BS 7000-2:2008

BRITISH STANDARD

Design management systems –
Part 2: Guide to managing the design of manufactured products

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Contents

List of figures

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 62, an inside back cover and a back cover.

Foreword

Publishing information

Presentational conventions

This part of BS 7000 is published by BSI and came into effect on 31 March 2008. It was prepared by Technical Committee MS/4, *Design management systems*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

This British Standard supersedes BS 7000-2:1997, which is withdrawn.

Relationship with other publications

BS 7000 *Design management systems*, consists of the following parts:

- *Part 1: Guide to managing innovation;*
- *Part 2: Guide to managing the design of manufactured products;*
- *Part 3: Guide to managing service design;*
- *Part 4: Guide to managing design in construction;*
- *Part 6: Managing inclusive design – Guide;*
- *Part 10: Vocabulary of terms used in design management.*

Other parts may be added.

Information about this document

BS 7000-2 is intended for use by those operating in the consumer and industrial product sectors of industry. It has been updated to take account of advances in product development since its last publication in 1997.

Users are advised to consider the guidance given in the BS 7000 series when devising or enhancing design management systems that are required to conform to any of the following standards: BS EN ISO 9001, BS ISO/IEC TR 10000 and BS EN ISO 14001, as well as BS 6079 and BS 7373.

Users are also invited to submit technical comments, observations and suggestions to the technical committee MS/4 secretary at BSI (see address on back cover). This will assist the committee when it reviews the standard in due course and when it considers additional parts to the series.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

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Introduction

Creating and delivering excellent products with market appeal and high levels of customer satisfaction requires an integrated approach to design, from the board of an organization to project managers and their multi-disciplinary teams.

Excellence in design is an important differentiating factor between competing products, and can be the key to company survival in increasingly competitive world markets.

The complex intellectual challenges presented in product design demand that the process is managed effectively if the outcome is to be successful. The concepts, principles and quality system elements described in this standard are applicable to all forms of manufactured products. Applying the principles described will facilitate the creation of products that are produced on time and within budget, meet customer and organizational requirements, and have a better chance of competing successfully in world markets.

This standard sets out the tasks and responsibilities for creating and implementing an effective design policy for:

a) senior executives (see Clause **4**);

b) project managers and those involved in the design process (see Clause **5**).

Figure 1 and Figure 2 provide a summary of key issues for each of these management levels.

In large organizations, these tasks and responsibilities are usually taken on by different individuals or groups. In small organizations, they are often undertaken by a single person but are, nevertheless, distinct and different. All those involved need to be aware of what is required of them. It is therefore recommended that they understand the full content of this standard and pay particular attention to the clauses that are directly relevant to their particular role.

Figure 1 **Checklist of key actions for senior executives/principals**

Design should be formally directed on a strategically planned basis; the following is a summary list of key actions:

a) reinforce the strategic importance of design by addressing design management issues regularly at top executive meetings;

b) specify and periodically update the organization's design objectives and strategies that facilitate the fulfilment of the organization's goals;

c) formulate the organization's design philosophy and promote it enthusiastically;

d) establish a design programme and control, review and update it at appropriate intervals to maintain its relevance to the fulfilment of the organization's objectives;

e) ensure that the design programme complements, enhances and is compatible with the other major plans of the organization;

f) understand the risks, and take steps to mitigate their effects;

g) determine the return on investment on all resources committed to design (not just capital);

h) plan to provide the necessary finance and other resources to enable the organization's design programme to be implemented effectively;

i) assign design responsibilities to competent and qualified executives, then motivate them to acknowledge these responsibilities and their ability to perform to specification;

j) communicate the organization's design objectives, strategies and programmes to all involved, and ensure that there is a common understanding of their substance and implications;

k) introduce and reinforce an appropriate design management system and infrastructure to sustain design work to the required standard, ensuring that it is integrated with other disciplines;

l) monitor and control expenditures against plans and time, and record achievements;

m) use the most appropriate skills available and bring others up to the required standard of performance through design awareness and training in design management skills;

n) underpin the importance of design as a strategic resource by maintaining a genuine and visible commitment to it.

Figure 2 **Checklist of key actions for managers responsible for design projects**

Summary of key actions to manage design at a project level:

a) understand customer requirements, always undertaking market research as part of the design process;

NOTE The main cause of failure of a product to gain market acceptance is that of not understanding customer requirements.

b) make changes during the relatively low-cost early stages of the design process;

c) consider areas for concurrent working at the start of the project and assemble a multi-disciplinary team that includes all relevant specialisms;

d) review the design process at regular intervals against the design brief and specifications;

e) control costs through continuous review against the budget, using techniques such as earned value analysis;

f) control the configuration of the product from the generation of the specification through to final disposal (see BS ISO 10007 for guidance on configuration management);

g) evaluate the project and deliverables on completion of the design activity, with a view to making improvements in the future;

h) identify any areas for improvement in management processes during the periodic reviews, audits and final evaluation, making changes as required for the benefit of future projects;

i) retain control over the design project at all times.

1 Scope

This standard gives guidance on managing the design of all types of manufactured products. It deals with every stage of the process from product concept through to delivery, use and ultimate disposal.

NOTE 1 This standard recognizes that small enterprises or those specializing in one-off products or special purpose machinery or equipment often need to adapt the process to suit their own needs and size of operation.

It addresses all levels of management, in all types of organizations involved in design.

Guidance is given on the application of general principles and techniques to the management of design, raising awareness of management issues and emphasizing the need for an integrated approach to product design. It is not the purpose of this standard to define design techniques.

NOTE 2 For many products, particularly those that are complex, an integrated multi-disciplinary approach to design is needed, preferably embodying systems engineering techniques. Guidance on systems engineering is widely available, including from ISO, IEC, ANSI and EIA standards listed in the Bibliography. Documents recommended for guidance on general management techniques are also listed in the Bibliography.

Guidance on the management of innovation, service design and construction design is given in BS 7000-1, BS 7000-3 and BS 7000-4 respectively.

NOTE 3 Guidance on procedures needed to meet statutory requirements, such as health and safety, or product certification and liability, is not intended to be comprehensive. Reference needs to be made to other documents where appropriate.

NOTE 4 This standard is intended to complement BS EN ISO 9001.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 6079-1:2002, *Project management – Part 1: Guide to project management*

BS 6079-3, *Project management – Part 3: Guide to the management of business related project risk*

BS 7000-10:2008, *Design management systems – Vocabulary of terms used in design management*

BS 7373-2:2001, *Product specifications – Part 2: Guide to identifying criteria for a product specification and to declaring product conformity*

BS EN ISO 9001:2000, *Quality management systems – Requirements*

BS ISO 10007, *Quality management systems – Guidelines for configuration management*

BS ISO/IEC 90003:2004, *Software engineering – Guidelines for the application of ISO 9001 to computer software*

3 Terms and definitions

For the purposes of this part of BS 7000, the definitions given in BS 7000-10 and the following apply.

3.1 analogy
aid to creativity that compares a concept with something that exists elsewhere

3.2 audit
systematic examination to measure conformity with predetermined requirements

3.3 chain of custody
process whereby an organization monitors its products through every stage of the supply chain, including all stages of manufacturing, transportation and distribution

3.4 combination
utilization of two or more existing design methods to reach a design solution

3.5 configuration management
co-ordinated activities to direct and control configuration

NOTE Configuration management generally concentrates on technical and organizational activities that establish and maintain control of a product and its product configuration information throughout the lifecycle of the product.

[BS ISO 10007:2003, definition **3.6**]

3.6 design control
component of a quality system that ensures the integrity of a design throughout its lifecycle

3.7 design policy
general rules relating to design discipline within an organization

NOTE Can help to guide corporate behaviour in circumstances that tend to recur, though it might not prescribe for every eventuality

3.8 design programme
specific activities and investments to be undertaken over a specified period, broken down into stages, with resources and associated timescales

3.9 design strategy
chosen path formulated to achieve business and design objectives, supported by an indication of how resources will be committed

NOTE Could relate to particular categories of design, types of project, sections of an organization and/or use of resources.

3.10 earned value analysis
determination of the monetary value of work performed in any stage of the design process through assigning a value to the achievement of project work completed and comparing this with the actual and planned costs of the project

NOTE Also known as "budgeted cost of work performed" (BCWP).

3.11 evaluation
systematic examination of the outcome of an activity to determine the extent to which specified objectives have been fulfilled

NOTE 1 Usually linked to a specific activity, e.g. system evaluation, project evaluation and design evaluation. Results are usually measured in terms of time, cost and achievement.

NOTE 2 Generally takes place at the end of an activity, but progress can be maintained by carrying out intermediate or stage evaluation, particularly where intermediate stage achievements have been planned.

3.12 general arrangement
overall scheme, usually a drawing, which shows the main components of a design

NOTE Also known as "design layout".

3.13 inversion
aid to creativity that considers the idea inside out or upside down

3.14 product specification
reference specifying the features, characteristics and properties of a product, giving all the information that is required to create it

NOTE Sometimes referred to as a technical specification or brief.

3.15 risk management
process whereby decisions are made to eliminate, mitigate or accept a known risk or hazard

3.16 specification
reference stating requirements that a product has to fulfil

NOTE 1 A qualifier should be used to indicate the type of specification, such as product specification, test specification, etc.

NOTE 2 Normally includes or mentions drawings, patterns and other references and indicates the means and criteria for checking conformity.

3.17 technical file
product technical information collated to satisfy the documentation requirements of European Directives applicable to the product (e.g. CE Marking)

NOTE May comprise specifications, drawings, items lists, design descriptions, risk assessments, test reports, copies of instructions for installation, use and maintenance (this is not an exhaustive list).

3.18 test plan
plan outlining the test work to be undertaken to ensure that the performance requirements of the eventual product can be achieved

3.19 validation
confirmation, through the provision of objective evidence, that the requirements for a specific intended use or application have been fulfilled

NOTE 1 In design and development, validation concerns the process of determining a product's suitability and conformity with user needs.

NOTE 2 Validation is normally performed on the final product under defined operating conditions. It may be necessary in earlier stages.

NOTE 3 The term "validated" is used to designate the corresponding status.

NOTE 4 Multiple validations may be carried out if there are different intended uses.

3.20 validation protocol
statement of the method by which validation will be carried out, typically comprising a list of each product specification element, and for each a description of the nature of the validation

NOTE Could be an inspection, test or review.

3.21 validation report
written report describing the results and outcome of conducting validation

3.22 value chain
all factors and activities undertaken by, or on behalf of, an organization that contribute to the value of its products as perceived by customers and users, from first conception through to final disposal and recycling

3.23 verification
confirmation, through the provision of objective evidence, that the specified requirements have been fulfilled

NOTE 1 The term "verified" is used to designate the corresponding status

NOTE 2 Confirmation can comprise such activities as:

- *performing alternative calculations;*
- *comparing a new design specification with a similar proven design specification;*
- *undertaking tests and demonstrations;*
- *reviewing documents prior to issue.*

4 Managing the design of manufactured products at organizational level

4.1 Taking organizational responsibility for design

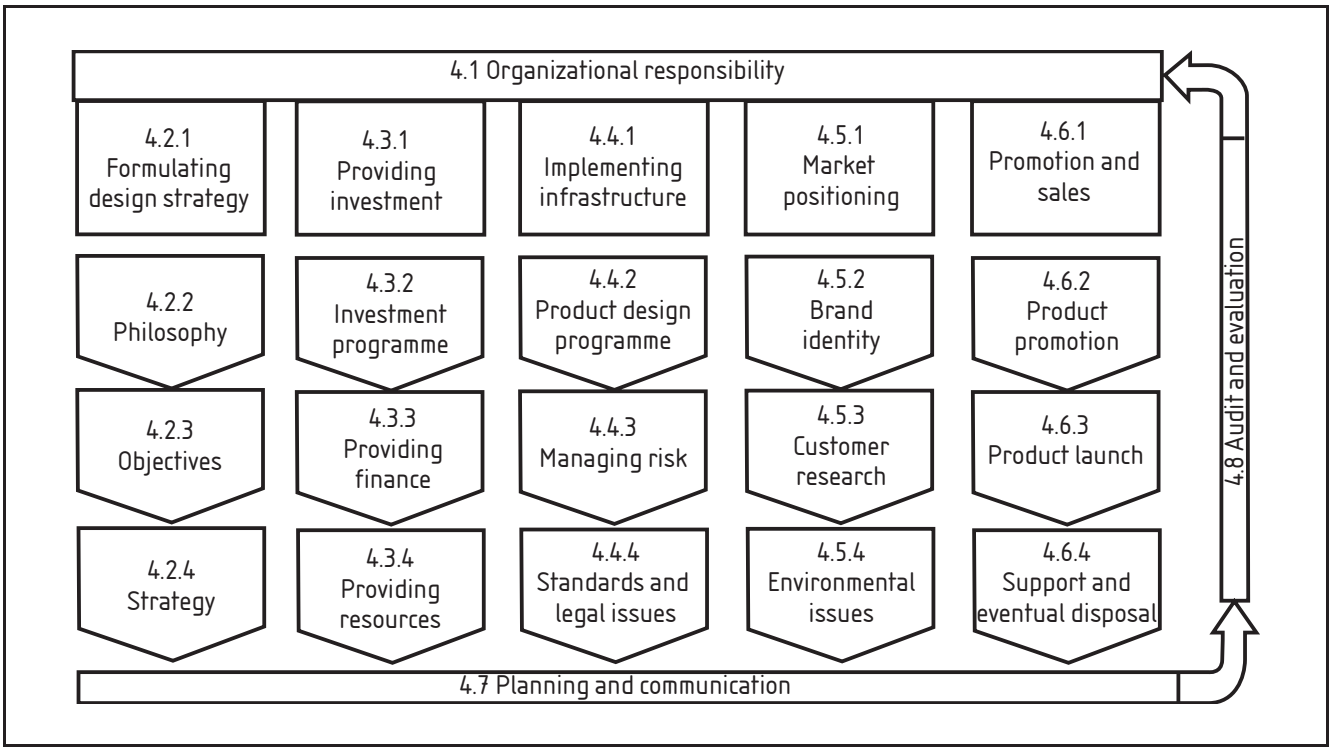
This clause addresses the management of design from the perspective of the organization as a whole. It focuses on the direction and guidance that those involved in undertaking or administering design activities are entitled to expect from board directors and principals. In small organizations, this guidance should come from owner-managers and partners.

