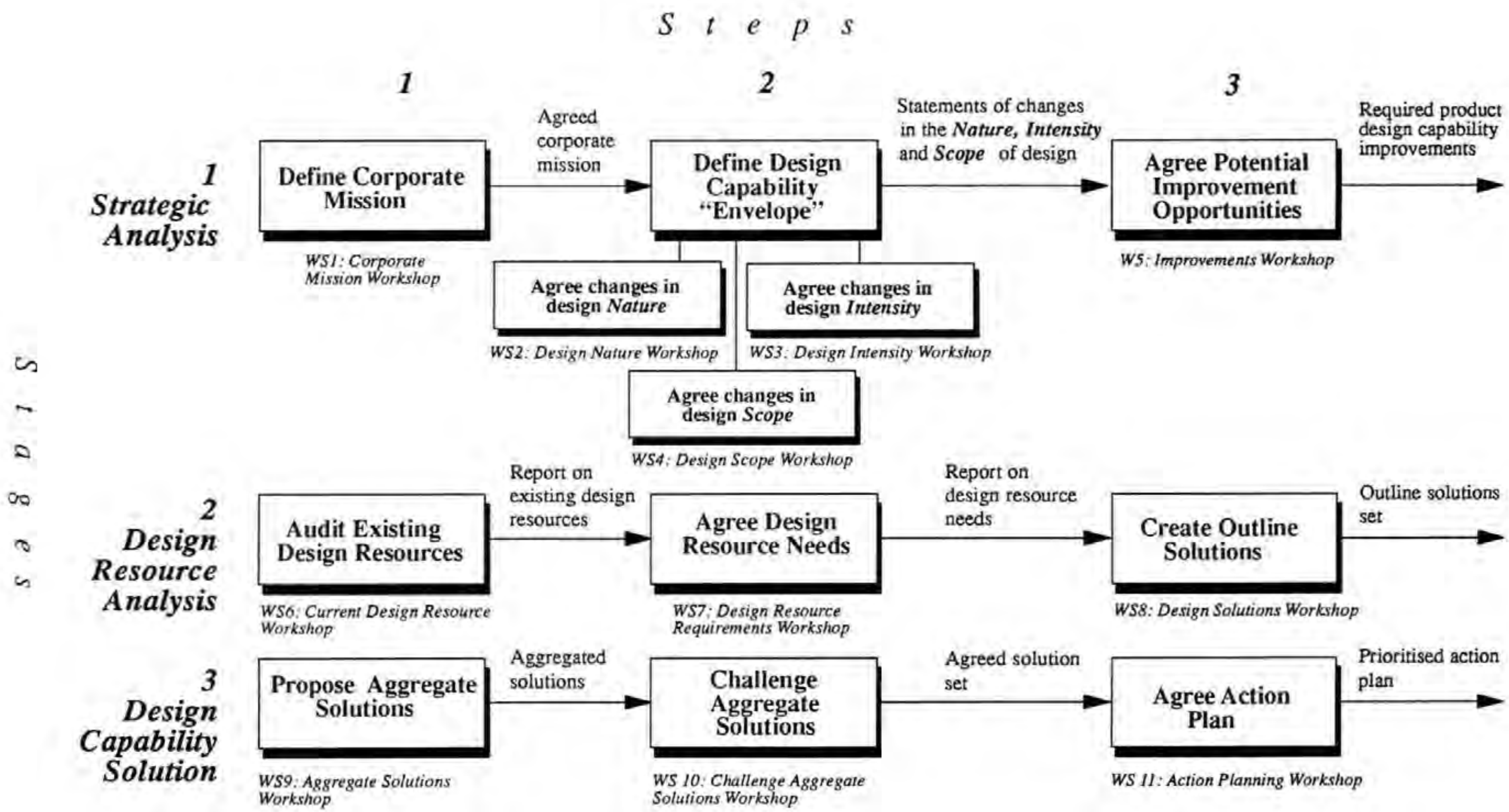
AGILITY Workshops

Workshops are used to generate contributions, to make decisions and agree actions.

Because many of the decisions are not algorithmic the most effective action can only be determined by generating a wide range of contributions from the individuals involved. Involvement is vitally important for another reason - without it there can be no ownership and commitment to the solutions generated.

To facilitate this process workshops are conducted in a non-critical, "egoless" atmosphere in which all present, regardless of status, feel they have a valid contribution to make to corporate revitalisation.

Figure 1: Overview of the *AGILITY* Methodology



In total, there are 11 workshops, each of which is listed below:

- Workshop 1: Corporate Mission Workshop
- Workshop 2: Design *Nature* Workshop
- Workshop 3: Design *Intensity* Workshop
- Workshop 4: Design *Scope* Workshop
- Workshop 5: Improvements Workshop
- Workshop 6: Current Design Resource Workshop
- Workshop 7: Design Resource Requirements Workshop
- Workshop 8: Design Solutions Workshop
- Workshop 9: Aggregate Solutions Workshop
- Workshop 10: Challenge Aggregate Solutions Workshop
- Workshop 11: Action Planning Workshop

Preliminary Activities

The process of specifying design capabilities is made more productive and effective by the assignment of carefully tailored Preliminary Activities (PAs) to be completed by participants prior to each workshop session.

In total, there are 10 Preliminary Activities, each of which is listed below for reference and described in greater detail on Pages 14 - 18 of this workbook.

- PA 1: Statement of company mission
- PA 2: Customer and market evaluation
- PA 3: Model of current design process
- PA 4: Employee evaluation
- PA5: Assessment of current design resources
- PA 6: Resource impact analysis
- PA 7: Prepare design capability solutions
- PA 8: Determine technical precedence
- PA 9: Determine resource requirements
- PA 10: Undertake financial evaluation

AGILITY Toolkits

Toolkits provide detailed instructions to workshop participants on how they should undertake certain activities. The complete set of 10 ***AGILITY*** Toolkits is included at the rear of this workbook. They are each listed below for reference purposes:

- Toolkit 1: Generating a Corporate Mission Statement
- Toolkit 2: Design *Nature* Analysis
- Toolkit 3: Undertaking a Product Portfolio Analysis
- Toolkit 4: Undertaking a Resource Impact Analysis
- Toolkit 5: Identifying Sales Product Families
- Toolkit 6: Using the $IDEF_0$ Process Modelling Tool
- Toolkit 7: Aggregating Design Solutions
- Toolkit 8: Checklist for Effective Management of Product Design
- Toolkit 9: Checklist for Effective Product Design Operations
- Toolkit 10: Checklist for Effective Support for Product Design

Where required, assistance in using the Toolkits is provided by the facilitator who has considerable experience of applying the techniques in a wide variety of environments.

AGILITY Techniques

AGILITY makes various techniques available to participants in order that they are able to carry out their tasks and activities as effectively as possible. There is currently only one technique provided, Structured Brainstorming, which may be found at the rear of this workbook.

The *AGILITY* Process

The process consists of five phases:

PHASE 1	Commitment
PHASE 2	Top Team Building
PHASE 3	Launch
PHASE 4	Application
PHASE 5	Close

PHASE 1 Commitment

If there is any single lesson to be learned from the experience of companies which have achieved superior electronics product design performance it is that clear *leadership* from the top is critical to success.

The first and most important step in introducing improved design practice is to generate corporate awareness of the commercial opportunities which good design can provide and the need for change to capitalise upon those opportunities. Furthermore, change must begin with recognition of the importance and impact of design deficiencies and knowledge of possible routes to improvement.

It is therefore crucial to the successful application of the methodology within the Company that top management is seen to give full backing to the improvement process. Without such support, it is questionable whether the process should be allowed to proceed.

The *AGILITY* methodology gains top team commitment by requiring the Facilitator to give a presentation to the Board of Directors of the company in which the route to product design excellence and the role of the methodology are described. The presentation emphasises the importance of product design to electronics businesses and explains the need for firms to create a resilient design capability.

Following the presentation, the Board may question the Facilitator.

PHASE 2 Top Team Building

The objective of the top team building phase is to agree the start date for the process and to identify the individuals involved from both the client management and facilitation teams. The following major roles and responsibilities are agreed:

- Project Champion

- Project Architect
- Facilitator
- Challenger ("Devil's Advocate")

Project Champion

The process of creating an effective electronics design capability is a complex process which is likely to affect the roles, skills and perceived interests of a variety of business functions and departments. As such, it requires a champion who is sufficiently senior to have influence and vision across functional departments. The most appropriate champion is usually the Managing Director because he or she is most capable of ensuring that the "product" of the programme, in this case an enhanced product design system, is in alignment with with the overall competitive requirements of the firm.

Project Architect

Someone who has more time than the Managing Director must take day–to–day responsibility for the management of the programme. This person, known as the Architect, is responsible for:

- Recording knowledge created during the innovation process so that it can be reused to improve the effectiveness of future projects;
- Coordinating any training and education;
- Building working alliances;
- Integrating the programme with other strategic initiatives.

It is preferable that the Architect should be drawn from outside the design function. However, it is vital that he or she should enjoy the respect, not only of design department managers and engineers, but of function heads throughout the company who may be affected by the changes.

Facilitator

The Facilitator steers discussions and suggests options and approaches. This role could be adopted by the Architect. At least initially, however, it is more likely to be carried out by an external or internal consultant.

The Challenger ("Devil's Advocate")

In the early stages of the programme it is useful if someone (possibly the Architect) takes the role of Devil's Advocate and actively challenges the status quo. Later in the project, one or more line managers should formally take the role of questioning the recommendations and decisions which emerge from the process to ensure that there is adequate discussion and that the recommendations, once implemented, will achieve real business benefits.

The Project Champion, assisted by the Project Architect, selects senior staff from the company to serve on the Top Team.

Usually, the individuals selected will be the most senior managers in the client organisation associated with:

- Marketing and Sales
- Manufacturing, Production, Engineering
- Finance, Accounts, Costing
- Purchasing
- Personnel
- Quality

Where necessary, appropriate representatives of customer and supplier companies should be included on the Top team.

The Project Champion sets the date and time of the **Executive Briefing**, which is immediately followed by **WORKSHOP 1, The Corporate Mission Workshop**, and notifies the participants. Participants are asked to bring their diaries to the meeting which will last approximately three hours. Participants are also advised that they will be required to attend a further 10 half day workshops.

Table 1 identifies the extent to which participants are involved at each stage of the ***AGILITY*** process.

Table 1: Participant Involvement Chart

Staff \ Phases	1 Strategic Analysis	2 Design Resource Analysis	3 Design Capability Solution
Project Champion	Strong involvement	Active involvement as and when required	Strong involvement
Project Architect	Strong involvement	Strong involvement	Strong involvement
Facilitator	Strong involvement	Strong involvement	Strong involvement
Challenger	Strong involvement	Little/no involvement	Strong involvement
Sales & Marketing	Strong involvement	Little/no involvement	Little/no involvement
Manufacturing & Engineering	Strong involvement	Active involvement as and when required	Little/no involvement
Design	Strong involvement	Strong involvement	Strong involvement
Finance	Strong involvement	Little/no involvement	Strong involvement
Purchasing	Strong involvement	Little/no involvement	Strong involvement
Human Resources	Little/no involvement	Little/no involvement	Strong involvement
Customers	Active involvement as and when required	Little/no involvement	Little/no involvement
Suppliers	Active involvement as and when required	Little/no involvement	Little/no involvement

Little/no involvement — Active involvement as and when required — Strong involvement

PHASE 3 Launch

The Executive Briefing

The process of specifying a product design capability is formally launched at a meeting, known as the Executive Briefing, Chaired by the Project Champion. The Project Champion notifies the participants that the Company has adopted the methodology and that they have been invited to serve on the Top Team.

The Programme Director then introduces the Facilitator, explaining his or her role in the process. The Project Champion must, at this stage, stress to top-team participants the importance to the organisation of the process of creating a product design capability and request the Top Team's full support.

The terms of reference of the Top Team are described and the roles of the participants agreed. Having concluded his introductory remarks, the Project Champion invites the Facilitator to describe the process.

The Facilitator describes the process and invites participants to ask questions and seek clarification of any point or issue as it is raised.

The Facilitator will stress that:

- Ownership and control of the process is in the Company's hands;
- The facilitator and the consultancy team are there to provide full support and assistance.

On conclusion of the presentation the dates and times of future workshops will be agreed and roles and responsibilities assigned.

Participants will be asked to note in their diaries the dates of future meetings. Where it is difficult for a participant to attend a meeting due to a prior commitment the Project Champion should, if necessary, request that the commitment be rescheduled if it is likely to seriously delay the process.

At the conclusion of the Launch Stage, participants will be asked to complete the Preliminary Activities described below.

AGILITY PRELIMINARY ACTIVITIES

Important note

Preliminary Activities (PAs) should be completed by those assigned to carry them out (or their staff) prior to each workshop session. The reports arising from concluded PAs should *always* be distributed to members of the Top Team well in advance of the next Workshop. This will provide participants with sufficient time to have read and digested those reports and should reduce the amount of time actually spent in the Workshops themselves.

PA 1 Statement of Company Mission

Prior to attending **WORKSHOP 1: The Corporate Mission Workshop**, Members of the Top Team are invited to complete PA 1 using **Toolkit 1: Generating a Corporate Mission** for guidance. PA1 delivers a brief statement on the Company's mission, the rationale underlying the mission and a description of the Company's short and long term goals.

The results of this work will be discussed by the Top Team at **WORKSHOP 1**, the objective of which is to produce an agreed corporate mission statement.

If the Company is part of a larger group, the **Project Champion** is invited to identify the group's corporate mission statement.

PA 2 Customer and Market Evaluation

Prior to attending **WORKSHOP 2: The Design *Nature* Workshop**, **WORKSHOP 3: The Design *Intensity* Workshop** and **WORKSHOP 4: The Design *Scope* Workshop** the Sales/Marketing Director should undertake an evaluation of the Company's customers and markets in order to provide the Top Team with an up-to-date insight into such issues as:

- Current product performance;
- Current product functionality;
- Quality requirements;
- Future product and process technology directions;
- Market demand.

As part of this exercise, the Sales/Marketing Director should also check with the Purchasing Manager to gather appropriate information regarding:

- Ability of suppliers to contribute to the firm's design process;
- Changes taking place in the firm's supplier network and
- Supplier relationship problems.

During this Preliminary Activity, the Sales/Marketing Director may utilise the Market and Product checklist which is included at the rear of this workbook.

PA 3 Model of Current Design Process

Prior to attending **WORKSHOP 5: The Improvements Workshop**, the Engineering/Design Director should initiate a process modelling exercise which will produce a set of models of the Company's current product design process.

The modelling should be carried out using the $IDEF_0$ technique. **Toolkit 6** provides an overview of $IDEF_0$.

The Engineering/Design Director should circulate the $IDEF_0$ models to all participants prior to the Workshop. The models should be accompanied by a report highlighting areas of waste and inefficiency in the product design process. In particular, the report should draw participants' attention to such issues as:

- Timescales involved in carrying out tasks;
- Complex documentation flows;
- Extensive feedback/checking activities;
- Frequency of design iterations.

PA 4 Employee Evaluation

Prior to attending **WORKSHOP 5: Improvements Workshop**, the Facilitator should carry out **PA 4: the Employee Evaluation** using the questionnaire provided. The Employee Evaluation is intended to provide employees with an opportunity to assesses their company's current product development environment. The questions are grouped into two categories, namely:

- Organisation;
- Product development.

In order to ensure that confidentiality is maintained, the completed questionnaires will be returned to the Facilitator for analysis. The Facilitator will present his analysis of the Employee Evaluation to **WORKSHOP 5** for discussion by the Top Team.

The Employee Survey should be sent to all the Company's employees.

PA 5 Assessment of Current Design Resources

Prior to attending **WORKSHOP 6: Current Design Resource Workshop**, the Engineering/Design Director should carry out **PA 5: the Assessment of Current Design Resources**. The assessment should be conducted along the Manage, Operate and Support dimensions (please refer to Toolkits 8, 9 and 10 for guidance in these areas) outlining the kinds of questions which can be asked around the M/O/S areas and should examine resource issues related to, for example:

- The control of product design and the minimisation of risk;
- Current hardware and software in use throughout the product design process;
- Resources devoted to process design;
- Design infrastructure;
- IT support for inter-personnel communications and for administrative tasks;
- Human resource management;
- Documented design procedures.

The results of the assessment should be presented to **WORKSHOP 6** for discussion by the Top Team.

PA 6 Resource Impact Analysis

Prior to attending **WORKSHOP 7: The Design Resource Requirements Workshop**, the Engineering/Design Director should undertake **PA 6: the Resource Impact Analysis** (please refer to Toolkit 4 for guidance in this area). The results should be analysed by the Engineering/Design Director and presented, in the form of a report on required design resources, to **WORKSHOP 7** for discussion by the Top Team.

PA 7 Prepare Design Capability Solutions

Prior to attending **WORKSHOP 8: The Design Solutions Workshop**, each Top Team participant should take away a copy of the *Report on Design Resource Needs* (Deliverable 7). These reports should be used by each participant to identify those solutions that fall within his or her particular area of responsibility and to prepare outline design capability solutions. Solutions which cannot be placed on a solution track should be listed and considered as solutions requiring discrete actions.

Each participant should present the results of his/her evaluation to **WORKSHOP 8** for discussion by the Top Team.

PA 8 Determine Technical Precedence

Prior to attending **WORKSHOP 11: The Action Planning Workshop**, the Engineering/Design Director should initiate **PA 8: Determine Technical Precedence**. The results will be analysed by the Engineering/Design Director and presented to **WORKSHOP 11** for discussion by the Top Team.

PA 9 Determine Resource Requirements

Prior to attending **WORKSHOP 11: The Action Planning Workshop**, the Engineering/Design Director should initiate **PA 9: Determine Resource Requirements**. The results will be analysed by the Engineering/Design Director and presented to **WORKSHOP 11** for discussion by the Top Team.

PA 10 Undertake Financial Evaluation

Prior to attending **WORKSHOP 11: The Action Planning Workshop**, the Financial Director should initiate **PA 10: Undertake Financial Evaluation**. The results will be analysed by the Financial Director and presented to **WORKSHOP 11** for discussion by the Top Team.

PHASE 4 Application

STAGE 1 STRATEGIC ANALYSIS

The Company must identify opportunities for improving the effectiveness of its electronics design operations and for building upon its existing strengths and competences in product design and development. Such opportunities exist on a number of different dimensions. These include:

- The *products* themselves;
- The overall *management* of the product design process, including structure and accountability;
- The *operational* activities involved in actually designing electronics products, including systems and processes;
- The infrastructural or *support* activities necessary to ensure effective utilisation of both human and technological resources, including people and culture.

At the product level, Strategic Analysis is particularly concerned with establishing the extent of change facing firms in three major electronics design dimensions:

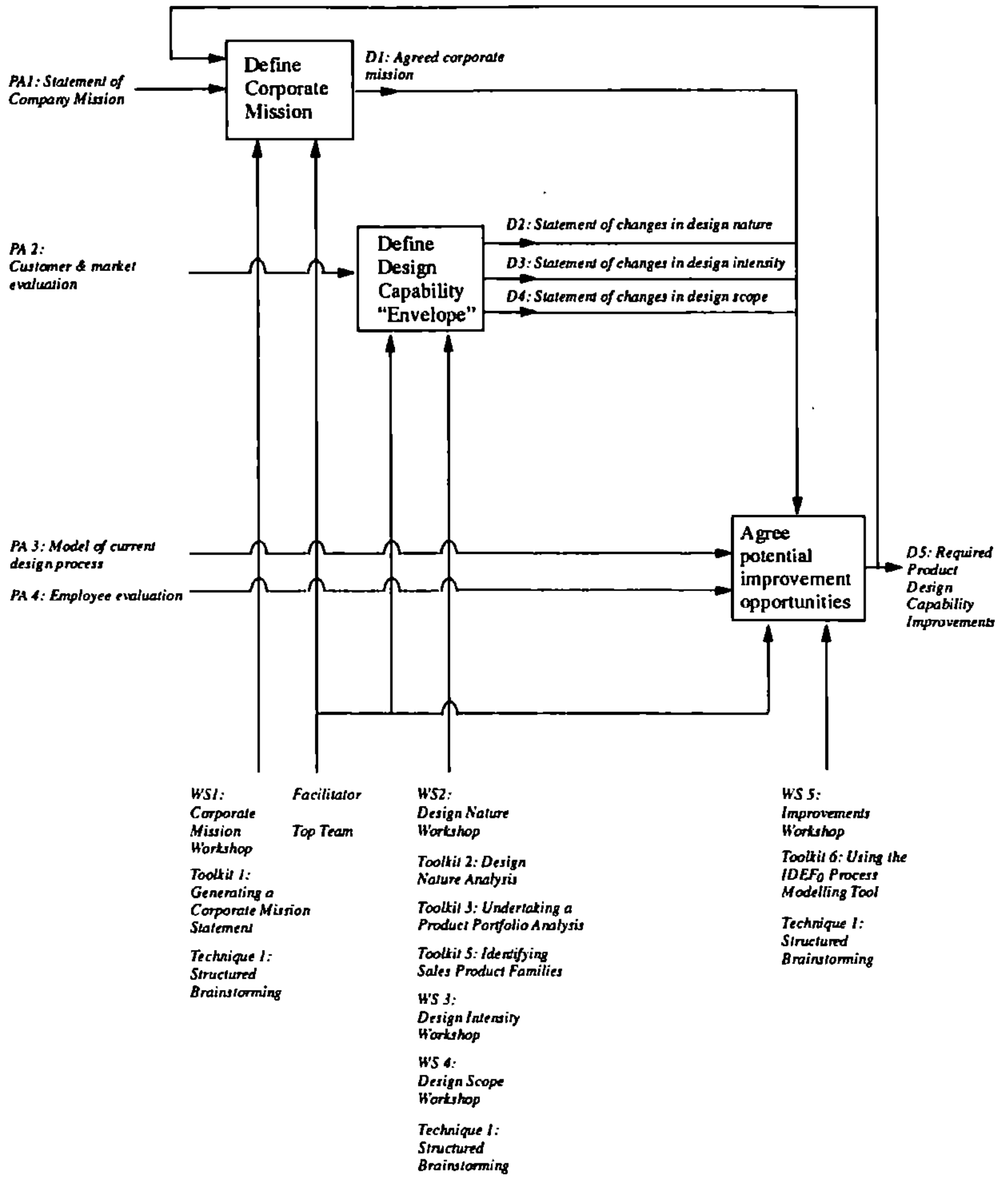
- The *nature* of the designs being undertaken – changes in the kinds of design projects the firm is likely to undertake, from complete product re-design through to small-scale incremental improvement;
- Design *scope* – a firm's ability to design products which satisfy their customers' lifestyles and aspirations, which are environmentally sound and which are manufacturable and testable;
- Design *intensity* – changes in the amount of designing the firm will need to undertake in order to remain competitive.

Strategic Analysis also requires the Company to audit its own product design and development environment in order to gain a clear picture of its strengths and weaknesses in this area. Achieving these objectives requires a willingness on the part of senior management to examine the way they organise, the way they see their customers and the way they educate, train, motivate and organise their people.

One important strategic factor to be grasped in this context, and one which is strongly advocated by the majority of successful electronics manufacturing companies, is the corporate requirement for a commonly understood mission which, at the same time, permits the firm to retain sufficient flexibility to exploit tactical opportunities.

An essential first step in the process of Strategic Analysis must, therefore, be the development of a clear, unambiguous statement of Corporate Mission. For those companies which have no mission statement, it will be necessary to start from first principles. Where such a statement already exists, it may be necessary to undergo a process of redefinition to ensure the corporate mission statement "fits" with the future aims and goals of the organisation.

Figure 2: The Strategic Analysis Process



NOTE: Feedback occurs throughout the methodology but, for the purposes of clarity on the diagrams, feedback loops have not been included.

Once agreed, a Company's mission statement provides a framework for identifying electronics design capability improvement opportunities, for developing a product portfolio which comprises existing and future products, and for creating an aggregate project plan which will enable the company to achieve and sustain competitive success.

As illustrated by Figure 2 above, the Strategic Analysis stage of the methodology consists of the following steps:

Step 1: Define Corporate Mission

Step 2: Create Design Capability "Envelope"

Step 3: Agree potential improvements

Step 1 Define Corporate Mission

Context

A Mission Statement is a single, clear statement which defines the Company's purpose and the broad scope of its business activities. It serves to unify the many diverse activities within a company by providing a common direction and allows individuals within the organisation to know what the company is attempting to achieve.

Rationale

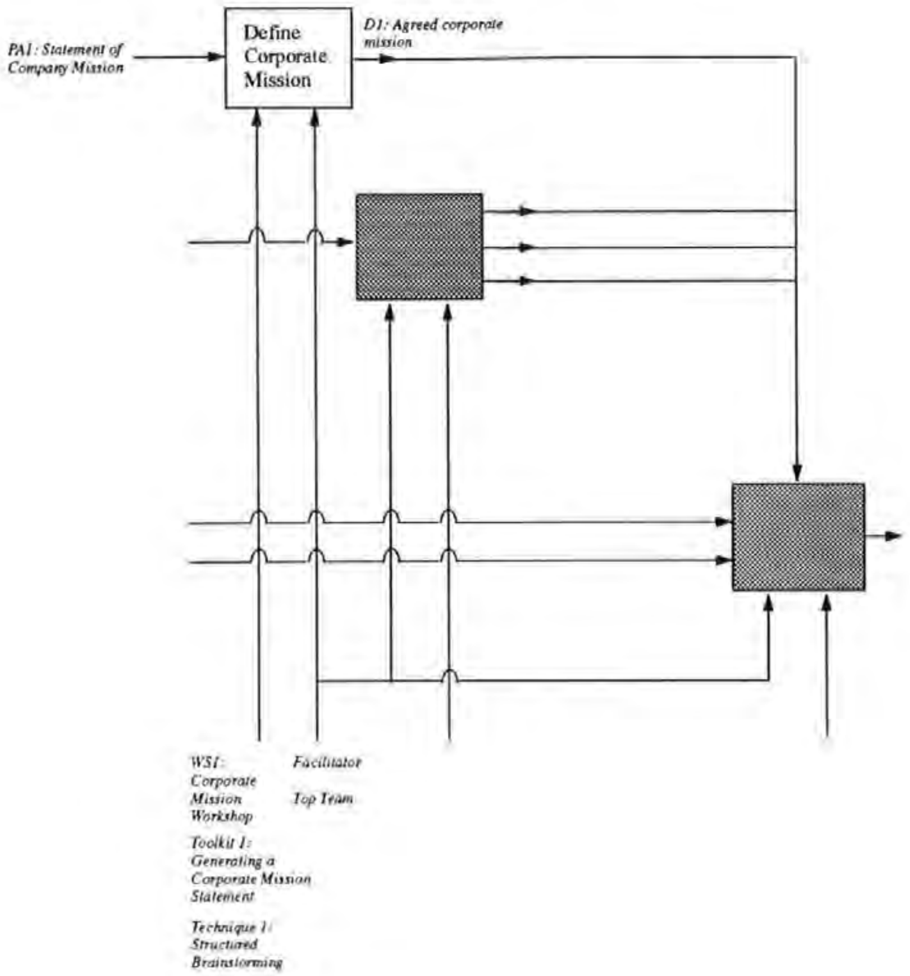
An essential pre-requisite to the process of product design capability improvement is the engagement, by the top management team, in a fundamental re-think of the Company's mission. Top management are often unsure of the real aims of their businesses, principally because a mission statement has never been articulated. Consequently, plans are drawn up and decisions made which may, over the long term, damage the Company.

The act of agreeing a corporate mission is an important first step for members of the Top Team. The process not only provides an opportunity for generating involvement and establishing teamwork, but, by provoking a fundamental rethink of the business it provides a critical focus for any subsequent business analysis.

At this stage in the methodology, however, participants will only be concerned with making a "first pass" attempt at defining a mission statement since their view of the firm's mission is likely to alter considerably having taken part in the process. The statement should lay out, in simple terms, what business the company is in, its distinctive competence, its main aspirations and goals. The initial mission statement may be successively refined as the participants progress through the Strategic Analysis phase.

Process

Define Corporate Mission



Top Team members should participate in **WORKSHOP 1: The Corporate Mission Workshop**. The Facilitator will guide the discussions and ensure that the contributions of all participants are taken into account when crafting the company's Mission Statement.

PA1: Statement of Company Mission should have been completed by each participant prior to the workshop.

Toolkit 1: Generating a Corporate Mission may be referred to by participants where guidance is required in producing a Mission Statement. Toolkit 1 provides examples of Mission Statements for a variety of organisation types.

Technique 1: Structured Brainstorming may be used by participants if the group feels there is a need to generate a lot of ideas quickly.

WORKSHOP 1 THE CORPORATE MISSION WORKSHOP

Objective

To generate an agreed mission statement.

Participants

Members of the *AGILITY* Top Team.

Format

Group exercise, using a flip chart and a "scribe" to record the content of the workshop.

Participants attending this workshop should have generated their own views on the Company's mission. They should also have completed **PA 1: Statement of Company Mission** and should be ready to discuss their ideas.

The Facilitator will provide the meeting with examples of other Corporate Mission Statements and will ask participants to write down what they consider to be the Mission of the Company. He or she will then write each of the ideas on the board/flip chart, without naming the contributors, and ask the participants to discuss each idea in turn. If the Company is part of a larger group, care must be taken to consider the parent Company's mission statement. As the meeting will be the first involvement of many of the staff in the process of specifying the firm's product design capability, the aims of the process and the role of the Facilitator should be described by the Programme Director.

It is likely that some people will react to this forum by contributing grievances and suggestions which have been held for some time about the current state of the company. It is important to note these comments as they may otherwise be lost. Though such comments are valuable it must be stressed that it is the intention of the team to approach the development of the design function in a well-ordered and logical way. All comments will be investigated further in **WORKSHOP 6, The Current Design Resources Workshop.**

Duration

No more than half a day.

