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Classification of information in the construction industry

Classification de l'information dans l'industrie de la construction

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The main task of technical committees is to prepare International Standards, but in exceptional circumstances a technical committee may propose the publication of a Technical Report of one of the following types:

— type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;

— type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;

— type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 14177, which is a Technical Report of type 2, was prepared by Technical Committee ISO/TC 59, *Building construction*, Subcommittee SC 13, *Organization of information in the processes of design, manufacture and construction*.

This Technical Report derives from many years of development work, initially in CIB Commission W74 and, since 1988, in Subcommittee 2 of ISO/TC 59/SC 13. The topic is still under technical development, hence the publication of this document as an ISO Technical Report rather than an ISO Standard.

This document is being issued in the type 2 Technical Report series of publications (according to subclause G.4.2.2 of part 1 of the ISO/IEC Directives, 1992) as a "prospective standard for provisional application" in the field of classification of information in the construction industry because there is an urgent need for guidance on how standards in this field should be used to meet an identified need.

This document is not to be regarded as an "International Standard". It is proposed for provisional application so that information and experience of its use in practice may be gathered. Comments on the content of this document should be sent to the ISO Central Secretariat.

A review of this type 2 Technical Report will be carried out not later than three years after its publication with the options of: extension for another three years; conversion into an International Standard; or withdrawal.

The expected conversion into an International Standard will involve revision in the light of a vigorous programme of work on international classification tables. Sections 6 and 7 will need to be rewritten and most of the Appendices will be omitted, it being expected that by then most of the projected international classification tables will be published or approaching publication.

Classification of information in the construction industry

1 THE PURPOSE OF THIS REPORT

There has never been a greater need for effective communication tools in the construction industry. Major factors motivating this statement are:

- Information becomes increasingly important as we move towards an information society. The computer gives possibilities to communicate and use more efficiently the vast amounts of information which are used and created in a project during design, site production, operation and maintenance. Losses of meaning may be minimized and everyone may be provided with the information he needs to fulfill his task. However, efficient use of computers requires a 'common language' of well designed classification and coding systems with clearly defined rules for structuring product models, databases and documents in a unified way.

- The increase in international trade of construction products, consultancy services and construction services makes internationally accepted principles for communication more important.

- The increasing attention being given to management of the use phase of facilities, including operation and maintenance, has increased the need for classification systems which may be used throughout the total construction process, from inception to demolition.

The primary purpose of this Report is to provide the basis for an improved information flow during the creation and use of facilities, and to give guidelines for organizing industry information. The recommendations are aimed at improving the information flow within particular countries and also from country to country.

The Report is intended to be read in conjunction with a series of Standards, each of which will define (defines) a recommended international classification table. Examples of such tables are Facilities, Spaces, Elements, Construction products and Attributes. The Report defines the underlying philosophy behind the tables, the relationships between them and the way in which, together, they will be (are) an integrated whole, a well co-ordinated and wide ranging classification system to serve the needs of the International Construction Industry for the forseeable future.

2 THE CONSTRUCTION PROCESS, ITS AGENTS AND DOCUMENTS

2.1 The construction process

This Report is concerned with the complete lifespan of construction facilities (e.g. houses, hospitals, roads, bridges, dams, utility services) from the client's first thoughts through to demolition, including design, production, operation and maintenance. For the sake of simplicity this complete lifespan is referred to as the construction process, which may be roughly subdivided into **creation, use** and **decommissioning** – see Figure 1.

CREATION			USE	DECOMMISSIONING
INCEPTION	**DESIGN**	**PRODUCTION**		
Example activities:	Example activities:	Example activities:	Example activities:	Example activities:
Assess suitability of site	Environmental and space design	Production planning	Facilities management	Demolition
Assess financial viability	Constructional design	Product supply	Facilities operation	Environmental + safety management
Formulate design brief		Construction/ installation	Facilities maintenance	
		Time/cost/ quality management		
Normally less than 1 year	Approximately 1–5 years	Approx 1–5 years	Up to. 100 years	Normally less than 1 year

Figure 1 The phases of the construction process

The construction process is long. There are normally at least 50 years between the birth of a project idea and the remodelling or decommissioning of the typical facility. During this time a massive flow of information takes place. Hundreds of persons from different organisations and with different tasks exchange and store thousands of facts in connection with the inception, design, production, maintenance and decommissioning phases of the construction process.