NOTE For the sake of brevity in the following text, the term "principals" is used to denote these individuals.

Typical areas of organizational responsibility for design are shown in Figure 3. This is intended to illustrate the context of corporate design management and the interrelationship of the topics (in each column) that are covered later in this clause.

It does not imply these elements should necessarily be tackled in the sequence shown, and iteration may be necessary. A corresponding model for design management at project level is given in Clause **5**.

Figure 3 **Organizational elements of responsibility for product development**



Ultimate responsibility for the excellence of designs produced by, or on behalf of, an organization, rests with the board of directors, owner-managers or partners.

It is the board's collective responsibility to ensure that the organization has a clear sense of direction with respect to design, so that all contributions may be harnessed to their full potential. It is the chief executive's responsibility to ensure that this direction is followed effectively and that design makes a full contribution to the organization's performance. Chief executives may assign day-to-day executive responsibility for design to other members of the board or executives in the management hierarchy who report directly to them. A chief executive's design committee, or design policy group, may be established to oversee the management of design at the organizational level. Figure 4 gives an example of how design project responsibilities may be shared between different senior staff.

Figure 4 **Table of roles and responsibilities**

Job function	**Project manager**	**Financial director**	**Marketing director**	**Production director**	**Design director**	**Sales manager**	**Service managers**	**Agents**	**Customers, etc.**
Stage in the process	Write the names (or number of people) who should be involved at each stage of the process								
Design concept									
Outline design									
Detail design									
Prototype construction and test									
Provision for manufacture, delivery, erection and commissioning									
Product launch									
Selling									
Monitoring									
Evaluation									
Decommissioning									
Disposal									

Principals should demonstrate their understanding of responsibilities for and commitment to design through their statements and actions. In particular they should ensure that competent and committed teams are brought together to address design requirements. Design responsibilities should be clearly articulated and communicated to colleagues throughout the organization. Executives and staff should be given guidelines within which to operate. They should know who to turn to for guidance, authorization to proceed with a particular design idea or project, or other design-related decisions.

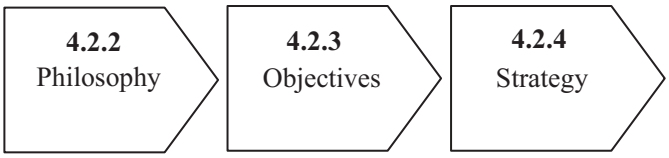
It is also vital that all executives who have design responsibilities, or otherwise get involved in design activities, should have these responsibilities and activities stated in their contract of employment. These factors should be reviewed periodically.

Organizations develop their competence in design management over time. Figure 5 provides a checklist of design management responsibilities.

Figure 5 **Checklist of design management responsibilities at organizational level**

a) Establish clear ownership of design responsibility.
b) Provide a vision of the future with clear objectives.
c) Demonstrate genuine and visible commitment to effective design.
d) Show awareness of customers' interests and needs.
e) Formulate the organization's design strategy and policy.
f) Establish and maintain the organization's design standards and guidelines.
g) Provide organizational systems.
h) Encourage an understanding of the environmental dimension of design.
i) Ensure there is an understanding of the legal requirements of design.
j) Establish the organization's design team.
k) Provide for training in design management skills.
l) Motivate staff involved.
m) Harness appropriate technologies.
n) Promote awareness of competitors and their external activities and innovations.
o) Assess opportunities and risks attached to investments in design.
p) Fund design activities.
q) Provide adequate resources (personnel, equipment, information and facilities).
r) Understand organizational capabilities and limitations.
s) Ensure production capabilities and requirements and their consequent effects on design are understood.
t) Demonstrate a commitment to quality and reliability.
u) Audit the organization's design and design management practices.
v) Understand the impact of design on corporate identity.
w) Evaluate the contribution of design to corporate performance.
x) Nurture an environment that encourages innovation and creativity.
y) Address corporate social responsibility issues.

4.2 Organizational design philosophy, objectives and strategy



4.2.1 General

Given the strategic significance of design in the development of new products and services, design should be given serious consideration at board level. Using design as a tactical tool on an ad hoc basis, or in an unstructured way, severely limits its contribution to the success of the organization.

Organizational design philosophy, objectives and strategy together define the boundaries of what is acceptable to the organization in terms of design activities and investments

4.2.2 Organizational design philosophy

Consideration should be given to establishing the organization's design philosophy. This will include the organization's general stance towards design, the basic reasons for design discipline and its contribution to the organization's performance.

4.2.3 Setting the organization's design objectives

The organization's objectives should provide the foundation and motivation for all activities, including design.

Principals should formulate corporate objectives in a precise and, whenever possible, quantifiable manner. These objectives should be documented at the organizational level and cited in operating and departmental plans.

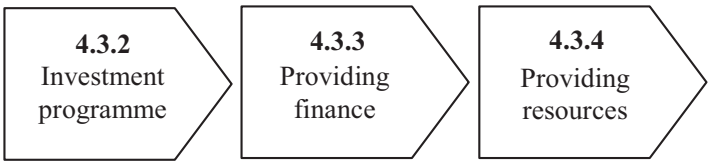
Principals may also wish to publicize and explain their aims in communications such as annual reports, briefings to financial institutions, and staff training programmes.

4.2.4 Formulating the organization's design strategy

The organization's design strategy should be drawn up as a prescription of approaches to be taken and how resources will be harnessed to achieve the objectives.

Where appropriate, these can be developed into short- to medium-term design activities and longer-term investments in design that are reviewed before being sanctioned for implementation.

4.3 Providing investment



4.3.1 General

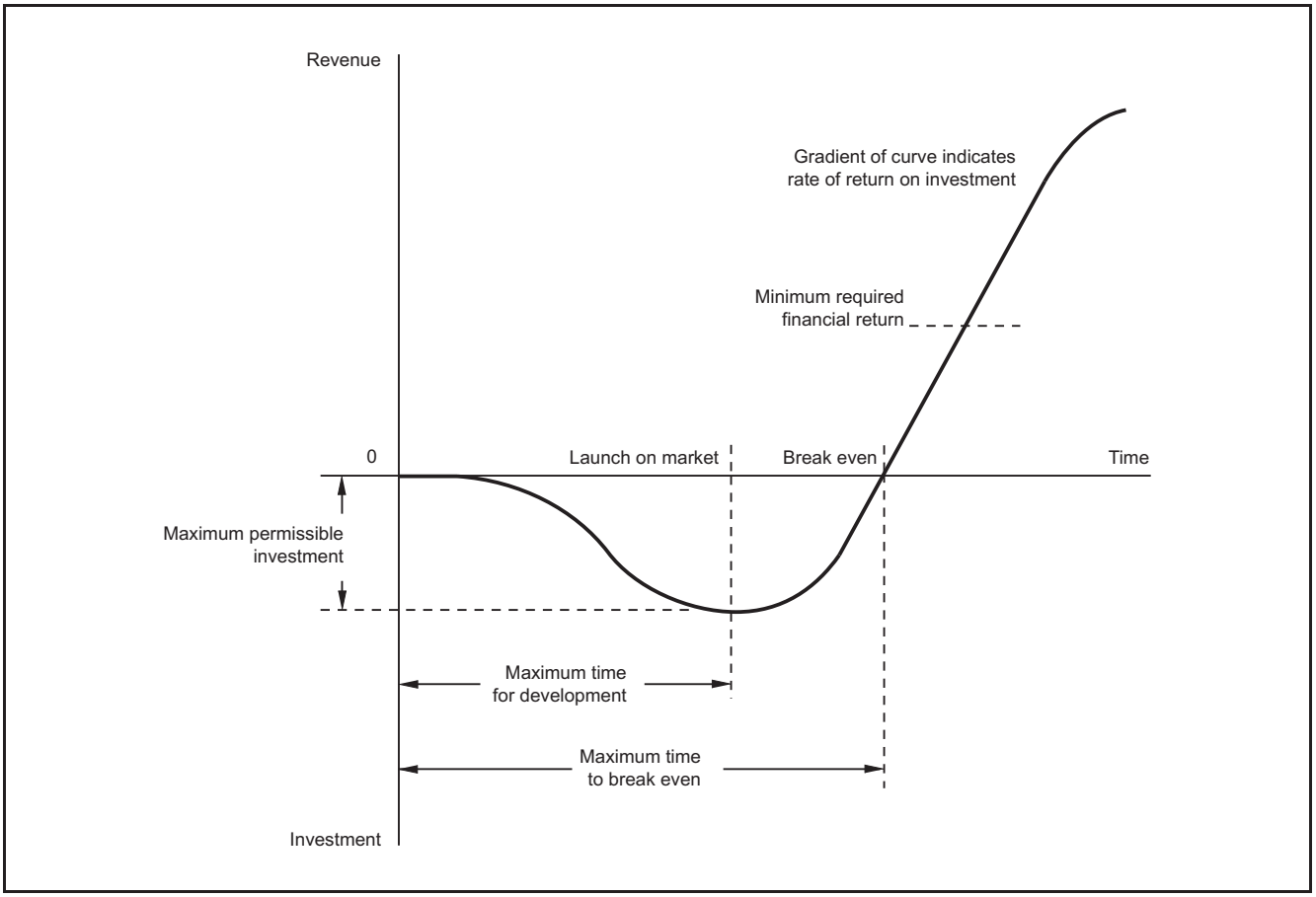
Products and associated services are the lifeblood of an organization. Skimping on investment in new product development is likely to jeopardize future competitiveness and profitability. Principals should ensure that appropriate resources are made available when required to undertake the research, design and development work, as well as the associated training needed. Continuity of adequate resources is essential to raise performance, and to sustain excellence over time.

4.3.2 Formulating the organization's investment programme

The financing of product design activities should be written into the organization's business plan. The achievement of excellence in design requires funds to be allocated from clearly identified budgets well in advance to cover the approved project plans. The investment requirements and cash flow implications of design activities should be forecast (see Figure 6) and set out in the organization's design programme.

This programme should set out all areas of design activity, the outcomes sought and the contribution to the attainment of the organization's objectives. The programme should also summarize design briefs and specifications, with the planned work broken down into stages. Skills and other resources to be committed and outputs to be generated at each stage should be specified, together with associated timescales.

Figure 6 **Profile of cash flow during project lifecycle**



An easily-comprehensible system of budgeting, with approved benchmarks on typical expenditure for different elements of work as well as the fair allocation of overheads, should facilitate financial planning for, and costing of, new or improved products.

Among the details that may be specified in the financial plans are:

a) cash flow forecasts;

b) sales forecasts;

c) gross profit forecasts;

d) nett profit forecasts;

e) payback periods;

f) returns on investment;

g) rating of risks involved;

h) maximum project budgets;

i) other budgetary constraints;

j) monitoring of expenditure;

k) revision of allocated budgets where necessary;

l) contingency planning.

Principals should ensure that funds allocated to product design and development are spent as intended and not withheld or diverted unless there are overriding reasons. These should be clearly stated and carefully checked. If funds have to be reallocated, the impact upon the project and the overall design programme should be taken into consideration and the plans revised as necessary.

4.3.3 Providing finance

A balance should be established between funding activities from sources such as departmental budgets, and organizational funding.

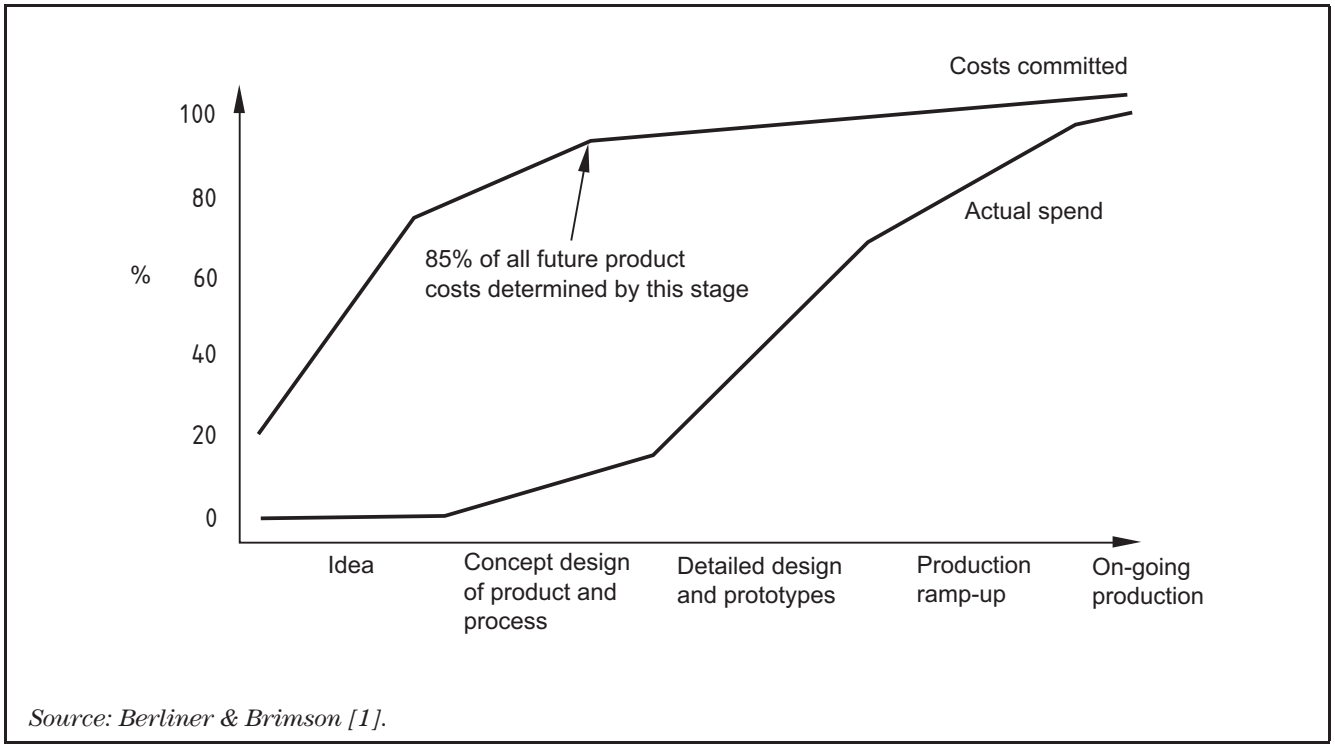
Principals should make clear those projects that will be sustained entirely from corporate funds, those that will be financed entirely from departmental budgets, and those where different parts of an organization will be expected to contribute a proportion of the budget. These should be agreed in advance.