Help

Toolkit 1 . . . . Generating a Corporate Mission

Technique 1 . . . . Structured Brainstorming

Deliverables

Deliverable 1 . . . . Agreed corporate mission

Step 2 Define design capability "envelope"

Context

Heightened competitive pressures are obliging many electronics firms to introduce new products every 12 to 18 months, on average, merely to maintain their market positions. In some areas, such as personal computers, the product lifetime is as little as a year or less and the product introduction opportunity window (usually defined as the first half of a product's lifetime) is now no more than six months.

The product development strategies of the best international electronics companies appear to be characterised by four measures:

- Fast reaction to competition changes;
- Shortening the product cycle to spur demand;
- Emphasis on competitive product properties;
- Planning for new opportunities.

At the product level, electronics firms are therefore having to cope with considerable instability along three major product design dimensions, namely:

- The *nature* of the designs being undertaken;
- Design *scope*;
- Design *intensity*.

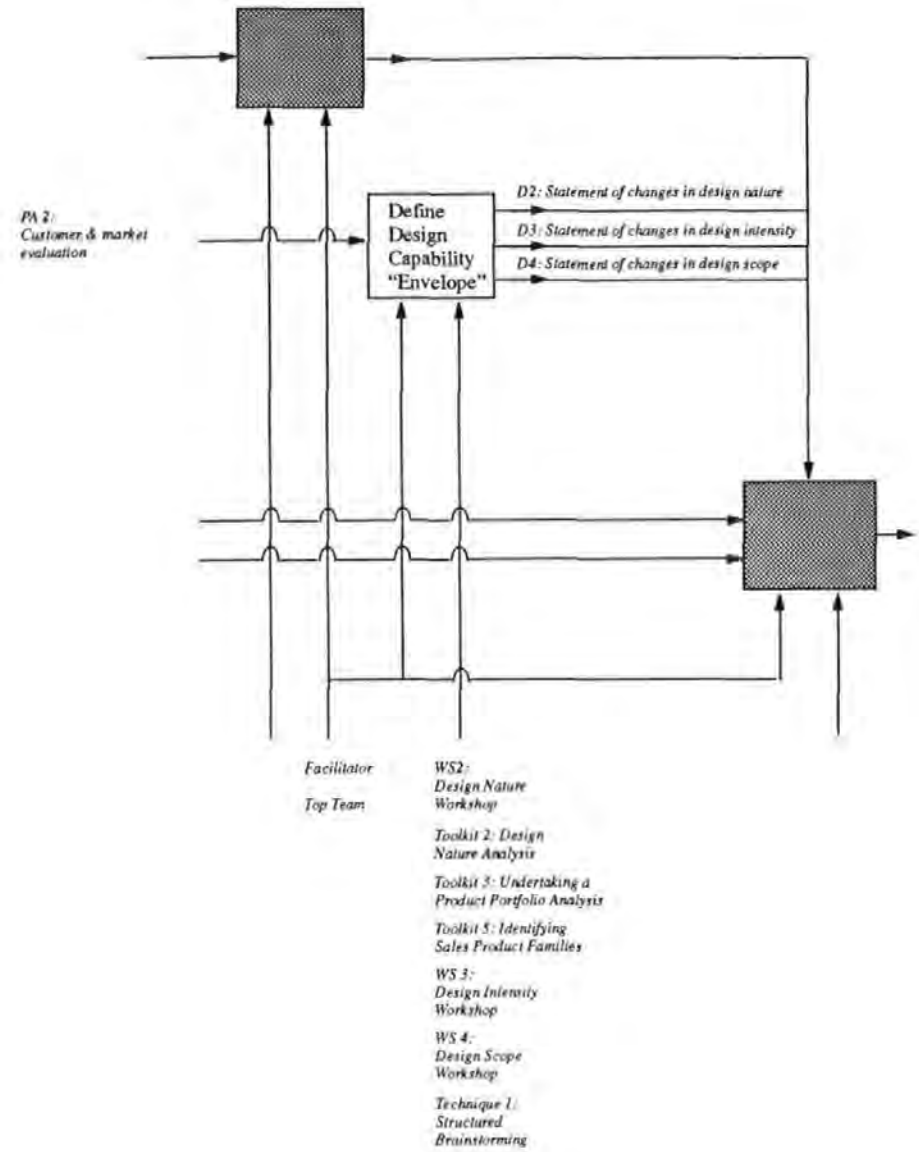
Rationale

The process of establishing the boundaries of the design capability "envelope" requires the firm to undertake a detailed examination of its customers, markets and competitors in order to establish the impact that developments in these areas will have upon the firm's overall product portfolio and on its product design capability.

In so doing, the Company will derive a clear idea of what improvements it will need to make to *existing* product families in order to make them more competitive. The Company will also understand what *new* products it will need to develop in order to create a sustained income stream and, in so doing, it will also have begun to recognise a requirement to absorb new component or manufacturing process technologies in order to successfully deliver these products to the market.

Process

Define Design Capability "Envelope"



As indicated in the above diagram, Top Team members should participate in **WORKSHOP 2: Design *Nature* Workshop**, **WORKSHOP 3: Design *Intensity* Workshop** and **WORKSHOP 4: Design *Scope* Workshop**. The Facilitator will guide the discussions and ensure that the contributions of all participants are taken into account when defining the design capability "envelope."

PA 2: Customer and Market Evaluation should have been completed by the Sales/Marketing Director prior to the workshop.

Task 1 Agree changes in design *Nature*

Context

Electronics design covers a wide spectrum of activities, from complete product re-design through to small-scale incremental improvement. It is therefore possible to categorise the nature of the design projects which may be undertaken by an electronics firm. These are:

- Research and Advanced Development projects;
- Strategic projects;
- Innovative projects
- Variant projects;
- Repeat Order projects.

Research and Advanced Development Projects

These projects involve the creation of knowledge -- know-how and know-why -- as a precursor to commercial development. They require:

- Understanding new basic physical principles;
- Exploration of limits of operation of new principles;
- Defining manufacturing tolerances required to cope with the application of new principles;
- Development of demonstrator product embodying new principles.

Strategic Projects

These projects require significant change in both the product and the process and, when successful, lead to the establishment of a new core product and a new core process. Much of the focus of such projects is on the product because it often represents a new application or function and depends upon attracting and satisfying new customers. However, process development will also require considerable attention because the manufacturing process is likely to be critical to the overall success of the product.

Such projects often tend to be high risk, with a low probability of success.

Innovative Projects

These projects are concerned with the creation of new "system" solutions for a broad range of core customer needs. Hence they involve significant change on either the manufacturing process dimension (for example, Surface Mount Technology), the product dimension (for example, migration from analogue to digital circuits) or both.

Innovative projects are especially important to electronics firms because they provide a base for a product and process family which can be developed and enhanced over several years. Innovative projects:

- Require know-how to be acquired by the firm either by hiring people with the requisite knowledge or by training existing staff. However, it will take time for staff to gain the necessary "feel" for the way in which the new knowledge may be most effectively used and for its potential impact on the manufacturing process;
- Can provide a significant base of volume and a fundamental improvement in cost, quality and performance over the previous generation;
- Require "aggressive" design (See Toolkit 2);
- Combine features from existing products;
- Require significantly more resources than Variant projects.

Variant Projects

These projects are concerned with the creation of products and processes which range from cost-reduced versions of existing products or add-ons/enhancements to an existing production process. These are typically the most common projects which firms undertake and may be:

- Incremental product changes with little or no process change;
- Incremental process change with little or no product change;
- Products involving incremental change in both dimensions.

Variant projects require substantially fewer design resources than products which break new ground because they merely extend the applicability of existing products or processes and may be supported using existing know how. Their success depends upon speed and flexibility, however.

Repeat Projects

These projects require no (or near zero) new knowledge either in design or in manufacturing and typically involve no extra design or production effort since the firm is simply building more of the previously designed product. They may, however, involve the company in:

- Cost reduction exercises to reduce parts. For example, modifying the design for ease of assembly or for increased reliability using established design and/or production techniques
- Manufacturing process optimisation where those processes impact the design of the product
- Design or manufacturing fault detection and correction through the application of continuous improvement techniques

Rationale

It is important for electronics firms to compete across as many of these product development activities as possible, particularly where *Innovative* projects are concerned.

Process

Top Team to undertake **WORKSHOP 2: Design *Nature* Workshop.**

PA2: Customer and Market Evaluation to have been completed by the Sales/Marketing Director prior to the workshop and the results distributed to all participants prior to the Workshop.

During WORKSHOP 2 participants should refer for guidance to **Toolkit 2: Design *Nature* Analysis, Toolkit 3: Undertaking a Product Portfolio Analysis** and **Toolkit 5: Identifying Sales Product Families.**

Technique 1: Structured Brainstorming may be used by participants if the group feels there is a need to generate a lot of ideas quickly.

WORKSHOP 2 DESIGN *NATURE* WORKSHOP

Objective

To prepare a statement on the changes in the *nature* of design facing the firm.

Participants

Members of the Top Team. The meeting should be chaired by the Project Champion and should include representatives from customer and supplier companies.

Format

Group exercise, using a flip chart and a "scribe" to record the content of the workshop.

The Sales/Marketing Director should have completed **PA2: Customer and Market Evaluation** and circulated his/her report to the group prior to the Workshop.

Using the information produced during **PA 2: Customer and Market Evaluation**, and taking each product family in turn, the Sales/Marketing Director will invite discussion amongst the participants to identify likely changes in the *Nature* of the company's design activities.

The Facilitator will assist by guiding the discussions and by ensuring that all options are explored, that nothing of any significance is overlooked and that all participants are allowed to contribute to the discussions on an equal basis.

Duration

No more than half a day.

Help

Toolkit 2 .... Design *Nature* Analysis

Toolkit 3 .... Undertaking a Product Portfolio Analysis

Toolkit 5 .... Identifying Sales Product families

Technique 1 .... Structured Brainstorming

Deliverables

Deliverable 2 .... Statement of changes in design *nature*

Task 2 Agree changes in design *Intensity*

Context

Electronics firms must cope with intense domestic and international competitive pressure and must maintain a high rate of new product introduction. However, many leading international firms undertake considerably more product design than their UK equivalents.

In particular, the Japanese approach to product development can be seen as one of continuous improvement within a carefully planned procedural framework which ensures that technical, quality, production cost and market issues are addressed in a coherent and integrated way. Japanese product development processes are also geared to provide a capability to introduce new product variations quickly and cost effectively to meet changing requirements.

Rationale

In order to compete successfully in future, UK electronics manufacturing firms will need to be able more rapidly to undertake a greater number of product design projects. However, greater *intensity* of design has obvious implications for a company's ability concurrently to manage and control multiple projects - particularly with regard to minimising the risks involved in product design.

Process

Top Team should undertake WORKSHOP 3: Design *Intensity* Workshop.

PA2: Customer and market evaluation should have been completed by the Sales/Marketing Director prior to the workshop.

Technique 1: Structured Brainstorming may be used by participants if the group feels there is a need to generate a lot of ideas quickly.

WORKSHOP 3 DESIGN *INTENSITY* WORKSHOP

Objective

To prepare a statement on the changes in the *intensity* of design facing the firm.

Participants

Members of the Top Team. The meeting should be chaired by the Project Champion and, where appropriate, should include representatives from customer and supplier companies.

Format

Group exercise, using a flip chart and a "scribe" to record the content of the workshop.

The Sales/Marketing Director should have completed **PA2: Customer and Market Evaluation** and circulated his/her report to the group prior to the Workshop.

Using the information produced during **PA 2: Customer and Market Evaluation**, and taking each product family in turn, the Sales/Marketing Director will invite discussion amongst the participants to identify likely changes in the *Intensity* of the company's design activities.

The Facilitator will assist by guiding the discussions and by ensuring that all options are explored, that nothing of any significance is overlooked and that all participants are allowed to contribute to the discussions on an equal basis.

Duration

No more than half a day.

Help

Toolkit 3 .... Undertaking a Product Portfolio Analysis

Toolkit 5 .... Identifying Sales Product families

Technique 1 .... Structured Brainstorming

Deliverables

Deliverable 3 .... Statement of changes in design *intensity*.

Task 3 Agree changes in design *Scope*

Context

In the electronics industry, particularly in the consumer electronics field, the competitive climate is forcing firms to dramatically extend the scope of their design activities.

Rationale

In some markets, electronics firms must lead their customers in the directions they want to go before the customers themselves are aware of those directions. The ability to achieve this naturally requires deep insight into the needs, lifestyles and positive aspirations of today's and tomorrow's customers

This "buyer's market" also heightens the need for products to be manufactured to the highest possible standards of quality and at the lowest cost. Electronics firms are thus having to adopt a wide variety of tools and techniques in order to achieve these seemingly conflicting objectives. Concurrent Engineering (CE), probably the best known of these techniques, integrates a number of methods which can be used to improve the quality and manufacturability of the product, including include design for manufacture and assembly (DFMA), design for test (DFT) and quality function deployment (QFD).

Finally, in today's environmentally conscious world, it is becoming increasingly urgent that designers evaluate their designs in terms of environmental impact. In the automotive industry, for example, engineers should be concerned not only with the construction but also the *destruction* of automobiles.

Such a design for disposal (DFD) approach should equally be adopted by designers in the wider electronics industry but it will require firms to make a number of changes to the way they design their products.

These include:

- Product simplification;
- Standardisation of components and product configuration;
- Modular designs, especially with components for reuse;
- Standardisation of material types;
- Easily detachable parts;
- Reduction in the number of pieces requiring disassembly;
- Easily accessible components in products;
- Reduction in number of material types to reduce sorting.

Process

Top Team to undertake **WORKSHOP 4: Design *Scope* Workshop.**

PA2: Customer and market evaluation to have been completed by the Sales/Marketing Director prior to the workshop.

Technique 1: Structured Brainstorming may be used by participants if the group feels there is a need to generate a lot of ideas quickly.

WORKSHOP 4 DESIGN *SCOPE* WORKSHOP

Objective

To prepare a statement on the changes in the *scope* of design facing the firm.

Participants

Members of the Top Team. The meeting should be chaired by the Project Champion and should include representatives from customer and supplier companies.

Format

Group exercise, using a flip chart and a "scribe" to record the content of the workshop.

The Sales/Marketing Director should have completed **PA2: Customer and Market Evaluation** and circulated his/her report to the group prior to the Workshop.

Using the information produced during **PA 2: Customer and Market Evaluation**, and taking each product family in turn, the Sales/Marketing Director will invite discussion amongst the participants to identify likely changes in the *Scope* of the company's design activities.

The Facilitator will assist by guiding the discussions and by ensuring that all options are explored, that nothing of any significance is overlooked and that all participants are allowed to contribute to the discussions on an equal basis.

Duration

No more than half a day.

Help

Toolkit 3 .... Undertaking a Product Portfolio Analysis

Toolkit 5 .... Identifying Sales Product families

Technique 1 .... Structured Brainstorming

Deliverables

Deliverable 4 .... Statement of changes in design *scope*.

Step 3 Agree potential improvement opportunities

Context

The process of establishing the boundaries of the design capability "envelope" requires the firm to undertake a detailed examination of the Company's customers, markets and competitors in order to establish the impact that developments in these areas will have upon the firm's overall product portfolio and its product design and development capability.

At this stage in the ***AGILITY*** process, the capability "envelope" will have been defined and participants must now identify opportunities for improving the effectiveness of the company's design operations and for building upon its existing strengths and competences in product design and development.

Rationale

Opportunities for improvement exist on a number of different dimensions. These include:

- The *products* themselves;
- The overall *management* of the product design process, including structure and accountability;
- The *operational* activities involved in actually designing electronics products, including systems and processes;
- The infrastructural or *support* activities necessary to ensure effective utilisation of both human and technological resources, including people and culture.

The starting point of any design process improvement effort must be to establish, as precisely as possible, a common understanding of how the Company's products are currently designed. This can best be accomplished by developing a set of process models which will help the firm to identify where gaps and opportunities for improvement exist and where support is required for areas of strength and critical competence.

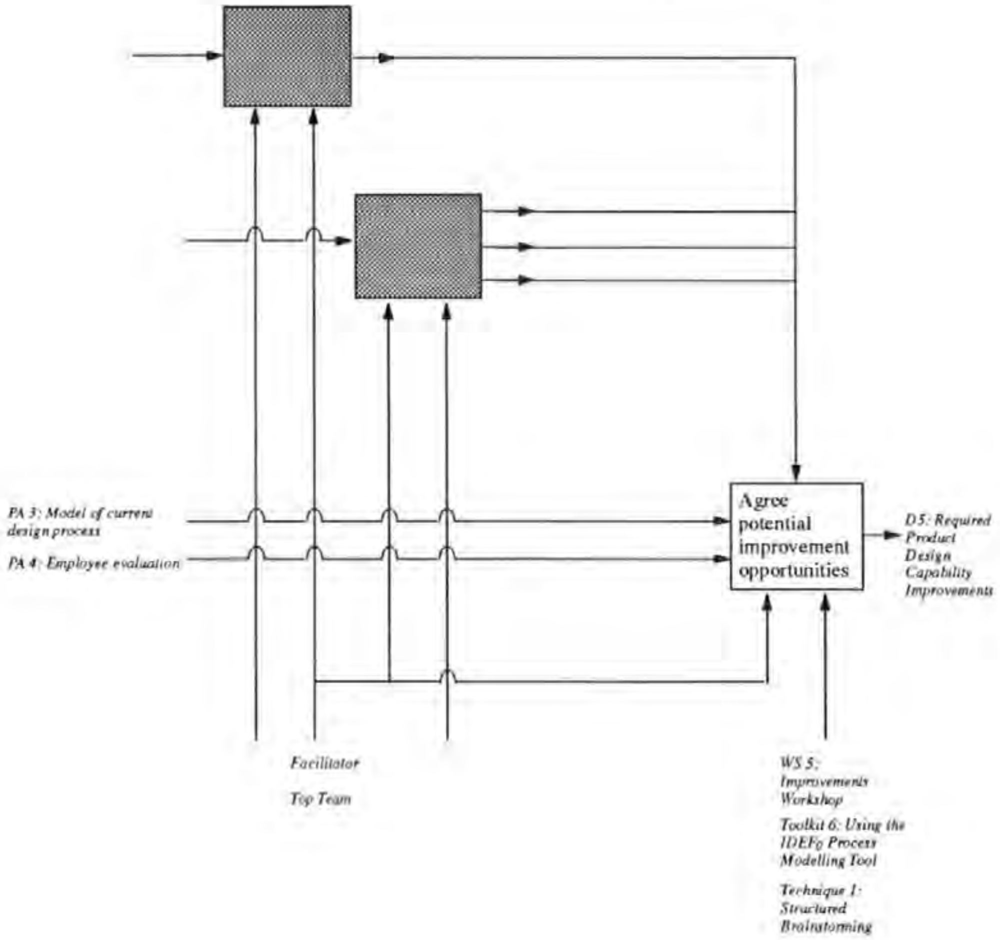
Improvements highlighted by the modelling exercise must be viewed in light of customer and market requirements for the firm's products, together with organisational and managerial innovations suggested by an internal audit of the Company's design operations.

Of particular concern in this regard will be the performance of the Company's existing products against those of its best competitors. Where its products are shown to be inferior to those of its competitors, the firm will undoubtedly need to create a carefully focused portfolio of new products with which to recapture the competitive initiative. Some underperforming products may have to be dropped.

Product superiority by itself is no guarantee of improved competitiveness, however. Unless a firm can get its products to the marketplace more rapidly than its competitors, any advantage which might have been gained from improving its products will undoubtedly be diluted. Delays may be caused by such factors as ineffective project management, inadequate product specification, poor translation of product designs into manufacture or the existence of an inadequate engineering change control regime.

Process

Agree Potential Improvement Opportunities



Top Team to undertake **WORKSHOP 5: Improvements Workshop**. The Facilitator will guide the discussions and ensure that the contributions of all participants are taken into account when defining the required product design capability improvements.

PA 3: Model of Current Design Process and **PA 4: Employee Evaluation** to have been completed by assigned personnel prior to the workshop.

While undertaking PA 3, participants should refer for guidance to **Toolkit 6: Using the IDEF$_0$ Process Modelling Tool.**

Technique 1: Structured Brainstorming may be used by participants if the group feels there is a need to generate a lot of ideas quickly.

WORKSHOP 5 IMPROVEMENTS WORKSHOP

Objective

To identify opportunities for improving the effectiveness of the firm's design operations.

Participants

Members of the Top Team. The meeting should be chaired by the Project Champion.

Format

Group exercise, using a flip chart and a "scribe" to record the content of the workshop.

The Top Team should define the company's required product design capability improvements using evidence obtained during Step 2: Define Design Capability "Envelope" (i.e. Deliverables 2, 3 and 4), as well as from PA3: Model of Current Design Process and PA4: Employee Evaluation.

Having initiated **PA 3: Model of Current Design Process**, the Engineering/Design Director should have circulated a set of $IDEF_0$ models of the Company's current product design process to all participants prior to the Workshop. The models should have been accompanied by a report highlighting areas of waste and inefficiency in the product design process. In particular, the report should have drawn participants' attention to such issues as:

- Timescales involved in carrying out tasks;
- Complex documentation flows;
- Extensive feedback/checking activities;
- Frequency of design iterations.

The Facilitator should have completed **PA 4: Employee Evaluation** and should have circulated the analysis of the employee survey to the group prior to the Workshop. The Facilitator will assist by guiding the discussions and by ensuring that all options are explored, that nothing of any significance is overlooked and that all participants are allowed to contribute to the discussions on an equal footing.

Duration

No more than half a day.

Help

Toolkit 6 .... Using the $IDEF_0$ Process Modelling Tool

Technique 1 .... Structured Brainstorming

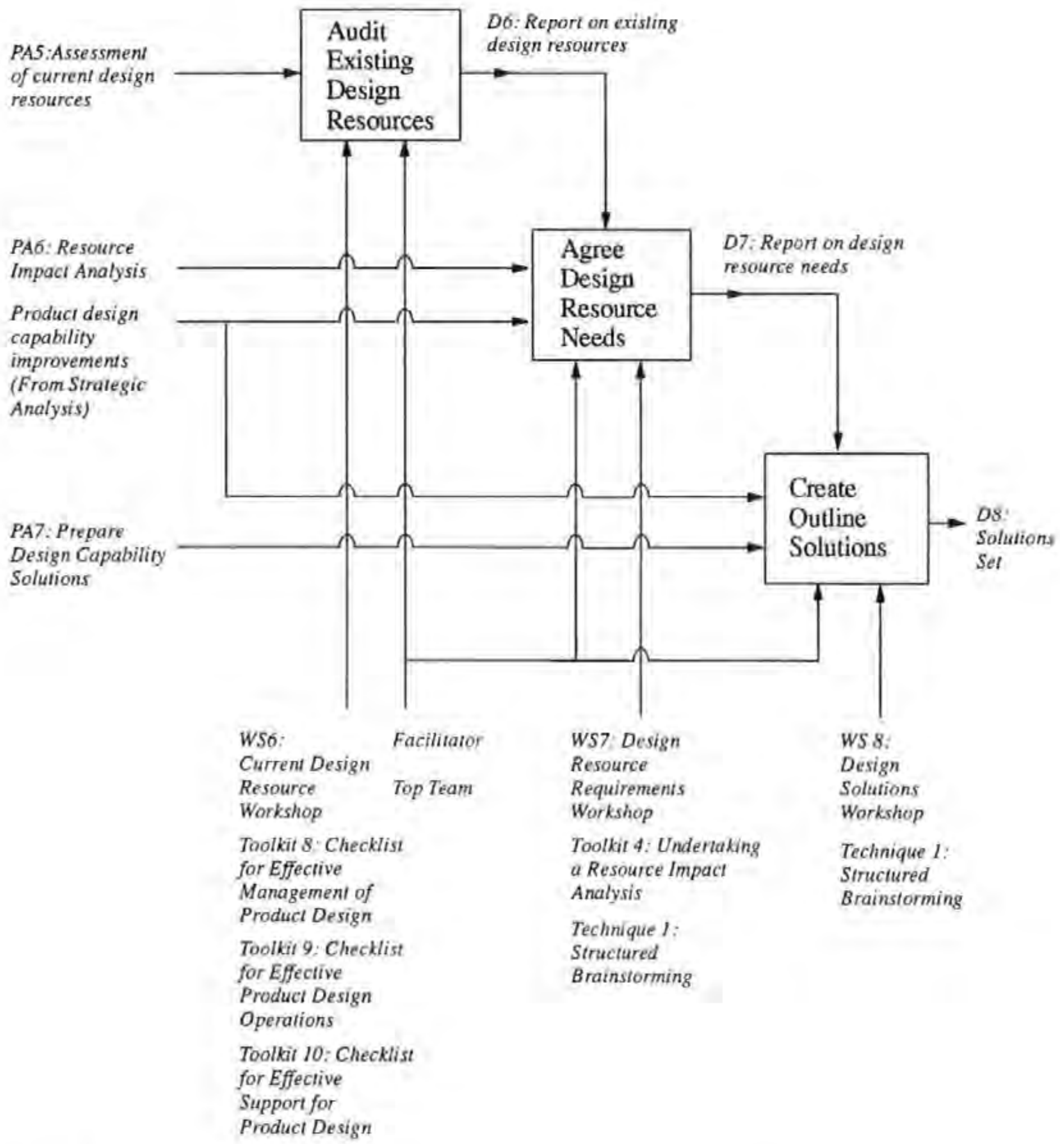
Deliverables

Deliverable 5 .... Design process improvement opportunities

STAGE 2 DESIGN RESOURCE ANALYSIS

In Strategic Analysis the design capability "envelope" was defined and a variety of improvement opportunities were identified along the Manage, Operate and Support dimensions of the Company's design activities. Quite rightly, no consideration was given at that time as to whether or not, or indeed, how the improvements might be achieved. Design Resource Analysis is concerned with how design resources can be adjusted and more fully utilised to achieve the required improvements.

Figure 3: The Design Resource Analysis Process



NOTE: Feedback occurs throughout the methodology but, for the purposes of clarity on the diagrams, feedback loops have not been included.

An essential first step in this process is a thorough audit of existing electronics design resources and capabilities. From this an informed assessment can be made of how specific resources affect each sales product family's performance. This provides valuable guidance on where to direct the Company's efforts to secure the required improvements.

Given that there are usually many ways in which improvements can be made a decision must be taken on the most appropriate resource to change to achieve the required results. In practice such decisions are rarely algorithmic. They require the imagination and creative contributions of relevant company personnel to generate and evaluate alternate solutions. A workshop is used to provide a forum to secure these contributions and determine which solution to adopt.

As Figure 3 above indicates, the Design Resource Analysis stage of the ***AGILITY*** process consists of the following steps:

Step 1: Audit Existing Design Resources

Step 2: Agree Design Resource Needs

Step 3: Create Outline Solutions

Step 1 Audit Existing Design Resources

Context

Step 1 involves a thorough audit of existing electronics design resources and capabilities. The audit should be conducted along the Manage, Operate and Support dimensions and should examine resource issues related to, for example:

- The control of product design and the minimisation of risk;
- Current hardware and software in use throughout the product design process;
- Resources devoted to manufacturing process design;
- Design infrastructure;
- IT support for inter-personnel communications and for administrative tasks;
- Human resource management.

Toolkits 8, 9 and 10 should be referred to for guidance in these areas.

Rationale

To determine the scope and depth of current electronics design resources.

The Company's ability to "design a product" will depend upon the specific engineering discipline involved, but certain generic knowledge, skills, tools and infrastructure may be identified. These include:

- Design theory, knowledge, codes and practices;
- Specification writing and maintenance;
- Engineering management and contracting;
- Simulation, model building and testing;
- Program and product quality assurance and testing.

Levels of employee skill should also be considered during Step 1. These can be broken down as follows:

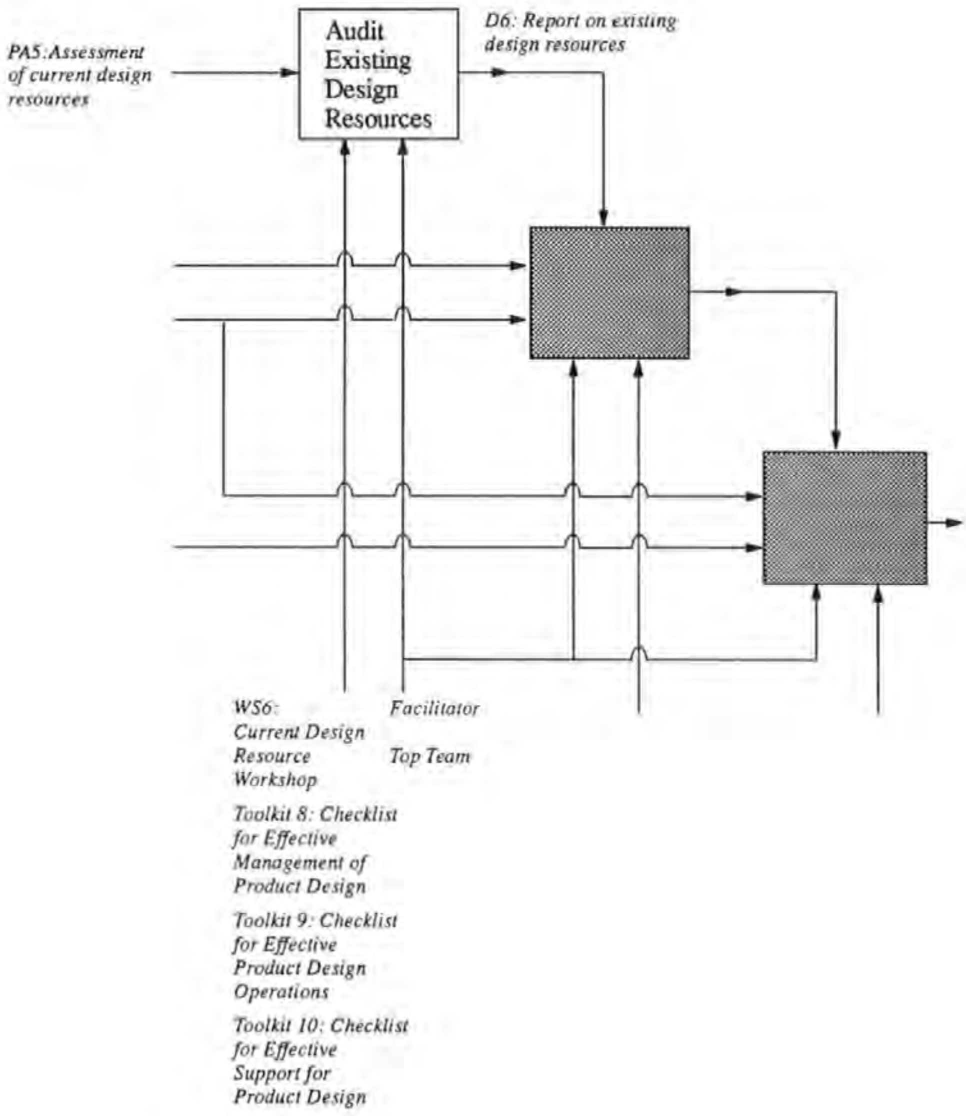
- No knowledge of subject;
- Knowledge of subject exists;
- Sufficient skill to buy service, product etc;
- Sufficient skill to exercise function independently.