It may also be observed that large amounts of economic and physical resources are used during the construction process – **resources** are transformed into **results** by **activities.** Thus both physical and information flows take place.

The construction process is described above as for a new facility, but it can be considered equally for the alteration or renovation of an existing facility. Many facilities undergo major changes at least once during their lives, either to make them suitable for a change of use or to upgrade their quality and level of performance. When this happens there is an inception phase, a design phase and a production phase before the commencement of a new, different use phase for the facility. The original facility can be thought of as the 'site' for the alteration/renovation project.

2.2 The agents of the construction process

The activities in the construction process are controlled and executed by persons with distinct roles. These persons are usually called the **agents** of the construction process. In every construction project a particular combination of agents participates, having to communicate with each other and with persons less directly involved in the project.

Traditionally, the 'agents' have been thought of as the organisations of the construction industry. The changing pattern of procurement and changes in the structure and operations of contracting organizations mean that the concept of agent – he/she who acts in the process – must be redefined. The sum total of each construction process – inception, design, production, use, demolition – is the same regardless of what kind of organisational pattern is involved. Each process can be broken down into the activities which must be performed to advance the project. In classification analysis the process is primary; the activity – not the person – is important. The new definition of agent is therefore **the person who is responsible for the process or activity.**

Thus in principle the roles of the agents are not affected by the organisational form for carrying out a particular project (turnkey project, early tendering, traditional tendering with a main contractor, separate trades contracting, management contracting, etc). Similarly, the information needs of the agents are not influenced by the organisational pattern of a particular project, e.g. whether the design team is working for the client or the contractor. The organisational pattern may influence the ease of obtaining certain types of information, but that is a quite different consideration.

Here is a listing of the most important agents and a description of their roles in the construction process:

- The **client** must define his requirements based on users' needs for space, facilities and environmental conditions.
- The **design team** (architect, civil engineer, structural engineer, mechanical engineer, electrical engineer, landscape architect, acoustical consultant, quantity surveyor, etc) designs the building or other facility including the structural system, services and electrical installations, etc. They also carry out associated activities such as obtaining statutory approvals, calculating quantities of work and products, making cost calculations and monitoring the on site production.
- The **developer** and/or **quantity surveyor** undertake investment appraisal.
- The **contractor's estimator** assesses the cost of using various types of resources and of managing the construction in order to prepare tenders.
- The **constructors** plan how the project is to be constructed, requisition the resources and carry out the site production.
- The **property manager** is responsible for operation and maintenance of the facility.
- The **manufacturers** produce and supply, either directly or through dealers and stockists, the construction products as well as the working aids used in the project.
- The **stockists/suppliers/distributors** (general agents, wholesale and retail stockists) supply and distribute construction products.
- **Machinery and construction plant lending firms** provide equipment to the site.
- **Authorities** (supra-national, national, regional, local), **information centres, institutions** and **standardisation bodies** produce and distribute regulations and other information about buildings and other facilities and their use.
- **Financing institutes** (banks and other money lending institutes, administrators of state subsidised loans) provide the necessary finance.

2.3 Human interfaces in the construction process

The following takes place many times in the construction process:

Person A (**the information sender**) who works on a project is about to transfer his knowledge about something to person B (**the information receiver**) who is working on the same project. The communication is carried out with the help of **signals** via **media**, e.g. drawings, written documents, electronic files or telephone lines. Person B must receive the signals and completely understand the information before he has the same knowledge as person A. See Figure 2.