The required funding may be split between capital and revenue accounts. Capital allocations should be made for anticipated changes in facilities and equipment to take advantage of enhancements in technology and systems.

Figure 7 illustrates financial commitment incurred during design, development and manufacture.

An easily comprehensible system of budgeting, with approved benchmarks on typical expenditure for different elements of work as well as the fair allocation of overheads, should facilitate financial planning for and costing of new or improved products.

Figure 7 **Financial commitments during product design, development, manufacture and support**



Source: Berliner & Brimson [1].

4.3.4 Providing resources

With the increased complexity of technology, the pace of product creation and the demands on capital, organizations should look beyond their in-house resources when undertaking development projects. Consideration needs to be given to harnessing the skills and experience of suppliers, distributors and customers around the world. All these parties may legitimately be considered members of the organization's design team whether or not collaborative initiatives and longer-term alliances are formed.

Resource plans should be prepared which specify the resources to be committed to design and design management issues. Particular attention should be given to the following questions.

a) Does the proposed project make appropriate use of in-house knowledge, skills and experience?

b) Will new technologies be bought in or subcontracted to design specialists and/or suppliers?

c) Will new equipment or design aids be developed specifically for the organization or could standard versions be used, perhaps with some minor customization?

d) Does the accommodation provide the necessary space and technical services (e.g. clean conditions and environmental control), to allow team members to operate effectively?

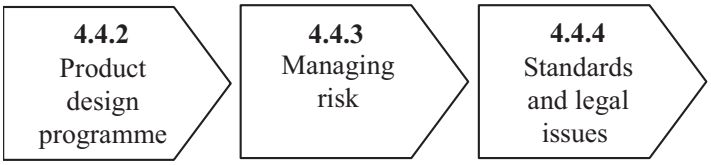
e) Are systems in place to enable the activity to progress smoothly from initiation through to completion? Are these systems adequately coordinated with the systems of other functions/disciplines?

f) Are the necessary ancillary resources and activities in other functions planned so that product design progresses smoothly without cross-functional difficulties, especially at the transitions between phases/stages where responsibilities transfer from one function to another?

g) Is training provided to raise awareness of design and the design processes among staff, and enhance design management skills?

Where an organization seeks to sustain a close working relationship with customers and suppliers, consideration should be given to offering them the opportunity to join in such training, as those who train together often relate and work better together. Substantial benefits could derive from better understanding between the parties and a common language, as well as a convergence of attitudes and approaches.

4.4 Putting infrastructure in place



4.4.1 General

To undertake design in an effective manner, an infrastructure of processes and standards needs to be in place which goes beyond the personal interests and approaches of individuals in charge. Therefore, an effective system for managing design should be formally adopted and linked in with the management systems of other business disciplines.

It is a key responsibility of principals to create such a "living" system and promote it to the point where it is fully implemented, operating smoothly, openly appreciated and firmly embedded within the organization.

4.4.2 Formulating and managing the product design programme

Proposals for investments in design should be coordinated within an organization's design programme. This programme should set out specific activities in all categories of design to be undertaken, the outcomes sought and their contribution to the attainment of organizational objectives. The programme should summarize design briefs and specifications, with the planned work broken down into stages. Skills and other resources to be committed and outputs to be generated at each stage should be specified, together with associated timescales. It is important that this programme can be referred to and influenced by those involved and interested in design in a formal, easily accessible working document.

There should be a formal procedure by which the organization's investments in design are evaluated and sanctioned. That procedure should be formally documented, transparent and made available to a wide range of personnel within the organization.

There should be a formal procedure for monitoring the progress of the organization's design programme, with reviews scheduled into the programme itself. Reports of findings should be submitted to principals for information and debate. Where slippage or deviations occur in relation to set goals, the principals should be informed of these as well as the remedial action taken

4.4.3 Managing risk

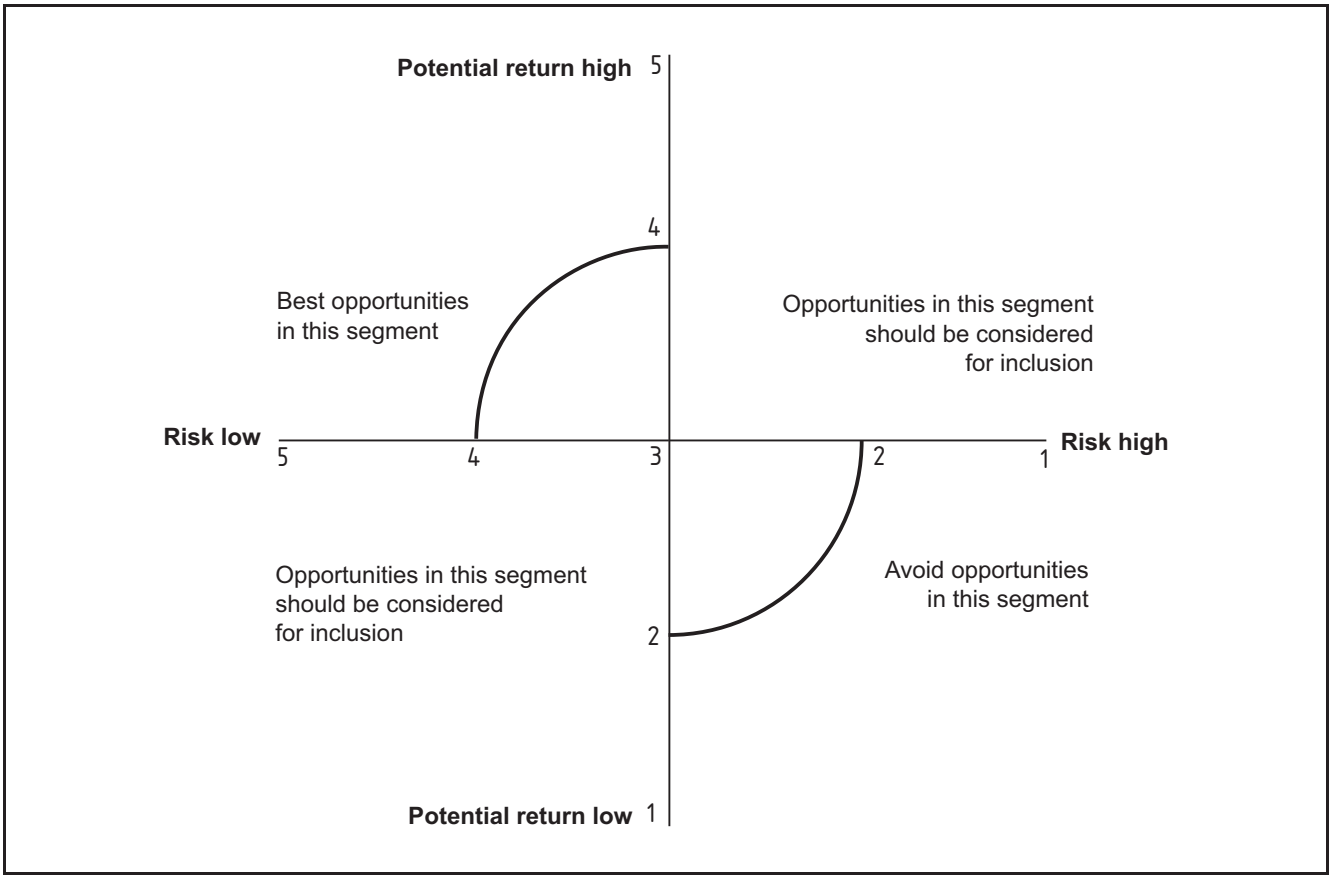
Risk management is an essential process for all organizations, regardless of size. Principals, project leaders and organizations can lose substantial sums of money as a result of not paying sufficient attention to the identification and management of threats to their goals and to the projects they commission. Similarly full advantage cannot be taken of potentially beneficial opportunities arising in the course of business activities if these are not recognized in good time. Risk management is therefore as much about looking ahead to identify further opportunities as it is about avoiding or mitigating losses.

It is essential that risks are identified systematically from the early stages of planning a project. A system of risk management should be introduced that works effectively alongside the creative work.

Reference should be made to BS 6079-3, which describes a process for identifying, assessing and controlling risk within a broad framework. The risk management process described is applicable to all aspects of business activity at all levels of decision making.

The relationship between risk and product potential is illustrated in Figure 8.

Figure 8 **Risk v potential**



4.4.4 Meeting standards and dealing with legal issues

All organizations operate to standards, many of which are imposed from outside by factors such as legislation, customer demand and professional regulation. Senior principals should ensure that all such standards are complied with and, where cost-effective, exceeded to achieve competitive advantage.

In addition to these externally imposed standards, the organization should implement its own internal practices and procedures to govern the product development process.

The legal dimension of product design is of crucial importance, due to the potential for litigation in the civil courts in respect of allegations made against products and associated manufacturing processes. It is also essential to protect the organization's intellectual property rights.

Copying products has become an easier and more rapid process. Counterfeiting and infringement of intellectual property rights is also more frequent and widespread. Consequently, there is a need for considerable vigilance to ensure that an organization conforms to local requirements wherever it operates, and profits for as long as possible from its intellectual assets.

There should also be formal procedures in place to:

a) maintain records of key decisions, actions and changes that affect the product design, (for use, among other things, as potential evidence in case of disputes and litigation);

b) check that similar designs, patents, trade marks and service marks have not already been registered;

c) register designs, patents, trade marks and service marks;

d) ensure that the design is documented and controlled from the start of the project;

e) ensure that potential customers and suppliers sign non-disclosure agreements before being supplied with commercially sensitive design information;

f) detect counterfeiting and other infringements quickly, and take strong action to stop them;

g) deal with product failures and customer complaints;

h) recall products from the market whenever necessary;

i) check conformity with all relevant standards, testing procedures, health and safety at work requirements, and requirements concerning the disposal of packaging and products after use;

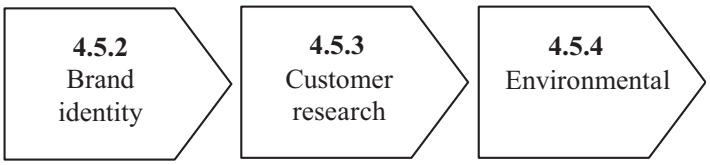
j) keep track of new legislation in all countries where the organization has interests;

k) make appropriate representations to influence the debate about proposed new directives, regulations or laws;

l) ensure that the organization is prepared well in advance to conform to new legislation;

m) use recyclable materials and reusable or refurbishable components wherever possible.

4.5 Market positioning



4.5.1 General

Customer satisfaction arises out of an overall experience with a product and its associated services, and so careful attention needs to be paid to every element that contributes to this experience. Senior executives should ensure that all these elements are identified and defined, understood, familiar among staff, and contribute to the intrinsic qualities of the product such that it can achieve the desired position in the marketplace. Procedures and appropriate resources should be in place to be able to position products competitively in the marketplace.

4.5.2 Coordinating the visual identity of products

Those who manage design should take account of brand identity and the public's perception of the organization's product range, care should be taken to ensure that the designs of products and associated outputs reflect and enhance brand identity, and that design and design management procedures are coordinated and in harmony with the current or intended product range.

Principals should decide the extent to which products are to be coordinated visually. That key decision might be influenced by factors such as:

a) the strength of an organization's visual identity;

b) the split of product ranges into brands with distinct identities;

c) the commercial benefits of being clearly differentiated from the competition in terms of consumer preference, greater market recognition and loyalty, and opportunities for cross-selling;

d) the additional costs imposed by being distinctive and sustaining that distinction;

e) the cost savings to be made by rationalization and adopting modularity of product configurations;

f) the cost savings to be made through consistency of presentation.

Visual identity is conveyed on products by:

a) colours;

b) materials;

c) textures;

d) shapes and styling of casings, disposition of controls and components;

e) graphic identification through use of company logos, symbols and typefaces;

f) presentation of information and instructions on casings and visual displays;

g) packaging and user manuals.

