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INFORMATION SYSTEM FOR INDUSTRIAL PROJECT PLANNING AND CONTROL [1/]

by

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1.0 INTRODUCTION

Terms of Reference, Scope and Contents of Report

The material in this report describes a conceptual view of an information system for project planning and control. The method of analysis used to develop this framework is an example of what has come to be called "systems analysis". Although naming the approach adds nothing to the analysis, the name "systems analysis" connotes a generality of methodology which has many applications, and a general logic that helps show why the particular approach used here was selected for a study of project information systems. Therefore, as a basis for the analysis, the discipline of systems analysis is described in Section 2.0.

In this study a project is considered to be a mobilization of resources over a determinable life for the creation or production of a specific end-product. Specifically, projects are characterized by:

1. An identifiable end item which we henceforth refer to as the manufacturing facility as most industrial projects require such a facility.

2. The fact that successful implementation depending on organizations and agencies outside the project manager's authority.

3. Large risks due to technological and market uncertainties.

4. A well defined end or completion point.

Since this study focuses on industrial projects, the end result will be an enhancement of the production capacity or of the productivity of the implementing organization. The end item will most often be a physical thing such as a building, new machinery, etc., but we do not exclude projects which upgrade the skills of the employees.

It is the difficulties implied by characteristics (2) and (3) above that a well designed information system tries to cure. For example, since there are several organizations concerned with and affecting the progress of a project, communication among these organizations is essential for meeting a project schedule. Moreover, while uncertainties are inherently a part of projects, a good information system can provide the basis of a rapid response to implement contingency plans.

he detailed conceptual viewpoint for the information system design is described in Section 3.0; however, the essential elements can be summarized here.

An information system is taken to be the specification of the following components:-

a. The initial input source of data.

b. A data processing capability - defined as rearranging or reorganizing data to aid decision making.[1] At some point processing becomes analysis as, say, when formal models[2] to reflect reality are used.[3]

c. A data or information transmission prescription including the source within the organization and the destination for each type of information. (We call this the reporting system, but its design is one and the same as the prescription of the organized structure.)

d. A data or information storage and retrieval capability.

Both planning and control of projects are combined within the scope of the study as they must be designed together in order to assure compatibility. Together they define the function called implementation. This description also integrates the functions of implementation and analysis because the combination is necessary for effective and efficient design.

It becomes convenient, in order to analyse and design the information system, to consider time stages of the project. The project defined as starting with the product or process idea that eventually defines the end product and it ends with a post-audit of the project's operations. The time stage viewpoint is introduced in Section 4.2

The starting point of any design is the definition of the goals of the users of the end item. In the translation of goals to design, it is convenient to focus on the decisions the user must make. This is complicated by the fact

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1/ Often this processing is defined as translating data into information although the distinction is meaningful only in the context of a particular use to which the information will be put.

2/ A model is any form of abstraction of reality. A child's airplane is a model, as is a budget or the game of chess. A model is a useful substitute for reality when experimentation on the real system is impossible.

3/ The processing of information with analytical models is not always included in the definition of an information system. Because of its total dependence on information availability, we include it in the definition of the information system, although the scope of the study did not allow examination of these models.

that each project exists in a complex environment of organizations (called the project environment) having different goals and their own systems, procedures and information systems. Therefore, it is necessary to define the total environment of the project in order to:-

1. assure that the project system is compatible with other systems with which it must interact;

2. take advantage of information generated by any source at the project level without the necessity of regenerating it or laboriously searching for it;

3. generate all information at the project level that will be needed at other levels.

The scope of this study, then, includes consideration of all organizations and levels that are concerned with a project. Naturally, in different countries the names and structure of these organizations will vary. These viewpoints are developed in Section 4.1.

One by-product goal of this study is to provide a basis for project managers to assess the adequacy of their information systems. A method for doing this, complete with a questionnaire design, is given in Appendix A.

In several instances in this report, precedence networks or critical path methods are used for illustration purposes. Therefore, a knowledge of precedence networks is helpful in understanding the presentation.

2.0 SYSTEMS ANALYSIS PROJECT INFORMATION SYSTEM DESIGN

During the last decade interest in applying science to decision making has spawned several new disciplines -- one of them is called systems analysis. Unfortunately, confusion has been caused as the name has been used to describe at least three activities:-

a. the analysis of the flow of information in an organization and of the procedures and data processing implementing that flow;
b. the engineering analysis of physical stability; and
c. the analysis employed for strategic decision making within an organization.

Although these definitions are different, they have an essential commonality since they all focus implicitly or explicitly on the information needs and processing to perform a given function. This commonality suggests the complementarity of information systems and systems analysis. More specifically, there are two relationships between information systems and systems analysis. On the one hand, information systems design is an integral part of systems analysis applied to any design problem, as it is in this paper.. This section (Section 2.0) reviews both of these relationships while the remainder of the paper discusses, in greater detail, how systems analysis can be applied to the design of information systems.

To initiate the discussion of systems analysis and information systems design, it is useful to distinguish between the following three levels of decisions in an organization:-

Strategic Planning Decisions:[1/] determining organization goals, allocating resources to these goals, and defining policies for using the resources.

Management Control Decisions:[2/] establishing procedures to assure the effective utilization of resources to accomplish the goals, according to the policies.

Operational (programmed or administrative) Control Decisions: "repetitive and routine to the extent that a definite procedure has been worked out for handling them so they don't have to be treated de novo each time they occur"[3/] or, in other words, application of the procedures established by management control decisions.

Each level prescribes the objectives of, and resources for, the next lower level of decision. Therefore, although "systems analysis" refers primarily to the analysis that supports strategic planning decisions, the analysis must be concerned with all levels of decisions since they are highly dependent.

1/,2/ Robert N. Anthony, Planning and Control Systems: A Framework for Analysis, Boston, Harvard University, Graduate School of Business Administration 1965, pp. 15-18.

3/ Herbert A. Simon, The New Science of Management Decision, New York, Harper and Row Publishers, Inc., 1960, pp. 5-6.

Proper interaction between the decision levels is the function of the information system. Stated in other terms, the information system satisfies the information needs of each decision level by transferring information between the levels.

Strategic decisions are those one-of-a-kind decisions which commit capital resources. Since projects are also one-of-a-kind operations, there is a natural relationship between systems analysis and project decisions. For example, the decisions concerning what project to undertake, where to locate it, how large to construct it are all strategic decisions.

Examples of a management control decision concerned with projects are those which define the type and form of project control systems to be used. Therefore, the selection of a precedence network for control purposes is a management control decision as are the decisions concerning how often reporting shall be done and how delays on the critical path shall be treated.

Operational control decisions are those concerned with gathering and reporting the information required to use the precedence network format.

Another way of describing systems analysis as used in this document is from an operational view, that is, what does one do to perform systems analysis. From this viewpoint, sy tems analysis consists of two tasks:-

1. A search to identify the significant variables and their interaction in decision problems, considering neither so narrow a scope as to exclude critical relationships nor so broad a scope as to render the problem unmanageably complex.

2. A systematic search for alternative designs and an explicit comparative evaluation of these designs.

Because of the limited scope of this study, the focus is on the definition of the variables and the scope (task 1) leav ng the more detailed design for subsequent work.

In the design of an information system, the scope includes such considerations as which users to include and which of their functions are to be supported. If the needs of an important user are omitted, the system may not be useful and may not be accepted. On the other hand, if the needs of all persons who may have a need for project information are considered, the design problem may become very complex and the operational cost of the system may be higher than can be justified. The design also includes which parameters describing the quality and quantity of information should be included.

The two previously described tasks of systems analysis can be further broken down into a number of functions as shown in Figure 2.1. The flow chart may seem to imply that the functions must be performed sequentially. That is not the case and the functions are typically performed by shifting back and forth among them. Here we describe nine functions, although this is only one of many compatible and possible views of systems analysis.