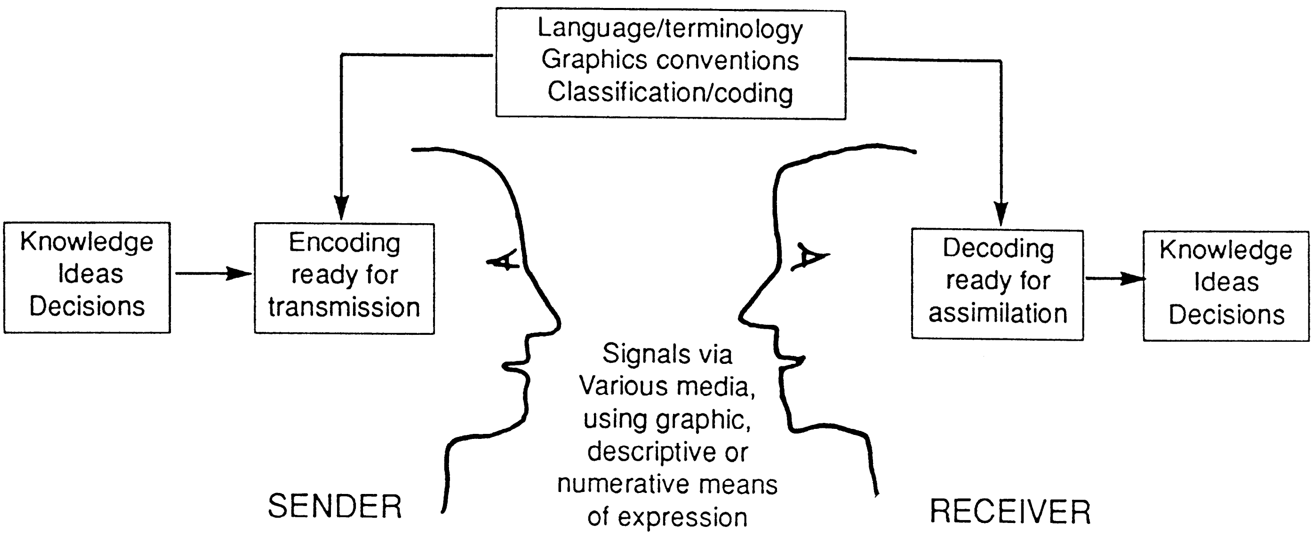

Figure 2 Communication of information

Often there are barriers which inhibit the effective communication of information. In a simplified model of the communication process the barriers are at the interface between sender and receiver. The barriers may be of many kinds, e.g.

- Lack of care in preparing the message for transmission.
- Lack of care in assimilating the message.
- Poor visual or audio quality in the media.
- Lack of common language, terminology and other conventions.

The construction process is information rich. The information flow is complex because it involves a great number of agents and interfaces. Many of the interface barriers may be overcome by using systematics for information communication such as classification, coding, controlled terminology, etc.

Those working within an organisation normally use the same systematics for structuring internal information within the organisation, so that the information flow between those working in the same organisation normally does not create major problems. If we widen our scope to a national construction industry we are inevitably confronted with interface problems if measures are not taken to create common systematics within that industry. If the construction process is to be efficient, the information flow must not be slowed down or stopped at the interfaces between persons, organisations or sectors within the construction industry, nor must there be loss of meaning or misinterpretation. The increasing emphasis on international exchange of products, services and information means that there is now a need, as never before, for internationally common systematics for communication.

2.4 The documents of the construction process

A 'document' has traditionally been understood as a paper document, but to an increasing degree a document may also exist in other forms, e.g. as electronic file or a display on a computer screen. The documents used in the construction process are the main media for communication between the agents. The interfaces are more easily bridged if the media are of high quality and if common systematics are used for coding, arranging and expressing the contents.

The documents used in the process of creating facilities may be divided into:

- **Project specific documents,** i.e. documents produced specifically for a certain project, including drawings, specifications, bills of quantities, general correspondence, etc.
- **Reference documents,** i.e. not produced specifically for a project, and which may be:
  - Documents from which information is transferred directly into the project specific documents, e.g. a library of specification clauses.
  - Documents to which specific reference is made (in whole or partially) in the project specific documents, e.g. product standards.
  - Documents which apply to the project because of a general requirement in the project specific documents, e.g. product information.
  - Documents which apply to the project because of laws and regulations.
  - Documents not normally invoked by the project documents, but which are used for knowledge acquisition generally in construction.

2.5 Information systems and databases

We are moving towards a situation where the information for a construction project is suitably structured and stored in a computerised information system as a database, it being capable of being exchanged between different computer systems and applications. Information will be built up progressively, starting with briefing information, extended with design information and ending with 'as built' information. Part of this information will remain available during the use phase and may be needed when the facility has to be demolished.

The information system has to control data of many different types, e.g. geometrical data, technical properties, cost data, maintenance data, participants, etc. for use within different applications such as CAD systems, specification systems, product information and cost information systems. All these data and relations must be structured in such a way that the stored information is consistent and reliable within and between the different systems.