4.5.3 Researching customer attitudes and needs

Research into customer and user attitudes and aspirations, work and lifestyle is essential. Particularly instructive is the observation of how users interact with products from the moment that they first perceive a product (or perhaps take it out of its pack) to final disposal. Ergonomic factors such as simplicity of design, user-friendly interface and ease of use by the infirm and disabled should be considered. Care should be taken to establish whether expressed needs or other factors are those that most influence purchase decisions, especially as these might vary between first and subsequent purchases. All these might suggest opportunities for new products, improvements to existing products and different ways to present products to the market.

Among the most powerful sources of ideas for new or improved products is the understanding of the following:

a) customer perceptions (especially of their needs and wants);

b) what triggers purchase decisions;

c) how decisions to purchase are reached; and

d) how customers use products and services.

Keeping close to customers and markets in this way is critical to success. Principals can do much to raise performance by insisting that such marketing and design research is undertaken continuously and that findings are acted on without undue delay. A powerful way of achieving such closeness is to establish strategic partnerships with key customers, distributors and suppliers.

4.5.4 Promoting environmentally sensitive design

Environmental factors influence purchase decisions, and many consumers appreciate buying from organizations known to be responsible members of the community, especially in their attitude towards the environment. In addition, legislation, as well as the impact of voluntary pressure from trade bodies is forcing organizations to re-assess their outputs. Consequently, organizations should adopt a "cradle to grave" approach to monitor practices, performance and impact from source of raw materials (their "chain of custody") through to final disposal and recycling of products. Senior managers should define clear organizational environmental objectives, and should address environmental issues relating to product design and development to achieve the following:

a) a reduction in consumption of energy in their manufacturing processes;

b) a reduction in their products' consumption of energy during use;

c) a reduction of material waste (e.g. during manufacture and in packaging);

d) a reduction or elimination of adverse impacts on the environment through emissions and discharge of waste;

e) the simplification or optimization of fabrication and assembly procedures (for example, by reducing unnecessary variety in materials and components used);

f) improvements in the performance of bought-in materials, components and equipment, as well as in the practices of suppliers;

g) the identification of uses for the by-products of the manufacturing process;

h) the introduction of recycling of materials and spent components (and facilitating their collection);

i) continuity of a product range, allowing compatibility when upgrading without the need to replace;

j) the extension of the durability and life of products by designing for refurbishment and designing-out unnecessary obsolescence;

k) increases in the efficiency of distribution by reducing size, and improving stackability and storage;

l) the containment or reduction of costs (including those for disposal of used or obsolete products).

NOTE Attention is drawn to the Environmental Protection Act, 1990 [1] and BS EN ISO 14001 for detailed guidance on environmental requirements.

4.6 Promoting and selling products

4.6.1 General

Principals should ensure that adequate resources are committed to product promotion and launch. Promotional activities should be considered well before completion of product development, and principals should ensure the organization's product development process produces the necessary inputs to initial promotion, product launch and subsequent promotional activity.

4.6.2 Promoting the product

Customers' overall experiences with products are affected by many aspects inherent in the products and/or their value chains. The following should be considered when organizing for the promotion of products.

a) advertising;

b) promotional literature;

c) packaging;

d) user instructions;

e) presentations and displays in stores;

f) showroom environments;

g) the appearance, courtesy and knowledge of sales staff;

h) the professionalism of delivery, commissioning and after-sales service personnel;

i) other associated functions and facilities such as telephone help lines and service workshops.

Principals should insist that quality is maintained across all such elements of the product so that they are seen as part of a mutually enhancing, attractive whole.

For smaller businesses undertaking product manufacture, promotion might be achieved through developing relationships with larger companies, for example working closely with those who sell products to end users, such as retailers, or those who get the products onto shelves, such as distributors.

4.6.3 Launching a new product

Creating a new product or improving a current product is only part of the product's lifecycle. Success also depends upon an effective launch and support in the market throughout the life of the product. Principals should ensure that the launch of new products, and relaunch of improved products, are taken seriously by all involved, and someone should be appointed early on in design and development projects to oversee this critical stage. The project budget should make adequate provision for funding the product launch. Commitments should also be obtained from those responsible for launch activities, especially where launches are planned in several countries around the world involving subsidiaries, partners, agents, licensees and other interested parties.

4.6.4 Supporting the product and eventual disposal

Principals should ensure that the responses of customers to the product, and indeed competitor's reactions, are monitored. This should include examining the way customers use the product to determine if they are achieving the full benefit from the design.

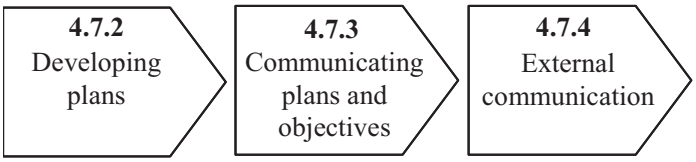
In the light of this customer feedback, principals should provide the necessary resources to support further development, e.g. to debug, refine and improve the product's performance to raise customer satisfaction.

Principals should ensure that there is an organizational infrastructure in place to provide the necessary level of customer support. This may be achieved, for example, by a customer services department, which might comprise a consumer helpline, or for more complex products, a technical "helpdesk" manned by staff with a more in-depth knowledge of the product.

There might also be a need for technical support at customers' premises and the provision of consumable items and spare parts. Principals have the responsibility for deciding the level of these resources, and if they should be made available in-house or subcontracted.

Where appropriate, guidance should be provided to customers and users for the disposal or recycling of products, especially where components may be hazardous or are subject to regulation (electronics, batteries, liquids). There is now a significant amount of legislation affecting the end-of-life disposal and disassembly/recycling of many types of product, and senior executives have a duty to ensure that the products their organizations offer to the market are disposed of responsibly in accordance with the law.

4.7 Planning and communication



4.7.1 General

Principals should ensure that all relevant design and design management issues are addressed during the business planning cycle, and that the results of deliberations are documented in the organization's strategic plan, and communicated to appropriate staff.

4.7.2 Developing organizational, business and product plans

Corporate and business plans should address the manner in which market demand and technological advances will be brought together in the range of products offered by the organization. Industries, markets and specific niches upon which particular attention and resources need to be concentrated should be highlighted. The emergence of new markets and forecasts of potential demand should be complemented by assessments of the position of current products and services in their predicted lifecycle, and thus future turnover and profits. This analysis may reveal potential gaps in the organization's performance. Design strengths and weaknesses, opportunities and threats should be highlighted and investigated. This information might be expanded into a separate document that focuses specifically on the organization's current and planned range of products and services.

4.7.3 Communicating organizational design strategy, objectives and programme

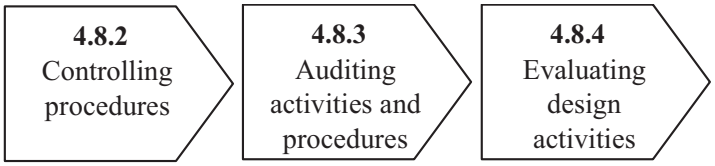
The value of plans will be enhanced if they are documented and communicated effectively. Executives and staff need to be fully aware of the direction and objectives set so that they work in unison. Considerable benefits can be derived from informing virtually all staff of the essential features of plans through team briefings, staff conferences and newsletters.

All staff should be made aware of their individual responsibility for the successful implementation of plans, and efforts should be made to issue a schedule of responsibilities that helps to motivate staff and build team spirit.

4.7.4 External communication

It is important that investors and other interested parties outside an organization are kept appropriately informed of its overall intentions and strategies. This will give reassurance that detailed preparations have been made to ensure future prosperity, and that there is transparency (within commercial-in-confidence limitations) and clear sense of direction to turn those intentions into reality.

4.8 Audit and evaluation



4.8.1 General

Principals are responsible for directing the quality of design work undertaken by, or on behalf of, their organization. This requires regular audits of outputs produced by different departments, facilities, subsidiaries and agents. Such audits allow the creativity of ideas and the craftsmanship of their execution to be evaluated, as well as their conformity to standards. Auditing should be extended periodically to encompass reviews of design and design management procedures. The same applies to facilities (such as location, working environment, amenities and equipment).

4.8.2 Controlling procedures

Principals should ensure that the organization has procedures in place to cover design activities. The 'ownership' of these procedures should be clear, and there should be a formal method by which procedures are reviewed and approved, and subsequently maintained.

The process for generating, modifying, reviewing and approving procedures should be clearly stated with guidance to assist executives and staff in putting forward suggestions for improvement.

4.8.3 Auditing activities and procedures

Periodic audits and associated reviews should be adequate where lead times and project time scales are relatively long and there are few product changes over that period. Where lead times and project time scales are short, and many changes are made to products, half-yearly or quarterly reviews should yield keener insights and allow greater control through faster response times.

These audits should be included in the organization's design programmes, and staff involved in design work should participate. Outcomes should be formally documented and circulated widely within the organization, especially to those who can act on the information to improve performance.

Audits should cover the following:

a) products and associated outputs (e.g. packaging, promotional literature and user manuals, point-of-sale material);

b) facilities (such as exterior and interior environments of workshops, showrooms, offices, warehouses);

c) equipment, other design aids (both hardware and software), and ancillary support;

d) design and design management procedures of suppliers and, wherever possible, of key customers and competitors;

e) the range of design and design management skills, knowledge and experience, (whether in-house or bought in), recruitment and selection, training, sources of outside advice;

f) competitors' products and associated outputs and services;

g) existing and emerging technologies (to check new developments and trends);

h) standards (internally generated or externally imposed) i.e. documentation, compliance, sanctions applied to ensure conformity);

i) the effectiveness with which the organization's resources are used.

4.8.4 Evaluating design activities

The organization's design objectives, strategies and programmes should be reviewed periodically to check their continuing relevance and effectiveness.

Evaluation at the organizational level should encompass multiple aspects of managing product design, the most significant assessments being:

a) the outcomes of design activities, especially the extent to which design and organizational objectives have been fulfilled, or how well progress is being made towards their achievement;

b) the overall organization's design programme (including control of progress, addressing design requirements, proper resourcing of activities, effective integration of design with other disciplines, effective release of products and reinforcing the position of design within the organization);

c) the contribution of the design programme to the organization's performance, especially in terms of financial results and the support of strategy, policy and objectives.

On completion of projects, final reviews should be conducted to identify any areas of improvement that might benefit subsequent investments in design, not least in relation to the objectives set and strategies pursued.

Principals should ensure that the lessons learnt from evaluations are properly documented and disseminated. Such sharing of experiences should help avoid mistakes being repeated and the unnecessary duplication of work. Problems should be anticipated or diagnosed earlier so that prompter and more effective action can be taken. Finally, the performance of executives with responsibilities for design should be evaluated.

5 Managing the design of manufactured products at the project level

5.1 Establishing the design process

This clause addresses the management of design at the project level, as distinct from the organizational issues that are discussed in Clause **4**.

A generic project model for the design of manufactured products is shown in Figure 9. This is intended to give an insight into the core design activities themselves, and set the context for design project management.

A more detailed design model might need to be developed to suit a particular product and circumstances. The relative importance and sequencing of activities may vary to some degree, and iteration between the elements of the model is usually necessary.

Figure 9 **The design process at project level**

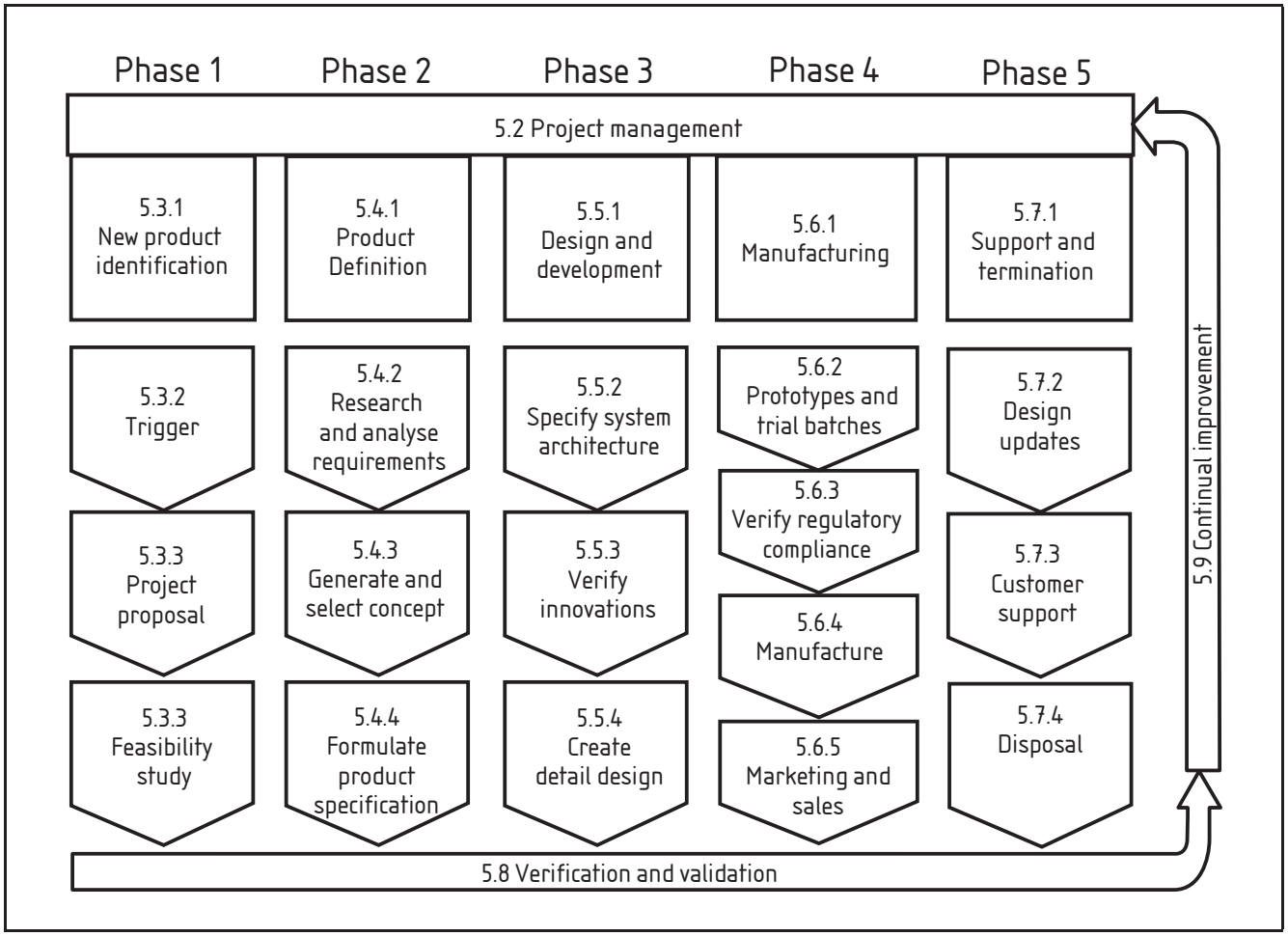


Figure 9 shows the process divided into five phases. The verification thread shown at the bottom of the diagram includes sanctioning continuation to the next phase.