Goal Definition

The first function is to define goals, which are often qualitative statements containing internal conflicts. For example, to state that the goal of project implementation is to "complete the project at minimum cost and as rapidly as possible" does not provide the information needed to decide how to use additional resources (and higher costs) to reduce elapsed time and vice-versa.

Each goal usually implies a number of sub-goals which, in turn, may be further broken down. To be useful, this process of analysis must eventually lead to statements which can be used to guide operational decisions and to measure the project's effectiveness. (The decomposition of goals is described in Section 3.1).

In information systems design for development projects, goal definition is especially important since the project may have social objectives which are equally as important as the financial ones.

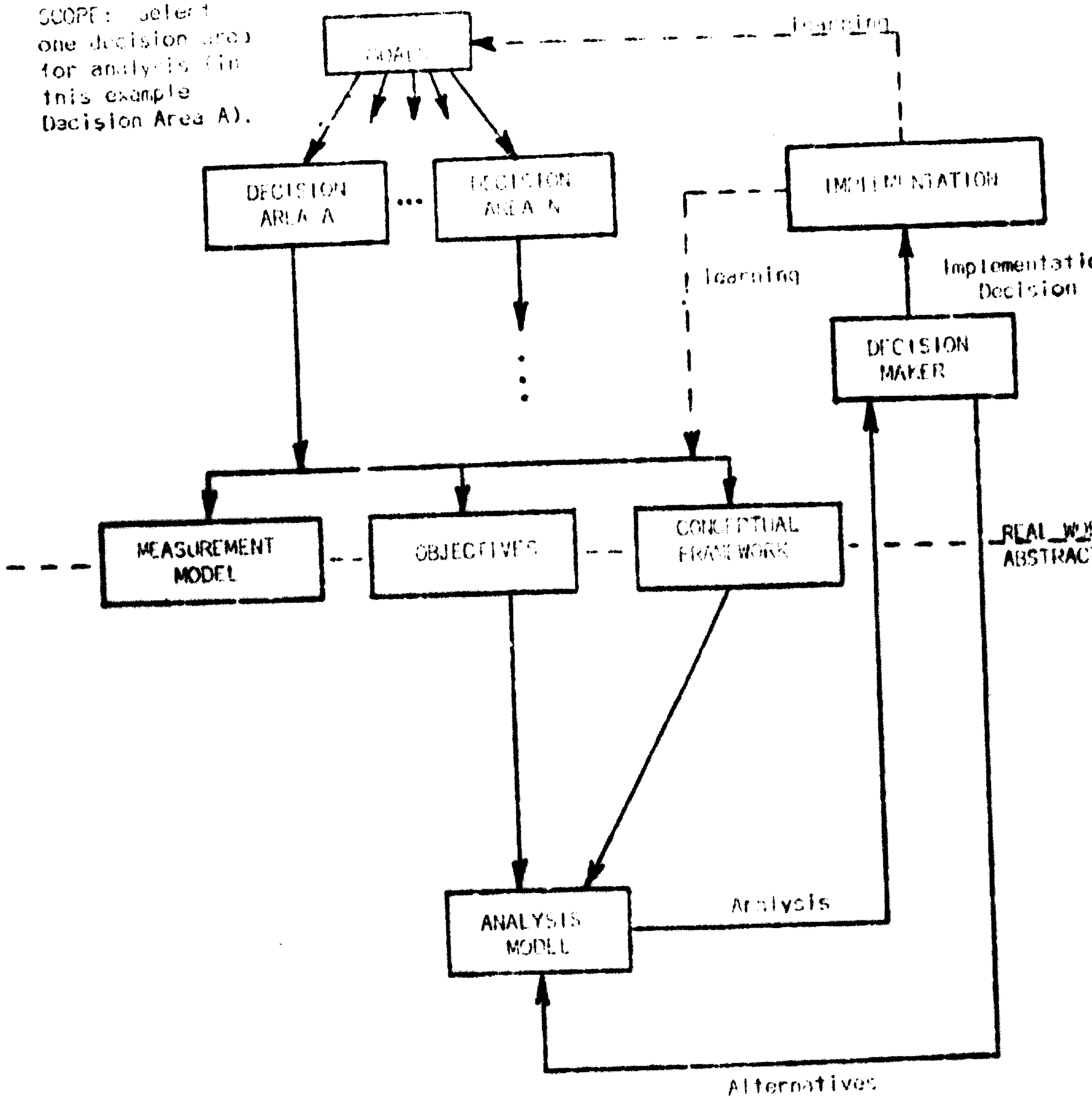


Figure 2.1 Relations of the Functions of Systems Analysis

Scoping the Study

Together with the process of goal specification, it is necessary to determine what are and what are not accepted means of accomplishing goals and then classify these means into related areas for analysis purposes. Specifying these areas of concern (called decision areas) is called scoping the decision. In short, the scope defines what is considered and what is not considered for the purpose of analysis. In the design of an information system for project planning and control, specification of whose goals defines much of the scope of the problem. For example, the management of the project has very different information needs from the investors.

In a different context, the design of a transport system to support industry in a region of a country, say Northeast Brazil, would vary depending on whether the scope included manufacturing for export or not.

Objectives of the System

Given a knowledge of the goals and the realm of operations, the next task in systems analysis is to specify the basis for allocating resources and for measuring the effectiveness of alternative allocations. For example, the goal of an industrial project may be to increase employment. This must be translated to numerical terms which can be measured to determine the success of the project. This may not be just the jobs provided in the plant since the project may both induce employment and eliminate jobs in other industries.

Rather than general statements such as "increase employment", etc., a specific statement of goals, called objectives is needed. Objectives are often quantitative. The milestone dates and costs in a PERT network are objectives.

The Conceptual Framework

In order to comprehend a system of the complexity of information needs in projects, we need to describe a framework for thinking and communicating about it. We call such an abstraction a conceptual framework. The conceptual framework is usually an abstraction which allows us to divide the problem into a number of smaller parts amenable to analysis in such a way that when the parts are reassembled, we have a valid analysis of the total system. The development of the conceptual framework is closely related to scoping the problem because limitations on our ability to conceptualize the problem may affect the scope that can be included in our analysis. An examination of the organizational structure and the information flow are two promising conceptualizations for project information system design. A precedence network, as in PERT, is another. A commonly used macro-economic conceptual model, is the Leontief input/output model.

Analysis Models

Having abstracted the so-called real world with the conceptual framework, we can now prescribe the means of analysis which guide decisions on how best to meet the goals. We call the means of analysis analysis models, although they may as well be called computational or decision models. The analysis model is a more highly structured or detailed conceptual model. They must be compatible and their difference is one of degree rather than of kind. The primary content of analysis models are rules prescribing manipulation and computation of data. The computational procedures for finding the critical path in a precedence network is an analysis model for project planning. A cost accounting system with definitions of cost standards and variances is an analysis model for project control. Sometimes analysis models are optimization models. One such useful model is the Simplex method for solving linear programming problems.

Measurement Models

The success of any analysis ultimately depends on the quality of the data or information used. Therefore, the systems analysis methodology must include the means of obtaining valid data; we call these methods measurement models. These models are a main component of the information system which defines the flow of data from the operating system to the analysis model (from the real to the abstract). The analysis model and the measurement model are often integrated, although they may be separate. Many of the most useful measurement models are taken from the discipline called statistics. Sampling procedures, estimation or prediction and regression analysis are commonly used measurement techniques.

Comparison of the Conceptual Framework, the Analysis and the Measurement Models

Three models which are included in systems analysis have been described. The following summary defines their differences:-

Conceptual Models - define the general structure of the model used in analysis; e.g., as a network model.