The situation described above requires a far more integrated information structure than when manual routines are used. In the traditional situation the human brain creates the interface between different documents and helps to reduce possible inconsistencies. In computerised systems built-in consistency checks are needed; these are possible only with a formal information structure.

For effective communication between different computer systems and between different computer applications standardised protocols are needed. Progress in this field is being made within ISO-STEP and EDI. ISO-STEP is concerned with the exchange of graphical and other data, including product properties. EDI originally started in the administrative field, but is also expanding in the direction of product data interchange. Both standards need a good structure for the exchanged data, not only for the exchange protocols but also for the information systems sending and receiving data.

3 CONSTRUCTION INFORMATION: A DYNAMIC VIEW

3.1 Process and data modelling of the project

In Section 2.1 the construction process is described in terms of the main sub-processes, i.e. inception, design, production, use, decommissioning. Also in Section 2.1 it is observed that these processes involve large amounts of information and physical resources, and that resources are transformed into results. Graphical models are helpful to visualise processes and relationships between different types of information.

A process can be thought of in terms of input, output, resources and control:

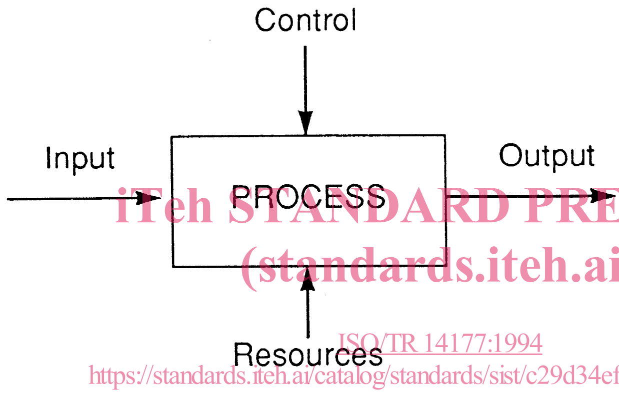

Figure 3 Basic process model

This simple model is used in the so called IDEFo analysis and modelling technique for processes. The basis of this is that a process causes an object to be transformed from one (input) state to another (output) state. Resources are used to energise, provision and support the process. The nature and orientation of the process are controlled by user requirements and regulations. This basic process model can be elaborated as shown in Figures 4 and 5:

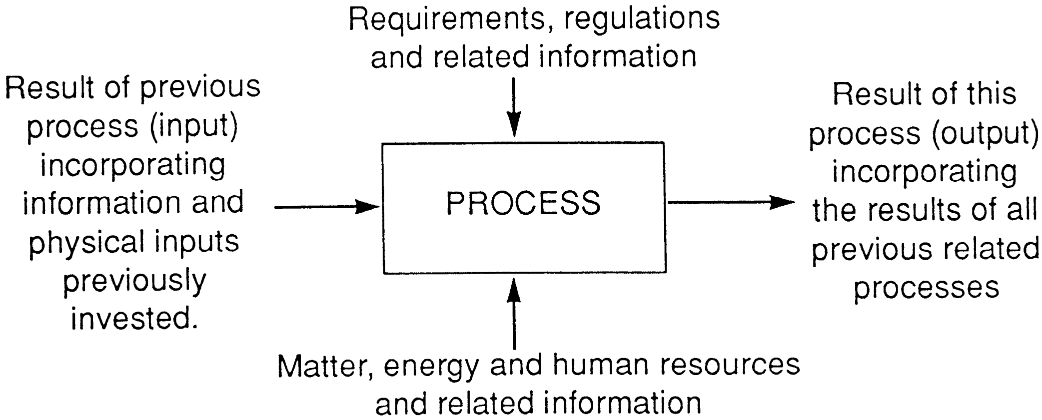

Figure 4 Elaborated process model

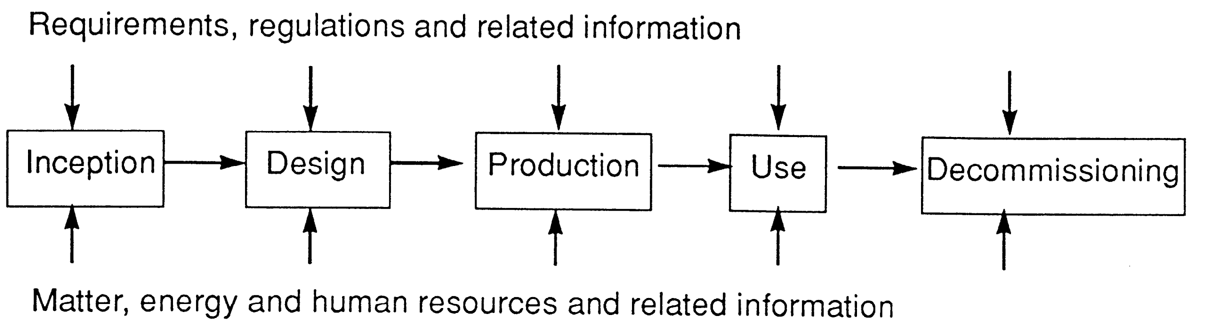

Figure 5 Process model of complete construction cycle.

Obviously, each of the major processes shown in Figure 5 can be broken down into subprocesses and sub-subprocesses. Information involved with the processes and subprocesses will be stored in a single or several information systems. Analysing this information in terms of entities, attributes and relations is a complicated matter, and modelling techniques can be very helpful. Appendix A2 gives some insight into the use of IDEFo process analysis diagrams and NIAM information analysis diagrams, based on the concepts defined in this Report.

3.2 The resources used in the construction process

Physical resources are of three kinds:

- Construction products which end up as part of the finished facility during production or maintenance. Clearly the construction products are themselves the result of the investment of many types of manufacturing resources.
- Construction aids used on site, not to be part of the finished facility, including plant, tools, equipment and consumables, including energy.
- Human effort, suitably skilled, including designers, managers and operatives.

Obviously, physical resources are used most heavily during the production process when the designed project is transformed into a physical reality – see Figure 6.

Information is also a key resource, as illustrated in Figure 6. During the inception process there is reliance on information of all kinds, the output of the process being project specific briefing information. This is the major input to the design process, during which large amounts of reference information are also utilised. Again, the main output of the process is project specific information in the form of drawings, specifications, etc.

The production process is especially dependant on information input, particularly project specific information but also reference information relating to construction products, labour, regulations, etc. An important output from the production process is 'as built' information, relevant to both the use and decommissioning processes.