Participants should also identify available design capacity and the demands which ongoing projects will make on that capacity. Hence, they should attempt to:

- Identify existing design resources available for product development efforts -- particularly the human resources;
- Identify currently active projects with their requirements for completion.

Process

Audit Existing Design Resources



Top Team to undertake **WORKSHOP 6: Current Design Resource Workshop**. The Facilitator will guide the discussions and ensure that the contributions of all participants are taken into account during the design resource auditing process.

PA 5: Assessment of Current Design Resources to have been completed by the Engineering/Design Director and circulated to all participants prior to the workshop.

During WORKSHOP 6, participants should refer to **Toolkit 8: Checklist for Effective Product Design Management, Toolkit 9: Checklist for Effective Product Design Operations** and **Toolkit 10: Checklist for Effective Support for Product Design.**

WORKSHOP 6 CURRENT DESIGN RESOURCE WORKSHOP

Objective

To conduct a thorough audit of existing electronics design resources and capabilities.

Participants

Members of the Top Team. The meeting should be chaired by the Project Champion.

Format

Group exercise, using a flip chart and a "scribe" to record the content of the workshop.

The Engineering/Design Director should have completed **PA5: Assessment of Current Design Resources** and circulated his/her report to the group prior to the Workshop.

Using the information produced during **PA 5: Assessment of Current Design Resources** and taking each product family in turn, the Design/Engineering Manager will invite discussion among participants to ensure that all existing product design resources have been accounted for and that they have been correctly allocated with regard to the Manage, Operate and Support framework.

The Facilitator will assist by guiding the discussions and by ensuring that all options are explored, that nothing of any significance is overlooked and that all participants are allowed to contribute to the discussions on an equal footing.

Duration

No more than half a day.

Help

Toolkit 8 .... Checklist for Effective Product Design Management

Toolkit 9 .... Checklist for Effective Product Design Operations

Toolkit 10 .... Checklist for Effective Support for Product Design

Deliverables

Deliverable 6 .... Report on existing design resources

Step 2 Agree Design Resource Needs

Context

In order to reach agreement on product design resource needs, participants are asked to undertake **Workshop 7: Agree Design Resource Requirements**. The workshop provides a forum in which participants can consider such questions as:

- If the volume of design is going to increase, do we need to buy more hardware and/or software or do we subcontract the design work?
- If we need to apply Concurrent Engineering techniques to our design process, what do we need to do with regard to training?
- If we are going to start designing more innovative products than we have in the past, where are the ideas going to come from? Do we need to hire in more suitably qualified people or can existing staff do the job if they are given appropriate training? What are the implications for the company's overall culture?

Rationale

An important consideration in establishing priorities is to identify the resources required and their availability. Without such consideration actions might be agreed without the means to implement them or that one particular resource, for example, a machine tool or process line might be allocated more jobs than it can reasonably cope with.

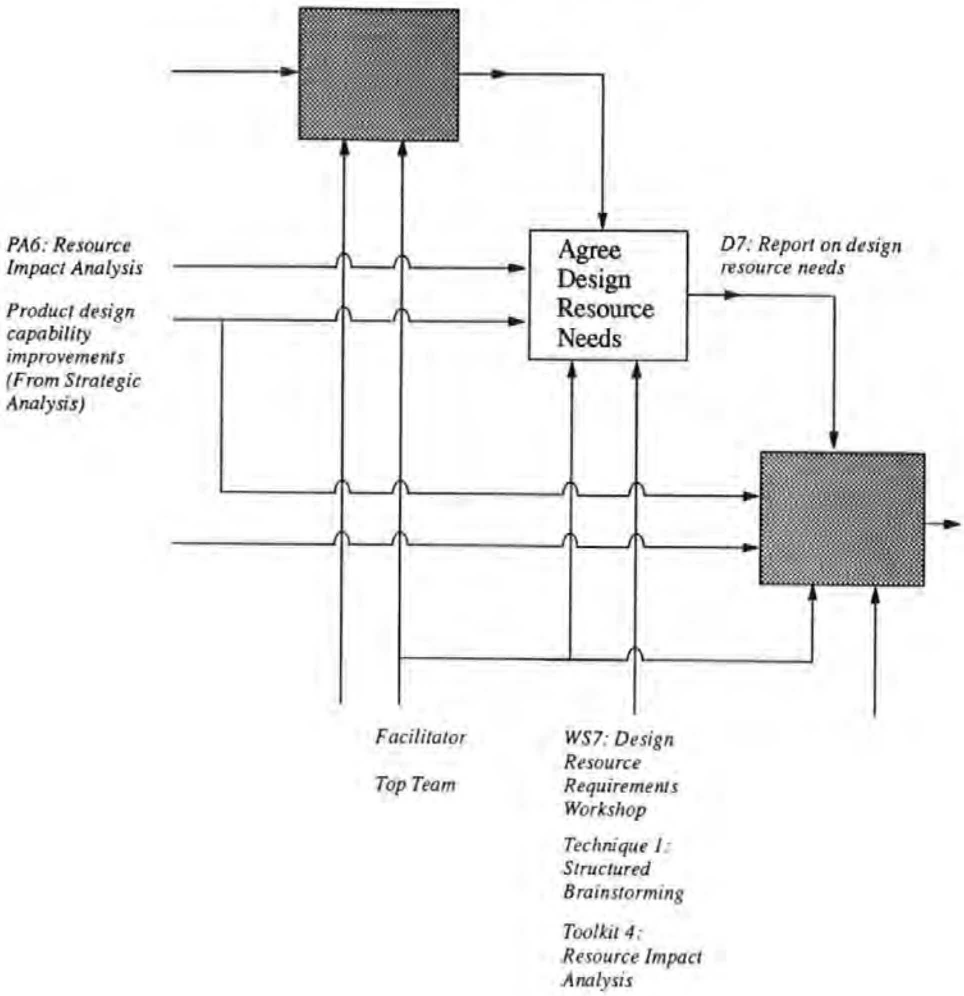
Process

Top Team to undertake **WORKSHOP 7: Design Resource Requirements Workshop**. The Facilitator will guide the discussions and ensure that the contributions of all participants are taken into account during the process of agreeing a set of design resource requirements.

PA 6: Resource Impact Analysis to have been completed by the Engineering/Design Director and circulated to all participants prior to the workshop.

During WORKSHOP 7, participants should refer to **Toolkit 4: Resource Impact Analysis**. **Technique 1: Structured Brainstorming** may be used by participants if the group feels there is a need to generate a lot of ideas quickly.

Agree Design Resource Needs



WORKSHOP 7 DESIGN RESOURCE REQUIREMENTS WORKSHOP

Objective

To agree upon the electronics design resources required to enable the firm to develop a flexible product design capability.

Participants

Members of the Top Team. The meeting should be chaired by the Project Champion.

Format

Group exercise, using a flip chart and a "scribe" to record the content of the workshop.

The Engineering/Design Director should have completed **PA 6: Resource Impact Analysis** and circulated his/her report to the group prior to the Workshop.

Using the information produced during **PA 6: Resource Impact Analysis** and taking each product family in turn, the Design/Engineering Manager will invite discussion among participants in order to arrive at an agreed set of product design resource requirements.

The Facilitator will assist by guiding the discussions and by ensuring that all options are explored, that nothing of any significance is overlooked and that all participants are allowed to contribute to the discussions on an equal footing.

Duration

No more than half a day.

Help

Toolkit 4 .... Undertaking a Resource Impact Analysis

Technique 1 .... Structured Brainstorming

Deliverables

Deliverable 7 .... Report on design resource needs

Step 3 Create Outline Solutions

Context

Design solutions are actions which can be taken, with respect to design resources and capabilities, to achieve the required competitive improvements for each sales product family.

Rationale

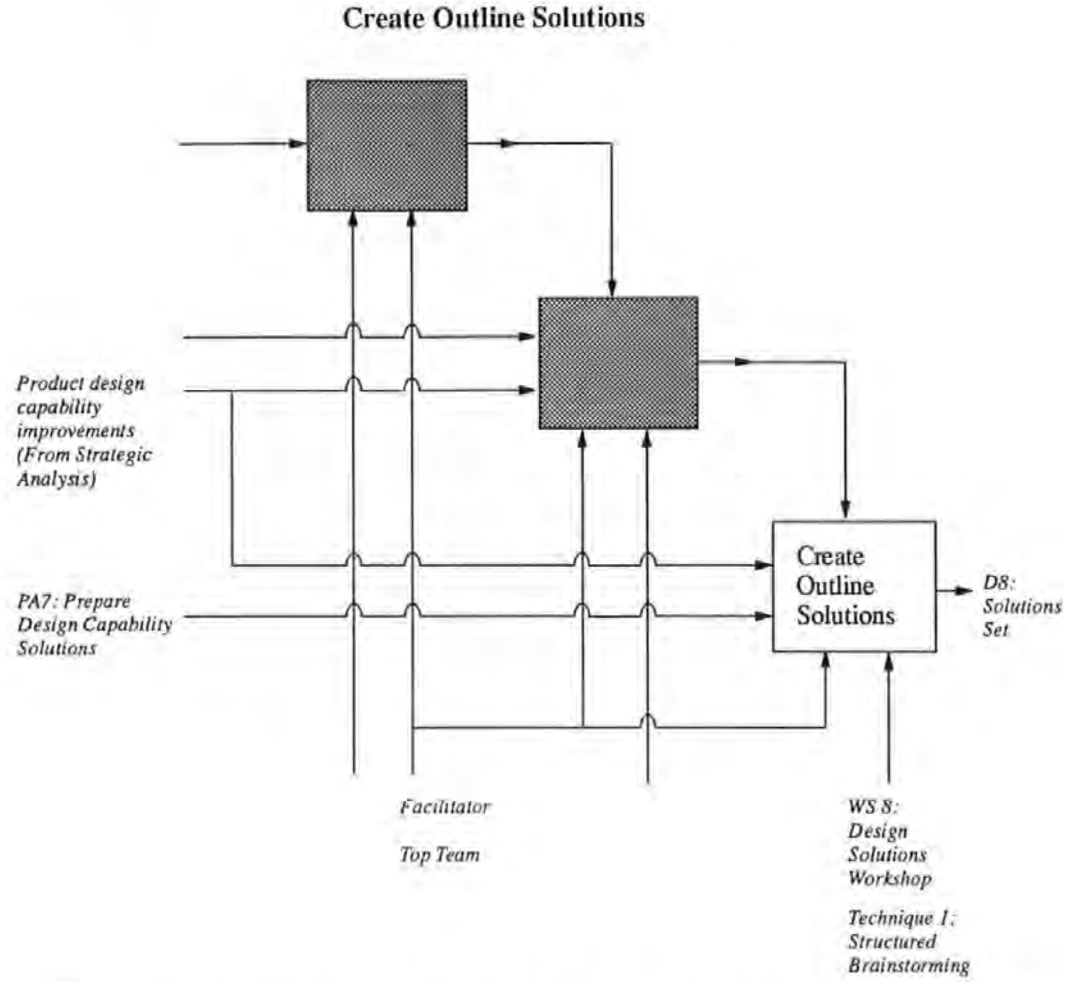
In Strategic Analysis opportunities were identified for improving the competitive performance of the Company's products, as well as for improving the way in which the Company manages, operates and supports the process of product design. In the first two steps of Stage 2, Design Resource Analysis, design resources and capabilities were identified and their impact on the achievement of the competitive profiles assessed.

Solutions must now be identified, evaluated and actions agreed regarding the manner in which design resources and capabilities may best be applied.

In most product design situations a large number of actions may be feasible to achieve a desired end. The process of deciding amongst alternatives is seldom algorithmic. In addition, as ownership and commitment to the solutions is vital, contributions from the controllers and users of resources need to be sought to ensure that the selected actions are effective.

Consequently, debate and discussion should be encouraged to generate the widest set of potential solutions, each of which should be subject to rigorous challenge to ensure that the most appropriate solution is selected.

Process



Top Team to undertake **WORKSHOP 8: Design Solutions Workshop**. The Facilitator will guide the discussions and ensure that the contributions of all participants are taken into account during the process of agreeing a set of design resource requirements.

PA 7: Prepare Design Capability Solutions to have been completed by each Top Team participant and circulated to all colleagues prior to the workshop.

Technique 1: Structured Brainstorming may be used by participants if the group feels there is a need to generate a lot of ideas quickly.

WORKSHOP 8 DESIGN SOLUTIONS WORKSHOP

Objective

The aim of this workshop is to agree on the actions to be taken with respect to the Company's design resources, management systems and infrastructural capabilities to achieve the required improvements in the competitive profile of each sales product family.

Participants

Members of the Top Team. The meeting should be chaired by the Project Champion.

Format

Group exercise, using a flip chart and a "scribe" to record the content of the workshop.

Using the information contained in **Deliverable 5, Product Design Capability Improvements** and in **Deliverable 7, Report on Design Resource Needs**, and taking each product family in turn, the Engineering/Design Director will invite discussion amongst the participants to identify the actions which might be taken to achieve the required improvements.

This process is likely to elicit a number of alternatives. Each alternative must be carefully considered and subjected to a rigorous challenge as to its technical, organisational and economic feasibility. At this stage detailed cost-benefits analysis is not likely to be appropriate.

The aim here is to exercise a reasoned judgement to screen more questionable proposals. Other proposals, requiring further consideration, can be put to one side and an action agreed to consider them later. It is vital that the widest range of possibilities be identified. Consequently, ideas and contributions should be encouraged.

The Engineering/Design Director is responsible for compiling the solutions and producing a report. The Facilitator will assist by guiding the discussions and by ensuring that all options are explored, that nothing of any significance is overlooked and that all participants are allowed to contribute to the discussions on an equal footing.

Duration

No more than half a day.

Help

Technique 1 .... Structured Brainstorming

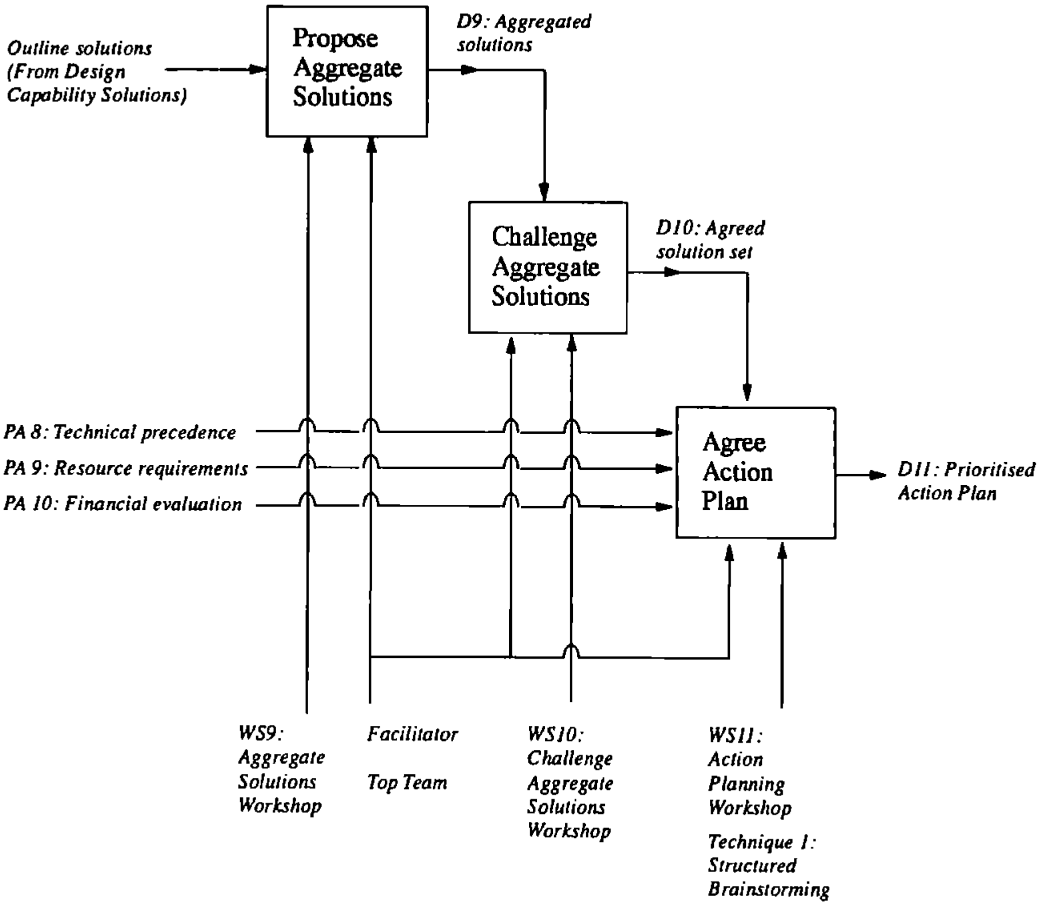
Deliverables

Deliverable 8 .... Solutions with respect to design resources, management systems and infrastructural capabilities

STAGE 3 DESIGN CAPABILITY SOLUTION

The various individual design capability solutions must be brought together into an overall plan for creating a flexible product design capability. The process of creating a design capability solution is illustrated in Figure 4 below.

Figure 4: Creating a Design Capability Solution



NOTE: Feedback occurs throughout the methodology but, for the purposes of clarity on the diagrams, feedback loops have not been included.

The Design Capability Solution stage of the ***AGILITY*** process consists of the following steps:

Step 1: Propose Aggregate Solutions

Step 2: Challenge Aggregate Solutions

Step 3: Agree Action Plan

Step 1 Propose Aggregate Solution

Context

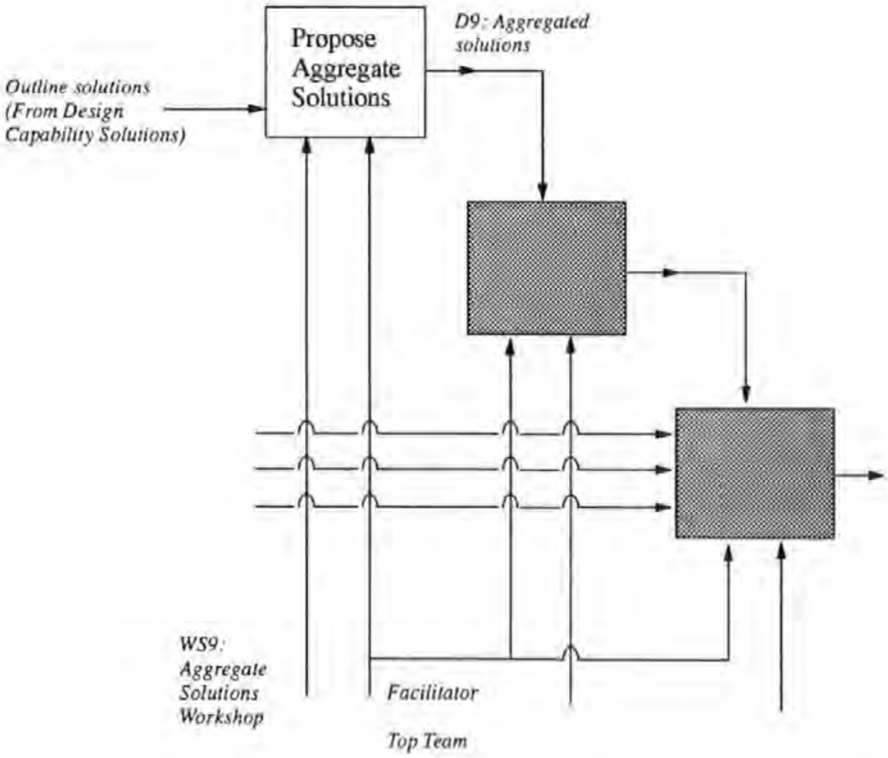
The solutions which emerge from the Design Resource Analysis process will relate to individual actions with respect to specific resources. Hence, the development of a *company-wide* solution requires some aggregation of solutions to take place.

Rationale

Aggregation of design capability solutions is necessary for two reasons. Firstly, because certain actions might not be justified on the basis of their affect on one product family alone but may be worthwhile as part of an improvement affecting many families. Secondly, by amalgamating individual solutions an overall solution might be identified which makes better use of the available resources.

Process

Propose Aggregate Solutions



Top Team to undertake **WORKSHOP 9: Aggregate Solutions Workshop**. The Facilitator will guide the discussions and ensure that the contributions of all participants are taken into account during the process of agreeing a set of aggregated solutions.

Although no Preliminary Activity is required, the results of the previous meeting should have been circulated to participants so that they can be better prepared at the start of this Workshop.

WORKSHOP 9 AGGREGATE SOLUTION WORKSHOP

Objective

To amalgamate individual solutions into solution tracks for each functional area.

Participants

Members of the Top Team. The meeting should be chaired by the Project Champion.

Format

Group exercise, using a flip chart and a "scribe" to record the content of the workshop.

Each participant attending the workshop will have a complete list of all the potential solutions associated with individual product families.

Taking each participant in turn the Project Champion will invite them to describe the rationale underlying the decision to amalgamate particular solutions. Participants will then be invited to comment on the amalgamated solutions identified and to consider their effect on and relationship to other solutions discussed.

This process will continue until a consensus is achieved on which amalgamated solutions to consider for action planning.

The Facilitator will assist by guiding the discussions and by ensuring that all options are explored, that nothing of any significance is overlooked and that all participants are allowed to contribute to the discussions on an equal footing.

Duration

No more than half a day.

Help

None

Deliverables

Deliverable 9 .... List of aggregated design solutions.

Step 2 Challenge Aggregate Solution

Context

To rigorously assess both aggregated and individual solutions in order to eliminate conflicts and ensure that solutions are effective and feasible.

Rationale

Having identified individual solutions and assembled related solutions into solution tracks they must be subjected to rigorous challenge before proceeding. Challenging solutions is essential for two reasons. First, the process of amalgamating solutions to develop the tracks may in itself have brought into question the Company's capacity to implement them. Secondly, both individual solutions and solution tracks need to be reexamined to eliminate or reconcile conflicts, avoid duplication and provide a realistic and achievable agenda for improvement.

In effect, this process represents the manufacturing team's last opportunity to assess the solutions before they are incorporated in the Company's manufacturing strategy and action objectives.

The result of challenging solutions is to agree a set of solutions which the Top Team own and commit to.

Process

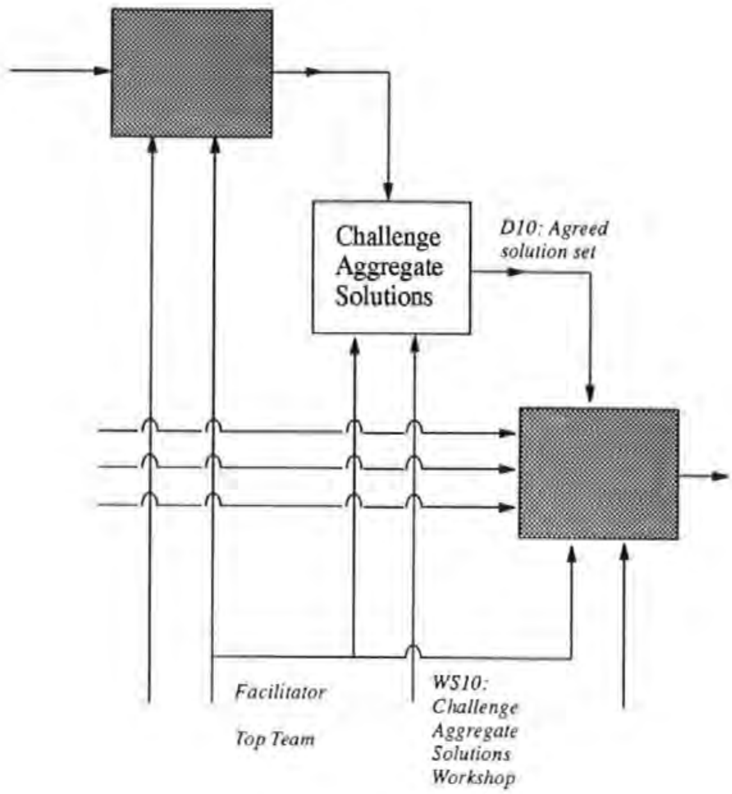
Top Team to undertake **WORKSHOP 10: Challenge Aggregate Solutions Workshop.**

During WORKSHOP 10, participants should refer to **Toolkit 11: Checklist of Economic, Social and Technical Issues.**

The Facilitator will guide the discussions and ensure that the contributions of all participants are taken into account during the process of challenging the aggregated solutions.

Although no Preliminary Activity is required, the results of the previous meeting should have been circulated to participants so that they can be better prepared at the start of this Workshop.

Challenge Aggregate Solutions



WORKSHOP 10 CHALLENGE AGGREGATE SOLUTION WORKSHOP

Objective

To challenge aggregated solutions.

Participants

Members of the Top Team. The meeting should be chaired by the Project Champion.

Format

Group exercise, using a flip chart and a "scribe" to record the content of the workshop.

Taking each aggregated solution in turn, participants subject it to a rigorous challenge to check that it will achieve the required competitive improvements. The issue should be approached from a highly practical point of view to encourage a realistic assessment, with each participant being encouraged to offer their views. Special attention must be given to potential conflicts and duplication so that a viable set of solutions is generated.

Wide ranging discussion should be encouraged with participants being allowed to change previously held views. Among other issues, participants should consider those economic, social and technical factors which might have a bearing upon the viability of the design capability solutions. The objective is to arrive at a consensus so that all present agree the solutions to be implemented.

The Facilitator will assist by guiding the discussions and by ensuring that all options are explored, that nothing of any significance is overlooked and that all participants are allowed to contribute to the discussions on an equal footing.

Duration

No more than half a day.

Help

Toolkit 11 .... Checklist of Economic, Social and Technical Issues

Deliverables

Deliverable 10 ...... Agreed solution set

Step 3 Agree Action Plan

Context

Agreeing and prioritising actions is a decision process designed to obtain a consensus and commitment to the actions which need to be taken, in line with the design capability improvement opportunities previously established, in order to achieve the required product family improvements.

Rationale

Having identified a number of design capability improvement opportunities and agreed a set of solutions which will enable the firm to enact those improvements, priorities must now be agreed and assigned to specific actions.