Analysis Models - define the computational procedures used in the analysis, e.g., the means of computing the critical path.

Measurement Models - define the means of obtaining data for the analysis models, e.g., how often progress information will be assessed.

Testing the Models

Given this structure for obtaining and analysing data, we must then be able to test the modelled environment of information systems to see if it is an accurate representation of the real world. This might be done over a period of time by comparing actual outcomes to projected outcomes. Before experience with the models is available, we can test them on historical data or rely upon the judgement and intuition of the operating personnel to see if projected results are logical and whether or not all factors have been included in a logical way.

Alternative Generation

After defining acceptable models, they are used to evaluate alternative information systems. Alternatives are defined in terms of alternative levels of system parameters. In Figure 2.1 we see the interaction of the decision-maker and the model. He observes the results of analysis and postulates new alternatives to be tested. The ability to generate imaginative alternatives and evaluate them is one distinguishing feature of effective analysis. Before the formalization of systems analysis and computerized modelling, planning was often performed by describing one feasible plan, rather than searching among a large number of plans for one which best meet the goals.

Implementing the Decision

The last step in systems analysis is to implement the decision resulting from analysis. There are a number of models which aid implementation. PERT is one such model that is commonly used. In the long run, implementation will affect goals and other elements in the problem structuring since projects teach participants what is feasible and effective as new programmes are installed. Hence, Figure 2.1 shows the feedback of implementation by dotted lines. Hastening this feedback can be planned through experimentation.

Example of the Application of the Steps

This brief description of systems analysis has been included to set the stage for the subsequent investigation of project information systems. Before this is done, an hypothetical application of the steps to industrial project selection in developing countries is given. This example is totally hypothetical and may or may not apply to any real situation.

EXAMPLE ANALYSIS

Goals	Selection of a set of industrial projects to increase employment in the Northeast region of Brazil.
Scope	Viewpoint: Northeast Brazilians, excluding immigration. Time Horizon: 10 years from initiation.
Objective Function	Maximize the numbers of persons employed in various vocations.
Conceptual Framework	A linear objective function and linear constraints on the training budget, the demand for persons in the various vocations from a manpower input/output description
Analysis Model	Any method of solving a linear programming problem.
Measurement Model	Sample existing industries to determine costs and manpower requirements.
Testing	Compare the results of the model simulating 10 years in the past to actual data.

3.0 CONCEPTUAL FRAMEWORK

3.1 Goals, Decisions and Organizational Structure

The *raison d'être* of operating entities is called goals. Goals are the ultimate guide to selection of functions and operating philosophy of the organization. The most elemental mirror of the goals is the decisions that are made at all levels throughout the organization. Focusing on decisions provides a means of examining the organization and of prescribing an information system since all decisions require information. Therefore, this study will examine the goals and decisions to be made by each organizational entity in the project environment.

The relationship of goals and decisions can be seen more clearly by conceiving of a project as consisting of four components:

1. a goals structure,
2. a set of functions,
3. an organization structure, and
4. decisions.

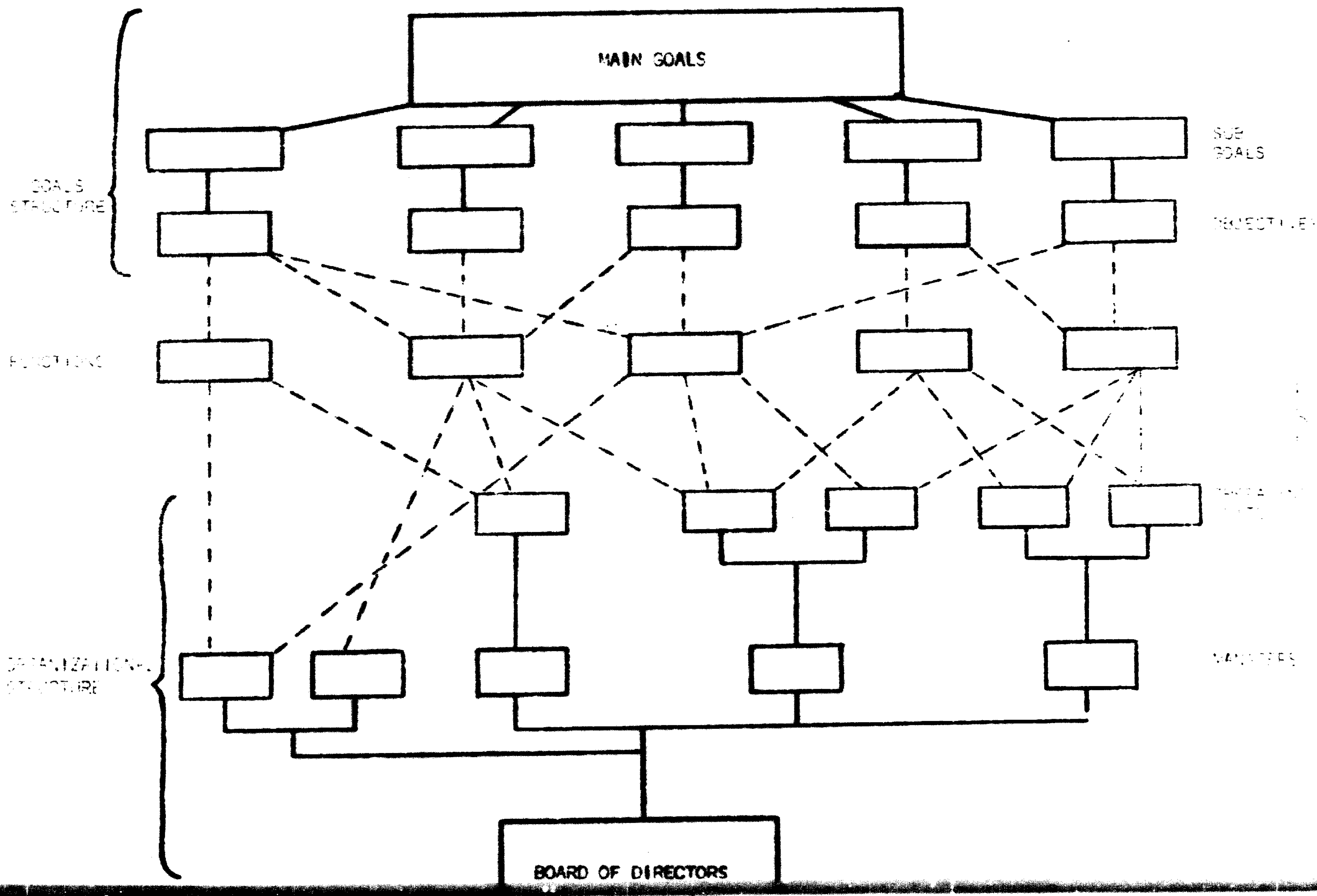
These components are related in the following way: organizational units perform functions which achieve goals. The process of selecting functions and selecting how they will be performed is called decision-making.

3.1.1 Goals or Organization Structure

The relationship of the first three of these components is shown schematically in Figure 3.1. The primary goals imply a number of sub-goals which, in turn, imply a number of objectives whose achievement can be measured. Although we will often speak of "meeting goals and sub-goals," we use the expression as a short way of saying "meeting goals and sub-goals as measured by objectives".

One function may serve more than one sub-goal and one sub-goal may be served by several functions. Each function may be the responsibility of one or more administrative units, and each unit may perform portions of more than one function. These relations are indicated by dotted lines. Higher levels in the administrative organization have increasingly higher levels of concern in the goals structure. The top executives are concerned

Figure 3.1 - Goals, Functions, Organizational Structure



with achieving the overall goals while each administrative unit strives to achieve a sub-set of the objectives.