- Phase 1 commences with the "trigger" which prompts the exploitation of an idea, and then goes on to investigate commercial viability and feasibility of the proposed project.

- Phase 2 establishes the overall product requirements, selects the preferred concept and generates the product specification.
- Phase 3 transforms the specification into a detailed design, while managing risks arising from innovative ideas or technology.
- Phase 4 moves the design into manufacture, and puts the product on sale.
- Phase 5 supports the product, and eventually considers withdrawal and disposal of the product.

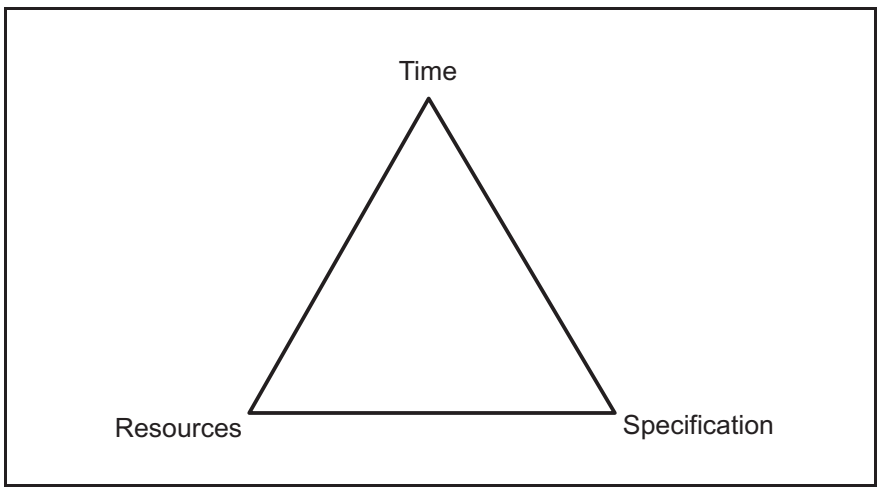
There is the opportunity at the end of each phase for principals to decide whether to proceed with the next phase.

Guidance on the management of each phase is described in the rest of this clause.

Where practicable, some elements of the process may be undertaken in parallel, often referred to as concurrent (or simultaneous) engineering. This requires a thorough understanding of requirements to be available at the beginning of each activity. A challenging aspect of efficient concurrent working is synchronizing major milestones in parallel parts of the process. Concurrent working demands effective communication and it is important that all affected functions participate in decision making.

Whilst the early stages of the design process might incur only modest cost, it is here that the key decisions are made that commit the project to particular technologies or solutions, timescales and costs. A balance needs to be achieved between the three key drivers: the specification, timescale and resources to be committed (implying cost). Establishing and maintaining awareness of risks to this balance during the project will define the chances of a successful outcome (see Figure 10).

Figure 10 **Balancing the key project drivers**



An effect known to design managers is that of “specification creep”, where enhancements are continually proposed. For this reason, firm control should be exercised by the project manager, and any changes to one or more of the drivers should be accompanied by corresponding amendments to the others.

Design and development quality management requirements are given in BS EN ISO 9001:2000, **7.3**.

More detailed guidance on project management is given in BS 6079.

5.2 Managing product design projects

5.2.1 General

This clause provides guidance to those who manage design projects. A brief overview of project managers' key tasks is shown in Figure 11.

Figure 11 **Key tasks of design project managers**

a) Agree priorities against other design projects in the organization.
b) Ensure a document control system is in place.
c) Ensure the overall design process/model is understood and in place.
d) Record risks.
e) Prepare a project plan for the design activities.
f) Identify activities that could be undertaken concurrently.
g) Establish the design team needed for the project.
h) Ensure team responsibilities are clear.
i) Identify and acquire resources for any training that may be necessary.
j) Formulate work packages for the team consistent with the project plan.
k) Report on progress to the authorizer of the project.
l) Determine what work, if any, will be outsourced.
m) Ensure effective communication and decision making.
n) Control and monitor progress and costs.
o) Collate cost and time data.
p) Select or approve the use of specialists and subcontractors.
q) Be the focal point for communication between the team and other parties.
r) Ensure that the final design meets the design specification.
s) Prepare a final report, evaluating the performance of the project, and incorporating lessons to be learned and opportunities for improvement.

5.2.2 Planning the project

In order to plan the project, the project manager needs to identify all work elements necessary to establish requirements and undertake the design and put it into manufacture, as set out generically in Figure 9. The exact nature of all the tasks and their interdependence should be established, so that the critical path can be mapped out. Where practicable, tasks should be undertaken in parallel. For anything other than the simplest of projects, the project manager is advised to use an appropriate project planning software package.

The work needs to be organized so that orderly progress is achieved. Planning should include:

a) establishing the extent of professional or specialist contributions required including identifying the competencies required to undertake the work, thus defining the composition of the design team;

b) identifying the need for other resources (such as development tools and equipment, work space, storage, technical information, instruments, computers and software);

c) establishing key dates for specific milestones, and the start and finish dates for tasks, to enable progress to be measured;

d) determining project costs and if applicable establishing when decisions have to be made to approve or reject demands for payment;

e) determining the structure of management information required for control purposes;

f) ensuring that intellectual property generated during the project is protected (see **4.4.4**).

Planning requires inputs from all relevant departments. Those with an interest in the project should be informed of all matters that affect their work. This is likely to encompass marketing, sales, finance, personnel, purchasing, manufacturing and technical functions such as quality assurance and project management. Where appropriate, planning might also include suppliers and customers.

5.2.3 Selecting the design team

In the early stages of a project, a small number of staff might undertake preliminary work on an informal or part-time basis. Once the project is sanctioned, a design team with appropriate expertise should be formally established and their specific roles in the project documented. For continuity, those involved in the preliminary work will almost certainly form part of the project team.

It is important that the project team is chosen so that collectively they have a good understanding of the scientific principles inherent in the proposed new product, and sufficient up-to-date knowledge of the relevant technologies and applicable standards. The team should also include staff with the necessary commercial and marketing awareness. This may be achieved by bringing in expertise from elsewhere in the organization, using subcontractors, or training by existing staff.

In larger project teams, it may be helpful to separate the role of project manager from that of technical leader. This can be done by nominating both a project manager to oversee the day-to-day management of the project, and a technical authority/chief designer, to be the "keeper of the design" and take responsibility for technical aspects.

The chief designer should stay in the team throughout the design process in order to maintain continuity. Others might only be actively involved as and when their expertise is needed, joining and leaving the design team as necessary.

5.2.4 Maintaining good communication

It is the project manager's responsibility to ensure that the team are well informed about all aspects of the project, and have up-to-date information with which to work.

Design team meetings should be organized to facilitate open communication. Ideally, attendance should be limited to less than ten members in order to enhance communication and efficiency. All members should be given an equal opportunity to contribute. If differences of opinion (or conflict) arise between members, the project manager should have ultimate responsibility for taking decisions.

Designers should be encouraged to communicate with the rest of the team both informally and formally through established channels such as team meetings and design reviews. Significant outcomes from formal or informal communications should be recorded.

Lines of communication should not be confused with lines of authority; communication may legitimately occur in any direction through an organization structure.

5.2.5 Controlling design

The project manager should maintain control over the design as it progresses.

Design control is the methodical control of the design process and its inputs and outputs. It is intended to ensure that the necessary design steps are taken, including reviews, verification and validation, and that information is recorded and controlled such that the design cannot be compromised. Eventually, design information should be put under configuration control to ensure that the design is properly managed (see BS ISO 10007).

The project manager should monitor the progress of work rigorously to ensure it remains focused on meeting the design brief and specification, especially with respect to performance, cost and timescale. Deviations from the plan should be sanctioned or corrected swiftly to prevent wastage.

Appropriate records should be kept and the status and distribution of working documents systematically controlled in accordance with a formal quality management system (see BS EN ISO 9001).

A project identifier, e.g. reference code or number, should be used on all project documents for traceability and control.

5.2.6 Conducting design reviews

At major milestones in the design process (e.g. at the end of each phase in Figure 9), the project manager should schedule formal, systematic reviews of the design to be conducted by suitably qualified staff. These design reviews should be identified on the project plan.

NOTE BS EN 61160 gives further guidance on formal design reviews.

The purpose of a design review is to check that the design is progressing correctly and implementing the specification accurately, and to identify and agree any changes required. Design review meetings should include members of the design team and be supplemented by others who have specialist technical expertise. It is often of great benefit to include suppliers, subcontractors and even customers at appropriate stages.

A design review is not the same as a progress review; it concentrates on technical issues rather than project performance issues.

Participants should receive the agenda for a design review at least one week before the meeting. The agenda should include the following:

a) areas for review (technical solutions, risks, problem areas, potential shortcomings, gaps in the brief/specification that need rectifying), as well as areas where corrective action might be needed;

b) points on which decisions are required;

c) where the relevant technical information resides.

Minutes should be taken at design reviews to provide a traceable record of decisions made, and for product liability reasons these should be kept on file throughout the useful life of the product. The minutes of the meeting should contain a dated action list that includes the names of those responsible for ensuring that actions are completed satisfactorily. Follow-up action should be monitored by the project manager.

5.2.7 Managing risk

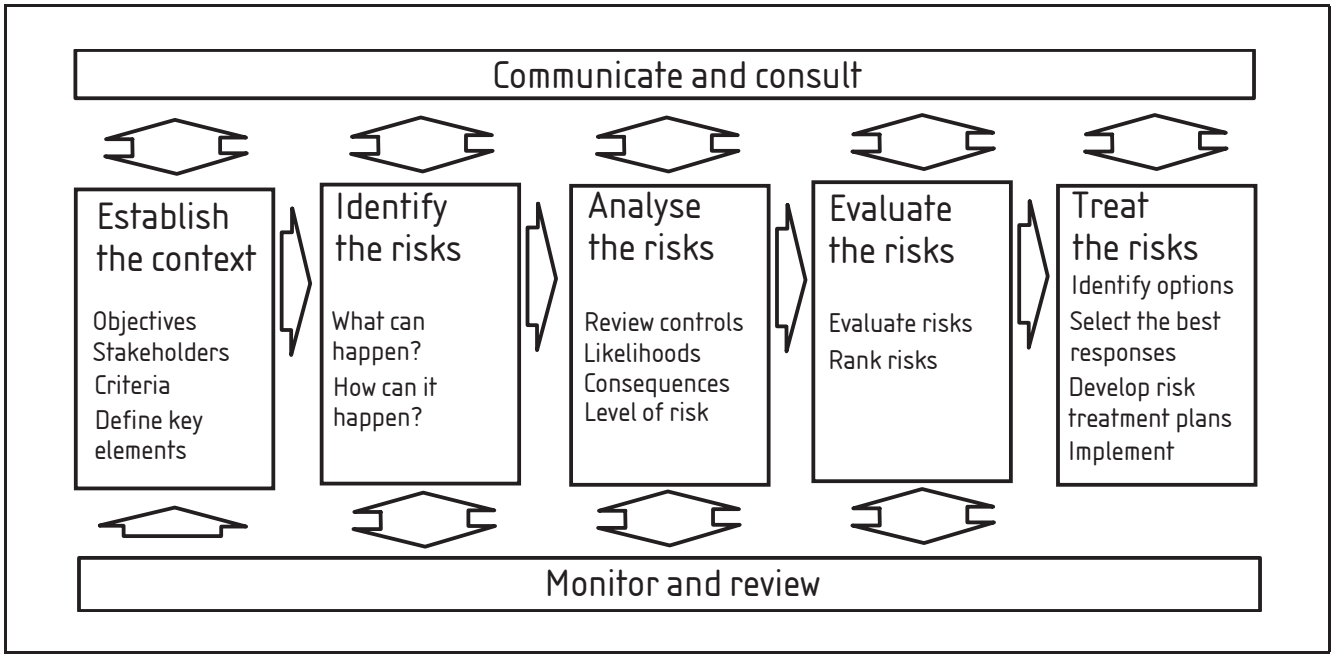
The objective of risk management is to identify and manage significant risks. It involves several stages: agreeing objectives, then identifying, analysing, evaluating, treating and monitoring the risks.

Risk management is not a discrete stand-alone process, but should be integrated with overall project management. The implementation of risk management should be the responsibility of all the project team and they should participate actively in the process.