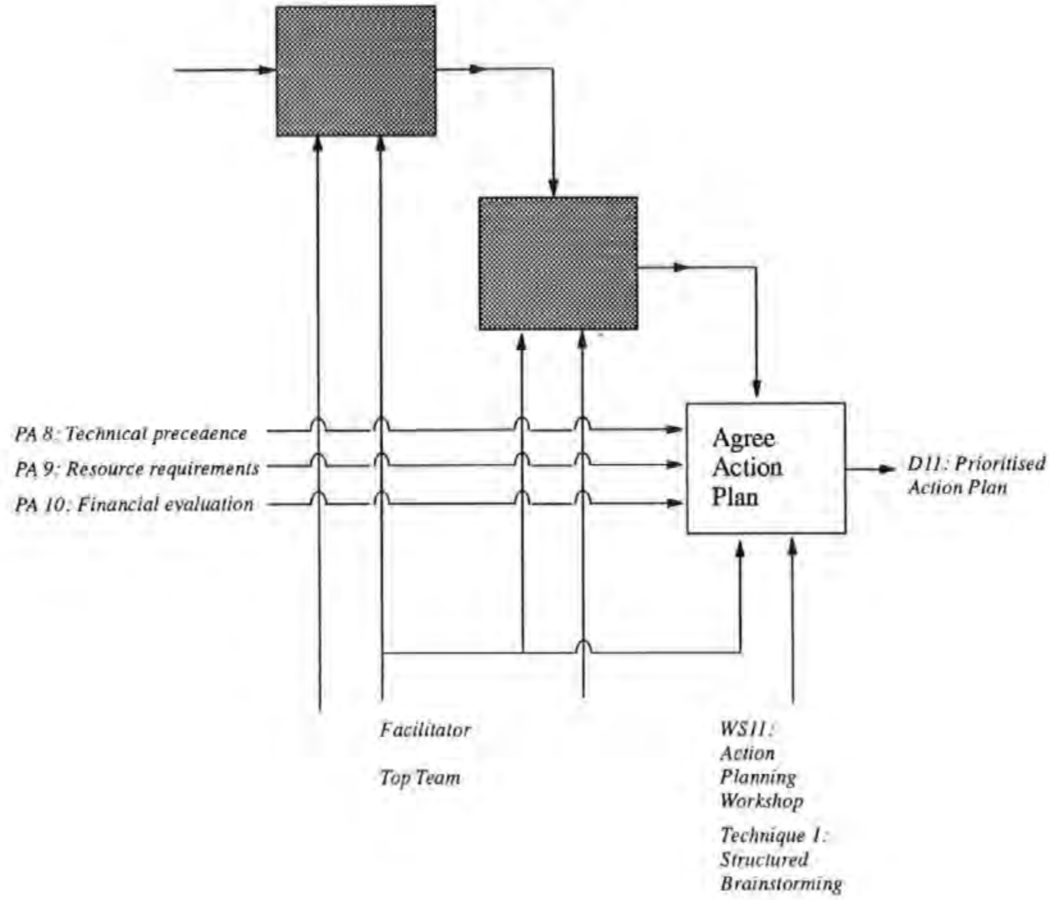
In order to assign meaningful priorities consideration must be given to three issues:

- Technical Precedence – what must be done before an action can be undertaken;
- Resources required to implement an action – for example, financial, equipment, materials and manpower.
- The value of taking action to the success and profitability of the company;

Without proper consideration of all of these issues, inappropriate actions might be adopted which would not utilise manufacturing resources effectively and which would be unlikely to maximise the desired competitive improvements. In order to establish priorities each action identified should be assessed against the following criteria:

Process

Agree Action Plan



Top Team to undertake **WORKSHOP 11: Action PLanning Workshop.**

PA 8: Determine Technical Precedence and **PA 9: Determine Resource Requirements** to have been completed by the Engineering/Design Director and **PA 10: Undertake Financial Evaluation** to have been completed by the Financial Director and the results circulated to all participants prior to the workshop.

Technique 1: Structured Brainstorming may be used by participants if the group feels there is a need to generate a lot of ideas quickly.

WORKSHOP 11 ACTION PLANNING WORKSHOP

Objective

To agree and prioritise actions

Participants

Members of the Top Team. The meeting should be chaired by the Project Champion.

Format

Group exercise, using a flip chart and a "scribe" to record the content of the workshop.

Utilising **PA 8: Determine Technical Precedence, PA 9: Determine Resource Requirements** and **PA 10: Undertake Financial Evaluation** participants take each solution in turn and determine its priority.

As it is almost inevitable that resource conflicts will occur some iteration may be required in order to agree priorities that can be implemented and which offer the greatest benefits.

The **Facilitator** will assist by guiding the discussions and by ensuring that all options are explored, that nothing of any significance is overlooked and that all participants are allowed to contribute to the discussions on an equal footing.

Duration

One day.

Help

Technique 1 .... Structured Brainstorming

Deliverables

Deliverable 11 ...... Prioritised action plan

PHASE 5 Close

The ***AGILITY*** process closes when action plans are approved/agreed by the Top Team and formally presented to the Board of Directors.

AGILITY Methodology

TOOLKITS

TOOLKIT 1

Generating a Corporate Mission

Introduction

The mission of a corporation is the most generalised objective and can be viewed as an expression of its "raison d'etre." The corporate mission should not focus on what the firm is doing in terms of products and markets currently served, but rather upon the services and utility that the products provide.

A Corporate Mission has certain key characteristics. It is **visionary** in so far as it does not reflect where the company is now or where it wants to be at some specified future date. Instead it expresses where an organisation is through time and, by persisting even when short-term objectives and strategy change, is likely to be **central** and **overriding**.

Generating a Mission Statement

Generally, the mission statement should be a simple statement consisting of:

- a verb
- an object
- one or more limiting clauses, relating to the product
- or service offered to the customer.

Examples of Corporate Mission Statements

For a Manufacturing company

1. To be European leader in the development and manufacture of marine propulsion systems.
2. To be the world leader in developing, manufacturing and selling state of the art instruments for laser surgery.
3. To be world leader in the design, manufacture and sale of hand portable and vehicle communications products.
4. To supply computer systems and software which fully meet our customers cost, quality and delivery requirements in defined vertical markets.

For a Local Government Authority

1. To be the best community of our size in the United Kingdom - known to provide:
   - Increasing employment opportunities and improving standards of living.
   - Highest quality educational, cultural and recreational opportunities.

For a Retailing Company

1. To manufacture and sell high volume consumer durables direct to the general public and to manufacture own brand items to supermarkets and DIY outlets.

For an Academic Institution

1. To provide both students and staff with the maximum opportunities to develop their knowledge and skills so that they are able to fully exploit their talents, energies and abilities to the benefit of themselves and to society as a whole.

TOOLKIT 2

Design *Nature* Analysis

Introduction

The manner in which leading Japanese electronics firms use design to achieve market success is of particular relevance for the UK electronics industry. The Japanese firms initially design products in an "aggressive" manner in order to create market share or to offer a level of functionality not found in other products. Having achieved these goals, their design capabilities are then deployed "consequentially" to ensure ease of manufacture and high product quality as part of a low cost business strategy.

Success in the electronics market is critically dependent upon being first to market with products which meet or even exceed customer requirements. Achieving this goal requires the establishment of a strategy for creating new markets and extending market share using a combination of aggressive and consequential approaches to product design.

In order to implement such a strategy, electronics engineering management must acknowledge the extreme difficulty of successfully managing a portfolio of product development projects using a "single track" approach. Clearly, a product which is simply a variation of an existing, well-understood product is likely to require far less design and production effort than would be necessary in the case of a product incorporating several entirely new and unfamiliar technologies. To date, however, projects involving both the "tried and tested" product and the "risky" product have been managed in a manner which typically fails to take into account the different levels of engineering risk involved in their respective development.

It is sensible to view engineering design as a process which attempts to minimise the costs associated with a given project, taking in account the needs of the engineer and of the creative aspects of engineering design. A four path approach to electronics product design should therefore be adopted which is tailored specifically to company and engineering needs.

This view is reflected in Figure 4, an adaptation of the Pahl and Beitz model embodied in BS7000 to account for selected design routes according to the amount of risk involved in the design. The detail each of the paths of this Four Path model is discussed below.

Four Design Routes

Repeat Design

A new product could be a company Repeat Design if there is zero (or near zero) new knowledge required to complete the product in either design or manufacturing. Repeat Order designs typically involve the following functions:-

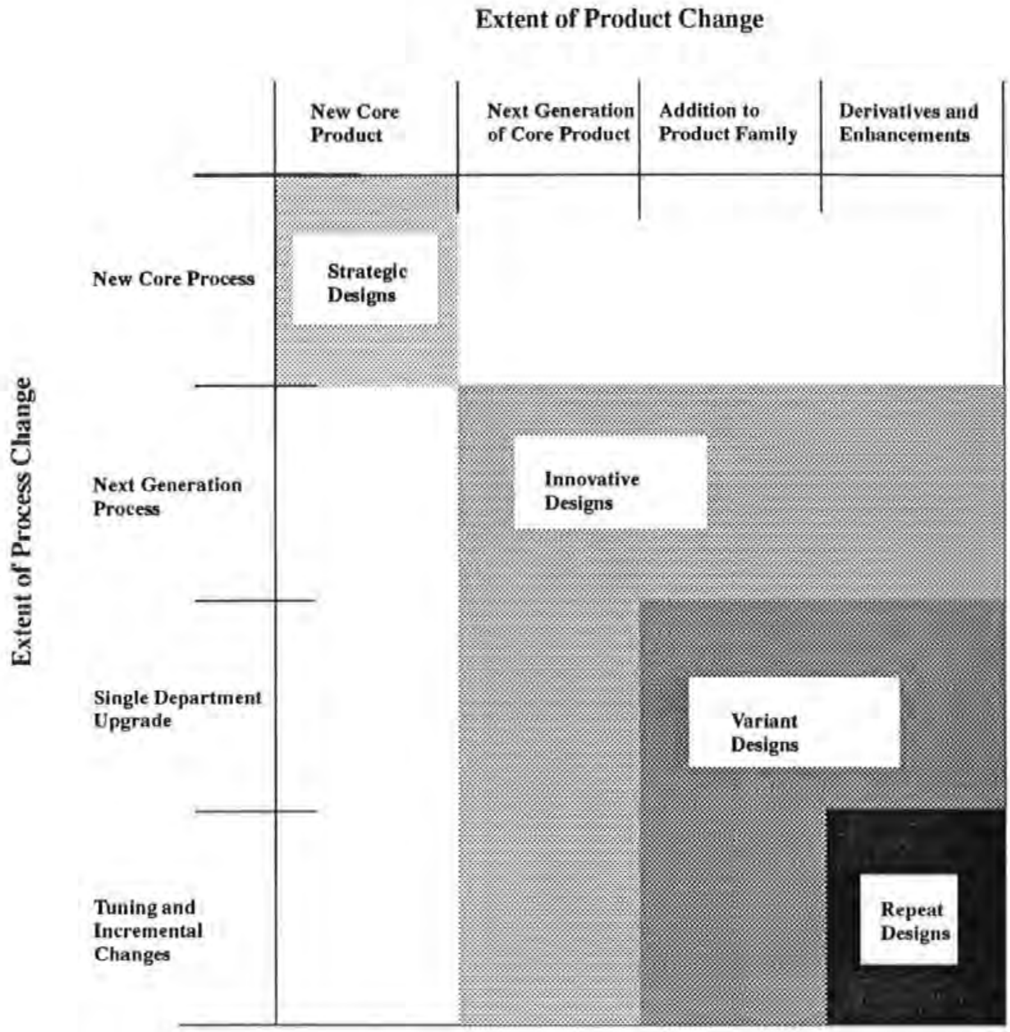
- No extra design or production effort, just build more of the previously designed order.
- Cost reduction by Design and Production for parts reduction, for example modify design for ease of assembly or for increased reliability, using established design and/or production techniques.
- Design and manufacturing fault detection and correction by iterative learning.
- Optimisation of manufacturing processes that impact on the design of the product.

Theoretically, a Repeat Design would require no new knowledge it would just vary in volume of production run. However in reality tooling changes, refinements in manufacturing techniques and component changes could impact on this criterion to take the design from a repeat order (with appropriate timescales and costs intimated) to a variant design (on a longer assumed timescale and costs), without management or even the engineers themselves appreciating the time over-run caused by the changes. In this way unanticipated change can undermine even the best controlled production facility.

A programme of continuous refinement for Repeat Designs, perhaps aimed at reducing manufacturing costs, can generate large numbers of engineering change notes and cause a considerable number of problems. These may be avoided by ensuring the correct procedures and practices are already in use on the shop floor and in design to handle this anticipated change.

A repeat order for an existing product does not always require any design engineering time to be expended. But, it is often the case that designs change over time, either through cost engineering exercises or through the discovery of a fault requiring a circuit revision to correct. Both require the time of a design engineer. The first since a component change introduced by production engineering or even purchasing should be assessed and have the approval of the original design team prior to implementation of the change.

Figure 4: Types of Development Projects



Adapted from Wheelwright S. and Clark K.B., Revolutionizing Product development, Free Press, Mew York, 1992, p93

Variant Design

A Variant Design is indicated, for example, if from one percent to about twenty percent new knowledge is required in either design or production engineering. Variant Designs are the most common category of design, and should involve a higher proportion of joint development than for repeat orders between design and production engineering. The aims of the Variant Design may be achieved, through one or more of the following operations:

- Incremental innovation by extension of existing product.
- Refinement of existing technology usage.

- Apply modified manufacturing technology, allowing variant re-design (finer lithography, for example, allows higher chip packing density or new solder technology requires different pcb layouts for solder traps)

Additionally, within the company context, portions of a product may require different design paths to be allocated. For example, a systems design or a software configured product may already have pre-existing sub-sections, to which new extensions are added, making a repeat order for the existing portions and a variant or innovative design path for the new sections. Systems design may require parts of existing products to be re-used in new designs and therefore only require making again. It may well be the configuration of such building blocks that is new and therefore will require all the preceding stages of this design process to check and evaluate the problems of the new concept. Also, with software technology tending to replace hardware and mechanical modules in products giving a new flexibility to a design; it is now possible to have a completely new product function, but employing existing mechanics and electronics; requiring only software changes to implement the new function.

Variant Design in electronic engineering should be supported by existing know-how within a company and only extend it by small increments, enabling a company to follow an evolutionary development path. Such a path will enable product developments to change over a period of time, perhaps tracking market trends or incremental changes in technology. For example, a company specialising in digital process control equipment can tailor their product developments to improvements in packing density, power consumption and processing speed brought about by the advances in digital integrated circuit fabrication.

Such a company might see improvement in printed circuit board packing, reductions in power supply requirements and improvements in numerical processing performance of their circuitry. The developments will extend their design engineers' knowledge in terms of these incremental performance figures in that they will appreciate aspects of circuit layout techniques demanded of the higher circuit operating frequencies, but they are unlikely to have to grasp unfamiliar basic principles of a new type of technology; for example to understand principles of analogue signal processing or to master completely new mathematical or algorithmic principles (such as neural networks or expert systems).

Designs in this category are more likely to have a smaller revision history during development than innovative or strategic designs; for in theory all the expertise required to develop a new variant product is held within a company and the use of this knowledge should reasonably well rehearsed in the professional engineers involved.

The boundaries of Variant Design are limitless and depend upon the nature of the underlying technology. If the technology is likely to be stable for a number of years, as digital logic has been and will continue to be for at least another five to ten years, then product developments can evolve by tracking advances in the underlying device physics.

However, in a competitive world, other boundaries can appear. Where, for example, a competitor company develops a analogue neural network processor (with significant advantages of resilience to noise and with no process characterisation) that offers the market a completely new type of product to solve their problems. A company, developing variant products based on up to 20% modification of existing designs (as the author defines above) as their evolutionary path, may have its market removed by a competing company offering radically new technological enhancements to the customer base. The only way to avoid this event, given the speed of technological change, is to have innovative and strategic design development activities running in parallel to the variant track.

Innovative Design

An innovative design is defined as requiring about twenty to fifty percent new knowledge in design or production engineering. This higher proportion of new knowledge allows radically new designs to be developed using by applying one or more of the following techniques:

- Innovation by new combination of features from existing products.
- New use of technology on existing solutions, for example: convert analogue circuits to equivalent digital circuits.
- Apply new manufacturing technology, for example; where surface mount technology has not been used in the company.

However, design innovations in this category are likely to be achieved through the use of new knowledge and know-how.

Strategic Design

Strategic designs cover the remaining portion of the continuum with over fifty percent new knowledge being applied to the problems and their solutions. A strategic design is often regarded as the domain of a company research group, a special section that normally does not have the pressures of commercial time scales explicitly tied to development work.

The remit of such groups often requires the development of new basic principles of operation, that are defined and developed as below:-

- Understand new basic physical principles.
- Explore limits of operation of new principles.
- Define manufacturing tolerances of new principles.
- Develop demonstrator embodying new principles.

The purpose of strategic design is to extend the design and production knowledge base of a company. It's goals are therefore seen to be different from the other three paths of design. Classically engineering research and development have not been tied to particular commercial product development programmes, but instead tied to demonstrator products that are then handed over to development and production engineering to turn the prototype into a production engineered design.

This lack of familiarity with commercial development requirements and procedures, and an all too frequent physical separation of strategic development staff from the "cutting edge" of manufacturing in a company can lead to a mis-understanding of the role of a strategic development engineer, both in the eyes of the development and production engineers and the research engineers themselves. This leads to communication barriers being formed between the groups and to the 'passing the buck' of problems that should have been solved in strategic development, rather than in production engineering.

Hence strategic design should embody novel electronics design with the development of any necessary manufacturing principles. Therefore Strategic Design, as with Repeat Design, Variant and Innovative Design, should involve design and production engineering experts.

In fact, a number of large companies attempt to address these problems by requiring their research engineers to accompany the strategic design through the remainder of the design process, helping to smooth the way to a product as well as learning aspects of engineering to tolerances, testing issues and other manufacturing requirements.

Implications

There are several implications of a multi-path design process model that relate to designers and their management. Firstly, for designers each of the four paths places different constraints on the range of possible solutions that are acceptable. For example, a project involving development of a Repeat Design cannot employ innovative techniques as solutions to any outstanding engineering problems. If, indeed, such techniques are suggested then a decision to move the design phase of the project from a Repeat Design status to a Variant Design status (or Innovative Design status) may have to be made. Likewise, a Variant Design cannot involve the application of significant new techniques, suggesting an Innovative Design, or even be only a minor modification in which case the design may well be a Repeat Design rather than a Variant Design.

Designs may also be constrained from a manufacturing point of view. For example a Repeat Design may additionally be prevented from being altered in a way that may affect manufacturing operations, and hence a circuit board re-layout in a Repeat Design will be unable to change the positions of tooling holes and assembly fixtures unless specifically authorised to do so.

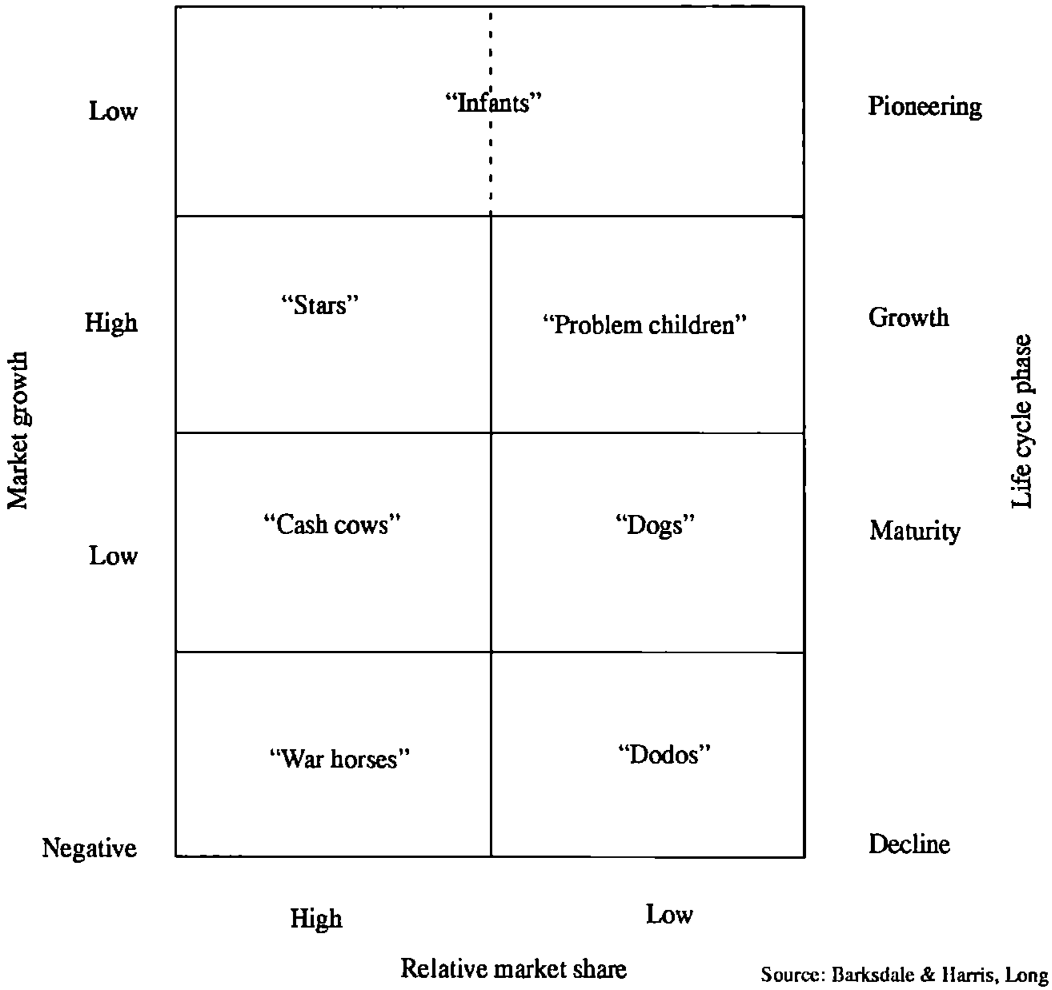
Secondly, an electronics product is likely to be complex and result from the application of the skill of many domain experts from marketing engineers, electronics, mechanical and software engineers, to production and test engineers. Hence, a new design may well be split into modules, each of which will be taken from requirements through to final design in each of these engineering domains. Where, for example, a design comprises an amalgam of digital and analog engineering components, of mechanism and materials engineering components as well as of production and test engineering, it is possible that such a design may be regarded as a Repeat Design for the electronics and materials, a Variant Design for the mechanisms and production engineering and an Innovative design for its software and test engineering elements.

TOOLKIT 3

Undertaking a Product Portfolio Analysis

Introduction

Product-Lifecycle-Portfolio Matrix



Source: Barksdale & Harris, Long Range Planning, Vol 15 (6), 1982, pp 74 – 83

Infant

Portfolio Analysis Characteristics

- Innovative products that create new product forms or classes
- Pioneering products which are new to the world
- Dramatically superior performance on one or two dimensions of interest to the customer
- Negative cash flow

Development Project Type

- Radical Breakthrough, Strategic

Strategy

- Expand distribution
- Increase sales
- Create or build the market
- Ensure "Infants" become "Stars"

Implications for design

- Need close cooperation between design and manufacturing
- Design for mass production (in consumer market)
- Expand the product range
- Design to improve quality, reduce cost

Stars

Portfolio Analysis Characteristics

- Large share of high growth markets
- Roughly self-sufficient in terms of cash flow
- Best opportunity for future growth

Development Project Type

- Next generation, platform or innovative

Strategy

- Build or maintain market share
- Find other markets for platform

Implications for design

- Need "Aggressive" design
- Create a product development framework for further progress
- Continue to feed in R&D/technology to improve product, extend product range
- Focus on optimisation i.e. improve theoretical understanding of the technology
- Create successor products based on core platform

- Improve quality, manufacturability,
- Front end design phase requires more creativity, insight and initiative
- Many more specs
- Cross functional problem solving

Problem Children

Portfolio Analysis Characteristics

- Low share of high growth market
- Three types:
    1. New brands in market or newcomers to industry
    2. Products introduced earlier which never gained strong position
    3. Products which were once "Stars"
- Negative cash flow

Development Project Type

- Next generation, platform or innovative
- Former Breakthrough, Radical or Strategic products

Strategy

- Build market share
- Move to "Star" or "Cash Cow" status
- Terminate

Implications for design

- Make significant changes in either product or process design or both (would need large cash infusions)
- "Aggressive" design

Cash Cows

Portfolio Analysis Characteristics

- Large relative share of mature, slow growth markets
- Valuable assets to any firm
- Generate more cash than they require for support -- surplus can be invested in future business growth

Development Project Type

- Enhancements, hybrids, variants or derivatives

Strategy

- Defend/maintain position in the market using least possible resources
- Need wide array of "Cash Cows" offering something tailored to every niche, distribution and competitor product

Implications for design

- "Consequential" design
- Cost reduced versions of existing products
- Enhancements to existing processes
- Incremental product change with little/no process change
- Enhancements to existing processes with little/no product change

Dogs

Portfolio Analysis Characteristics

- Three categories:
    1. Products which failed to reach high share in growth stage
    2. New brands introduced to challenge cash cows
    3. Former cash cows

Development Project Type

- Enhancements, hybrids, variants, derivatives

Strategy

- For category 1., there are 4 possible options:
    1. Reposition
    2. Harvest
    3. Maintain
    4. Terminate
- For category 2., build market share in a mature, low growth market (risky because it is likely to trigger aggressive price cutting by competitors)

Implications for design

- For category 1.:
    1. Reposition: moving from Dog to Cash Cow (or better) requires major commitment of resources and is a high risk strategy; aggressive design
    2. Harvest: involves reducing expenses to the point where the product yields a positive cash flow; will result in declining sales and declining market position; "repeat order" design
    3. Maintain: keep product going despite low share of a mature market; "repeat order" design
    4. Terminate

Warhorses

Portfolio Analysis Characteristics

- Veteran products which, in a declining market, have been successful and hold a strong market position
- If properly managed, can be significant cash generators

Development Project Type

- Enhancements, hybrids, variants, derivatives

Strategy

- Orderly adjustment to declining market opportunity through:
    1. Holding/maintaining
    2. Harvesting
    3. Repositioning

Implications for design

- Consequential design if strategy involves holding/maintaining the product or harvesting (expenses reduced to the point where sales of the product yield a positive cash flow)
- Aggressive design if strategy involves repositioning the product

Dodos

Portfolio Analysis Characteristics

- Low shares of declining markets

Development Project Type

- Enhancements, hybrids, variants, derivatives

- Repeat order

<u>Strategy</u>

- Terminate

<u>Implications for design</u>

- None

TOOLKIT 4

Undertaking a Resource Impact Analysis

Introduction

Design Resource Analysis starts by auditing existing design resources and capabilities. The results of the design audit will then enable the company to make an informed assessment of how specific resources affect each sales product family's performance. Given that there are usually many ways in which improvements can be made a decision must be taken on the most appropriate resource to change to achieve the required results. This will be accomplished through a Resource Impact Analysis.

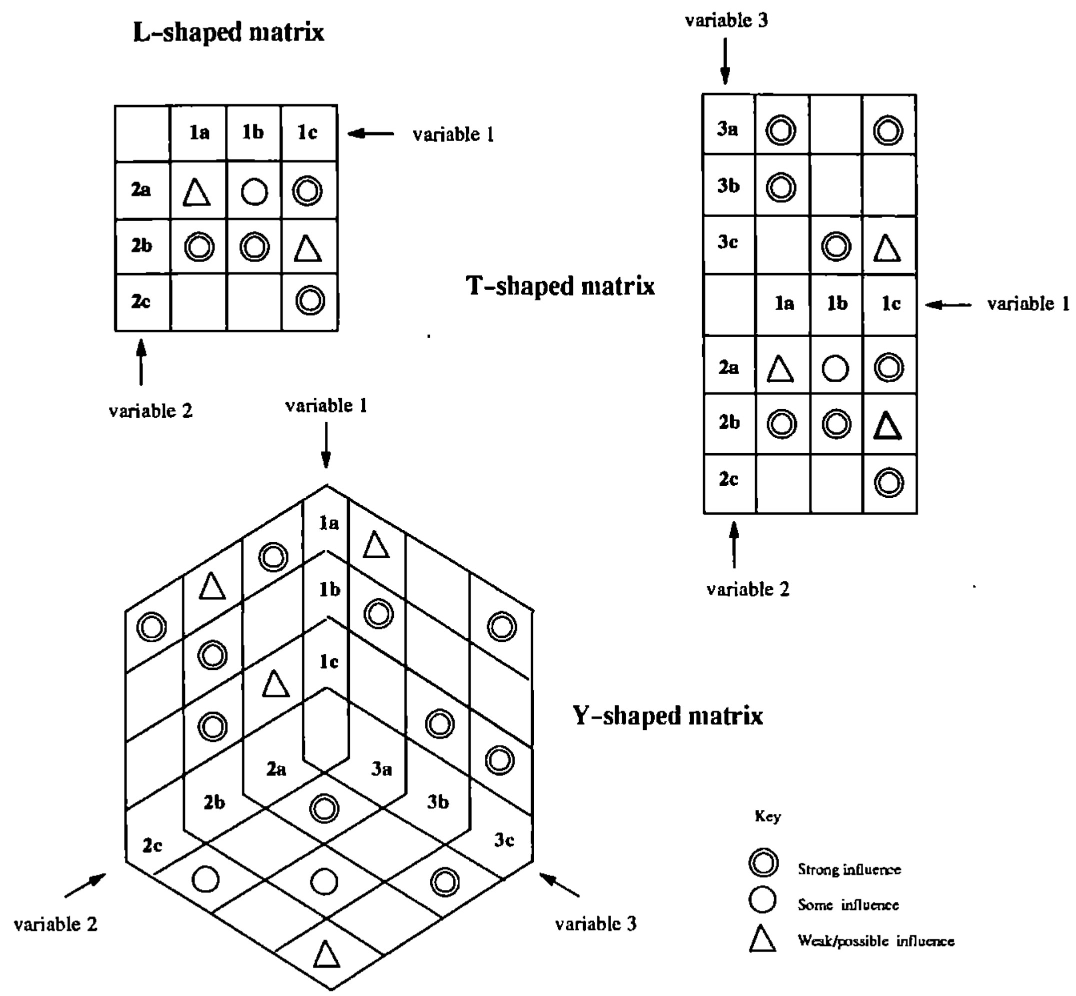
Resource Impact Analysis is used to assess the effect of various manufacturing resources and capabilities on the achievement of the required competitive improvements in each product family. The objective of Resource Impact Analysis is to identify those resources which exert the greatest influence on the achievement of the required improvements. This will enable the company to direct its efforts to the most productive areas to achieve the desired results.

The list of resources shown below is only a guide. Resources not identified in the audit of existing design resources could be added if they relate to resources required for potential new products. The workshop proceeds with the participants assigning to each box in the matrix a letter to indicate the level of effect of the resource upon the particular Competitive Dimension of each product family. .

While the matrices are being completed, participants may wish to record notes of ideas they may generate, or clarify why certain relationships exist. A certain amount of note-taking should be encouraged though this must not be allowed to inhibit discussion. Once complete, the Resource Matrices show which resources affect the various competitive dimensions most strongly. This information will be used in determining what solutions will fulfil the sales product family's competitive profiles.

Matrix diagram formats

The primary reason for the widespread use of the Matrix Diagram is its flexibility. First of all, the content that is chosen for any matrix is limitless. Secondly, there are at least five standard formats which allow you to show relationships among two, three or four sets of variables in either two dimensions (showing relationships between only two individual sets of variables at a time) or three dimensions (showing the relationship among three individual variables simultaneously). The following are three of the most commonly used matrix formats.