Information flow within an organization can be looked at in two ways: It can be viewed as a flow between organizational levels, as shown in Figure 3.2, or it can be viewed as information flow between the functions of the organization. The functional view is independent of the organization structure. When an organizational flow has been prescribed, it necessarily also prescribes the assignment of functions to organizational units.

3.1.2 Decisions

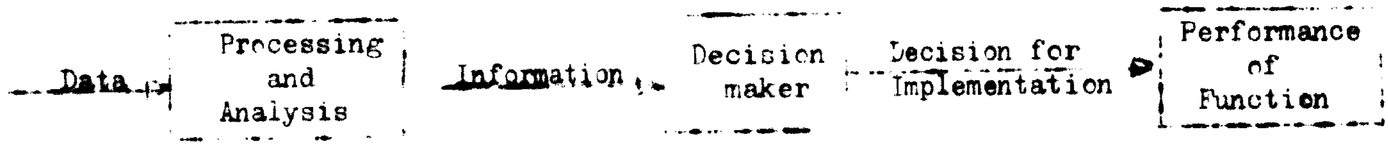
Decisions execute functions to meet the organizational goals. Decisions are made on the basis of information, hence the quality of the information system has a direct effect on goal achievement.

When prescribed decisions are effectively made and implemented, an organization runs well. When an organization is not operating well, there are several plausible reasons which can be grouped into three categories:

a. the decisions are not clearly identified (usually because the organizational goals have not been clearly defined and the goal-achieving decisions have not been allocated to decision-makers throughout the organization);
b. there is not sufficient data and information being provided to the decision-maker;
c. the decision-maker lacks the computational capacity or the analysis know-how, or both (henceforth called processing or analysis) to utilize the data in making effective decisions;
d. other.

Naturally, other will include a multitude of factors ranging from political to personalities. For the purposes of this study, which focuses on data and data processing, it serves to combine these factors in one group. Though the focus of this study is on decisions in categories (b) and (c), no amount of attention to them will be successful if the difficulty is because of (a) or (d).

The location of the decision-making function is shown in the following schematic:



This conceptualization also indicates a commonly accepted difference between data and information; the latter being data processed to a form useable for a particular decision.[1/] The processing varies in degrees of complexity from a very simple manipulation or reorganization which is typically called data processing, to more advanced computation and optimization performed according to a specification called a model. The distinction between the application of modelling and data processing is one of degree, but it is a very commonly used distinction.

A focus on the decisions of those primarily concerned with the success or failure of the project will not reveal all the information that project leaders must collect, process and store. Other information demands are imposed by other organizations and external entities by the authority they have over the project, either real or de facto. However, since these other levels may require this information for their decision-making purposes, examining the decisions in the entire project environment will reveal all information demands on the project information system. From the project point of view, these other demands are for "legal" reasons as opposed to "decision-making" reasons. Under the legal classification is included information for accounting to higher authorities, e.g., the government concerning responsibility granted by them. Information establishing legal

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1/ This distinction, no doubt, stems from the common definitions which attribute to information a factor of intelligence as in Webster's definitions:
"Data-- factual material used as a basis especially for discussion or decision".
"Information-- the communication or reception of knowledge or intelligence".

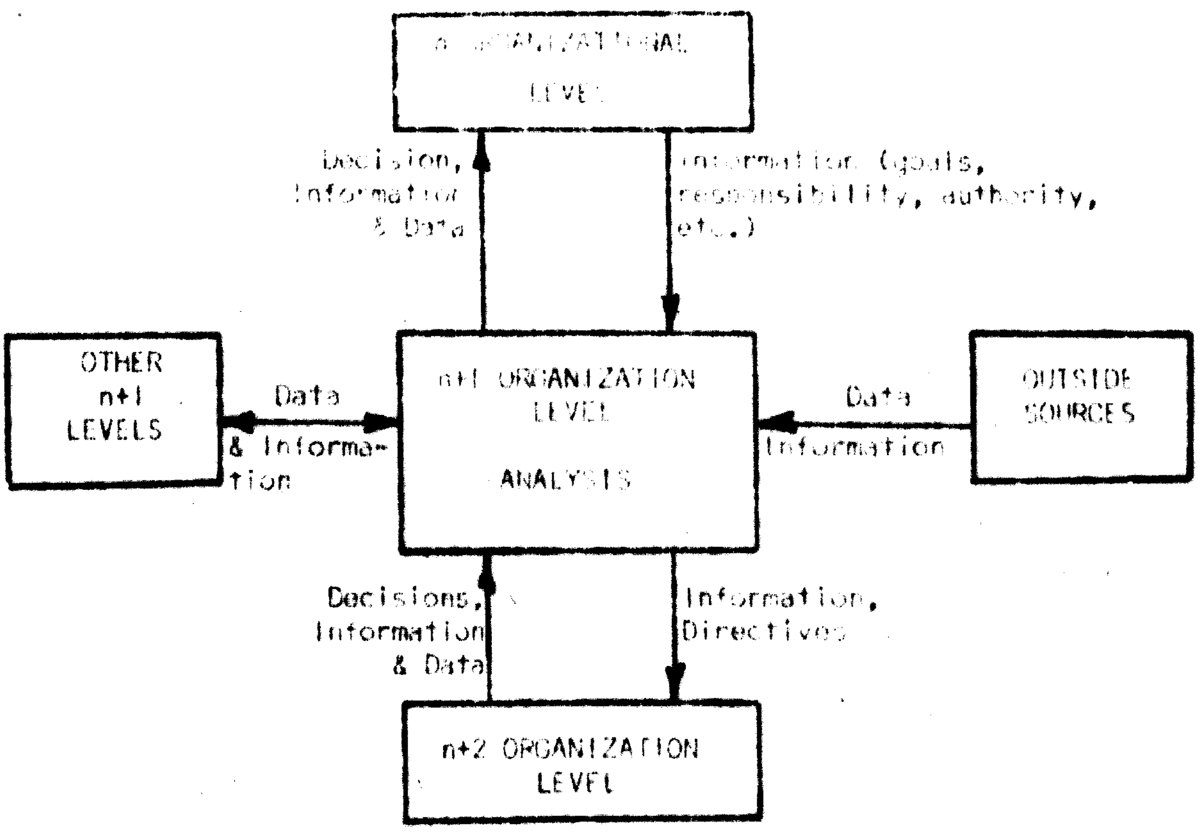

Figure 3-2. Organizational Information Flow.

claims is also in this grouping. These two reasons, though not mutually exclusive, include all motivations for data collection and processing.

In summary, this study is concerned with the quality, quantity, collection, storage and transmittal of information in order to support "decisions concerning the analysis, selection and implementation of project Goals, organizational structure, functions, and decisions are considered on because they are essential to the design of an information system.

3.2 COMPONENTS OF THE INFORMATION SYSTEM.

At any time that information or data is observed, it will be in one of three states that describe the components of an information system:

a. It will be flowing from one organizational unit to another (the prescription of the flows is called the reporting system);

b. It will be in the process of being manipulated and altered in a number of ways (e.g., averaged, normalized, etc.);

c. It will be stored (on punched cards, tapes or on documents in files, drawers, etc.).

3.2.1 Reporting Systems

The reporting system is dependent on the structure of the organisation since the flows are to support functions (and decisions) which are assigned in the organization. In addition, the reporting system includes the following parameters which define the quality and quantity of information:-

1. Quantity: Breadth--coverage of aspects required; depth--level of detail.
2. Timeliness. The time interval between reports; the lag between the end of collection and the availability to the decision-maker, usually the processing and distribution time.
3. Content: The technical level relative to the training of the user; the presentation--clarity, conciseness and ease of comprehension.
4. Availability: Ease of obtaining both periodic reports and information for ad hoc needs.