This is project risk management in the broadest sense, not to be confused with product safety risk assessments undertaken at the engineering level. Safety risk assessments, as an ongoing activity, should commence at the point the design solution is identified.

Detailed guidance is given in BS IEC 62198, from which the process model Figure 12 is taken.

Figure 12 **The project risk management process**



The project manager should commence risk management activities at the outset of the project, develop a risk management plan, and continue with risk management activities throughout the project lifecycle. The project manager should be asking the questions given in Figure 13.

Figure 13 **Risk management questions**

Risk management process step	*Question*
Establish the context	What are we trying to achieve?
Identify the risks	What might happen?
Analyse the risks	What might that mean for the project?
Evaluate the risks	What are the most important issues?
Treat the risks	What are we going to do about them?
Monitor and review	How do we keep them under control?
Communicate and consult	Who should be involved in the process?

5.2.8 Making technical information available

The project manager should ensure that the necessary technical information is made available to the design team; this might include statutory instruments, standards, specifications, codes of practice, commercial data sheets and other design data. Such information will normally be available from one or more of the following sources:

a) the internet

b) an internal library or knowledge archive;

c) external libraries (public, institutional, educational);

d) information databases;

e) standard practice manuals;

f) suppliers;

g) specialist and proprietary sources.

It should be the responsibility of the project manager to ensure that such information is verified before being incorporated into a design.

5.2.9 Selecting appropriate computer based tools

The project manager should ensure that the responsibility for the choice of suitable computer applications and design packages (development tools, modelling tools, computer aided engineering and design tools, configuration management tools, choice of hardware platforms and software development tools) is clearly defined. The timing of the acquisition of such tools should be organized so that they can be installed and tested/validated, and staff trained in their use, before they are fully introduced onto the project.

Procedures for the control and secure storage of design data and backup files should be defined and enforced. Training in the use of new or enhanced tools and ongoing technical support should be provided by in-house specialists or system suppliers.

The risk of the design not performing to specification can be reduced through the greatest practicable use of computer simulation and modelling. This may also reduce the cost and lead time of developing complex and high technology products.

5.2.10 Managing software development

The management of software development is often an intrinsic part of the project manager's role. The project manager should ensure that the design team includes the necessary software specialists, and that the software development process is understood and procedures are in place (see the TickIT Guide [1)]).

Software may be applicable to several aspects of the design:

a) as an external interface with the product;

b) as an integral part of the product, e.g. an embedded control system (including self-diagnosis);

c) to facilitate the design process itself, such as virtual prototyping of aspects (or all) of the final product.

Where software is integral to the product, the project manager should ensure the necessary software development activities and milestones are embodied in the overall project plan. This should include the verification and validation activities.

For the design of software reference should be made to BS ISO/IEC 90003.

5.2.11 Providing configuration management

Configuration management is a discipline that applies technical and administrative control to a design. It provides ongoing recording and management of the "design so far".

The first stage is to identify the items to be controlled, these become the "configuration items" which together define the complete design of the product.

[1)] Available from www.tickit.org

The status of each configuration item is then recorded, reflecting the "completeness" of that item.

A configuration change control system should then be put in place to allow and track changes to the configuration items, bringing the necessary degree of control to the design.

Finally, and particularly important for software, a configuration release process should be put in place to record the versions of design that are put into service, or used subsequently in the ongoing design. This becomes the "version control" of the design.

For guidance on configuration management, reference should be made to BS ISO 10007.

5.2.12 Controlling project costs

The project manager should ensure that procedures are in place to monitor design expenditure against the budget. The recommended method of achieving this is to allocate a budget for each stage of the design plan; most project planning tools provide this facility. It will then be straightforward to collect costs as the project proceeds, compare them with the authorized spend, and detect when costs deviate from plan. The time and cost data thus acquired should be assessed at regular, typically weekly, intervals throughout the project.

Expenditure on materials and expenses should be monitored at the same time.

Any changes in design costs should be made available to the project manager as soon as they occur.

5.2.13 Controlling product cost

The cost of the product should be carefully evaluated and controlled during the design programme, and the following should be considered:

a) design strategy to achieve cost targets;

b) design approach (use of standard parts and/or modular construction);

c) material selection;

d) value analysis;

e) selecting manufacturing techniques appropriate to the design and volume;

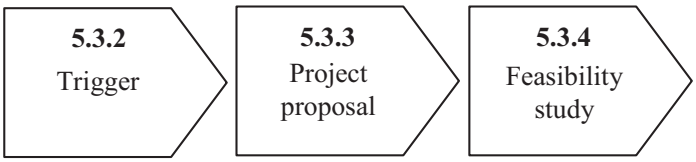
f) process analysis to determine factors that add value (business process re-engineering).

5.2.14 Reporting on project progress

The project manager should issue regular written reports on the progress of the project. The frequency, content and format of these progress reports should be agreed with all interested parties at the start of the project.

These progress reports need to highlight the actual or potential deviations from the project plan and the reasons for such deviations. The project manager should be responsible for ensuring that corrective action is taken to resolve problems.

5.3 The "new product identification" phase



5.3.1 General

There can be many sources for a new project initiative, both external and internal, and they may emanate from anywhere in the organization. The most common are market-pull, technology-push, customer requests, and any organizational circumstances that create opportunities to develop new products.

5.3.2 Triggering a new product

In broad terms, the most suitable opportunity or idea needs to be identified. Everyone in the organization should be encouraged to report potential triggers for new product ideas, and such initiatives should be communicated both upwards and downwards in the hierarchy. A checklist of possible triggers for a new product is given in Figure 14.

These factors might initiate additional studies that could include specially commissioned reports on market research, warranty, servicing and competitor activity.

The outcome of this stage should be recognition that there is an opportunity for a new product to be formalized in a project proposal

Figure 14 **Some triggers that could lead to a new design projects**

a) An enquiry from a customer.
b) A response to a perceived market need (market-pull).
c) Government initiatives and charters.
d) A research finding, perhaps associated with the development of a new technology (technology-push).
e) A new way of applying technology that may result in an innovation.
f) A license or franchise agreement.
g) A creative thought from any source.
h) A change of company assets providing an opportunity to redesign the product.
i) Problems, failures or deficiencies with existing products.
j) Loss of sales to competitors or a decline in orders.
k) Improvements to existing products to simplify, rationalize or "stretch" the design.
l) Complaints and ideas from, or surveys of, customers, sales staff, dealers, etc.
m) Published market research findings.
n) New patent applications.
o) Inventors, academics, scientists and consultants.
p) New regulations, legislation, standards and codes of practice.
q) Economic trends.
r) Suggestion schemes (including customer suggestion schemes).
s) Observation, imitation or improvement of competitors' products.
t) Environmental issues.
u) A change in the organization's or a competitor's vision or image.
v) Augmenting the product to get closer to the customer (e.g. direct delivery).
w) Increased leisure time.
x) Community welfare need.
y) Experience and intuition.
z) Natural change (e.g. the tooling of an old product needs replacing).
aa) New materials become available.
bb) Change in consumer behaviour/style.

5.3.3 Preparing the project proposal (or brief)

A proposal for the new product development should be prepared to take the suggested ideas forward. The proposal should detail:

a) the availability of resources;

b) the synergy with current product operations;

c) anticipated and acceptable timescale for completion; and

d) the availability of design resources.

Estimated cost and profit should be compared to the required return on investment, or other financial performance measures, as necessary. The proposal should provide a preliminary definition of the new product, and conform to the organization's objectives.

This proposal for the project is not the product specification: that will emerge later (see **5.4**).

If the project is deemed viable, the outcome of this stage should be that the defined criteria can be met. If it is not viable, the project may be revised or abandoned.

The project proposal should be evaluated by principals. This will include appraisal of the outline of the envisaged product, and some consideration of:

a) project objectives;

b) market segments for the proposed product;

c) the need for regional or niche market variants;

d) potential demand;

e) outline characteristics;

f) environmental considerations;

g) phases and completion timings;

h) project costs;

i) capital requirements;

j) subcontract requirements;

k) documentation requirements;

l) the project contribution to the organization's turnover, profit and return on investment.

The project proposal should include provisional details of the product, any research requirements and methodology, milestones, timescales, financial resources and costs.

For those product concepts that are worthy of a more searching feasibility study, the topics shown in Figure 15 should be considered and evaluated.

The outcome of this stage is formal approval for continuation, the need for changes to the proposal, or a decision to abandon the proposed project. If the project is approved, principals need to commit the necessary resources to proceed with a feasibility study.

Figure 15 **Checklist of factors to consider when formulating a proposal**

1) The operational brief.
2) Project plan and breakdown of project stages.
3) Product lifecycle.
4) Demographics (including the area and boundary of the prospective operation).
5) Competition.
6) Market segment.
7) Size of market.
8) The need for regional or niche market variants.
9) Customer and user standards.
10) Anticipated customer/user experiences.
11) Personnel requirements (including skills and experience).
12) Personnel availability.
13) Technology requirements.
14) Risk assessment.
15) Manufacturing process requirements.
16) Manufacturing resources requirements.
17) Manufacturing resources available within the organization and among suppliers.
18) Materials required.
19) Budgetary requirements, financial resources needed and available.
20) Return on investment, or other financial requirements.
21) Price and costs.
22) Timescale for product delivery and availability.
23) Reliability and maintainability.
24) Ease of use.
25) Frequency of purchase.
26) Speed of response to market and the organization's business needs.
27) Guarantees.
28) Special needs and product requirements.
29) Environmental considerations.
30) Legislation.
31) Socio-political market considerations.
32) Conformity to relevant standards, charters and codes of practice.
33) Shipping, delivery and erection restrictions.
34) Commissioning and decommissioning.
35) Disposal and potential for recycling.

5.3.4 Undertaking a feasibility study

The purpose of this stage is to establish whether the proposed development is viable and aligned to the objectives of the organization and its design programme. The output of the study will confirm that it is practicable to satisfy the product requirements and still conform to the organization's objectives.

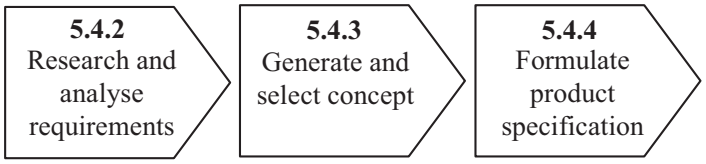
Tools that the project manager can use at this stage are shown in Figure 16.

Figure 16 **Tools that can be used when undertaking a feasibility study**

a) a product audit of current capabilities, suppliers and distributors;
b) market research;
c) competitor analysis;
d) benchmarking;
e) identification of barriers to entry;
f) cost benefit analysis;
g) discounted cash flow (DCF);
h) risk analysis;
i) decision trees;
j) timescales and milestones;
k) project appraisal;
l) project network planning techniques (see BS 6079 for further guidance).

The project manager should prepare a report on the feasibility study, which should make a case for proceeding with the proposed development. More questions might be raised that will refine the feasibility study. These need to be answered before moving to the next stage of the process. On completion of this phase, the organization should have sufficient confidence to commit resources to create the product. If the project is judged to be not feasible, it may be reassessed or abandoned.

5.4 The "product definition" phase



5.4.1 General

The detailed characteristics of the product now need to be established. The outcome of this product definition phase should be a completed requirements specification that describes a framework to which any chosen solution should conform. This specification should define requirements and constraints (e.g. regulations), but should not dictate solutions. In certain instances, a case may be made for excluding particular approaches or solutions.

The process up to this point should have been principally concerned with defining the product from the customer's point of view. Subsequent phases will focus on the process of developing and delivering an acceptable product to customers.

5.4.2 Researching and analysing requirements

The project manager should now establish the details of the perceived opportunity.

Research on how the opportunity could be satisfied should now be undertaken to establish the general functional requirements for the new product, for example:

a) key functions;

b) description and block diagram;

c) statements that describe what the product has to achieve;

d) ergonomic and aesthetic/graphic considerations (shape, finish, colour, graphics, etc.);

e) patents that might constrain the product;

f) user interface considerations;

g) inclusive design considerations;

h) environmental issues;

i) required life-span;

j) level of reliability;

k) requirements for robustness, waterproofness, shock, vibration, acceleration, temperature (both operational and ambient), chemicals, etc.;

l) requirements for materials (e.g. particular grades);

m) compatibility with other products or systems either in its use, function or appearance;

n) manufacturing strategy;

o) testing strategy, to determine how testing will be performed to prove conformity to the specification;

p) customer acceptance criteria;

q) strategy for product disposal.

Any design solution is inevitably a compromise between various factors, so the identification and selection of the best option may depend on evaluating many considerations, including some of those listed in Figure 17.