L–Shaped Matrix

This is the most basic form of Matrix Diagram. In the L–Shaped diagram, two interrelated groups of items are presented in line and row format. It is a simple two–dimensional representation which shows the intersection of related pairs of items as shown above. This exhibit shows that variable 1c has the strongest influence on the greatest number of variable 2 issues. Such a matrix can be used to display relationships between items in countless operational areas such as administration, manufacturing, personnel and R&D. The well–known Quality Function Deployment charts, used to capture the "voice of the customer" in product design, are an excellent example of L–Shaped matrices.

T–Shaped Matrix

Because a matrix is only two–dimensional, it can only show relationships between two items at a time. This is often sufficient, but sometimes a user wants to see a third set of items that would provide a more complete implementation picture. The T-Shaped Matrix doesn't create a third dimension but it does provide an additional "leg" which allows for a relationship analysis among three sets of items on the same page. The T-Shaped Matrix still only allows you to compare two sets of items at the same time. The third set of relationships can only be inferred and not shown directly.

In the exhibit above, the T-shaped matrix shows the relationship between variables 1, 2 and 3. However, the only *direct* relationships are between variables 1 and 2 and variables 1 and 3. There is only an *indirect* relationship between variables 2 and 3.

Y–Shaped Matrix

The Y-Shaped Matrix allows the user to combine and compare three sets of items (two at a time). In the exhibit above, therefore, the Y-shaped format now allows you to relate variables 2 and 3 directly in a way that was not possible with the T-Shaped Matrix.

Construction of a Matrix Diagram

The process of constructing any of the various format Matrix Diagrams is straightforward. Your understanding of which matrix format will shed light on your problem is the most critical factor. The steps are described below.

1. Choose key considerations for a successful implementation

   Every time we generate a list of options or actions to be taken we must also decide what is going to make or break any implementation plan developed. Where our Design Resource Impact Analysis is concerned, we are essentially concerned with three sets of items, each with a number of key elements. Set 1 includes Design Management, Design Operations, Design Support while Set 2 consists of the *Nature* of the designs, the *Intensity* of design activity and the *Scope* of the designs. Set 3, the design resources themselves, potentially consists of quite a large number of elements including financial resources, managerial resources, knowledge of existing electronics technologies, knowledge of new electronics technologies, knowledge of design best practice, existing computer hardware and software and access to University expertise.

2. Assemble the right team

In Matrix analysis, once tasks and the sets of items which they will be related to are chosen, then the correct team must be assembled to make those relationship decisions.

3. Select the appropriate matrix format

Having identified the existence of three key considerations, the matrix format which would give us the greatest insight into the company's present and future resource needs is likely to be the Y-Shaped Matrix.

4. Decide the relationship symbols to be used

There is initially no limit to the variety of symbols which can be used to indicate the kind of relationship that exists between two items in a relationship. In fact, a matrix user can develop any graphical symbols so long as each symbol is accompanied by a legend. That legend should clearly explain the meaning of each symbol so that interpretation is consistent, even by someone not involved in the original analysis.

As illustrated below, the most common symbols fall into two categories: Strength of Relationship and Level of Responsibility.

Strength of relationship	Level of responsibility
◎ Strong relationship	◎ Primary responsibility
○ Some relationship	○ Secondary responsibility
△ Weak/possible relationship	△ Should be kept informed/may need information from them

It is common to associate a numerical value with the various symbols mentioned above. This enables the user to generate some composite numbers which are helpful for prioritising tasks etc.

5. Complete the matrix

Example of a completed T-Shaped Matrix - Simplifying Order Entry

◎	High
○	Medium
△	Low
◎	9
○	3
△	1

Resources needed	21	19	13	10	9	21	15	Total
Capital investment	◎	△	△	△	○	○	○	21
Staff time		◎	◎	◎		◎	◎	48
Training time		◎	○		○	◎	○	27
Space	○							3
Equipment availability	◎							9
	Increase monitor size	Menu driven	Improve prompts	Increase size of type	Colour code forms by prod. groups	Shorten 11-digit prod. code	More obvious diff. among prod grp. codes	
People Purchasing	○				○			6
Software		◎	◎	◎		○	○	36
Hardware	◎	○	○	○				18
MIS	○	○	○	○		◎	◎	30
HRD					△			1
Distribution						△	△	2
Production	△	△	○	△	◎	○	○	21
								Total

◎	Prime responsibility
○	Secondary responsibility
△	Kept informed

TOOLKIT 5

Identifying Sales Product Families

Introduction

A sales product family is a grouping of products which are sold to a particular set of customers. For many companies sales product familys will already exist, probably in the form of the order book or catalogue of products grouped by product family. If this data does not exist the following guide may be used to group individual products into families.

Grouping into product families

If no grouping exists, and assuming the company is not a jobbing shop, then a simple method of grouping involves:

- Listing all standard products;
- Finding natural groups. Most groupings are achieved by size or by functionality and features.

Examples of natural groups are given below:

1. **Functionality**. For example, a machine tool manufacturer might group all his products by function ie, turners, borers, drills, mills etc;
2. **Size**. For example, a car engine manufacturer might group by engine size ie. 1300cc, 1600cc, 2000cc etc;
3. **Market Segmentation**. For example, car manufacturers group according to small cars, middle range, executive and family cars;
4. **Material**. A wire manufacturer might differentiate firstly on the type of metal eg. steel, copper etc. and then on its features eg strength, brittleness, etc;
5. **Volume**. In some cases volumes may be a useful means of grouping. If a company manufactures only one simple product, with minor variances, then those products that are sold in high volumes can be differentiated from those that are more specialised.

TOOLKIT 6

Using the $IDEF_0$ Process Modelling Tool

Introduction

In order to provide a basis for incremental and radical change in any organisation it is necessary that some comprehensive effort be made to analyse existing processes. This may best be achieved through the development of a process model. A number of possible modelling tools exist which could be used at this stage. The most well-known tools include flow charting, Role Activity Diagrams (RADs) and $IDEF_0$. This Toolkit will describe the most widely used of these, $IDEF_0$, and its application in analysing a process in a manufacturing company.

$IDEF_0$ models are useful in identifying areas for improvement in three main ways. Firstly, they act as a means of understanding the process. Secondly, because of the hierarchical nature of $IDEF_0$ the models are useful in communicating this understanding of the process to senior executives. In essence, because $IDEF_0$ insists on consistency amongst levels yet allows for abstraction of terms, the models can be shown to strategic meetings where radical re-engineering decisions are made. Thirdly, the models allow an analysis of the process to take place.

The principal strengths of $IDEF_0$ are, firstly, that it is a tool designed for modelling processes and is relatively easy to use (though more difficult than flow charting). In addition, it uses a structured set of guidelines based around hierarchical decomposition, with excellent guidance on abstraction at higher levels. If used well this ensures good communication and facilitates the adoption of a systems perspective.

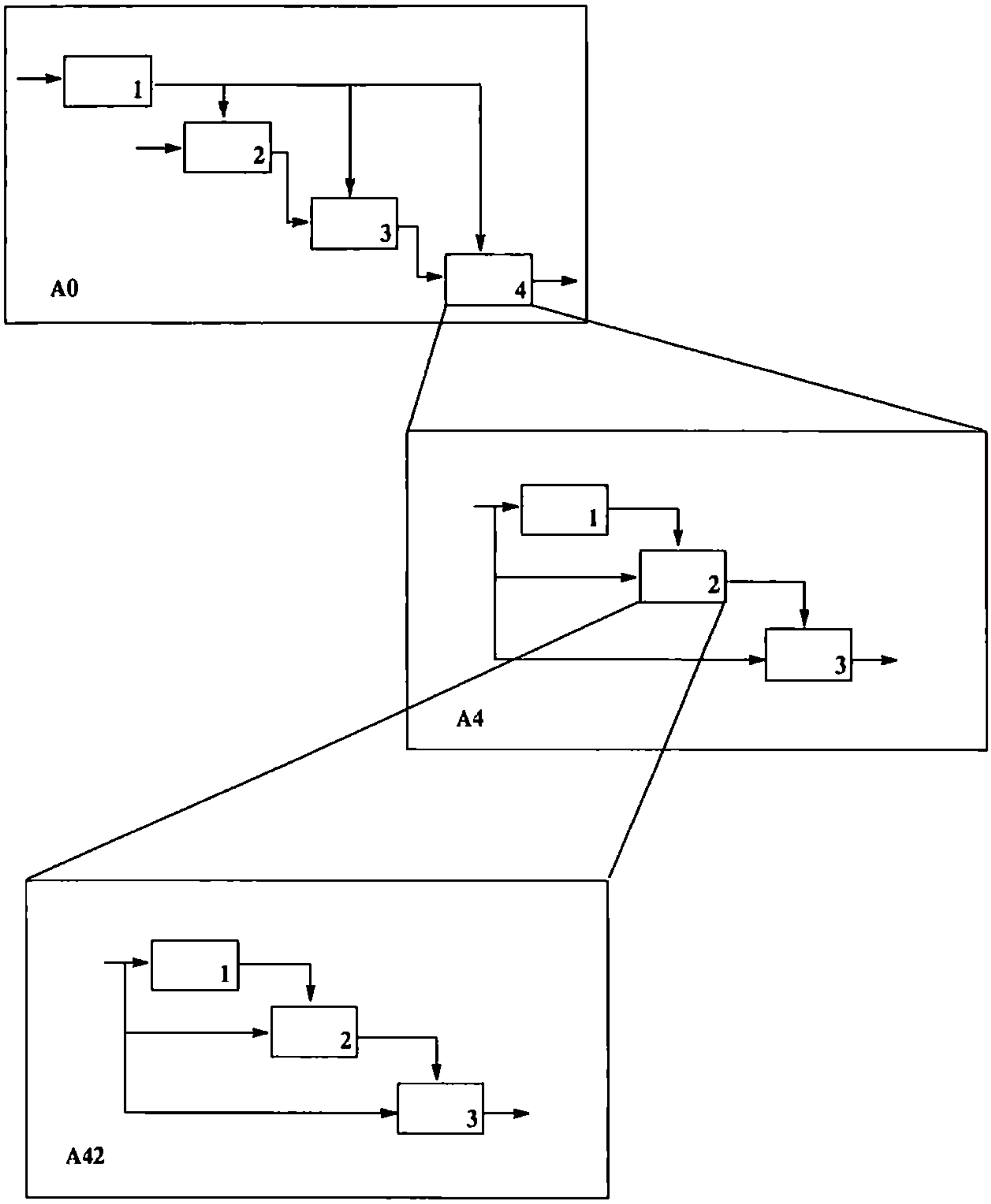
The ICAM Definition Method

$IDEF_0$, the *I*CAM *Def*inition method, is widely used in the manufacturing sector for modelling processes. It was developed by SOF'TECH for the US Air Force's ICAM (Integrated Computer Aided Manufacturing) programme. ICAM was established to improve the productivity of aerospace contractors through the systematic application of computer technology. The programme, which began in 1977, was initially aimed at sheet metal fabrication and has received funds in excess of $100 million. $IDEF_0$ comprises:

- A set of methods that assist in understanding a complex subject;
- A graphical language for communicating that understanding;

- A set of management and human-factor considerations for guiding and controlling the use of the methodology.

Figure 5: Top down decomposition in $IDEF_0$



As Figure 5 indicates, $IDEF_0$ uses top-down decomposition to break-up complex topics into small pieces which can be more readily understood. An $IDEF_0$ model is an ordered collection of diagrams. The diagrams are related in a precise manner to form a coherent model of the subject. The number of diagrams in a model is determined by the breadth and depth of analysis required for the purpose of that particular model, although three is felt to be a reasonable minimum (for below a diagram of two can usually be incorporated into a higher level diagram) and six as a maximum because of individual cognitive limitations. At all times the system and the relationship of any part of the whole remains graphically visible.

The graphical language of $IDEF_0$ uses boxes and arrows coupled together in a simple syntax. See Figure 6.

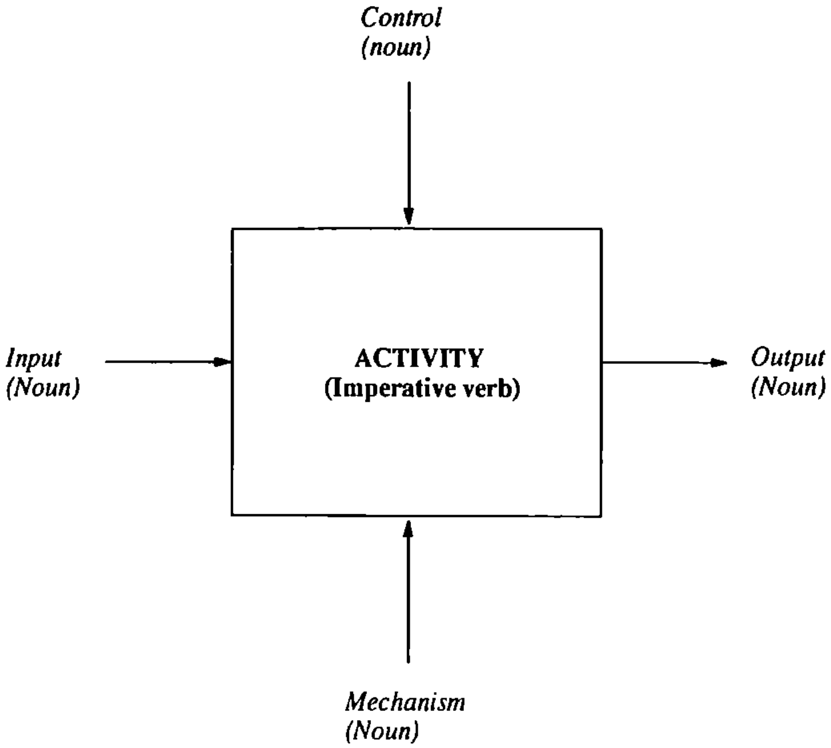
In outline, the $IDEF_0$ process modelling tool enables firms to derive a clear understanding of:

- What activities are required to carry on the business;
- What inputs are being transformed into outputs;
- What influences, controls, regulates or constrains these activities;
- By what means the activities are performed.

Boxes on a diagram represent activities. The arrows that connect to a box represent real objects or information needed or produced by the activity. The side of the box at which an arrow enters or leaves indicates that the arrow is either providing an input to or an output from the activity, or that it represents a constraint/control upon the activity.

Incoming arrows (which are shown on the left and top of the box) show the data needed to perform the activity. Outgoing arrows (right of the box) show the data created when the activity is performed. An input is converted by the activity into the output. A control describes the conditions/circumstances that govern the transformation. The arrow which appears at the bottom of a box indicates the mechanisms or means (for example, department, person, device or computer model) used to carry out the activity.

Figure 6: The $IDEF_0$ Modelling Notation



$IDEF_0$ rules

$IDEF_0$ has a number of relatively simple rules, the most important of which are:

- Every box must have a control;
- Only one diagram is allowed per page;
- The minimum number of boxes per diagram is 3 and the maximum is 6. Three is felt to be a reasonable minimum (a diagram of two can usually be incorporated into a higher level diagram) and six a maximum because of individual cognitive limitations.
- Activities must be described using a combination of nouns, adjectives and *imperative* verbs;
- All arrows must be clearly labelled;
- Arrows may join or split;
- Arrows may be combined at higher levels and decomposed at lower levels;

TOOLKIT 7

Aggregating Design Solutions

Introduction

A sound method of assembling individual resource solutions into aggregated design capability solutions is to assign solutions to specific functional areas, for example, sales order processing, research and development, design, production planning, production control, manufacturing operations, quality, purchasing, data processing and personnel.

The individual responsible for each functional area considers each solution in turn to assess its affect on their area of responsibility. Where solutions affect resources at their disposal these are put to one side for further consideration.

Having identified all the solutions affecting their area of responsibility the solutions are grouped into specific types of solution which relate to a particular subset of resources.

A number of examples illustrate this process:

Design

- Redesign for manufacture;
- Develop new products;
- Improve product features;
- Reduce design cycle time;
- Value engineering.

The above illustration, which is by no means comprehensive, shows the type of solutions which might be grouped together for consideration as an aggregated solution. In practice, after this first attempt further refinement could take place. Take for example solutions relating to purchasing. Such solutions might be further refined into:

Purchasing

- Renegotiate contracts;
- Identify new suppliers;
- Speed up order release.

After these iterations each solution track should be reexamined to check that all the solutions which could be considered as a track have been considered.

Solutions which cannot be placed on a solution track should be listed and considered as solutions requiring discrete actions in Phase 4, Action Planning.

TOOLKIT 8

Checklists for Effective Management of Product Design

The Management of Design

Electronics product design is a process which *must* be managed since new product development in the modern competitive context can no longer be undertaken successfully using the previously tolerated, essentially haphazard approaches. It is vital, therefore, that senior executives of electronics companies drive the product development process, including its design aspects, and that they ensure the process is effectively managed.

The British Standards Institution (BS7000, 1989) stipulates that the control of engineering design projects should occur at three levels:

1. The management of product design at a corporate level;
2. Managing product design at project level;
3. Managing the design activity itself.

Managing design at the corporate level

At the corporate level, effective product design requires the establishment of precise and, where possible, quantified corporate objectives which should be communicated to and understood by all concerned. Design management also involves the production of a number of plans, for example, a business plan, a product plan and a resource plan, and it requires the establishment of a set or organisation-wide policies covering such areas as design protection, product liability, recording design data and engineering change control.

The following is a check list for senior management:

1. Define, and periodically redefine, the corporate objectives;
2. Make the objectives known and understood by all involved;
3. Ensure that the chosen product plan is compatible with corporate objectives;
4. Provide resources to match the product plan;
5. Ensure that the organisational policies and procedures are adequate;
6. Ensure that those responsible for design have clear objectives, are personally motivated and motivate their staff;
7. Ensure that achievement and expenditure are monitored against time;

8. Maintain a sincere and visible commitment to high standards of product design;
9. Evaluate achievements and communicate this evaluation to all concerned.

Managing design at project level

At the project level it is important to establish project objectives, to develop project plans and to create a project control regime aimed at bringing each project to a successful conclusion.

The following is a check list for the project manager:

1. Ensure that a product is defined that will meet the corporate plan;
2. Organise the preparation of the design brief, ensuring a wide enough spectrum of interests involved. Modify when necessary;
3. Allocate budget and control expenditure and organise cash flow;
4. Ensure that programmes integrate the efforts of all functions, monitor progress and take remedial action when necessary;
5. Ensure that the resources of all functions are adequate or made adequate to meet the programme;
6. Ensure that the project organisation is adequate and that any variations from normal are made known;
7. Control external communication;
8. Keep senior management aware of achievement and expenditure against time;
9. Organise the evaluation of the project and the management of the project.

Management of the design activity

The management of the design activity itself involves ensuring that the product design meets the design brief, that the necessary resources are planned and deployed and that the design process - from concept to realisation - is implemented and controlled.

The following is a check list for the design management:

1. Participate in the formulation of the design brief to ensure it is practical and adequately defined;
2. Provide adequate design resources to meet the programme;
3. Ensure that design skills are reviewed and updated by suitable training and that all design supervisors have general management training;
4. Ensure that the organisation, procedures and information services are adequate and updated as required;

5. Divide the tasks among the designers, ensuring that the individual and overall requirements of the brief are clear;

6. Motivate all staff;

7. Monitor the success in meeting the brief by means of the design review and negotiate changes to the brief when necessary;

8. Ensure action is taken on service experience;

9. Monitor achievement of cost against time:

10. Contribute to the evaluation of the project;

11. Evaluate the design and quality procedures and improve these as necessary.

TOOLKIT 9

Checklist for Effective Product Design Operations

Introduction

Operational activities may be classed as those which are directly concerned with satisfying the requirements of the internal or external customer. These are sometimes referred to as "core" activities because they add value by acting directly on the flow of business.

In engineering design terms, these operate activities essentially comprise the design both of the product and the process used in its manufacture. They also comprise the set of methods, tools and techniques used by engineers during the process of product design, for example Concurrent Engineering, Quality Function Deployment (QFD), Design for Manufacture and Assembly (DFMA) and structured brainstorming.

This checklist proposes that the design of an electronic product should typically follow a chronological sequence consisting of four phases:

Phase 1. Product concept generation (Diagram 1);

Phase 2. Product solution generation (Diagram 2);

Phase 3. Product development (Diagram 3);

Phase 4. Product validation.

In the sections which follow, TOOLKIT 9 will demonstrate diagramatically the contents of each of these phases and provides a checklist for each phase which may be considered by participants in the *AGILITY* process.

PHASE 1: Generate Product Concepts

The outcomes of new product processes are largely decided in those early stages of the new product process which precede the actual development of the product. This is especially true of the concept and solution generation phases of the process. However, Western companies typically devote most corporate product development resources to the middle and back-end stages while the pre-development activities which determine product success and failure are poorly resourced and carried out.

It is therefore important that managers resist the temptation to by-pass these crucial stages in order to move an ill-defined and poorly investigated project into development. The establishment of a series of strong release gates is a quality control mechanism on the product development process which ensures that all essential tasks have been completed, that their execution is sound and that the project is still viable. Each release gate also charts the path forward for the next product development phase.

Gates are key points at which the business operation, the risk and the project are evaluated and, where necessary, adjusted. They should be placed at those points in the evolving product design process where the creation of results or the degree of definition or the rate at which staff become more knowledgeable do not rise constantly as a function of time, but exhibit some static periods.

Each release gate should have its own set of measures and criteria for passing the gate and which deal with various facets of the project. Such measures and criteria include:

- Does the project continue to make economic and business sense?
- Have the essential steps been completed -- those steps or activities necessary to pass through the gate? Is the quality of execution of these activities adequate?
- Is the project on time and in budget? Have the milestones been hit?
- What steps or tasks need to be undertaken in the next phase or stage of the project. What milestones, dates and budgets need to be attached to these tasks?
- What are the consequences of stopping the project? What are the consequences of continuing?
- Have all project decisions been noted?

This checklist assumes that most electronic equipment is made, and usually designed, by a supplier for a customer who is, or represents the user. The specification comes from the user when he/she wants equipment designed in a bespoke manner, as opposed to buying it off-the-shelf. The fact that both the supplier and the customer may be large or small organisations, or even groups of similar firms, clearly indicates that different types of specifications will be required, each of which will involve different amounts of user design effort.

Generate Product Concepts

ACTIVITY 1: Formulate Customer Product Requirements (CPR)

- It is crucial to develop an unambiguous product requirements definition because, among other things, the specification language used can present major difficulties.
- The accuracy of decomposition of the specification into marketing, purchasing, engineering and production aspects must be checked and requirements prioritised according to customer importance.

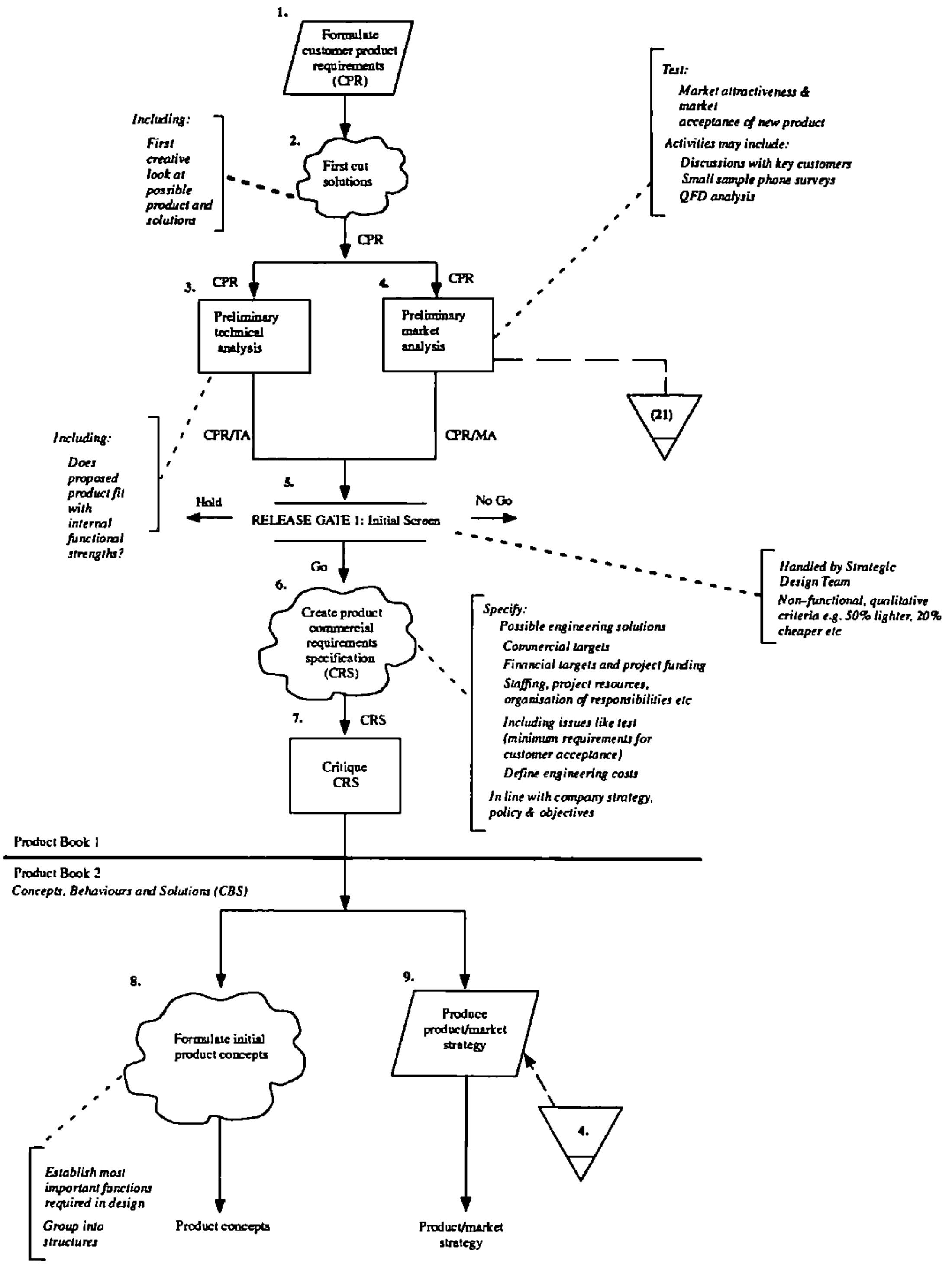
- Customer acceptance and test requirements must also be defined at this stage.
- The customer should take considerable care in specifying product requirements. This may be accomplished by thinking in terms of deliverables and by ensuring that specification document statements are prefixed with **MAY/MAY NOT** and **MUST/MUST NOT**. In order to ensure agreement between the company and its customer, it is prudent to eliminate any degree of flexibility from the requirements generation process.

- ACTIVITY 1 should also lead to the establishment of a set of principal design criteria.
- In seeking to develop an understanding of customer requirements and to remove ambiguity from the CPR document, the company's first task should be to check whether the CPR is legally binding. A CPR may be couched in legal terms and will have to be carefully examined to determine the document's business, engineering and manufacturing implications. Since any misunderstandings of the CPR will undoubtedly cause significant problems later, company lawyers must be given the opportunity to annotate the CPR, highlighting significant legal phraseology.
- Having been passed by the legal department, the CPR should then be analysed by senior personnel from marketing, design, production, test and purchasing. Where appropriate, the team should also be able to call upon industrial design expertise.
- The primary purpose of understanding the CPR is to identify those requirements which might:
    1. Prevent implementation;
    2. Require a longer development period than is available;
    3. Cause design/production difficulties;
    4. Limit production volumes.
- The deliverable from ACTIVITY 1 is an agreed Customer Product Requirements document.

ACTIVITY 2: First cut solutions

- Once the new product has been agreed, it must be assessed technically and commercially in order to determine whether it can be sold, designed and engineered and manufactured to the customer's requirements.
- ACTIVITY 2, which is the company's first creative look at possible product solutions, thus constitutes the first step in the conduct of a Feasibility Study. The overall objective of the study is to acquire sufficient information upon which to base investment decisions. If it can be demonstrated that the proposed product has a high probability of commercial success, effort

Diagram 1



should then be directed at generating the product Commercial Requirements Specification (CRS) -- a detailed business proposal. This takes place during ACTIVITY 6 below.

- The first cut solutions will tend to be "back of the envelope" sketches and calculations which provide preliminary data on significant aspects of the proposed product. They should take into account the known state of the art of the technology, the perceived market need and the technological capabilities of the company itself. They might also take account of relevant competitor activity.

- Any Feasibility Study must have both a technical and a marketing dimension. These are provided by ACTIVITY 3 and ACTIVITY 4 respectively.
- The deliverable from ACTIVITY 2 is a set of preliminary solutions to the customer's specified product requirement.

ACTIVITY 3: Preliminary technical analysis

- ACTIVITY 3 (Preliminary technical analysis) and ACTIVITY 4 (Preliminary market analysis) take place in parallel with each other. While interaction may take place between those personnel carrying out the preliminary technical and market analyses, 90% of communication is likely to be informal and meetings should be scheduled to facilitate knowledge sharing.
- Examine the CPR in respect of design and manufacture feasibility. Detailed and practical engineering and design procedures should be created and evaluated in order to assess whether the requirements specified in the CPR can be achieved using available or accessible technology, at an acceptable cost and with sufficient speed to take advantage of a known time-to-market "window of opportunity".
- Assess company "capability" in respect of design and manufacture, in order to determine the extent to which the proposed project fits with internal company strengths. Evaluate the firm's ability to complete the project on time and within budget.
- Undertake some detailed design work, in the form of practical tests and experiments, but only sufficient to determine what is technically possible and useful, what practical limitations exist and what design procedures are best.
- Any product partitioning (hardware, software, firmware, mechanical etc) undertaken here will not be binding upon the project, but recommendations would be appropriate. A more detailed analysis, which occurs after the CRS/A document has been released (ACTIVITY 7), is used to provide a more definitive partitioning of the product into its hardware, software and mechanical elements and to provide a detailed risk analysis of the project.
- On a bespoke product, the technical people must liaise with their counterparts in the customer company in order to discuss the finer points of the technical specification proposals.
- The deliverable from ACTIVITY 3 is the CPR/TA document. This provides the technical input to the overall Feasibility Study.