5. Quality -- absence of errors of all kinds.

These classifications are not necessarily mutually exclusive as means of enhancing usefulness. For example, quantity may act to compensate for quality.

3.2.2 Processing

Processing ranges from simple rearranging to use in optimization models which search for sub-sets of data with unique characteristics such as the rate of return of the cash flow associated with a project. Among the functions included in processing of project information are:-

Rearranging
Summarizing
Computation of Statistics
Estimation
Optimization

As stated earlier, higher levels of sophistication in the processing are called modelling or analysis. This usually means that the data is processed in a way that simulates some process in the real world and allows for projection or prediction of the effects of decisions or actions. Models useful in the project framework are critical path methods such as PERT; probability or decision trees which map out the various contingent paths that the project may take; various scheduling methods that describe the most effective way of allocating resources in time. The scope of this study does not allow more than the mention of these models though they comprise a very extensive body of literature classified under the names of industrial engineering,1/ operations research,2/ programme management,3/ production planning and control.4/

1/ Grant, Eugene L., and Ireson, W. Grant, Principles of Engineering Economy, The Ronald Press Company, New York, 1964, 4th Edition, Revised Printing.

2/ Wagner, Harvey M., Principles of Operations Research, Prentice Hall, Inc., Englewood Cliffs, New Jersey, 1969.

3/ Steiner, George A., and Ryan, William G., Industrial Project Management, The Macmillan Company, New York, 1968.

4/ Buffa, Elwood S., Modern Production Management, 3rd Edition, John Wiley and Sons, Inc., 1969.

3.2.3 Storage

The design and location of storage depots (frequently called "data banks") requires a trade-off between the cost of access and the cost of storage. Specifically, the location of data banks depends upon several parameters, such as proprietary nature of the data, who must access it most frequently, the trade-off between storage cost and communication costs, the frequency of updating the information, etc. Another decision concerning storage is the degree of centralization and duplication required of the files. These decisions are a question of economic trade-offs including the personnel time required during the searching process.

It is common to distinguish between data or information storage and document storage. The difference is that the requestor can specify the precise data desired in the former while, in the latter, he must specify or select and receive documents or document titles. An example of the document system is traditional libraries. Hard copy document storage is relatively inexpensive, but retrieval of specific information is not easily done unless one knows the exact document containing the desired information. Computer storage allows rapid response to non-specific requests such as a keyword query system in which the request is stated in subject "keywords". For example one might request all documents described by the words: INDUSTRY, BRAZIL, CEMENT.

4.0 ALTERNATIVE VIEWS OF THE INFORMATION SYSTEM

4.1 The Organizational View - Users and Their Goals

A project can be thought of as existing at the bottom of a six-level hierarchy of functions. We call this hierarchy the project environment. These levels are usually not all in one organization, although it is conceivable they may be consolidated in centrally planned economies.

The nominal organization during what we call the implementation stage is shown in Figure 4.1 where each box represents a function that exists in some form in every project environment. Many deviations from the structure as shown are possible, including combination of functions both at the same level and at adjacent levels. Functions may have a variety of names as shown in Table 4.1.

The functions and levels are described in the following sections.

4.1.1 Level (1) - National Planning

This function is usually performed by a governmental body and is dominated by the political philosophy of the ruling group. The goal of this level is presumable improvement of the productivity of the economy consistent with the philosophy. The philosophy will prescribe such matters as time horizon and ownership. This level prescribes the relative importance of industry relative to other sectors of the economy. This importance will be translated into measures of industrial sector performance, usually growth measures in aggregate terms. The function of planning at this level requires information about the structure of the economy (embodied in econometric models) and its level (aggregate macro-economic measures).

4.1.2 Level (2) - Industrial Planning

The industrial planning level takes the policies of the national planning group and translates them into a strategy for industrialisation. This group will generally be concerned with the relative emphasis on sub-sectors, although this may also be provided by the national plan. Its responsibilities usually extend to include the prescription of at least large industrial projects while small ones may be left to the discretion of an implementation agency which receives a certain discretionary budget for that purpose. This level's achievements will be measured by the number of studies identifying potential industrial productivity generated.

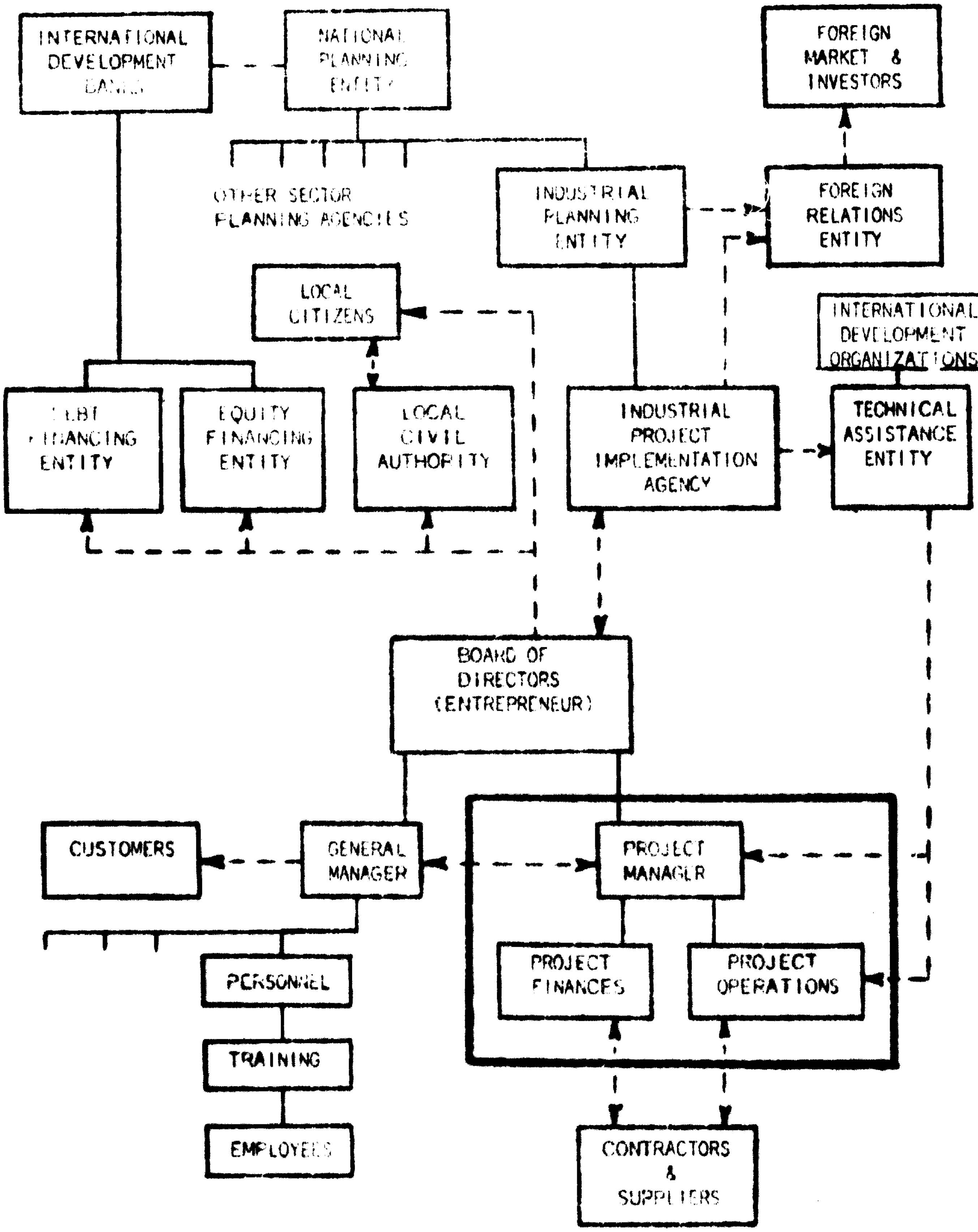

Figure 4.1 Information Flow in the Project Environment During Implementation.