Figure 17 **Checklist for evaluating product requirements**

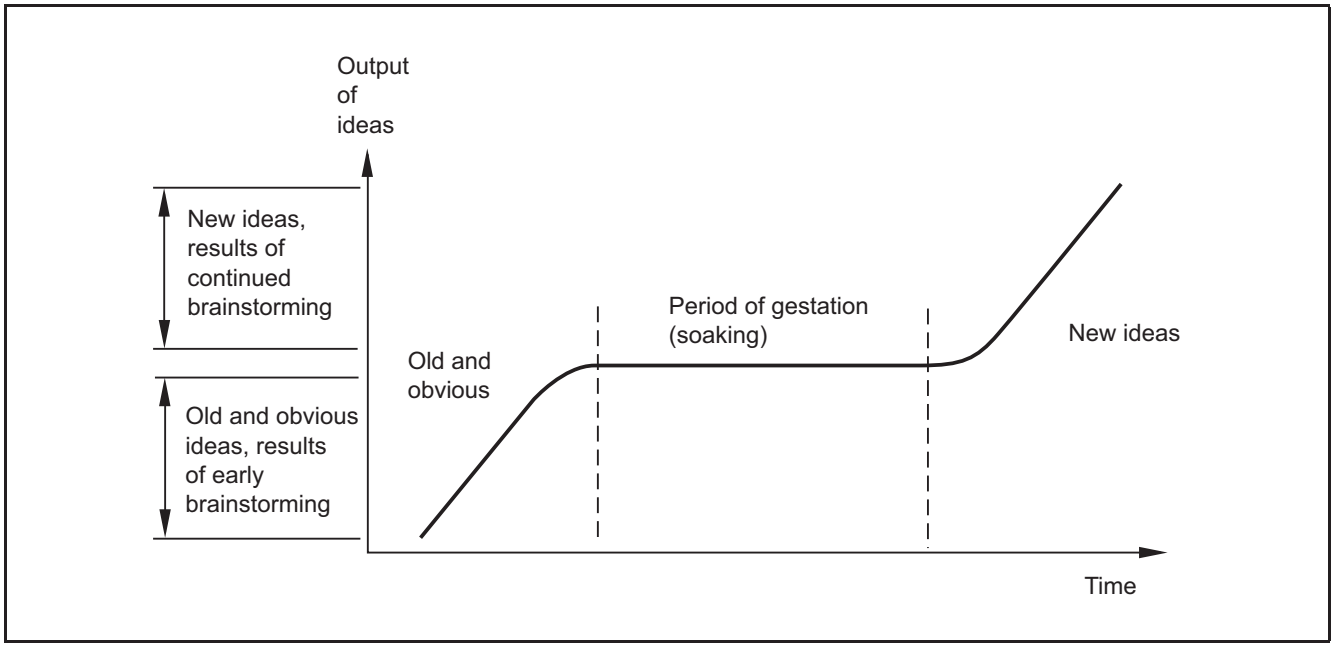
a) Risks involved.
b) Proprietary protection required and whether it can be arranged.
c) Organizational arrangements needed.
d) Procedures required.
e) Elements of technology needed.
f) Whether information on current and past practice exists.
g) Skills that should be included in the project team.
h) Market requirements.
i) Industry custom and practice.
j) Conformity to relevant standards.
k) Inclusive design requirements.
l) Physical resources.
m) Financial resources and costs.
n) Back-up resources and contingency funds.
o) Research requirements.
p) Forms of communication (internal and external).
q) Records required.
r) Verification including tests, models, field trials, etc.
s) Legislation.
t) Timing, dates and deadlines.
u) Launch date.
v) Distribution and sale.
w) Service and product support.
x) Product use and abuse.
y) Value for money, profit and return on investment sought.
z) The organization's financial capabilities.

5.4.3 Generating and selecting the concept

It is at this stage that the emphasis moves to the process of devising the product. Generating concepts provides a number of options to how the product might be designed. There could be several options that fulfil the requirements of the product design brief and specifications.

The project manager should organize a brainstorming session to generate concepts. Initially, the aim should be to generate as many options as possible to fulfil the requirements of the product design brief and specifications. This is best undertaken in multi-disciplinary groups working in comfortable, undisturbed surroundings. Quantity of ideas is more useful than quality at this stage; finding original ideas takes time. Figure 18 shows how ideas and options tend to be generated during brainstorming sessions. Participants should have a break when ideas seem to dry up: there can be a gestation period from which new ideas might emerge if the session is resumed later or next day.

Figure 18 **Generation of ideas over time during brainstorming sessions**



Tools that aid the brainstorming process include value analysis and design methods such as analogy; combination; lateral thinking; inversion; and Delphi (forecasting).

Each idea, whatever the source, should be assessed to establish whether it:

a) is compatible with the organization's objectives and strategies, and all other business criteria contained in the business plan;

b) has the potential to meet all technical and commercial objectives detailed in the project proposal;

c) can be made within all sourcing, manufacturing and distribution objectives contained in the project proposal;

d) will lead to a worthwhile return or benefit to justify the commercial risks or financial outlay specified in the business plan.

A preferred option should be identified from the various concepts developed. Where appropriate, combine options that are particularly good at satisfying different aspects of the design brief.

Techniques to be used in this process include rating, ranking, classification and risk analysis.

The outcome of this stage should be the preferred option that best fulfils the requirement described in the product specification.

5.4.4 Formulating the product specification

The project manager should arrange for the information compiled so far to be expanded into a complete product functional specification. The elements to be included vary depending on the type of product being designed. A typical list of elements is shown in Figure 19.

Figure 19 **Typical elements in a product specification**

- Introduction.
- Functional criteria.
    - Requirements.
    - Use/modes of operation.
    - Environmental conditions.
- Performance criteria.
    - Operational performance.
    - Safety.
    - Manufacturability.
    - Availability.
    - Reliability.
    - Durability.
    - Adaptability.
- Physical properties.
- Interface requirements.
- Manufacturing requirements.
- Support requirements.
    - Supporting systems.
    - Maintenance.
    - Training.
    - Labelling and packaging.
    - Transport.
    - Safety.
- Regulations and standards.
- Verification and validation.
- Cost.
- End-of-life requirements.
    - Disposal.
    - Disassembly.
    - Recycling.

NOTE See BS 7373-2:2001, Annex F

The following process can be used for generating the specification:

a) consider each topic in order to determine whether it is relevant;

b) differentiate between elements that are essential and those that are merely desirable;

c) consider each topic from a customer's perspective;

d) document the details of each topic;

NOTE 1 Wherever possible, details should be quantified, though benefit can still be derived from qualitative descriptions.

e) where possible, put a tolerance on all quantities.

NOTE 2 Generally, the tighter the tolerance, the higher the cost of providing it.

NOTE 3 Further guidance on preparing specifications is given in BS 7373-2.

The outcome of this stage should be a completed functional specification that describes the technical details which the chosen option should fulfil. This specification should define requirements and constraints (e.g. regulations), that will steer the development of solutions.

Only when at least one achievable design solution has been identified is the project viable. The project should be fully appraised and formally approved by principals for continuation, revision or abandonment. If approved, the necessary resources should be committed to follow through to the design and development phase.

5.5 The "design and development" phase

5.5.1 General

The project manager should now assemble the multi-disciplinary design team to undertake the design, with its composition based on experience and the skills required and if applicable, any other political considerations. The role of each member of the team should be specified, clearly understood and agreed.

Not all team members will contribute continuously throughout the project, their intermittent activities should be set out in the project plan.

The whole life costs of operating the product should be considered, such as energy consumption, maintenance, and repairs. The project manager should agree with all interested parties design costs versus operating costs, durability, life expectancy and use.

NOTE For guidance on lifecycle costing, see BS 60300-3-3.

5.5.2 Specifying the system architecture

The project manager should ensure that the structure of the system architecture is determined at this stage. For complex products or machinery, this stage can be very important in achieving a viable design. For example, to achieve the required safety or fault-tolerance, a certain interdependency or redundancy of modules might need to be designed in at the outset otherwise the design objectives might not be achieved. Care should be taken to ensure that safety is never compromised as design progresses through to manufacture and launch.

Once the system architecture is determined, the design of the product should be structurally developed to show the features included in the chosen option, together with their spatial arrangement (embodiment design, design scheme or general arrangement (GA)). This should show the type of interfaces and the items to be manufactured as well as their appearance.

The outcome of this stage should be that the product is resolved into a framework of modules or components that is now ready to be detailed.

5.5.3 Verifying innovations

This stage of the design process exists to ensure that innovative technology or applications are theoretically understood and technically proven before significant effort is expended to exploit them. Extra attention should be paid to the more innovative parts of the design where lack of experience makes it more difficult to forecast performance.

It is inadvisable to base a new product design on unproven ideas or technology, without verifying the underlying principles. This stage provides the opportunity to validate the proposed solution. If there really is nothing innovative about the proposed product, this stage can be omitted.

There are benefits in translating design concepts into reality as soon as possible, particularly when ideas, principles or parts of the design need to be tested. It also helps to facilitate decision making when choosing between alternative design solutions. The project manager should arrange for computer simulation, laboratory or experimental work and prototyping to be carried out to verify that any innovative concepts perform as anticipated.

The outcome of this stage is confirmation that innovations incorporated in the new product (where these exist) will operate satisfactorily.

5.5.4 Creating the detail design

The individual components of the product should now be detailed and procedures and methods for their manufacture and delivery identified and specified. These need to include machine and tooling design, production manuals and quality assurance specifications. This stage should also include the design of any literature.

The project manager should ensure that the design is verified by a testing and validation programme running concurrently with the final detail design process (see **5.6.3**).

Where components have a long lead time, it will be necessary to place firm orders well before the manufacturing stage commences (see **5.6**).

The project manager should also ensure that the means by which the product will be manufactured and delivered is defined, including agreement as to whether:

a) suppliers will be producing their components to their own specifications and designs; or

b) suppliers will be required to manufacture components according to detail designs passed to them by the organization; or

c) suppliers will be expected to respond to outline specifications applying their own design and manufacturing expertise.

A serious option to consider might be strategic partnerships with suppliers to create particular components in order to make use of the latest available technology.

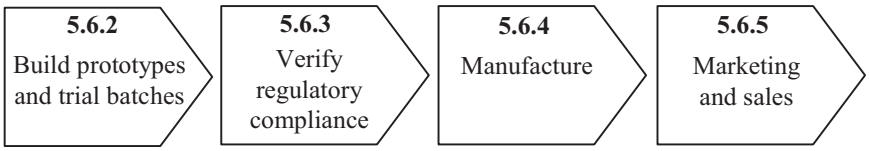
Examples of information resulting from the detailed design stage are shown in Figure 20.

Figure 20 **Information contributing to the detail design**

a) Specification(s).
b) Detail models/drawings of the assemblies that make up the total product.
c) Detail models/drawings of the components that make up the assemblies.
d) Material specifications (including environmental considerations).
e) Manufacturing process specifications (including production equipment).
f) Assembly instructions and processes.
g) Bills of material/item lists.
h) Approved suppliers.
i) Preferred components.
j) Target component costs.
k) Tooling specifications for components and assemblies.
l) Target weights.
m) Detailed performance criteria.
n) Reliability predictions.
o) Launch date.
p) Product test specifications.
q) Test equipment requirements.
r) Verification records.
s) Validation records.
t) Technical file and declaration of conformity to applicable standards.

The outcome of this stage should be a detailed design of the product with documentation and instructions on sourcing, manufacture, delivery, operation and support through to final disposal, for the guidance of staff, suppliers, customers and other interested parties.

5.6 The "manufacturing" phase



5.6.1 General

Typically 45% of the total expenditure in the stages prior to full scale production occurs towards the end of design process when manufacturing facilities need to be set up. These capital expenditures are usually necessary for items such as premises, tooling, equipment, raw materials and bought-in goods.

The project manager should ensure that the previously defined manufacturing and delivery plans are implemented. Resources such as purchasing, tooling and other production equipment, and maintenance equipment should be developed and acquired. Any additional personnel required should be recruited and trained. The marketing and launch of the product should be addressed and organized (see **4.6**).

The outcome of this phase should be the capability to provide the complete product.

5.6.2 Building prototypes and trial batches

It is often helpful to produce mock-ups, prototypes and other development articles at various stages of the design process. These test the function, performance and aesthetic characteristics of the proposed product, and may include the following.

a) Mock-ups, representative in physical form only, of the proposed product. These are often made during the early stages of design (sometimes referred to as a "looks-like" model).

b) Experimental rigs, representative of aspects of the function, but not the form, to test whether a proposed design solution works as intended (sometimes referred to as a "works-like" model).

c) Test prototypes that are partially representative of the intended final product may be used to verify the functional characteristics of the design, and a series of such prototypes may be produced at different stages of the design process to test different aspects of the product (sometimes referred to as a "looks-like, works-like" model).

d) Development prototypes may occasionally be used to verify the design in terms of its characteristics (e.g. functional performance, ease of assembly, customer acceptability, reliability, maintainability), or to submit to an independent test house for standards pre-compliance or compliance testing.

e) Trial or pre-production batches should be produced to verify manufacturing, inspection and testing processes.

5.6.3 Verifying regulatory compliance

Pre-production prototypes should undergo testing and verification to confirm the performance of the product in all respects (e.g. that performance, safety, quality, reliability and maintainability requirements have been attained). This is a phase of the project where concurrent working can be exploited, as all details are finally chosen, tested and confirmed. Testing may take the form of accelerated life tests and field trials, preferably with typical customers.

Reference should be made to relevant parts of BS 5760, BS EN 60812 and BS EN 60300 for detailed guidance on reliability and maintainability management, testing and assessment, and also to BS EN 60706-2 with regard to maintainability of equipment.

Depending on the nature of the product and the countries where it will be sold, it will probably be necessary to formally test the product to the relevant standards (e.g. for electrical safety, mechanical safety, electromagnetic compatibility, etc.), and assemble the evidence of compliance in a technical file.

It might be prudent to involve an independent test house or notified body in conducting such tests independently. For some products this is a mandatory requirement of European Directives, or legislation in the country of sale.

5.6.4 Manufacturing the product

The choice of manufacturing resources is an important consideration, and a decision should be made as to whether the product will be manufactured by:

a) existing organization's manufacturing resources;

b) new or increased manufacturing resources, requiring new investment;

c) outside manufacturing resources offered by subcontracting suppliers; or

d) new outside resources requiring new investment either within the project or by the supplier.

Ideally, this decision will have been made at organizational level, but if not, the project manager should ensure the choice of manufacturing resource is agreed.