ACTIVITY 4: Preliminary market analysis

- Marketing inputs should play a key role right from the outset of the project. Preliminary market analysis constitutes an early and inexpensive step designed to test the market attractiveness and market acceptance of the new product. However, the process of assessing the market attractiveness of the embryonic product is complicated by the absence of a tangible object.

- This problem can be addressed using desk research techniques involving the collection and analysis of published market data. However, the establishment of dialogues with customer companies is probably a more useful and reliable method of undertaking a market assessment exercise. It is therefore essential to ensure that ACTIVITY 4 is not simply left to staff in the marketing department.
- Estimates are required of:
    1. Total size of the market
    2. Market share
    3. Product life span
    4. Probability of commercial success
- Some evaluation should be made of existing and potential competitive threats. In fact, competitive analysis should be an on-going and vital part of a company's strategic planning process. This is not to say that the product development team should suddenly be expected to make a "cold start" at assessing competitor products, prices, costs, technologies, production capabilities and capacities and marketing strategies. It should rather be the case that such corporate information is fed into the design process at this stage with appropriate team members being tasked with fine tuning the analysis with respect to the product under consideration.
- The technological environment also requires close attention not only because of its evolutionary impact on existing products but also because many innovations are introduced from outside a traditional industry. This study also suggests that replacement technologies may emerge and develop while companies using the old technology are lulled into complacency by near term prosperity.
- Thorough analysis of a firm's customers and non-customers is a vital, but often undervalued strategic activity. However, it should go beyond attempting to devise ways of getting the customer to repeat or expand an order and should reveal emerging technologies, competitive advantages and disadvantages and new product ideas.
- Other areas which need to be monitored, but which do not directly concern us here are the economic, political/regulatory and social environments.
- Relevant technical information produced during ACTIVITY 3 can be used to assist the market assessment process.

ACTIVITY 5: RELEASE GATE 1 — Initial screen

- An initial screen allows an independent, company-level audit of the viability of the project. Failure to carry out such an audit could result in the company undertaking an unprofitable project. The most common problem encountered here will be that of "wandering goal posts" caused by changing customer requirements as the incomplete specification evolves. It is vital to avoid proceeding without fully agreeing the customer's needs.
- It is at this point that decisions are first made to commit resources to a project.
- It is always tempting to cut corners on the company-level audit, or even to avoid carrying it out entirely, particularly where the project team is working to tight deadlines. However, the cost implications of failing fully to complete the initial screen will only be understood much later in the design process and at stages where significant real costs are already likely to have been incurred.
- It is worth pointing out that this audit activity is traditionally one of the most weakly executed in the product development process. In particular, the GO/KILL/HOLD decision nodes are poorly executed in most firms and omitted altogether in other areas.
- The initial screen should be carried out by senior company management personnel up to Board level, and should be based on a standardised list of screening criteria. These should be largely non-financial and based upon a number of "must meet" and "should meet" criteria. Examples of such criteria include: 50% lighter, 30% cheaper and 25% improvement in development time.
- If a NO GO decision is taken, a decision must be made by senior technical management to either iterate (by seeking clarification or further information) or call a halt to the project.
- If the project is allowed to continue, a dispassionate assessment of the current state of the project and its documentation may be needed.
- Project viability measures should be continuously reviewed to ensure they are in line with overall company objectives. The decision to proceed on a project should be based on the assessment of such information as:

    1. The recognition of a market requirement;
    2. The proposal of a specification for a product;
    3. The evaluation of the proportion of the available market lost to the competition;
    4. The evaluation of how many of the specified products would be sold and over what period of time
    5. The evaluation of the design and production introduction costs;
    6. The availability of resources;

7. The evaluation of the timescale leading to the first and subsequent production models;
8. The accuracy of the above data i.e. the risk factor.

- If any of the above data were to change, it might be concluded that the project was no longer viable. It is therefore necessary to continuously or frequently review the basic data and, in the event of change, to reassess the viability of the project.

ACTIVITY 6: Create Product Commercial Requirement Specification (CRS)

- Translate the customer's product requirements, as defined and agreed in the CPR, into an internally understood technical specification and business proposal which the company can use as the basis for proceeding with actual product development.

- Document such factors as specific engineering cost requirements (definitions of sizes, power consumptions, speed of operation and so on), levels of funding, estimates of manpower requirements, project timescales and company objectives. This will allow the enterprise view of the product development project to be easily understood by readers of the CRS document.

ACTIVITY 7: Critique CRS

- Ensure that the CRS (product development business proposal) is correct and that the development of the specified product will not make unreasonable financial, technical and human resource demands upon the company.
- Prevent incomplete, ambiguous or contradictory requirements from being enshrined in the CRS.
- Test the commercial product specifications against company knowledge derived from past projects (assuming such knowledge has been captured and can be made available in meaningful format) as well as in relation to the personal "know-how" of those who will be called upon to implement the terms of the CRS once it has been approved.
- The documented output from this analytical activity will consist of an internal interpretation of the CPR and, hence, part of this activity will involve comparing the agreed CPR requirements with those set out in the CRS. Every effort must be made, at this point, to ensure that **all** CPR requirements are faithfully mapped across to the CRS.
- If the contents of the CRS are approved, the latest copy (dated and revision controlled) of the document and attached appendices should be released to all relevant personnel. A check should be made to ensure that the internal mailing list is correct.
- If the CRS is rejected, the company must seek to understand the cause of the failure. If the problem lies with the CRS itself, the team should convene as per ACTIVITY 6, Create Commercial Product Specification. Similarly, if the CPR is deficient, the team must consult with the customer in order to resolve any problems.

ACTIVITY 8: Formulate initial product concepts

- At this stage, two things must happen in parallel: a set of initial product concepts must be formulated and, using this information, together with information produced during ACTIVITY 4 (Preliminary market assessment), a product/market plan must be produced.
- The design team must attempt to generate new ways of solving new and possibly old problems. To do so, it must take a structured look at the product beyond those attributes specified in the CPR and CRS. This may be the first time specific function details are laid down. The reason for this is that commercial and customer requirements may not go into detail over how to achieve specific product facilities. So, for example, the CPR and CRS may

just say "must have magnetic data reader", but not suggest any conceptual, behavioural or circuit solutions.

- A number of tried and tested "ideation" and creativity enhancing techniques may be applied here and the results analysed in **ACTIVITY 10: Analyse concepts** below.
- Concept formation should not just be limited to the function of the product, but to the way in which it could be manufactured and tested.
- Depending on the make-up of the design team during this activity and **ACTIVITY 12: Develop behavioural solutions**, the concepts which emerge from this activity may contain aspects of behavioural solutions. The object of separating these two concerns is not to prevent this type of "mixed mode" thinking, but to prevent a diversion of energy from ideation to behavioural modelling.

ACTIVITY 9: Produce product/market strategy

- A product/market strategy for a business addresses four issues:
    1. What products will be offered (breadth and depth of the product line)?
    2. Who will be the target customers (boundaries of the market segments to be served)?
    3. How will the products reach those customers (distribution channels to be used)?
    4. Why will the customers prefer our products to those of competitors (distinctive product attributes)?
- Once a set of initial concepts has been produced, it is appropriate to begin the creation of a product/market strategy which addresses these issues. The strategy should, in particular, define an appropriate set of Innovative and Variant products. It should also specify the frequency of new product introductions.

Generate Product Solutions

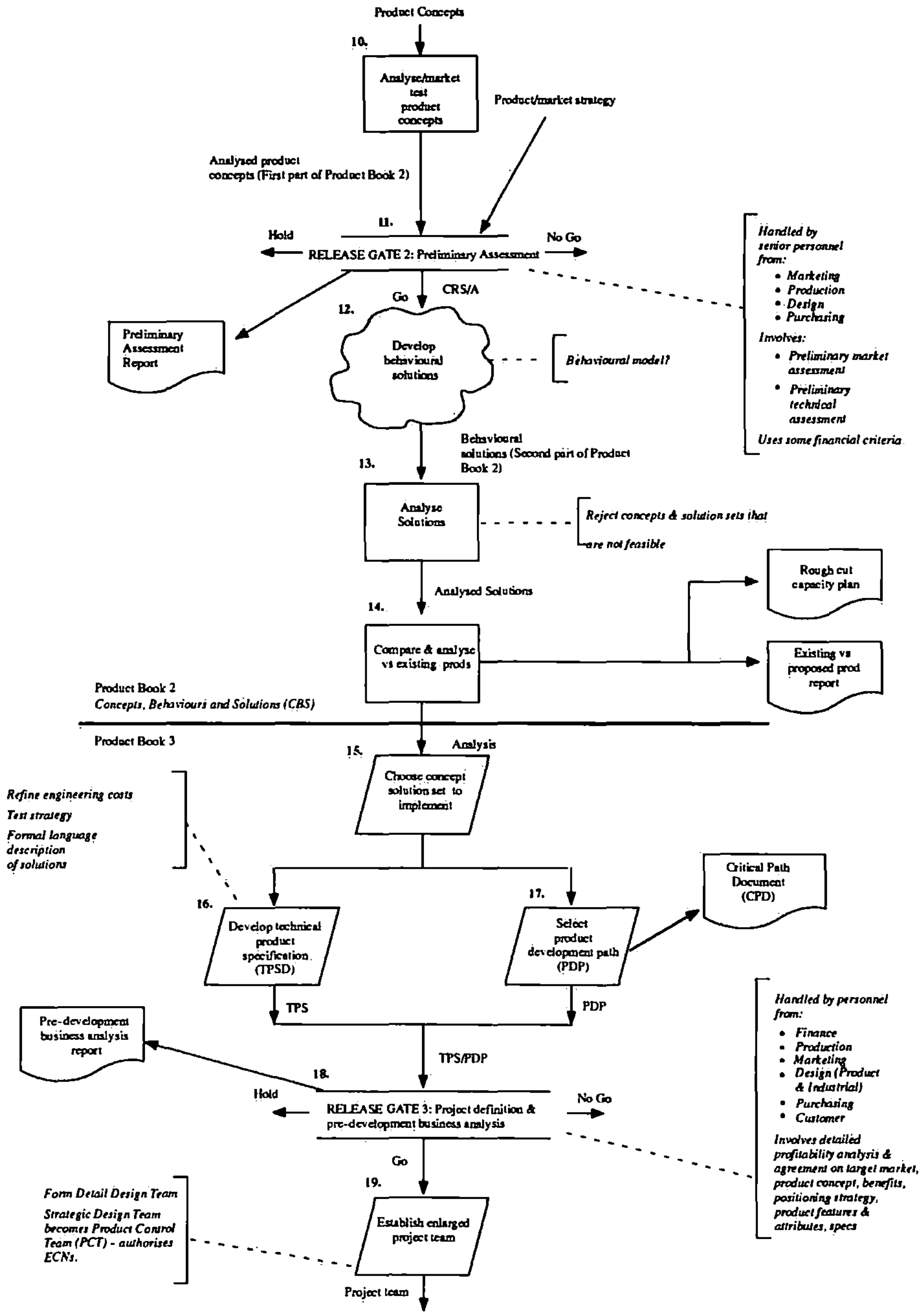
ACTIVITY 10: Analyse/market test product concepts

- This activity should be carried out by the same design team that created the initial concepts. The resulting ideas should then be "fleshed out" in terms of behaviour or even circuit description if required in ACTIVITY 12 (Develop behavioural solutions). QFD may be used in order to ensure that the product concepts formulated above are compatible with the customer requirements.
- Although it is tempting to develop the behavioural solutions here, ACTIVITY 10 is only necessary as a stepping stone to ACTIVITY 12 (Develop behavioural solutions). The only criteria used here are those of "structural integrity", such that each set of conceptual ideas

proposed as possible ways of achieving the CRS should be logically sensible. Any options that have not been defined sufficiently to allow this level of scrutiny should either be rejected or a decision made to explore the concepts in more detail.

- ACTIVITY 10 also involves testing the proposed product with customers (either in focus groups of larger sample surveys) to determine likely market acceptance. Despite the fact that the product is not yet developed, a model or representation of the product can be displayed to prospective users to gauge reaction and purchase intent. Information gained from the market test should be included in Product Book 2.

Diagram 2



Product Concepts
10.
Analyse/market test product concepts
Product/market strategy
Analysed product concepts (First part of Product Book 2)
11.
Hold
RELEASE GATE 2: Preliminary Assessment
No Go
Handled by senior personnel from:
• Marketing
• Production
• Design
• Purchasing
Involves:
• Preliminary market assessment
• Preliminary technical assessment
Uses some financial criteria
Go
CRS/A
12.
Preliminary Assessment Report
Develop behavioural solutions
Behavioural model?
Behavioural solutions (Second part of Product Book 2)
13.
Analyse Solutions
Reject concepts & solution sets that are not feasible
Analysed Solutions
14.
Rough cut capacity plan
Compare & analyse vs existing prods
Existing vs proposed prod report
Product Book 2
Concepts, Behaviours and Solutions (CBS)
Product Book 3
15.
Analysis
Choose concept solution set to implement
Refine engineering costs
Test strategy
Formal language description of solutions
Critical Path Document (CPD)
16.
17.
Develop technical product specification (TPSD)
Select product development path (PDP)
TPS
PDP
Pre-development business analysis report
TPS/PDP
18.
Hold
RELEASE GATE 3: Project definition & pre-development business analysis
No Go
Handled by personnel from:
• Finance
• Production
• Marketing
• Design (Product & Industrial)
• Purchasing
• Customer
Involves detailed profitability analysis & agreement on target market, product concept, benefits, positioning strategy, product features & attributes, specs
Go
19.
Form Detail Design Team
Strategic Design Team becomes Product Control Team (PCT) - authorises ECNs.
Establish enlarged project team
Project team

ACTIVITY 11: RELEASE GATE 2 — Preliminary Assessment

- ACTIVITY 11 repeats RELEASE GATE 1 (ACTIVITY 5) but, in this case, evaluators have better market and technical information. Development and manufacturing financial criteria can be introduced at this gate as well.
- This activity is an audit on activity completion prior to this point and a resumé of the potential project risks. It seeks to avoid committing cash and manpower to a non–viable project.
- A good specification is essential to project success. In order to recognise correctly the state of progress of a project, it is necessary to:
    1. Verify the specification is explicit and complete.
    2. Verify that the equipment, subassemblies and components conform to their specifications.
    3. Verify that the product which meets the specification also meets the requirement.
- Where it is discovered that important issues have not been addressed prior to this review, progress of the project must be halted until any oversight has been rectified. This is easy to avoid doing in a project with tight deadlines. However, the cost implications of NOT completing the CRS to company satisfaction will only be understood much further down the line in the design process, at points where real costs will have ben incurred.
- If a NO GO decision is taken as a result of the review, a decision must be made by senior technical management either to iterate (by seeking clarification or further information) or to call a halt to the project. However, where it is decided to proceed, a dispassionate assessment of the current state of the project and its documentation may be needed. This is necessarily a group activity involving all members of the STRATEGIC DESIGN TEAM.
- A company standard for customer liaison should be enacted at this point to discuss the issues raised that are causing delay in the project. Care should be taken in handling one's customers, but a frank exchange of views is always desirable.
- The deliverables from ACTIVITY 11 are a Preliminary assessment report and the CRS/A document (where "A" denotes Appendix).

ACTIVITY 12: Develop behavioural solutions

- The creative team, which may be a different group of people from that involved in the formulation of initial product concepts (ACTIVITY 9), now has to develop an understanding of the possible behaviours of the concepts created above. Currently modelling by simulation or prototyping are the most cost–effective methods available, although formal verification may prove a useful adjunct to these methods in the future.
- The initial solutions should be created by ideation techniques, then substance given to them by proof by simulation, verification or experiment.

- Knowledge gained from this activity should be used to augment Product Book 2: Concepts, Behaviours and Solutions (CBS).

ACTIVITY 13: Analyse Solutions

- At this point in the product development process, there is a need to take an objective look at the wider issues involved. Unless this occurs, the company may limit its perspective to the technology it knows (for example, microprocessors) and may, by reconciling the customer CPR with an existing product, decide to skip most of the previous stages. This state of affairs would inhibit the evolution of company products, a process which should take place as new technologies become available.
- The company must look at the wider implications of solutions, including technical implications. Solutions should be analysed against some criteria which may include assessing the risk involved in "sticking to the technology you know" in order to get to the market faster. However, it is rare for design personnel to know or understand the implications of their decisions on production engineering and if, for example, design staff have worked on the assumption that a process has a poor yield, production must be informed of that fact.
- It is important to accept that solutions not acceptable to the company should be rejected at this point. The seemingly pointless task of creating ideas, exploring solutions (Activities 8 to 12) and then rejecting them is important, however. It prevents the company from becoming narrowly focused in technology and strategy terms because the design team has been forced to take a formal, short term "look over the horizons" at competitors and the market place.

ACTIVITY 14: Compare and analyse vs existing products

- Identify common ground between existing and proposed products in order to reduce design time and manufacturing costs.
- After a series of outward looking activities have established the best sets of solutions for the proposed product (ACTIVITY 3 to ACTIVITY 13), it is now necessary to perform a detailed comparison of these with existing products. Most design engineers will exhibit a natural bias toward existing designs, but prior to ACTIVITY 14 this bias should be kept in check to ensure a careful survey of specification, behaviours and implementation strategies can take place.
- The analyses are technical and financial in nature and should focus on attempting to define the cost of making the proposed product a variant design of an existing product. It may be that one of the options explored at the earlier stages in the design process was exactly this, but the relative costs of each proposed solution set must be calculated and compared.
- Thus a report on why the product is evolving as defined is being recorded by the company during the early development phase, a time when normally documentation is fragmented and held in marketing, design, accounting, purchasing and management files.

- This work would be carried out with the addition of an invited guest, the technical author scheduled to document the product.

ACTIVITY 15: Choose concept solution set to implement

- Narrow product implementation options to one.
- The degree of "sameness" or compatibility with existing products is known, allowing production engineering to give the first estimate of the production scheduling needed when entering the manufacturing phase of the development. The Master Production Schedule (MPS) for the factory may be adjusted or consolidated as necessary, giving a rough cut capacity plan if the project is leading toward a variant, innovative or strategic product development path.
- It is important to note here that this checklist is only concerned with information and activities related to the task of product design. Strategic decisions that significantly alter the product lead times are outside the scope of this model, therefore any impact on manufacturing due to choice of design route and the consequent product lead times are assumed to be normal and achievable.
- Deliverables from ACTIVITY 15 are a rough cut capacity plan and a report on existing versus proposed product.

ACTIVITY 16: Develop technical specification document (TPSD)

- The TPSD is a specification document. Therefore, the chosen block structure, partitioning, timing and other engineering costs must be expressed in tabular and diagrammatic form. This allows a formal consistency cross check of customer requirements and company solutions.

ACTIVITY 17: Select product development path

- Allocate a design path to the project and subsequently perform a critical path analysis of the manpower and development budget requirements, creating the Critical Path Document (CPD) and selecting the Product Development Path.
- There are four paths: *Repeat design*, *Variant design*, *Innovative design* and *Strategic design*. It is important to point out, however, that each of the design paths differs from the others in one major way only: the level of risk involved. Strategic and Innovative designs will involve a company in finding solutions to engineering problems it has never previously experienced. Those solutions may well require the adoption of new design techniques, such as Concurrent Engineering or Design for Manufacture and Test, or they may involve the use of unfamiliar materials and manufacturing processes.
- This task may be performed by a design manager, but the CPD must be part of the body of knowledge reviewed at RELEASE GATE 3 (ACTIVITY 18), to ensure that senior managers understand the implications of the design route chosen.

ACTIVITY 18: RELEASE GATE 3 — Project definition and pre-development business analysis

- ACTIVITY 18 is the critical final gate prior to product development. In addition to the usual evaluation criteria for each project review stage, the company should focus upon reaching agreement on project definition. This will involve consideration of target market, product concept, benefits to be delivered, positioning strategy, product features and attributes and product specifications. The **CRS, TPSD and CPD** are needed for this activity.
- ACTIVITY 18 is a significant stage in the product development project since it requires that commitments are made with regards product development materials, resources and manpower.
- A company standard for customer liaison should be enacted at this point to discuss any issues that are causing delay in the project. Care should be taken in dealing with customers, but the truth must always be given.
- A decision may be made not to proceed with the project where, for example, tight timescales have caused a partial sign-off of the **TPSD** and subsequent approval to commit more company cash to the project before all the risks have been highlighted and approved. Although the **CPD** may be considered by financial management to be the single important review document, the **TPSD** is crucial too, for it is not unknown for mistakes and previously unknown constraints to be uncovered during the translation process from **PCBFC**.
- If NO GO decision is taken, a decision must be made by senior technical management either to iterate (by seeking clarification or further information) or call a halt to the project. An attempt must be made to understand the issues which have caused the failure of the project.
- The deliverable from this review is a pre-development business analysis report.

ACTIVITY 19: Establish enlarged project team

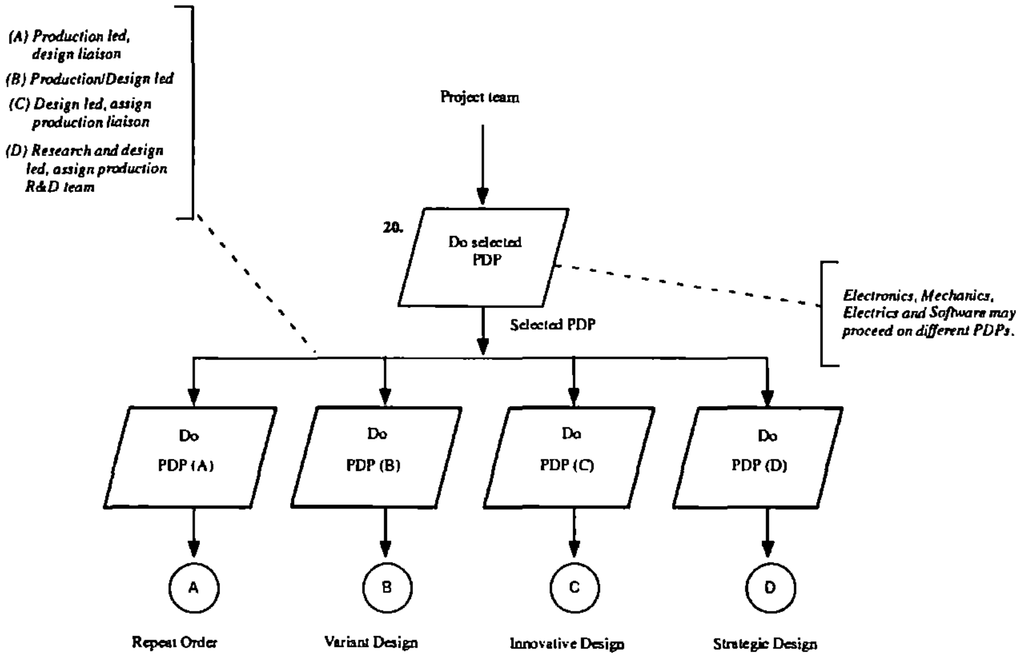
- Repeat Order Design: Production led, design liaison.
- Variant Design: Production/Design led.
- Innovative Design: Design led, assign production liaison.
- Strategic Design: Research and design led, assign production to R & D team.

Develop Product

It is important to understand that there are four main ways of designing an electronic product. Each impacts differently on the company in terms of resources required and the product lead times. Therefore, it is imperative that any new project be categorised in these terms to make explicit the issues of resourcing and product lead time as early as possible in the project itself.

Senior management should recognise the need of all four types of design within the company and adjust company policy, objectives and strategy in line with the four possible design tracks. Additionally, the ability to accurately categorise product development programmes being Repeat Design, Variant, Innovative or Strategic is important and it must be recognised by the most senior management in the company as being so.

Diagram 3



It is unlikely that any real evaluation of the problems of the new development project in these terms is possible until a careful analysis has been made of the proposals and existing product lines already in manufacture. This should be carried out in **ACTIVITY 14: Compare and analyse vs existing products.** Although it may be company policy to only do Repeat Designs and Variant Designs, a long term company view highlight the need for Innovative and Strategic development projects.

Failure to take such a perspective has led to a number of company projects in the U.K. being approached as *development* projects when, in fact, they should have been run as strategic or innovative *research programmes*.

ACTIVITY 20: Do selected PDP

- Start the detailed product design. This point may be reached within a few weeks for a small scale development project, or may require upwards of a year for large scale engineering systems.

PRODUCT DESIGN PATH A: Repeat Design

A Repeat Design project is one which has a near zero percent change to the design or production of an existing product. The key issue is that there is no new knowledge required to implement the design changes, as newness represents uncertainty and risk.

It may seem counter intuitive to have to run through all the above stages just to recognise that the customer can be satisfied with a repeat design of an existing product. However, the reason for this potential route is two-fold, firstly to allow for systems design techniques and secondly for software configuration techniques. Systems design may require parts of existing products to be re-used in new designs and therefore only require making again. It may well be that the configuration of such building blocks is new, however, and the firm will need to carry out the preceding stages of this design process to check and evaluate the problems of the new concept.

Furthermore, with software technology tending to replace hardware and mechanical modules in products, it is now possible, employing existing mechanics and electronics, to create a completely new product function. Only software changes are required to implement the new function. Again, it may become apparent only at **ACTIVITY 15: Chose concept solution set to implement** that software modification of an existing product is a viable option.

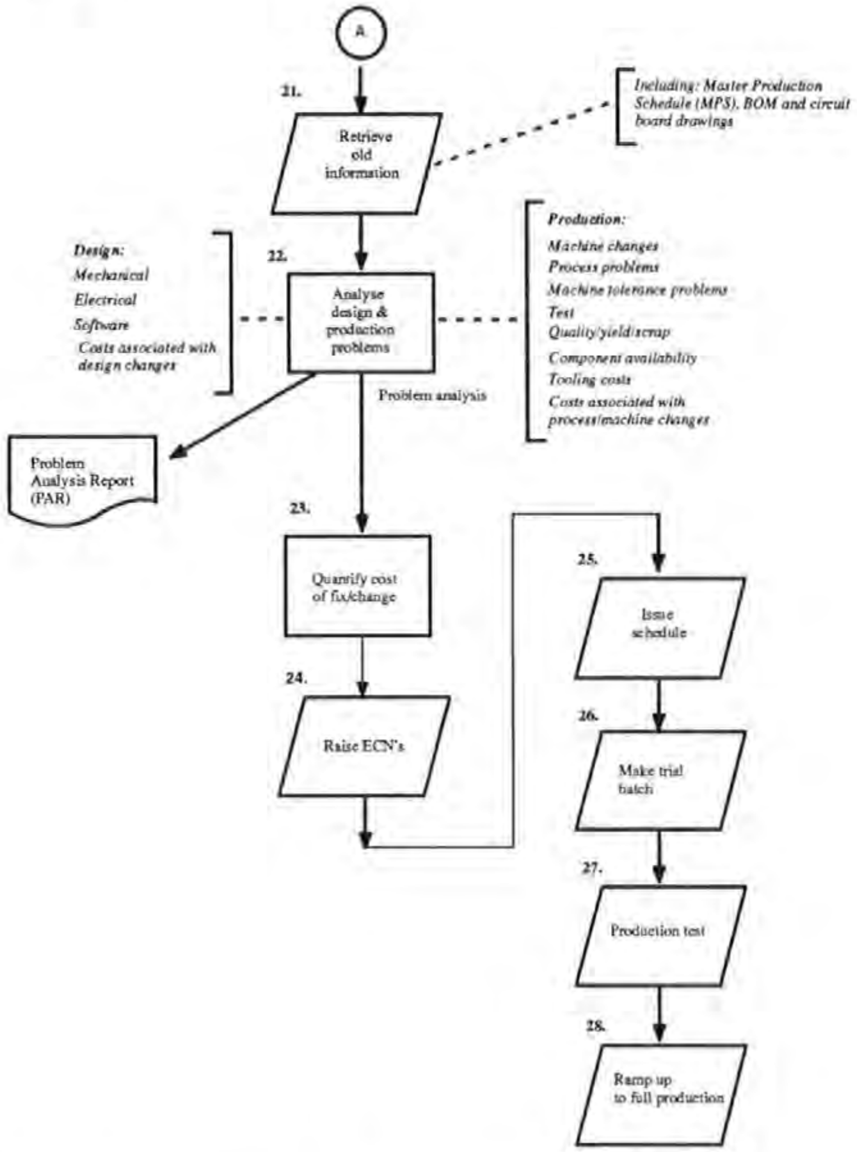
It is debatable whether a software change would entail the company to absorb new design knowledge or not. It is more likely that the design process model would split up at ACTIVITY 19 (Establish enlarged project team), requiring the hardware to follow a Repeat Order route and the software to follow a Variant Design route.

ACTIVITY 21: Retrieve old information

- Investigate modifications and problems outstanding from the last product run.
- Ensure that production information is up to date and stable prior to making the product.
- After having recovered the design and manufacturing information for the product it is appropriate to review the status of the last production run and check that there are no "outstanding" Engineering Change Notes (ECN).

- It is important to have a stable set of information with which to schedule and control production.