Table 4.1 Sample Alternative Entity Names

ATIONAL PLANNING ENTITY
Ministry of Planning

NDUSTRIAL PLANNING ENTITY
Ministry of Industry
Regional Development Corporation

DEBT FINANCIER
Central Bank
Commercial Bank
Industrial Bank
International Development Bank
Inter-American Development Bank
International Bank for Reconstruction and Development
International Development Institution

EQUITY FINANCIER
International, Not-for-profit Financing Institution (e.g., International Finance Corporation, an equity investment affiliate of the World Bank)
International Equity Institution (e.g., ADELA, a private equity corporation investing in Latin America)
National Financing Institution (National Fianciera - Mexico)
Stockholders

ENTREPRENEUR
Board of Directors

The information needed for this function is that describing the structure and content of the industrial sector.

This level may also be responsible for promoting domestic industrial investments to foreign capital investors. This promotion may be done either through a foreign relations entity or directly.

4.1.3 Level (3) - Implementation Spectators

The third contains all entities having functions related to project implementation but not directly responsible for the control of implementation. We call this group spectators because like sporting event spectators they do not call the plays directly but rather express their interest and exert their influence in indirect ways much as spectators do by cheering or applauding.

The entities of this level vary considerably in goals including such dissimilar organizations as banks and local governments. For reasons of this variety, the level will be sub-divided for discussion purposes.

Debt Financier

Essentially, the lender is interested in a "payback" measure, where payback, in the language of engineering economics, is the time it takes a project to repay the capital investment. The lender is interested in the time to repay the loan and, in fact, the loan contract will specify such a payback schedule. Much of an unscheduled nature can happen at the project level and not threaten the ability to payback, therefore the degree of interest of the lenders in the project is dependent on the status of the implementing organization relative to the project. The following are the possible cases:

a. The implementing organization does not have its own capital to undertake the project, but could probably repay the loan from profits from other operations (we call this case an expansion project);

b. The project is so large that it dominates the implementing organization, i.e., the project's failure would threaten the organization's viability (which we call a risk project);

c. The project is the basis of a new implementing organization which will produce and sell whatever the factory produces (a case called an innovative project).

In case a., the lender may have little interest in the project's progress per se, and may wish only to track the general financial condition of the implementing organization through their periodic financial statements.

In the risk and innovative project cases, the lender may be interested in the time and cost schedule and in any major events or discoveries that threaten the viability of the factory's operation. He is interested in time lags only if they portend inability to meet the first repayment date. He is more directly interested in the cost schedule if there is not sufficient financing to allow for overruns. In the case of a discovery or occurences which threaten the viability of the project, he wishes to know immediately in order to take action to preserve the value of the assets in the project.

In summary, the lender requires a small sub-set of the information that must flow in the project environment, hence, his needs can be easily met and do not impose new requirements.

Equity Financier

The division of projects into expansion, risk and innovative is relevant as well to the equity investor. His authority to exercise direct corrective action may be constrained to action through the Board of Directors. Often, investors will contract to assure representation on the Board even if their equity share does not assure them an elected representation. Other common contractual terms allow them to achieve representation or take control of the Board if certain milestones are not met.

Generally, the investor is interested in profitability. Typically, we do not think of an industrial project as being profitable only since it represents the capital investment cost while the return is earned by the operation of the factory. However, if the investment is greater than anticipated, the return on investment of the operating factory will be lower than anticipated. In some cases, the project itself will be profitable in a direct sense as when it is undertaken on a fixed price contract to create an end item. In either event, the time and cost progress of the project both affect the profitability of the factory's operations.

Unless the investors have contractual rights to affect the progress of the project, it is not effective to provide more information than is legally required by the investment contract or by public law with regard to stockholders.

Project Implementation Agency

In a planned economy, the project implementation agency may have direct ultimate authority for the project and will act as the entrepreneur. They will perhaps allocate authority to a Board of Directors.

The more general case is if the governmental implementation agency has no direct authority. In this case, their concern is that the project succeed for the economic benefits it will bring. To this end, they may have some prescribed resources they can bring to bear to encourage success. Typically, these resources will be ones that we have already included in our system (Fig. 4.1), i.e., technical assistance or financing.

Another function the implementation agency may perform is to assist in the identification and cultivation of a foreign market for the item produced and in the solicitation of foreign investment for the production phase. This may be done through an organization which is especially chartered for liaison in foreign matters such as an industrial promotion organization or a commercial section of a Foreign Relations Ministry.

To perform most of their goals, the implementation agency probably wishe to know general progress of the project and to receive exception reports when there are significant problems.

Technical Assistance

The technical assistance agency has no interest in the project until it is requested to provide assistance, at which time its interest is very specific depending on the help requested. Such a request may come to the technical assistance agency directly from the project management or through the project implementation agency.

Much of the technical assistance requested will be for very specific technical problems, but it may also be for general management trouble shooting. In the latter, the person providing technical assistance puts himself in the project manager's position and receives that information. In the case of technical assistance on particular details, the technical assistant stands in the place of whatever technician has responsibility for that function. Therefore, the technical assistance function creates no new information needs.

Naturally technical assistance may be offered to other entities in the project environment but for purposes of simplification these interactions can be ignored in this study.

Local Civil Authority

The local civil authority (such as city or town governmental agencies) is legally responsible for seeing that the project conforms to the appropriate regulations of the legal political jurisdiction. This includes matters such as conformance to zoning regulations, payment of taxes, etc. The local authority typically is interested in the success of the project so that it creates new jobs, generates taxes and purchasing power which helps the local economy.

Except to check conformance to law and custom, the local authority has no other legal "right to know". The information provided to the local authority, then, will be primarily that required by law. Legal information will usually include the original construction plans, subsequent modifications, manpower levels, and the value of completed work. There seems to be no reason for the project entrepreneur to provide more of a progress report except for very highly summarized status reports and other stories that have public relations value.

Local Population

Communication to the local population through the usual news vehicles has several motivations. First, the local citizenry, presumably, have approval authority through their representatives in the local civil authority. It is important, then, that they be well informed on the project so that no misunderstandings arise concerning the project which could lead to withdrawal of local approval. While it might be argued that idealistically the local authority has responsibility for conveying this information, they typically do a poor job and should not be relied upon. Moreover, the concern of the populace will supercede the legal constraints on the project. Anything that pollutes or disrupts the environment will be of concern to the populace. However, there are always benefits to compensate for these intangible costs. Both sides should be presented to the populace in an objective fashion. Typically, the project entrepreneur presents a one-sided story concerning the project stressing benefits and not problems such as congestion or pollution. This balance is a matter of subjective taste and as such will not be considered further here.

Secondly, the project may wish to draw from the local labour supply both in the project phase and during production. Therefore, communicating this fact and the characteristics of the project is important.

4.1.4 Level (4) - Entrepreneur

The entrepreneur is the name given to whatever person or organization performs the function of bringing together all of the factors required to create a project. The entrepreneur is the risk-taker, the creative element, and the one who reaps the lion's share of success - or failure. Most often, the entrepreneur holds an equity share of the project.

Any of the functions shown in our idealized project environment can be combined with the entrepreneurship function, or the entrepreneur may be a totally different entity. In any event, he will, most likely, have ultimate control of, and responsibility for, the project.

In a corporate structure, this level is most likely exercised through a Board of Directors on which the entrepreneur is dominant or is strongly represented. Naturally, others may be represented on the Board from other levels. In fact, the Board may be the centre for communications among the various levels of the environment.