RESOURCES USED IN THE CONSTRUCTION PROCESS

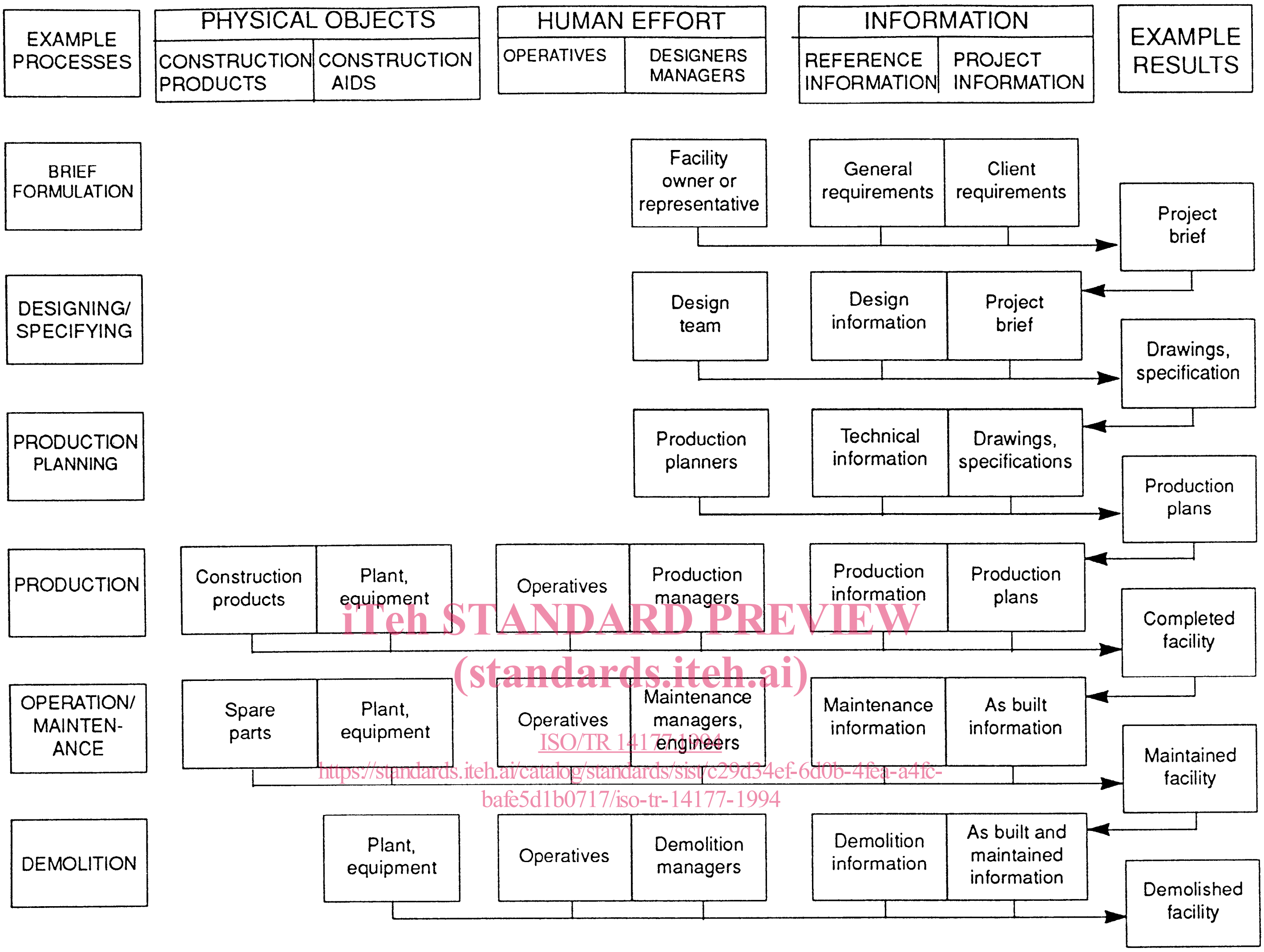

Figure 6 Resources for various processes

Other resources: The resources described above, including those involved in the manufacture of construction products, are included in the Construction Industry, and can be said to be the Construction Industry. But of course the Construction Industry forms part of the general industrial economy, and relies on the existence of other resources of a general kind. The land upon which facilities are constructed, and the supplies of energy, water, etc. on which they rely, all belong to this more general class of resources. The money required to finance the construction of facilities, and to provide the operating capital for construction industry organisations, is also a general resource. These general, 'external to the construction industry' resources are not covered by this Report.

3.3 The results of the construction process

The facility and its parts are the focus of interest for all construction processes:

- In the **inception phase** the desired spaces and functions of the facility are contemplated.
- In the **design phase** the facility and its parts are studied as models of a desired reality.
- In the **production phase** the parts of the facility are produced.
- In the **use phase** the facility is used and maintained.
- In the **decommissioning phase** the facility is often the object of quite violent attention.

The end use of the facility – the living or mechanical system for which the facility is needed – is the primary consideration during the design process and consequently during the production process too. This is true of the facility as a whole and also of its parts, which are of two kinds: the **spaces** and the **physical parts.**

3.4 End use spaces

According to ISO 6707-1:1989 'Building and civil engineering – Vocabulary', a space is an *'area or volume bounded actually or theoretically.'* In other words a space is not necessarily enclosed or demarcated by walls, floors and other space-dividing physical parts. Spaces may be external (e.g. a street space) or internal (e.g. an office space). If internal, a space may be a room, an aggregation of rooms, or part of a room. We have to consider spaces in connection with the classification of the uses to which the spaces are put.

In the case of engineering facilities the spaces will usually be to accommodate objects rather than people, e.g. roads accommodate vehicles, dams accommodate water, docks accommodate ships. In the case of public utility services for water, gas, electricity, effluent, etc. the main function of spaces is to provide a reserved longitudinal zone, either underground or overground, to provide unimpeded access.

In the case of buildings the spaces will usually be to accommodate human activities, but they may also be to provide shelter for equipment, goods or animals. Buildings may have a single main function, e.g. hospitals, churches, warehouses, office buildings, one family houses, but they may also be complexes accommodating several main functions.

Whole buildings and building complexes may be divided into a hierarchy of functional spaces; these can be defined at a general level but can also be broken down into sub-functions in a complex and overlapping way. Many spaces serve more than one function, and 'collections' of spaces can be defined from different points of view. Such complex analysis of space functions is the essence of design and economic appraisal of buildings and building complexes.