Repeat design



ACTIVITY 22: Analyse design and production problems

- Any outstanding ECNs must be attended to and problems corrected prior to manufacture. Design related problems include revision of circuit board to account for wiring changes, component changes and functional faults reported from test and field service.
- Manufacturing-related problems include revision of assembly instructions to account for new equipment, component changes, cost reductions and yield problems from manufacturing test.
- A review of customer feedback reports, field service reports and manufacturing reports for information that may lead to improved efficiency or lower production costs should be carried out.

- Problems, their fixes and costs are reported in the Problem Analysis Report (PAR).

ACTIVITY 23: Quantify cost of fix/change

- Once identified, any change recommended in the PAR must be assessed for cost and impact on deadlines before approval to carry out the changes can be given.
- If the cost of change is too high then if must be referred to a higher authority for approval or dismissal. Since the additional cost may have to be borne by the customer, rather than the company.

ACTIVITY 24: Raise ECNs

- If a problem has been identified, costed and accepted, the change notice paperwork should be raised and distributed to the appropriate personnel for approval.
- If approval is not granted, iterate around the change proposal loop. The reasons for failure here are likely to be business oriented, rather than technology oriented.
- Where the change is approved, make the necessary changes to the production processes. No design work is involved.

ACTIVITY 25: Issue schedule

ACTIVITY 26: Make trial batch

ACTIVITY 27: Production test

ACTIVITY 28: Ramp up to full production

PRODUCT DESIGN PATH B: Variant Design

A Variant design project is one which has up to twenty percent new knowledge in electronics design or production of the new product. There is a need for *speed* and *flexibility* in this area. These requirements can be illustrated by considering the fact that when an aerospace company in the South East developed a new flight simulator they took longer and spent more than they had done for their first generation product. This happened even though the product was almost an exact copy of the first. Company historical data was almost non-existent and key personnel were different in each development project.

Within a product development project there is likely to be varying amounts of work required across the engineering sectors of the company. Therefore, it is likely that the design process model would split up at ACTIVITY 19 (Establish enlarged project team), perhaps requiring hardware to be a Repeat Order, with software and mechanics being treated as Variant designs. If the product needs industrial design (human interface, packaging technology, aethestics), it may even involve some innovation. This would require the firm to follow an Innovative design path for this aspect of the product.

ACTIVITY 29: Retrieve old information

- See ACTIVITY 21 above.

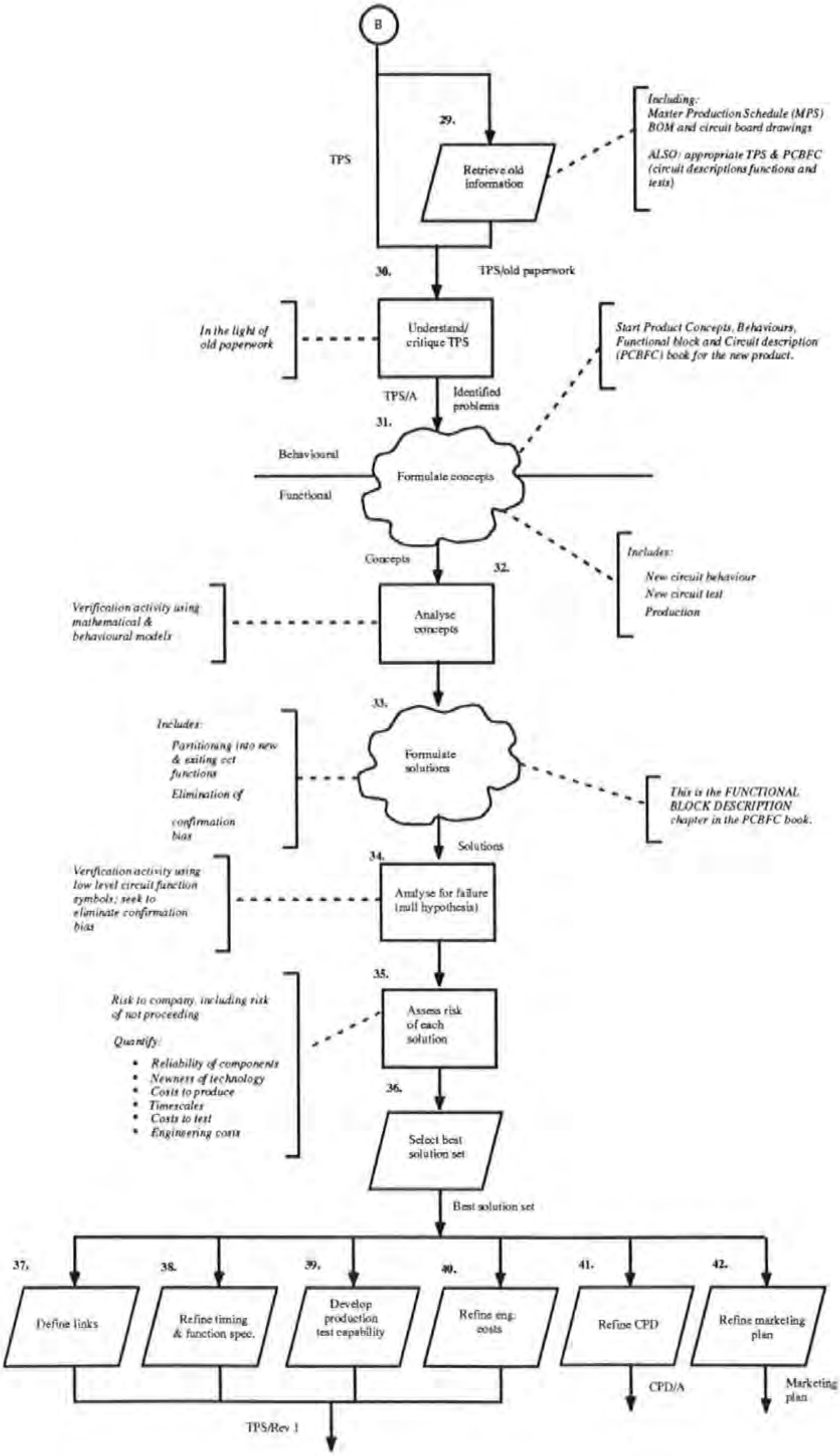
ACTIVITY 30: Understand/critique TPS

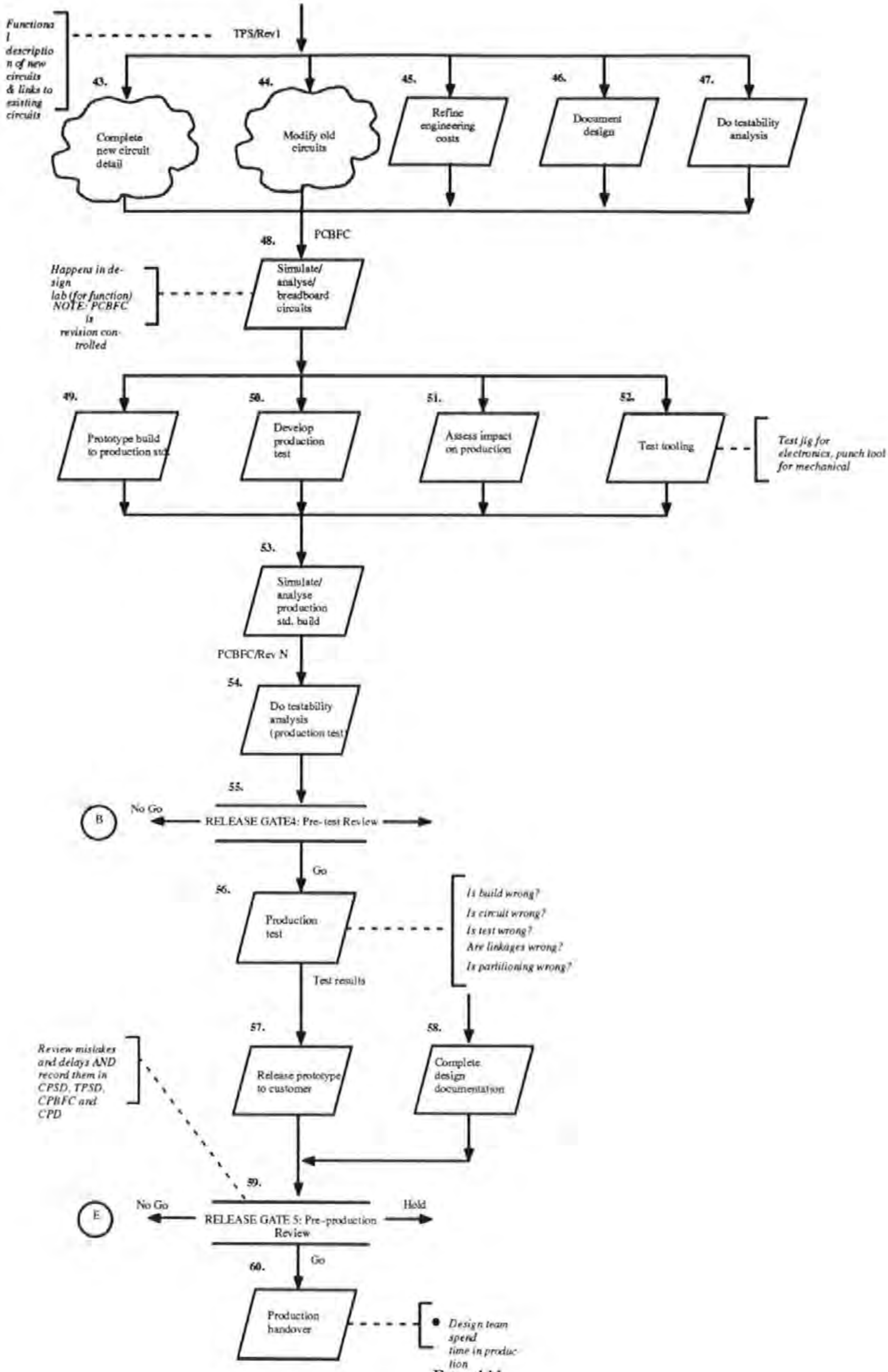
- Since the project team has increased in size to accommodate the work load, the new members of the team will need to repeat the exercise of understanding the TPSD and perhaps questioning some of the specifications defined within it.
- This activity will raise some problems in respect of the functionality of the design proposed in the TPSD. All possible problems should be aired at this juncture and documented as an appendix to the TPSD (the **TPSD/A**). This enables the next creative phase to be carried out in line with a set of clear requirements. ("How are we going to get the required behaviour in the space we know is available and and with the required power consumption?")
- Other aspects of the TPSD may define a particular circuit function or even circuit schematic in detail. The task of the design team in these cases is to check whether this detail actually ties up with the technical specification. In doing so, they are also developing an understanding of the operation of the defined circuits and functions that are relevant to their own specialisations.

ACTIVITY 31: Formulate concepts (Behaviour -> Function)

- Design is a cyclic activity involving innovation/creativity and then analysis/criticism. The customer **CPR**, the new **CRS**, the **TPSD** all involved aspects of this cycle in their creation. As a continuation of this stepwise refinement from abstract to concrete, company engineers should make the transformation of required behaviours to functions.
- The style of partitioning behaviour into functional blocks takes many forms and appears to be guided by prior experience of the engineer. For example, digital engineers with microprocessor design experience will form microprocessor block functions, those lacking this knowledge may attempt to partition the required behaviours into finite state machine automata.
- A summary of the concepts should be appended to the TPSD.

Variant design




Functional description of new circuits & links to existing circuits
TPS/Rev1
43.
Complete new circuit detail
44.
Modify old circuits
45.
Refine engineering costs
46.
Document design
47.
Do testability analysis
48.
PCBFC
Happens in design lab (for function) NOTE: PCBFC is revision controlled
Simulate/ analyse/ breadboard circuits
49.
Prototype build to production std
50.
Develop production test
51.
Assess impact on production
52.
Test tooling
Test jig for electronics, punch tool for mechanical
53.
Simulate/ analyse production std. build
PCBFC/Rev N
54.
Do testability analysis (production test)
55.
B
No Go
RELEASE GATE4: Pre-test Review
Go
56.
Production test
Is build wrong?
Is circuit wrong?
Is test wrong?
Are linkages wrong?
Is partitioning wrong?
Test results
57.
Release prototype to customer
58.
Complete design documentation
Review mistakes and delays AND record them in CPSD, TPSD, CPBFC and CPD
59.
E
No Go
RELEASE GATE 5: Pre-production Review
Hold
Go
60.
Production handover
Design team spend time in production
Page 111

ACTIVITY 32: Analyse concepts

- Ensure that, while other aspects of the TPSD may define particular circuit function or even circuit schematic in detail, all aspects of the design tie up with their development.
- The **TPSD/A** must now be extended to critique each set of concepts.

ACTIVITY 33: Formulate solutions

- A variety of solutions may be formed rapidly at this stage. It is important to generate as many solutions as possible for the same reasons as those presented in **ACTIVITY 9: Formulate initial product concepts** because this allows a broad view of the design to emerge before it is necessary to focus down on a particular implementation strategy.
- The TPSD/A must be extended to include a set of product solutions.

ACTIVITY 34: Analyse for failure (null hypothesis)

- Estimates of circuit speed, size, cost and power consumption may be made at this point. The discussion group should have at least one member playing the role of "devil's advocate" attempting to prove the design will fail. This approach is follows the Null Hypothesis method of scientific theorem proving -- failure to prove the theorem is wrong by implication proves it is right (until proven wrong at a later date!).
- The TPSD/A must be extended to include a critique of each solution set.

ACTIVITY 35: Assess risk of each solution

- Assess the risk to company, including risk of not proceeding. It should attempt to quantify such factors as:
    1. Reliability of components
    2. Newness of technology
    3. Costs to produce
    4. Timescales
    5. Costs to test
    6. Engineering costs
- The TPSD/A must be extended to include a risk analysis of each solution set.

ACTIVITY 36: Select best solution set

- The best solution set is the one which exposes the company to the least amount of risk. It will not necessarily turn out to be the nicest or most elegant solution set. The chosen solution set should be appended to the TPSD as a separate appendix.

ACTIVITY 37: Define links

- Whereas the functional block diagram is concerned with the detailed functional aspects of the circuits, the linking signals are defined in ACTIVITY 37 based upon knowledge of the functional requirements. Digital designs require bus bit widths, control signal names and data structure definition. Analogue designs need voltage and current characteristics of linking signals defined.

ACTIVITY 38: Refine timing and function specification

- A more detailed timing estimate can now be added to the design project knowledge pool.

ACTIVITY 39: Develop production test capability

- As circuits are being defined, it is appropriate to embark on the important task of developing the production test capability.
- The existence of a complete suite of functional block diagrams for the product allows production test engineering to confirm that the original test philosophy has been adhered to. If new production test equipment is being developed, this is the point at which the first detailed analysis of testability may be carried out. However, a bed-of-nails cannot be defined until the circuit wiring boards have been placed and routed. Nor is it possible to assure the correctness of any functional testing.

ACTIVITY 40: Refine engineering costs

- An engineering cost is an aspect of the specification of the circuit that is separate from the functionality required. Engineering costs represent metrics of project success that often relate directly back to the original customer CPR. For example, a customer product requirement could specify that the device must be battery powered and must last at least four hours before recharging. In such circumstances, the engineering costs of power consumption for each circuit in the device must be estimated at early stages in the project to constrain the type of implementation chosen. These estimates must then be refined during the project to ensure that they are not exceeded because a reduced battery life may cause the project to fail even though the device functions perfectly.
- This activity is progressed though the project to completion. Estimates of engineering costs are continuously being refined by all aspects of the work. Cost, speed, power consumption, electromagnetic susceptibility, size of final circuits are but a few of the engineering costs which should be constantly considered and refined.

ACTIVITY 41: Refine Critical Path Document (CPD)

- A Variant project will cause a certain amount of new knowledge to be explored and understood by the design team. Each bit of new knowledge to be absorbed by the company could have a direct effect on the time scale of the project, and thus affect the critical path of the project. Therefore, the CPD must be revised regularly and all delays analysed for impact on the project timescale and profit.

ACTIVITY 42: Refine marketing plan

ACTIVITY 43: Complete new circuit detail

- Functional block diagrams be converted into circuit schematic diagrams. This is a direct application of the basic electronics knowledge schooled into the engineer at college and subsequently enriched by professional experience and training.
- Revision control is an internal matter for the design team, but should be recorded as a matter of course.

ACTIVITY 44: Modify old circuits

- Edit old circuits appropriately to conform to new requirements (a complete understanding of the circuit behaviour is needed to accomplish this).
- Revision control is an internal matter for the design team, but should be recorded as a matter of course.

ACTIVITY 45: Refine engineering costs

- As the circuit schematic diagrams develop a more detailed picture can be formed of the component count, the board area estimates and power consumptions.

ACTIVITY 46: Document design

- Design engineers engaged on the project must keep up to date descriptions of their circuits and the modifications, tests and other salient information.

ACTIVITY 47: Do testability analysis

- Ensure the evolving design is testable and is within the testability philosophy written down in the CRS and TPSD.
- The activities defined here are expected to take place throughout the circuit definition phase of the design.

ACTIVITY 48: Simulate/analyse/breadboard circuits

- The design team should simulate/analyse/breadboard circuits to evaluate function and engineering costs. It is normal to define the input stimulii and to evaluate the internal function by recording the resulting outputs. It is important to trace ones activity during this phase of debugging, to avoid cyclic behaviour and repeated test/modification sequences.
- Depending on the status of the project, this phase of the design may not be version or issue controlled (if early prototyping). Later, if problems are discovered during ACTIVITY 49 (Prototype build to production standard) or during manufacture then redesign and re-work will be controlled by the in-house quality assurance system.
- Errors should be written down to ensure the "why it went faulty" or "why we chose this design route rather than the other route" are recorded for future reference. Company culture and managerial appraisal of engineers should both encourage anonymous reporting of mistakes in a manner similar to the CAA pilot error reporting programme.

ACTIVITY 49: Prototype build to production standard

- Ensure that the device can be made to production tolerances. Not doing ACTIVITY 49 could make it possible for the design and layout engineers ignore manufacturing costs.
- Making to production standard does not mean that the prototype has been made on the production line. Although the production line may have a special build facility, entailing running the job through production as a "special", it is more likely that a prototyping line or wireman will assemble the product at this point, taking care to work within production tolerances.

Things to look out for are:

1. Printed wiring board not conforming to production standard in physical design rules: track to track distances, solder trapping junctions, drill hole diameters and other physical parameters.
2. Components not on company "approved list".

ACTIVITY 50: Develop production test

- The existence of a complete suite of functional block diagrams and circuit diagrams for the product allows production test engineering to initiate the production test programme.
- Production test is required to ensure that the build process results in a completely functional and fault free product. High reliability automatic fabrication may allow reduced testing, but a final assembly test will still be required, often after a 'on-soak' period.

ACTIVITY 51: Assess impact on production

ACTIVITY 52: Test tooling

- For example:
    1. Bed of nails format
    2. Functional test harness

ACTIVITY 53: Analyse function of production prototype

- ACTIVITY 53 may result in the development of the first real prototype, especially if simulation techniques have been used through out the design process. Checking the functionality and the conformance to requirements is an essential task. If the work involves printed wiring boards, then the design revision level should be up to date i.e. make sure the correct version of the electronics is being debugged.

ACTIVITY 54: Do testability analysis (production test)

- The acceptable level of test is dependant on the type of design and desired production throughput. Integrated circuits are normally 95 to 100% testable at present. Bed of nails testers can achieve 100% testability, although 100% functional test may be interpreted differently by customer and company respectively.
- It is important to refer back to customer acceptance requirements in the CPR to define the assessment needs of this decision activity.

ACTIVITY 55: RELEASE GATE 4 -- Pre-test review

- RELEASE GATE 4 begins the post development stages of the product development cycle. The gate revisits the question of whether the project continues to be a viable business venture in light of the new information gained during product development and the development of the marketing plan. It also serves as a quality control check on the development phase.
- A number of performance measures may checked and recorded at this point too, allowing design management to assess the project progress in terms of design iterations, problem lists, new knowledge sought, failed deadlines, failed critical paths and plan corrective action.
- **RELEASE GATE 4: Pre-test review** (ACTIVITY 55), is the most important review gate prior to ACTIVITY 60 (Production handover). It is extremely important to ensure that the product design is complete in all aspects.
- This may be the first time mechanics and electronics (and software) have been operating together. Failure to hold up progress until Release Gate 4 has been fully completed may lead

to premature production release of the electronics, with subsequent testing of the mechanical/electronic interface revealing design failings in the electronics.

ACTIVITY 56: Production test

- Determine whether all the production tests are in place in manufacturing to ensure fabrication of the product is correct.

ACTIVITY 57: Release prototype to customer

- The customer will often require an early version of the product to work with. Modifications requested by the customer to correct problems at this stage must be analysed as either: (a) the company's fault, or (b) the customers fault. This allows costs to be negotiated accordingly. It is important that any contractual matters in this respect must be defined at or before RELEASE GATE 3 (ACTIVITY 18).
- Customer comments are important but their impact on the project MUST be assessed carefully by the design team.

ACTIVITY 58: Complete design documentation

- Technical authors should complete user guides, maintainence guides and assembly instructions, in cooperation with the design team.
- If changes are required, ECNs will have to be raised at this point.

ACTIVITY 59: RELEASE GATE 5 -- Pre-production review

- Evaluate test results. If tests are considered valid, the project is ready for handover to production. Additionally, most control documentation, **CPR**, **CRS**, **TPSD** and the various Product Books will be complete and ready for issue "freezing".
- Review the CPD and record delays and the mistakes and problems that caused them in an appendix to the CPD (for future reference). Also, feedback problems to all concerned for project debriefing.

ACTIVITY 60: Production handover

- Personnel from the design team will be involved (share responsibility) in dealing with any problems found during the first production batch and until full production is achieved. They will effectively being "on call" for the duration, perhaps even being resident in the factory during the trial batch production run.

PRODUCT DESIGN PATH C: Innovative Design

An Innovative Design involves new combinations of proven ideas and new technology. Take, for example, a company which manufactures cellnet telephones and has experience of designing computer control systems in the cellnet telephones. An Innovative product might be created by combining the cellnet communications facilities with computing machines, giving true mobile computing ability. The technical risk associated with such an innovative design would lie in chosing a computer operating system and a hardware configuration to satisfy the new customer base.

The design process model makes no suppositions that the project has real or potential customers for the facilities being designed, only that by due consideration of the percentage of new knowledge to design or production engineering, an *Innovative Design* path is indicated. This signals to senior company management that appropriate project support is required and careful assessment of risk is necessary. For safety, a company may only wish to carry one innovative project, whilst running a number of variant design projects.

PRODUCT DESIGN PATH D: Strategic Design

A Strategic design involves new principles of engineering for the company personnel. The risks on this type of project are considerable.

The management of strategic projects is different from the other design paths described above since routes A, B and C all have relatively near-term goals. Keeping project focus is therefore easier. In addition, the fact that the problems posed by a Strategic design will be largely new for the engineering staff, the potential solutions will neither be obvious nor easy to elicit by brainstorming or other group methods. Training or external consultation may be needed in addition to the existing support tools, since information, knowledge and wisdom has to acquired from somewhere.

The design process model makes no suppositions that the project has real or potential customers for the facilities being designed, only that by due consideration of the percentage new knowledge to design or production engineering, a *Strategic Design* path is indicated. This signals to senior company management that appropriate project support is required and careful assessment of risk is necessary. For safety, a company may only wish to carry one strategic project, whilst running a number of variant design projects.

TOOLKIT 10

Checklist for Effective Support for Product Design

Introduction

In circumstances where there is likely to be a high level of technical change, the wider application of the technology in terms of application and information use typically leads to a corresponding need for a high level of organisational adaptation to achieve business success. It is therefore important to develop infrastructures which maximise the fit between demands made by technology and the skills, needs, values and attitudes embodied in the social and technical structure of the firm.

Where the needs of an electronics manufacturing company are concerned, the design infrastructure may be viewed as the totality of supporting functions which allow the design activity to take place. As such, the design infrastructure includes provision of technology support in the form of appropriate IT hardware and software aimed at facilitating day-to-day administrative activities (wordprocessing, spreadsheets) and routine inter-personnel communication (email). It also embodies a variety of organisational and cultural elements, the most significant of which include:

- The methodologies or guidelines which firms adopt in order to ensure the various design tools are used correctly.
- The management methods used to ensure designs conform to requirements.
- The procedures necessary for identifying, capturing and reusing company knowledge.
- Policies providing for long term investment in people in order to enhance skill levels, improve job satisfaction and reduce staff turnover.
- The creation of an environment which promotes active, cross functional communication and which encourages the frequent, personal sharing of information and knowledge;

IT Support

Product design is a cooperative effort in which groups of engineers, other experts and managers work on different facets of the product under the direction of a project leader. In a Concurrent Engineering (CE) environment, all these project members belong to interdisciplinary groups which rove across traditional departmental boundaries. In order to operate effectively, such cooperating individuals need to be supplied with computer based services which will enable them to transcend the barriers of distance, platform and the use of different types of hardware and software tools.

In such circumstances, it may be useful to consider using some or all of the technologies presented below:

- **Communication systems** -- email systems;
- **Shared work space systems** -- remote screen sharing facilities; face-to-face meeting support using shared individual screens and large public screens; electronically aided, intelligent white boards which provide support for such activities as drawing, listing, collating and printing out;
- **Shared information systems** -- Multimedia, multi-user hypertext systems; shared optical disk or CD-ROM systems; multi-user databases;
- **Group activity support systems** -- Procedure processing or work flow systems enabling electronic forms to be sent on predefined routes of people and roles; activity processors which allow a more general form of work flow/procedure processing; methodologies and support tools for groups to analyse, define and prototype the organisation, procedures and equipment with which they are to carry out a group activity; co-authoring tools to support the joint writing of documents by two or more people; idea generation and prioritising tools to aid group creativity.

Design culture

The creation of an effective product design capability rests upon more than simply investing in computer hardware upon which to run a suite of design automation software. It is important that management should also recognise the human and organisational context within which the design activity takes place and acknowledge that it is a complex activity which may have its own culture. Such a culture may be rather well defined, as a part of the firm's mission or reflecting dominant ideas of the organisation's founders or leaders, or it may be relatively obscure.

The importance of culture in the context of electronics product design is reinforced by the fact that Japanese companies regard design as one of a portfolio of strategic activities in which significant resources are devoted both to the development of in-house design automation tools and to the support of "up front" engineering activities. This point is further illustrated by the manner in which the Japanese firms design to achieve market success. They initially design products in what may be termed an "aggressive" fashion in order to create market share or to offer a level of functionality not found in other products. Having achieved these goals, their design capabilities are then deployed "consequentially" to ensure ease of manufacture and high product quality as part of a low cost business strategy.

Human Resource Management

The effectiveness of a firm's engineering design activities is heavily dependent upon its human resource management (HRM) policies. These should particularly focus upon minimising staff turnover through the provision both of education and training facilities focused on key technological areas and of appropriate reward and recognition systems. Low staff turnover can increase company effectiveness in a number of other ways, not least because it is possible for those firms to retain hard won engineering experience. Such experience is not usually recorded within electronics firms, either in computer databases or on paper.

Education and Training

An increasingly important concern for the electronics industry is the fact that a considerable proportion (industry estimates put this figure as high as 20%) of a firm's entire body of technical knowledge must be updated each year merely to keep abreast of technical advances taking place in the industry.

The implications of that figure are, of course, considerable from an education and training perspective since it means that an electronics company's entire body of existing technical knowledge could become redundant every five years. Furthermore, there is every likelihood, given the level of technological change currently engulfing the electronics industry, that the pace at which firms need to take new knowledge on board -- and to jettison out-of-date knowledge -- will dramatically increase in the next decade.

Reward and Recognition

The formula for successfully managing key members of staff "is deceptively simple" - attract the best people, keep them, develop them, motivate them and manage their performance.

In order to achieve these objectives, companies must offer both *extrinsic* and *intrinsic* inducements to the individual to work and to work hard. Extrinsic rewards include wage, salary, bonuses, commission payments, working conditions and pension arrangements. Intrinsic rewards, on the other hand, are those which enable people to satisfy other goals - lifestyle, comfort, a sense of achievement, companionship, status, public acclaim and challenge.

Learning across Projects

To be successful at electronic product design, a company must have a thorough understanding of its existing product range, including all product functions and technological limits. In order to achieve such an understanding, firms must be able to archive and retrieve all salient product knowledge. However, it is precisely in this area that most electronics companies are highly vulnerable since their ability to develop such products depends, to a significant extent, upon the availability of "old style" expertise -- which is sometimes referred to as "wisdom" or "lore". Unfortunately, such distilled long term interpretation of knowledge is usually only retained by the individual and is rarely, if ever, systematically identified, captured and reused at the company level.

There are a number of problems associated with current approaches to electronics design knowledge reuse which need to be addressed. These include:

- The failure of manual knowledge capture methods to act as an effective feedback mechanism since recipients (other than designers) often tend to file paper documents away and ignore them;

- The failure of designers to record sufficient *contextual* information and knowledge about an evolving design. In an effort to minimise effort and cost, electronics designers typically only provide documentary evidence of their work in the form of a circuit diagram and a description of its function;

- The idiosyncratic and largely unstructured nature of personal engineering log books. This makes it difficult for other designers to interpret and understand the original designer's decision-making processes;

- Failure by engineering management in many firms to grasp the importance of enforcing a thorough approach to product design documentation as a mechanism for capturing design knowledge and "wisdom";

- Poor use of the knowledge storage and recall capabilities of CAD/CAE tools.