The entrepreneur is ultimately concerned with the profitability of the project - a concern he shares with the equity investors. However, his concern for profitability is more direct and he exercises control to assure profitability. Therefore, during the project stage, he is interested in time and cost progress and major impediments or unexpected occurences which drastically alter plans. He will not exercise direct action to catch up to schedule, but will exercise control through the project manager.

Since his control is not exercised on a day-to-day basis, the entrepreneur wishes to know only the deviations from project status or deviations from other estimates concerning all aspects of project plans. He will use this information to decide to apply more resources to obtain problem solutions. One possible resource is to call for technical assistance. The ultimate action the entrepreneur can take, short of terminating the entire project, is to replace his project management.

4.1.5 Level (5) Management

General Management. Although this study is not directly concerned with general management of the organisation which will have on-going responsibility for the finished factory, we briefly consider it because it most probably interacts with project management.

During the time of project implementation, the general manager may have responsibility for specification of systems and procedures, a management information and control system and other aspects of the continuing organisation. These responsibilities may also include recruiting and training of employees, negotiating with government bodies and unions, and advanced marketing.

Some of these functions may interact with the project, such as training which must be done on installed equipment. Moreover, changes may be contemplated during the project which will affect the continuing organisation and its management system. Therefore, the general manager needs to be kept informed on general progress of the project and of design changes.

Project Management. The project manager is the lowest level with overall responsibility for all aspects of the project. In the information system he is the switching point between all but the most technical engineering detail of the project and other levels of the environment needing to know more generally how the project is progressing. He is responsible for bringing together on a timely basis all the various entitites supplying services to the project.

Financial and general accounting control is also the responsibility of the project manager. He is the level responsible for assuring a correspondence between the actual physical-financial status and the information reporting on the status.

Specifically, the project manager must:

Schedule the use of all resources (men, capital, material, machinery);

Predict and adjust the schedule based on:

design changes
factor price changes
progress
delays
other contingencies

Predict forthcoming problems

4.1.6 Level (6) Project Operations

All levels below the project manager have a need for specific and detailed information rather than comprehensive information. Moreover, they all derive their authority from the project manager and typically receive a sub-set of his information.

They are, moreover, the source point for much of the data that feeds into the information system. The validation of the data is the responsibil of project management.

The components of the information system at the sub-project management level are:

Accounting System

Project Task Scheduling and Control

Cost Control

Cost Accounting
Materials Pricing

Inventory Ordering and Control

Manpower and Resource Scheduling

Quality Control

4.1.7 Type of Information Used.

Combining all the needs of each user allows the creation of a set of classes of information used in the project environment. Such a system is shown in Table 4.2. The policy section contains the plans created by three levels of government bodies - national, regional and sectoral. The second general class contains data describing the world economic situation and the total economy of the country. This includes such things as production, consumption, import, resource prices, etc. The third set is local economic data that determines the specific operating invironment of the prospective project. The fourth set is that generated by and describing the project itself. The final set is operational data generated by the project when and if it becomes a producing entity.

4.1.8 Information Flow and Standards

Generally, the information becomes more condensed and less detailed as it moves up in the project environment. A schematic rendering of upward flow is shown in Figure 4.2. Time and cost information is shown as having four components - summarised, reported by resources, reported by tasks, and the standards of performance. As information moves from the project, representing the lowest level of the organization structure, to the central planning agency, the highest level, the flow lines become narrower, indicating summarization. At some points, classes of information are truncated indicating that the information has no value to higher levels. This is the case of engineering design details which do not go up to the project management, and time and cost information which goes beyond the financing level only as summaries.

To some extent, the type of information that moves is a function of the project type; however, ther are general classes. The time progress and financial data are general while the engineering and other problems and exceptions are peculiar to individual projects. To be useful, the information must be conveyed with standards of performance, either industry standards or internal project objectives used as standards. The relationship of standards and the information systems deserves additional discussion.

Table 4.2. <u>Classes of Information Needs</u>

POLICY INFORMATION

National Plan
Regional Plan
Industrial Sector Plan

GENERAL DATA

Production
Imports
Consumption
Theory
Resource Availability
Factor Prices
Alternative Technology Coefficients
Labour Productivity
Industry Standards

LOCAL DATA

Market Data
Regulations, Codes
Factor Prices
Resource Availability
Labour Availability
Profitability

PROJECT DATA

Milestones
Costs
Technical Data

OPERATIONAL MANAGEMENT DATA

Production
Resource Level
Income and Costs

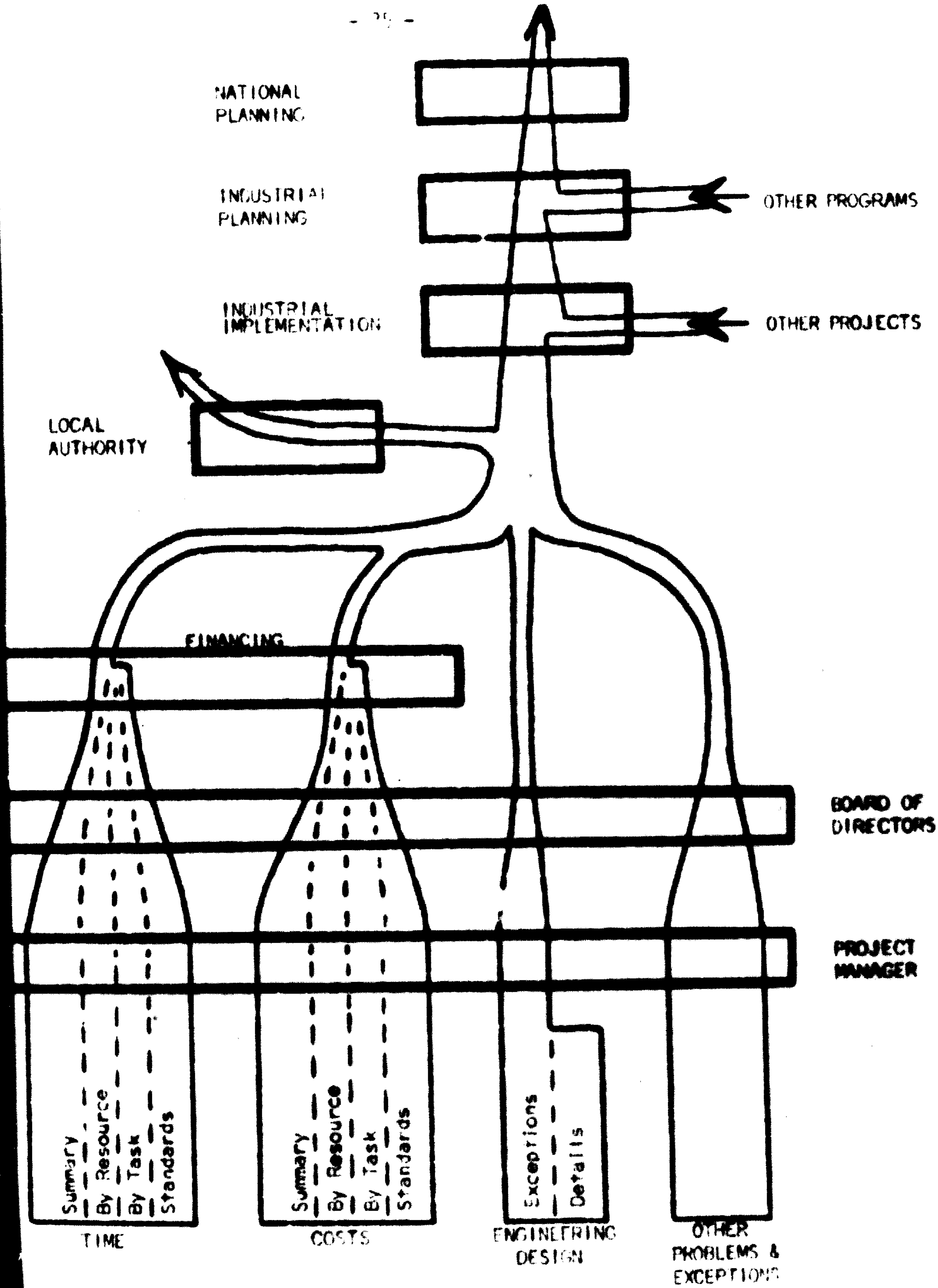

Figure 4.2 Schematic of Upward Flow of Information in the Project Environment

The basis of any evaluative system is a set of standards against which n w inf rmation progress can be compared. In fact, any information system is useful only when such standards exist, but they often exist in the minds of the receiver; hence, do not need to be transmitted. In the case of project information systems, they typically do need to be transmitted since a project by its inherent nature is a non-standard activity.