The project manager is responsible for the smooth handover of the design to production, but usually not responsible for the manufacturing programme itself. However it is likely that manufacturing will require technical support, if queries emerge over design details that cause manufacturing problems, components become unavailable in the necessary timescales, or problems arise with the performance of the product. Thus the project manager should arrange to provide support from the design team to help resolve manufacturing problems. The organization should avoid committing all design team resources to alternative projects before the current commitments are complete and all fundamental manufacturing issues are resolved.

Product delivery should be relatively straightforward if previous stages of the model have been fully processed. However, in the case of large, one-off products, the exact logistics of delivery should be carefully planned and checked to ensure efficient routing and a clear passage to the final destination.

5.6.5 Marketing and selling the product

Despite the design team finishing the bulk of their work before the product selling stage, it will almost certainly be necessary for them to provide technical support during this stage, and thereafter during the product's life.

When preparing for the product to be introduced to its intended market, the project manager should consider:

a) promotion, including advertising;

b) test marketing;

c) the launch;

d) customer or agent training;

e) seminars and workshops;

f) technical advice and problem solving;

g) customer support;

h) distribution of the product to stockists.

The project manager should ensure that product information is provided to sales organizations and their personnel to ensure that they are fully conversant with the features and performance of the product.

During the selling and use stage, the opportunity should be taken to gather potentially valuable data concerning users' experiences with the product, in order to ascertain improvements and future product design requirements. The project manager should therefore ensure that good communication links are established with other parties such as:

a) manufacturers and their subcontractors;

b) distributors, dealers and sales organizations;

c) customers and users;

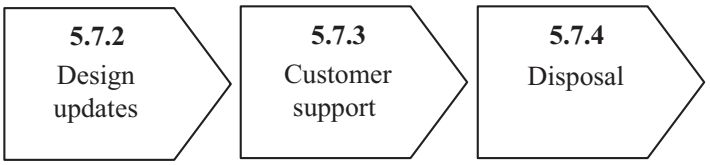
d) post-sales service, support and refurbishing facilities;

e) re-sellers;

f) disposal facilities.

The outcome of this stage is the capability to maintain the product on the market.

5.7 The "support and termination" phase



5.7.1 General

Where practicable, the project manager of the original development should contribute to the support phase, as his product knowledge is likely to be of great value. In particular, the project manager should be involved in sanctioning any proposed design updates, as he will be aware of the reasons for the original design decisions, and can prevent erroneous assumptions being made by those not involved in the original design.

5.7.2 Managing design updates

The project manager should ensure that the manufacturer continues with testing and information gathering in order to identify any areas where failure might occur in the longer term. This will enable early corrective action to be taken and effort made to eliminate or reduce potential problems.

Experience and statistics gathered during the manufacturing stage can also point to areas for improvement.

Types of issues that may result in feedback are as follows:

a) failures and rework in manufacture;

b) scrap levels;

c) deviations from the specification;

d) failures during in-house testing;

e) statistical process control results;

f) manufacturing yield;

g) product nonconformances;

h) audit noncompliances.

5.7.3 Customer support

It is essential to provide some form of after-sales support, whatever the nature of the product. As a minimum this might be a consumer helpline provided by a customer services department. More complex products might require a technical "helpdesk" manned by staff with a more in-depth knowledge of the product.

There may also be a need for support in the form of technicians to replace faulty parts or undertake routine maintenance or servicing. This will almost certainly require the provision and availability of consumable items and spare parts and the employment of personnel who are suitably trained. Such resources can be provided in-house or subcontracted.

If either of the above requirements is foreseeable, the project manager should assume some responsibility for ensuring the necessary resources are provided.

Sales might continue for a long time, perhaps prolonged by used-sales activities. So the after-sales service and spare parts activities should continue for the anticipated life of the product.

5.7.4 Disposal

When a product line is withdrawn, discontinued or replaced, contractual and legal liabilities and warranties will remain in force for products still in use.

There may also be a continuing demand for after-sales support, spare parts and consumable items.

The factors that need to be attended to at this stage should have been considered in the concept and feasibility stages of the project, described in the product design brief and specification and included in the project plan.

These factors may include:

a) warranty;

b) disposal;

c) waste management;

d) biodegradability;

e) service and maintainability;

f) provision of spares;

g) skills provision;

h) continuing safety and security;

i) recycling;

j) social and environmental impact;

k) transfer or sale of the project;

l) upgrading of product;

m) intellectual property rights.

After considering the need for continuing sales support, remaining stocks of products, spares and consumable items might be sold to a specialist dealing in discontinued products.

With regard to k), if consideration is given to selling the remaining assets of the project to another party, then legal advice should be sought regarding liabilities and intellectual property. It is important not to give away intellectual property that might be needed for future products.

5.8 The "verification and validation" phases

5.8.1 General

The project manager should ensure that verification and validation activities are considered in detail, embodied in the overall project plan, documented in a test plan and validation protocols, and that a validation report is issued on completion of the test plan.

NOTE Verification and validation are a recurring theme throughout the design process (see Figure 9), and although they should be integral to the various stages of the process, they are considered here for clarity as a separate clause.

The aim of verification and validation activities is to demonstrate that the product meets the specification, meets customer's needs and is safe (see BS 7373-2:2001, Clause **8** and Clause **9**, and BS 7000-4:1996, Annex A).

5.8.2 Planning verification and validation activities

When planning these activities, it is recommended that the project manager considers using a risk-based approach. This involves prioritizing verification and validation resources according to the severity and likelihood of the outcome.

Protocols should be prepared to define the specific verification and validation activities in detail. A competent person should be nominated by the project manager to review the protocols.

A protocol should define:

a) the purpose of a test;

b) the section of the document or risk assessment which gives the requirement;

c) who will carry out the test;

d) the test instrumentation and set up;

e) evidence of calibration for test instrumentation;

f) preparation for use, including setting and adjustment;

g) the method of test;

h) precautions to protect against any safety hazards that might arise during the test;

i) the expected result;

j) any analysis of the results necessary;

k) the pass/fail criteria, as related to the requirement.

5.8.3 Verifying the design

Verification of the design is confirmation by examination and the gathering of objective evidence that specified requirements have been fulfilled. In design it concerns the process of examining the result of a given activity to determine conformity with stated requirements (see BS 7373-2:2001, Clause **8**).

Verification should be applied at any point in the design process when design output is to be issued or incorporated into subsequent design processes. Verification activities should be shown as discrete tasks on the project plan, and will occur throughout the design process.

The techniques used should include, for example:

a) testing, by field trials, pilot schemes, market testing, etc.;

b) independent verification of the design and any associated calculations;

c) design reviews;

d) repetition (i.e. design calculation repeated using an alternative method);

e) comparison with a similar proven design.

5.8.4 Validating the design

Validation of the design is the confirmation by examination and the gathering of evidence that the particular requirements for a specific intended use are fulfilled. It should establish that the design conforms to customer requirements. The process of examining a product to determine conformity with user needs should be carried out on an example of the final product under defined operating conditions. It might also be necessary at earlier stages and multiple validations may be carried out if there are different intended uses. Ideally design methods and sources of design data should also be validated.

Validation of the design may be by any of the following:

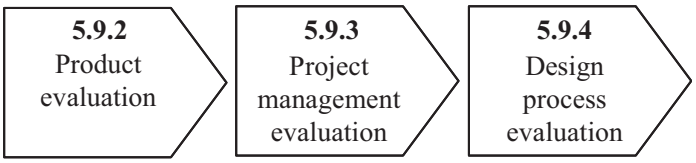
a) usage or trials;

b) review or observation;

c) testing.

A validation strategy should take into account particular features where they involve risk in respect of health, safety and the environment. The agreed validation protocol and results of the validation tests should be documented (see BS 7373-2:2001, Clause **9**).

5.9 The "evaluation and continual improvement" phases



5.9.1 General

The product, the project and the whole design process should now be evaluated, and any areas for improvement identified in the design, the management of the project, or the organization's underlying design process. This will be of benefit to future projects.

The project manager should arrange for the monitoring of in-use performance through feedback from customers and staff. This should provide valuable insights into possible improvements (refinement, retrofits, modifications or changes to the design), or generate ideas for new products.

The project manager should ensure that systems are in place for:

a) monitoring delivery statistics;

b) monitoring customer feedback;

c) identifying problems and taking corrective action;

d) identifying market changes.

The outcome of this phase should create the potential for continual improvement in the product and the design process.

5.9.2 Product evaluation

The three major interrelated areas of customer, in-house and independent evaluation should be considered:

a) Customer evaluation. Customer feedback should always be sought; it is a prime element of customer care and continual improvement. It should include the customer's evaluation of the product itself (not only its function but ease of use), the user documentation, value for money, quality and reliability, customer service and the receipt or delivery of the product.

b) In-house evaluation. This is a self-analysis for which the criteria will normally include the rate and level of take up of the product, reaction of the competition, wastage, contribution to profit, meeting the company plan, training needs, return on investment, reports on complaints and recovery action taken, ease of operation within the organization, and changes in reputation and standing of the organization.

c) Independent evaluation. This may be carried out in accordance with independent standards (where such apply) and might, in some cases, be a legal requirement. Elements of this evaluation may include independent assessment to the appropriate product standards or regulations (e.g. those for electrical safety, see **5.6.3**).

The outcome of this stage should create the potential for improvement in the design.

Project managers should ensure that members of the design team contribute to, and are involved in, an evaluation of the product design. They should also ensure that recommendations and necessary corrective actions arising from the evaluation are properly implemented and that the lessons learned are carried forward into future projects.

5.9.3 Evaluating the management of the project

Before concluding the project, the project manager should evaluate management of the project and draw up recommendations for improvement. The issues addressed should include the following questions:

a) Were all objectives achieved: if not, why not?

b) Was planning comprehensive and were project plans appropriate?

c) Could progress have been improved, for example, by undertaking stages in parallel?

d) Were the organization's resources and systems adequate to support the project (e.g. in accordance with ISO 9001)?

e) Was the motivation and use of internal and external staff adequate?

f) How useful was the contribution of subcontract design staff?

g) How beneficial was the contribution of consultants?

h) Were the right staff recruited with appropriate job descriptions and salaries?

i) Were the organization structures appropriate?

j) Was the training of staff adequate?

k) Were the tools and equipment available adequate and effectively used?

l) Were the procedures specific to the project adequate and were they compatible with the organization's standard procedures?

m) Do any issues require attention to improve performance in subsequent projects?

5.9.4 Evaluating the design process

An evaluation of the design process itself should be completed. A review of the progress of design as illustrated in the design model might reveal areas where improvement could be made for the next design project.

The evaluation of the design process should examine both company procedures and those that are specific to the project. The evaluation might include the following topics:

a) design procedures;

b) documentation systems;

c) design reviews;

d) change control systems;

e) information systems;

f) roles and responsibilities;

g) competencies and technologies available;

h) the adequacy of design tools, and the skills to use them;

i) the basis of decision making in design and project management;

j) internal and external communication in design;

k) project planning systems;

l) auditing procedures and the timing of audits;

m) return on investment, or other financial performance measures.

The project manager should produce an evaluation report that includes the following:

a) an internal assessment of strengths and weaknesses, comparison with the project proposal, reason for discrepancies, and feedback from the manufacturing functions, customers, service organizations, etc.;

b) an assessment of the adequacy of the project proposal, design brief, and various specifications;

c) identification of those procedures that worked well and those that did not, and of the causes of misunderstanding or delay;

d) proposals for changes for the next project;

e) authorization from management to implement agreed changes.

The project manager should consider reporting any ideas that could increase the efficiency of the design management process. These include reducing time-to-market, controlling design and product costs, controlling costs in use, and earned value analysis.

5.9.4.1 Reducing time-to-market

Every attempt should be made to reduce the time for the product to reach the market. The advantages of this are:

a) the product reaches the market ahead of the competition;

b) premium prices can be charged;

c) if money has been borrowed, it can be repaid in less time, so interest payments are lower and the cost of the product design is less;

d) design can start earlier for subsequent models and other designs;

e) it can improve company reputation and morale.

A reduction in time-to-market can be achieved by the following measures:

a) having a thorough and detailed design process model for the particular product being designed;

b) making management and design decisions early in the design process;

c) utilizing up-to-date design tools to the full;

d) reducing the number of design changes late in the design process (by getting things “right first time”);

e) harnessing talent and employing effective communication by involving all those who have something to contribute;

f) using concurrent working.

NOTE This is not an exhaustive list, and gains may also be achieved in the areas of marketing, manufacture and pre-launch activities.

5.9.4.2 Earned value analysis

Earned value analysis (EVA) is used to determine the value of useful work (or earned value) performed at a chosen date, either in man-hour or monetary terms. By comparing this earned value with the planned and actual costs to that date, it is possible to see whether the design work has been carried out efficiently (cost effectively) and to schedule. The technique also enables predictions to be made of the estimated final cost and completion date of an activity, group of activities or a complete project.

To operate EVA effectively, a system (such as time sheets) which records the actual cost or man-hours to date should be in place. Moreover, arrangements should be made for regular visual assessments of the percentage completion of all activities to date. Thus the actual cost and percentage complete are the only regular inputs required to produce tabular and graphical outputs, either manually or by computer, that will provide sufficient control data to enable design managers to take remedial action when unacceptable deviations occur from plan. Such graphical outputs would show:

a) cost to date,

b) progress to date;

c) overall percentage complete of the project (or selected portions);

d) cost performance index or efficiency;

e) schedule performance index;

f) cost variance;

g) schedule variance;

h) estimated final cost;

i) estimated completion date.

NOTE Refer to BS 6079-1: 2002; 6.6.6.

EVA is based on performance measurements and replaces traditional cost control practices that only compare planned and actual costs.

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