AGILITY Methodology

Market and Product Evaluation Checklist

Market and Product Evaluation Checklist

Market issues

1. What economic growth rates are expected for existing and potential markets?
2. What are the major factors contributing to the growth or decline of these markets?
3. What market share is currently held for each sales product family?
4. What developments are likely to take place in each of the following areas which might affect our marketing planning?
    - Product safety
    - Product reliability
    - Packaging
    - Advertising
    - Pricing control
    - Pollution control
    - Legislation
5. What changes are taking place in the area of product technology which are likely to affect our products and markets?
6. What changes are taking place in the area of process technology which are likely to affect our products and markets?
7. Are new markets emerging for the company's products?

Order winning and order qualifying requirements

8. What customer service requirements, particularly with regard to product design and development, does the company need to meet in order to *qualify* to do business.
9. What customer service requirements, particularly with regard to product design and development, does the company need to meet in order to *win new business*.

Quality

10. What quality issues do we need to pay most attention to?
11. Has BS5750/ISO9000 been implemented?

Product Design

12. How often are product design changes made?
13. In the event product design changes are made, what scale of change would generally be made?
14. Is the customer interested in setting up supplier partnerships?

15. If the answer to Question 14. is "YES", what kinds of changes would we need to make to our design capability?

Our product performance

16. Rate the performance of each of the products you buy from us using the matrix above by entering a number from 1 to 5, or an asterisk (*), in the relevant box in accordance with the rating scheme shown below.

5	Excellent
4	Above average
3	Average
2	Below average
1	Very poor
*	No opinion/not applicable

Response to change requests								
Technological sophistication								
Appropriateness of product materials								
Overall product size								
Product documentation								
Product performance in use								
Product support								
Functionality & features								
Depth of range								
Breadth of range								
Price								
Reliability								
Quality								
Control over product specification								
Performance Category / Product								

The future

17. In future, is demand for our products likely to increase or decrease?

18. By how much will demand increase/decrease.

19. What factors will influence demand for our products?

AGILITY Methodology

Employee Survey

Employee Survey

This anonymous survey aims to help the company to assess its current product development environment. The questions are grouped into two categories, namely:

- Organisation;
- Product development.

These categories are further grouped into key areas for each category.

Please answer *all* the questions to the best of your ability, unless you don't know the answer or unless what is asked is not relevant to your area of responsibility or product.

Completing the questionnaire should take less than 30 minutes. Thank you for your cooperation.

ORGANISATION

Company Goals and Values

20. The company's culture encourages employees at all levels to be innovative in their work

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

21. The company's core values emphasise effectiveness, adaptability, responsiveness and risk taking

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

22. The company's organisational goals are oriented towards effective problem solving, innovation and growth

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

Organisational structure

23. The company has few procedures and rules and those it has are general in nature

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

24. The company's procedures and rules are usually informal and unwritten

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

25. The company's authority structure is dispersed and operates more like a network than a formal hierarchy

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

26. There is effective communication between engineering departments and between engineering and production

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

27. The company encourages collaboration between different functional areas

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

Management

28. The company has a clear long-term strategy for competitive success

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

29. The company has a well defined long-term product strategy aimed at achieving long-term growth

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

30. Considerable importance is attached, in the long-term product strategy, to monitoring changes in customer lifestyles

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

31. Considerable importance is attached, in the long-term product strategy, to increased customer expectations

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

32. Considerable importance is attached, in the long-term product strategy, to product aesthetics

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

33. Considerable importance is attached, in the long-term product strategy, to the moves of competitors

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

34. The company has a well defined short-term product strategy aimed at satisfying its short-term funding needs

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

35. The company's product strategy is compatible with its overall corporate objectives

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

36. Sufficient resources have been provided to match the product strategy

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

37. The corporate objectives for the design function are clearly defined and periodically reviewed

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

38. Has the company established a corporate product development process (PDP) which is supported by senior management?

Yes ☐ No ☐

39. Senior management believe that product design is the foundation upon which the company's success or failure is built

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

40. The company recognises that responsibility for product design begins at the top

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

41. There is a sincere and visible corporate commitment to high standards of product design

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

42. There are procedures in place to ensure that relevant, up-to-date market and technical information is available to the design team

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

43. Product design achievement and expenditure are monitored against time

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

44. Product design results are properly evaluated

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

45. Product design evaluations are routinely communicated to all concerned

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

46. There are strong collaborative, information and evaluation links between the design team and other parts of the business

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

Resources

47. Design and development are adequately resourced

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

48. Company product plans are supported by a matching resource plan

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

49. The resource plan covers all investment necessary to develop, manufacture and launch the company's products successfully

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

Research and Development

50. The company devotes sufficient resources to R & D

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

51. The company's R & D effort provides the company with a steady stream of new product opportunities

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

52. The company's R & D department has strong links with design and production

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

53. The company's R & D department has strong links with the company's customers

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

54. As projects move from lab to market, engineers are moved with them

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

Training and Education

55. Please specify, by placing a "✓" in the appropriate box, the average number of days training you receive per annum

0 – 4	☐	15 – 19	☐
5 – 9	☐	20 – 24	☐
10 – 14	☐	Other (Please specify)	______________

56. Design and engineering staff are provided with the opportunity of working in a variety of different areas of the company in order to broaden their knowledge and experience

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

57. Within the design function, technology and knowledge transfer are largely carried out through "on the job" training within small groups

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

58. Please rate the quality of the training you receive by placing a "✓" in the appropriate box of Table 2 below.

Table 2: Training Quality Assessment

Training type \ Performance Category	Excellent	Above average	Average	Below average	Very poor	No opinion/not applicable
General technical training						
Job specific technical training						
Computing training (including CADCAM)						
Procedures, tools and standards						
Team effectiveness (single discipline team) **						
Team effectiveness (mixed discipline team)						
Team effectiveness (senior management team including customers, suppliers)						
Management training						

** Effectiveness training includes how to solve problems, set goals, think creatively, use standards, utilise experts and work with other disciplines

Empowerment

59. Design staff are provided with sufficient information about company plans to do their jobs properly

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

60. Design decisions are made by the supervisors and managers

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

61. Customer and supplier representatives participate in making design decisions

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

62. Individual designers are responsible for scheduling and completing their tasks on time

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

63. Individual designers are responsible for the outcome of their tasks

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

64. Individuals are rewarded for their contributions

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

65. Teams are rewarded for their contributions

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

Team Integration

66. Individual employees and teams understand their roles and tasks in the context of the overall product development process

Strongly agree	☐	(5)	Disagree	☐	(2)
Agree	☐	(4)	Strongly disagree	☐	(1)
Uncertain	☐	(3)			

Automation support

67. Managers ensure that all necessary product development tools are provided

Strongly agree	☐	(5)	Disagree	☐	(2)
Agree	☐	(4)	Strongly disagree	☐	(1)
Uncertain	☐	(3)			

68. These tools are integrated and provide access to product data

Strongly agree	☐	(5)	Disagree	☐	(2)
Agree	☐	(4)	Strongly disagree	☐	(1)
Uncertain	☐	(3)			

69. The company has a clear, well constructed IT strategy

Strongly agree	☐	(5)	Disagree	☐	(2)
Agree	☐	(4)	Strongly disagree	☐	(1)
Uncertain	☐	(3)			

70. Please identify what you consider to be the main weaknesses of the company's IT strategy

71. There are significant weaknesses in staffing for IT

Strongly agree	☐	(5)	Disagree	☐	(2)
Agree	☐	(4)	Strongly disagree	☐	(1)
Uncertain	☐	(3)			

72. Where do you think the main IT staffing weaknesses lie?

73. There are significant weaknesses in the company's IT hardware resources

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

74. Where do you think the main IT hardware weaknesses lie?

75. There are significant weaknesses in the company's IT software resources

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

76. Where do you think the main IT software weaknesses lie?

PRODUCT DEVELOPMENT

Product Management

77. Technical reviews and inspections are carried out at the appropriate milestones

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

78. Disciplined and consistent product management is used for a project effort

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

79. A communication path exists between all aspects of project management and systems requirements

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

80. Managers and interdependent project teams are automatically and concurrently informed of problems and their status

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

Product Data

81. Product development data is controlled by the individual

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

82. Individual designers have access to the product development data related to the different disciplines involved in product development

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

83. Individuals and teams have access to company-wide product development data that includes data from customers and suppliers

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

84. During the development process, product development specifications and designs are utilised and documented in an established manner

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

85. Product development data is stored, controlled, changed and versioned in a similar or common computer database

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

86. The data on the product development database is usable by the various design automation tools used by the company

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

87. Evolving product requirements, specifications and development data are automatically change and version controlled

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

Requirements Definition

88. Customer expectations are determined and converted to established, documented customer or marketing requirements

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

89. The customer or marketing requirements are partitioned into established, documented functional specifications

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

90. Traceability exists from individual functional specifications back to the customer or marketing requirements

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

Planning Methodology

91. There is a bottom-up design process in which all individuals contribute to the planning, evaluation or creation of the product or functional specifications

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

92. There is a top-down design process in which the customer, product or system design requirements lead to documented specifications for the functional subsystem design

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

93. A mixed-discipline team is required to consider tradeoffs that may change the product technology, design architecture or design-to-manufacturing process

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

94. The product requirements and system design requirements lead to interrelated tasks and processes

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

Validation

95. The individual functional subsystem specifications are validated according to customer requirements

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

96. The discipline-specific requirements are validated against customer requirements

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

97. The mixed-discipline and process requirements are validated against customer requirements

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

98. Interactive methods are used to monitor and warn the senior management team when a requirement mismatch occurs

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

Standards

99. The company has a mechanism for monitoring compliance with applicable design standards

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

100. The company uses design standards to ensure product reliability

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

101. The company uses design standards to ensure product testability, manufacturability, supportability and usability

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

102. The company regularly reviews and improves its design standards

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

Component Engineering

103. Individuals are responsible for the development of their own components and component libraries

Strongly agree	☐	(5)	Disagree	☐	(2)
Agree	☐	(4)	Strongly disagree	☐	(1)
Uncertain	☐	(3)			

104. Company-wide standards are used to represent component data

Strongly agree	☐	(5)	Disagree	☐	(2)
Agree	☐	(4)	Strongly disagree	☐	(1)
Uncertain	☐	(3)			

105. A single library system is used to manage the component data of all the different product development disciplines

Strongly agree	☐	(5)	Disagree	☐	(2)
Agree	☐	(4)	Strongly disagree	☐	(1)
Uncertain	☐	(3)			

Design Process

106. The company's new product process recognises that the most critical activities are the up-front and market oriented ones

Strongly agree	☐	(5)	Disagree	☐	(2)
Agree	☐	(4)	Strongly disagree	☐	(1)
Uncertain	☐	(3)			

107. There are serious gaps -- omissions of steps, poor quality of execution -- in the way the new product process is carried out in the company

Strongly agree	☐	(5)	Disagree	☐	(2)
Agree	☐	(4)	Strongly disagree	☐	(1)
Uncertain	☐	(3)			

108. What are the main problems associated with the company's new product process?

109. The company has adopted a "portfolio" approach to product introduction in order to plan for product evolution beyond the current design

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

110. There is effective utilisation of existing products or product data for relating to new products or modifications

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

111. Lead times for new designs and modifications are competitive and under control

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

112. The company's design procedures acknowledge the fact that different products involve different levels of engineering risk in their development

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

113. Design quality is reviewed by design personnel in collaboration with personnel from other relevant functional areas of the company

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

114. There is adequate evaluation of the reuse and shared use of product technology and product design units

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

115. Adequate methods are used to integrate the product and processes

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

116. Information is extracted from the physical design (back annotated) to perform more detailed analyses of the product features and performance

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

117. Analysis methods are used at the conceptual or detailed design stage to account for downstream issues such as cost, testability, reliability and manufacturability

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

118. What analysis methods are used?

119. Computer based tools are used to "police" the design process, enforcing appropriate checks

Yes ☐ No ☐

Continuous Improvement

120. The company has goals for product and process improvement

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

121. Problems are analysed as to their root cause and then corrected

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

122. Problem reports are logged, prioritised, scheduled for correction (or rejection) and tracked until the problems are corrected

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

123. Action items, problem reports and enhancement requests are stored in a decision database and then used as indicators of customer satisfaction

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

124. The trends of action items, problem reports, enhancement requests and all other decisions are analysed to continuously improve the product development process

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

125. Major project decisions and the factors leading to them are documented, distributed and analysed for guidance on other projects

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

126. Product designs, development processes, requirements and tools are concurrently analysed and continuously improved as part of a company-wide improvement strategy

Strongly agree	☐ (5)	Disagree	☐ (2)
Agree	☐ (4)	Strongly disagree	☐ (1)
Uncertain	☐ (3)		

AGILITY **Methodology**

TECHNIQUES

TECHNIQUE 11

Structured Brainstorming

Introduction

Brainstorming is an intentionally uninhibited approach to creative problem solving which can be applied either at the individual level or in groups numbering between 5 and 12 people. Its objective is to produce the greatest number of alternative ideas for later evaluation and development.

Brainstorming enables a Company to:

- Generate a large number of ideas quickly.
- Identify potential root causes of a defined problem.
- Identify alternative methods of achieving a specified result.
- Find improvement opportunities.
- Identify difficulties, objections, disturbances, sensitivities and side effects.

The group of people selected for a brainstorming session should be diverse. It should not just comprise experts or those knowledgeable in the problem area, but should include a wide range of expertise. The role of the group leader in a brainstorming session is to ensure that the format of the method is followed, and that it does not generate into a round-table discussion. An important prior task for the leader is to formulate the problem statement used as a starting point such that it is phrased neither too narrowly nor too vaguely.

There are a number of rules associated with the conduct of brainstorming sessions. These include:

1. **Criticism is ruled out:** Judgement must be suspended until a later screening or evaluation session. New ideas are fragile things and need to be protected, at least until it can be established whether or not they will lead to something worthwhile.
2. **Free-wheeling is welcomed:** The wilder the ideas, the better. Even off-beat, impractical suggestions may trigger practical ideas in other members of the group.
3. **Quantity is wanted:** The greater the number of ideas, the greater the likelihood of winners. It is easier to pare down a long list of ideas than it is to expand a short list.
4. **Combination and improvement are sought:** In addition to contributing ideas of their own, group members should suggest ways in which ideas put forward by

others can be improved, or how two or more ideas could be combined into a still better idea.

5. **Involvement then incubation:** It is useful to alternate between a period of involvement in a problem and a period of detachment or incubation. Incubation is often followed by a sudden burst of insight.

Brainstorming is valuable only for creative-type problem solving, especially where the problem is well-defined and fairly specific in its scope since, in group situations addressing a broad issue, different individuals might put forward ideas relating to different aspects of the problem. Indeed, they may not even be addressing the same problem. This difficulty can be resolved by brainstorming in successive "cuts" at a complex question, first by breaking it down into its broad sub-problems and then by attacking one or more of these in a similar manner until a fairly specific problem is arrived at.

The brainstorming technique is of little use in resolving fact-type questions or strictly judgement-type problems.

Basic Rules

- Get the people together who can make the maximum contribution, including both those who do the job and those who receive the results of the job being done.
- Ensure that those who take part do so with equal status, that there is no criticism of individuals and that there is no stifling of ideas.
- There should be no discussion of the ideas generated until after they are all captured.

Method

- Elect/appoint a facilitator or leader.
- Define the problem/situation that is to be brainstormed. This could be a problem that has already occurred, a situation that needs to be prevented or a result that needs to be achieved.
- Ensure that each participant understands why he/she has been asked to take part.
- Poll the group, inviting one idea per turn.
- Strive for quality of ideas by encouraging free-wheeling and building upon the ideas of others. No evaluation of ideas should take place while this is happening.
- The ideas should be captured quickly, expressed simply and concisely and recorded for later analysis.

- Where appropriate, group and classify the ideas and, during discussion, expand them and eliminate the unlikely ones.
- Use voting to achieve consensus.
- Use the results.

The following slides may be used by the Facilitator/Project Champion to guide workshop participants during the Structured Brainstorming sessions.

Structured Brainstorming

- **New patterns of thinking**
- **React from creative "gut level" rather than from intellectual, logical level**

Structured Brainstorming

Ground Rules

No criticism

Judgement must be suspended until a later screening or evaluation session. New ideas are fragile things and need to be protected, at least until it can be established whether or not they will lead to something worthwhile.

Free-wheeling is welcomed

The wilder the ideas, the better. Even off-beat, impractical suggestions may trigger practical ideas in other members of the group.

Quantity is wanted

The greater the number of ideas, the greater the likelihood of winners. It is easier to pare down a long list of ideas than it is to expand a short list.

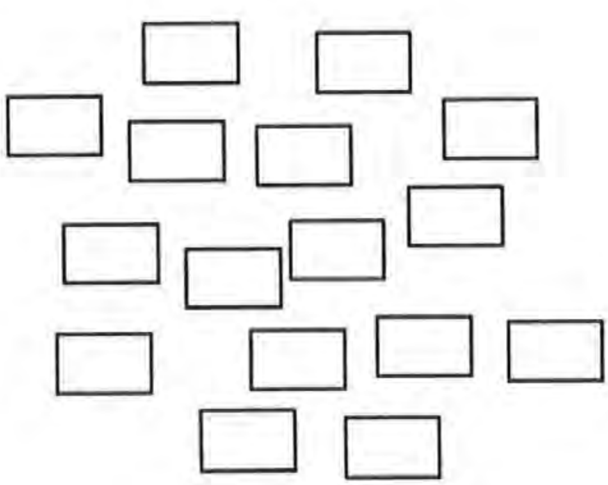
Ideas recorded exactly as spoken

No attempt should be made to interpret what is recorded.

The Process

Generate ideas

- No more than 5 – 7 words
- Nouns and verbs
- Recorded on "Post it" notes/flip chart
- One idea per "Post it"

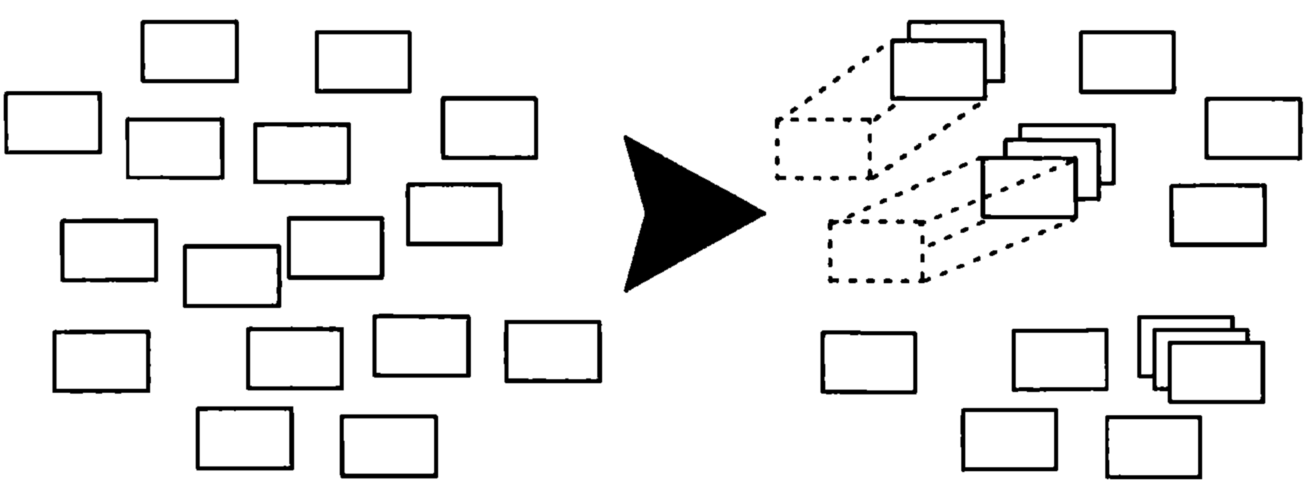


Slide 3

The Process

Group cards

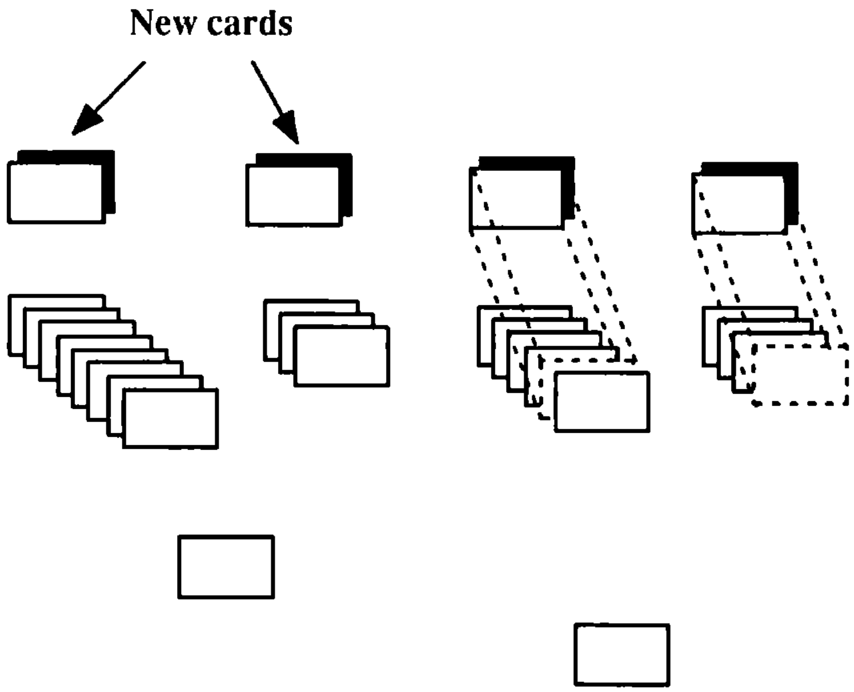
- Random spread
- Cards which are related in some way
- 6 - 10 groupings
- Silence
- Entire team simultaneously
- "If you don't like where the card is, *MOVE IT*"
- Don't try and force fit
- *SPEED* not *DELIBERATION*



The Process

Create header cards

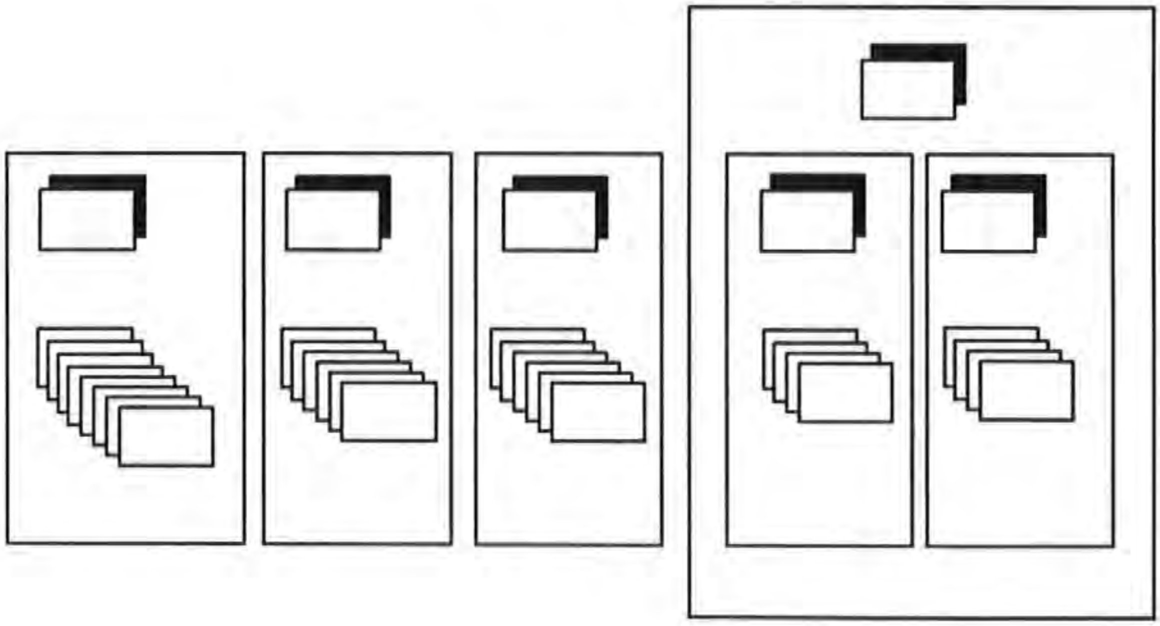
- Card in each group which captures the central idea
- 3 - 5 words
- If none, create



The Process

Draw the finished diagram

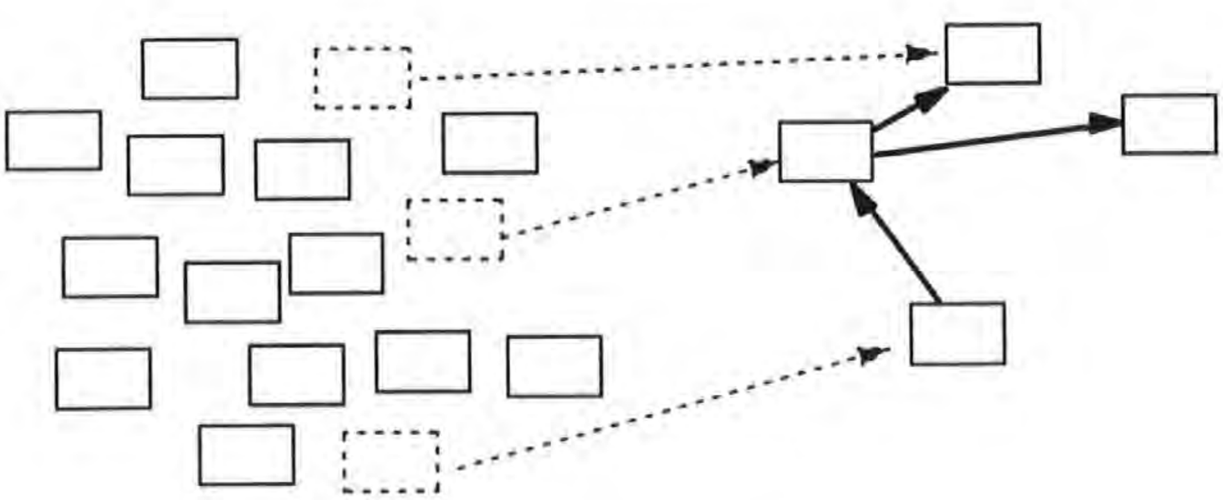
- Draw lines around each grouping
- Related groupings near each other
- Where necessary, create "super–header" cards



The Process

Establish interrelationships

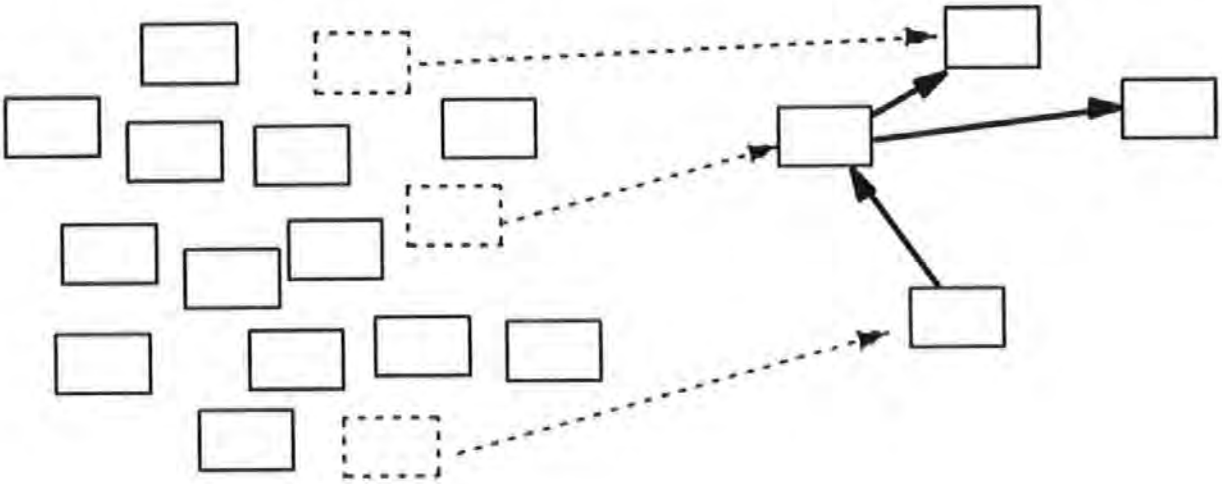
- Random distribution
- Remove header cards
- One by one
- "Does any other card either cause this issue or result from this issue?"
- Draw arrows in appropriate direction
- Repeat
- "Does this card either cause or result from any other card in the chart?"



The Process

Drawing the arrows

- Avoid two-way arrows - go for the *major* influencer
- Build bridges when arrows cross



The Process

Selection of key items

- Find the card which has the largest number of arrows either leading to it or coming from it
- Continue to find the cards with the next highest number of arrows etc

Outgoing arrows dominant

- Indicates basic cause which, if solved, will have a spillover effect on a large number of items

Incoming arrows dominant

- May indicate a secondary issue or bottleneck which may be as important to address as the original item

Ends Planning

- **A design for the organisation or system which stakeholders would replace the existing system with today if they were free to do so**

- **Idealised design**
  - Seeks to generate maximum creativity
  - Constraint 1: Must be technologically feasible
  - Constraint 1: Must be operationally feasible

Ends Planning

Select a mission

- General purpose statement of responsibilities the organisation/ system owes to its environment and stakeholders
- Vision of what the organisation/ system could be like

Specify desired properties of the design

- Comprehensive list of the desired properties which should be built into the system

Design the system

- How all the specified properties of the idealised design can be realised

Means Planning

Policies and proposals

- Generated and evaluated
- Bridging the gap between the desired future and the way the future looks from the current perspective

Creativity

- Needed to discover ways of bringing the organisation/system towards the desired future

Alternative means

- Different ways of reaching the specified ends should be carefully evaluated and a selection made