The standards applicable to project planning and control fall into two classes. First are standards derived from industry-wide experience, as for example, construction times and costs for component pa ts, and op rating profits as a percentage of sales. The other class are those standards internally generated which may, in turn, be based on industry standards. They might also be called planning targets. The primary example of these is the PERT milestone which is the best estimate of performance based on experience.

The next question is how shall progress be compared to the standards. Although there may exist a number of ways to conceptualize cost and time standards, the two ways that have been used successfully are the Gantt Chart and precedence network methods such as PERT. The Gantt Chart is, in essence, a one dimensional graph which plots tasks as a function of time. The PERT Chart sacrifices the plot against the time dimension to show the precedence relationship of tasks. To some extent, the time dimensions can still be included though it may result in clumsy appearing graphs. As the heart of an information system for project control, we suggest a combination of the two ideas, i.e., a PERT Chart on which progress towards goals is shown as bars on the links. Assume that each link is graduated by percentages and the bar shows the accomplishment in percentage terms. The nodes would contain both a cost number for the link as well as a date of completion. Superimposing both cost percentage and time percentage on the same graph would show the relationship between the two.

4.2 The Time Stage View

4.2.1 Introduction

Many writings on project analysis and control have defined time stages of a project.[1] For our use in information system design, each different stage should require unique information, for if it does not, no stage distinction need be made.

Given this criteria, the stages considered here are as shown in Table 4.3 together with the essential decision to be made.

We are now in a position to analyse information needs from the combined viewpoint of users and their goals according to the time stages. These needs are expressed in tabular form in Table 4.4. For completeness, we also include in the same format (Table 4.5) the information generated and fed into the information environment by each user at each time period. These tables should be self-explanatory.

We previously described organisation levels in the project environment (Figure 4.1). This was done primarily from the implementation point of view. From Table 4.4 it can be seen that there is a great difference in needs between the analysis stage and the implementation and operations stages. This can further be seen by reconstruction of the flow lines of Figure 4.1 for the analysis stage which is done in Figure 4.3. Flow lines here primarily represent the gathering of information by the Board of Directors who will decide whether or not to undertake the project.

1/ The UN Manual on Economic Development Projects, (p.7) lists the following stages:

a. Selection
b. Preliminary Projects to Justify Further Investments
c. Preliminary Projects to Determine Preferences
d. Allocation Between Projects
e. Preparation of Final Projects
f. Install New Productive Units
g. Production

The US Air Force uses the following definition:

a. Conceptual Phase
b. Definition Phase
c. Acquisition Phase
d. Operational Phase

Table 4.3 PROJECT TIME STAGES

STAGE	DECISION REQUIRED
* Identification and Selection	Select list of candidates
- Opportunity Definition	Pick best candidates
- Pre-Feasibility Studies	Select project or projects for implementation
- Feasibility Studies (may be one or more)	
* Implementation	
- Implementation Programme	Select plan, schedule, etc.
- Survey Resources	Select resource source
- Engineering Design	Select design
- Obtain and Analyze Bids	Select contractor
- Construction and Installation	Control
- Organization and Management Systems Design	Select design
* Operations	
- Operation	Control
- Post-Audit	Better design of future projects

4.3 Data Bank

There are a number of possible data banks required in the project environment. These are shown in Figure 4.4 which is similar to Figure 4.1 except that the data banks are included and the lines of communication and authority are excluded. The solid lines that remain define which organisational entity is guardian of the data bank. Where there are more than lines, responsibility is vested in either of the two entities. The dotted flow lines indicate that data from some banks is included in summary form in other banks.

The most general kind of data, which applies to all countries, would include industrial standards for various categories of industry. Technology co-efficients as well as cost data fall in this category though obviously both would be modified somewhat for a particular country. The data is most logically kept by a development oriented international organisation such as UNIDO. In fact, this activity has been undertaken by UNIDO in the form of their profiles of manufacturing establishments.1/

The next data bank contains data concerning the total economy, what we have called general data. The guardian of this data may be the national planning entity.

The aggregate of all industrial development projects in the country is the content of the next data bank, which is maintained by the industrial planning entity. In addition, this data bank may contain economic information pertaining particularly to the industrial sector depending upon whether or not this information is included in the overall national economic data bank.

Another kind of data bank is that available to the technical assistance entity which contains the theory required for technical assistance. In fact, so-called theory data banks are required by many entities throughout the project environment. Because theory is more or less applicable across international boundaries, this data bank should also be maintained by an international

1/ United Nations, Profiles of Manufacturing Establishments, Volumes I and II UNIDO, 1967.

Table 4.4. User Information Needs by Time Stage.

		NATIONAL PLANNING AGENCY	INDUSTRIAL PLANNING AGENCY	SPECTATORS: FINANCIERS	SPECTATORS: LOCAL AUTHORITY	SPECTATORS: LOCAL POPULACE	SPECTATORS: IMPLEMENTATION AGENCY	SPECTATORS: TECHNICAL ASSISTANCE	ENTREPRENEUR	MANAGEMENT	CONTRACTORS
ANALYSIS	Opportunity Definition	National Needs	National Needs						Policy and General Data		
	Pre-Feasibility	General Data	General Data						General Data		
	Feasibility			Profitability					Local Data		
IMPLEMENTATION	Implementation Planning								Local Data		
	Survey Resources								Resource Availability		
	Engineering Design				Local Codes				Theory/Technology Coefficients		
	Bidding								Standards		
	Construction		Progress	Time/Costs			Time/Costs		Project Data		
	O & M Design								Theory/Local Practices		
OPERATIONS	Operation			Profitability							
	Post-Audit	Employment Production	Employment Production	Profitability							

				SPECTATORS							
		NATIONAL PLANNING AGENCY	INDUSTRIAL PLANNING AGENCY	FINANCIERS	LOCAL AUTHORITY	LOCAL POPULACE	IMPLEMEN-TATION AGENCY	TECHNICAL ASSISTANCE	ENTREPRENEUR	MANAGEMENT	CONTRACTORS
ANALYSIS	Opportunity Definition	National Plan	Industry Plan Imports					Technical Data, Theor.			
	Pre-Feasibility		General Data		Local Data	Market	Reg'l. Plan Gen'l. Data	"			
	Feasibility		Local Data	Resource Avail.	Local Data Codes	Market	Gen'l. Data Local Data	"			
IMPLEMENTATION	Implementation Planning				Codes	Labor		"			
	Survey Resources						Avail. and Prices	"			
	Engineering Design				Codes			"			Factor Prices
	Bidding				Codes			"		Propl.	
	Construction							"			
	O & M Design										
OPERATIONS	Operation							"		Mgt. Data	
	Post-Audit									Mgt. Data	

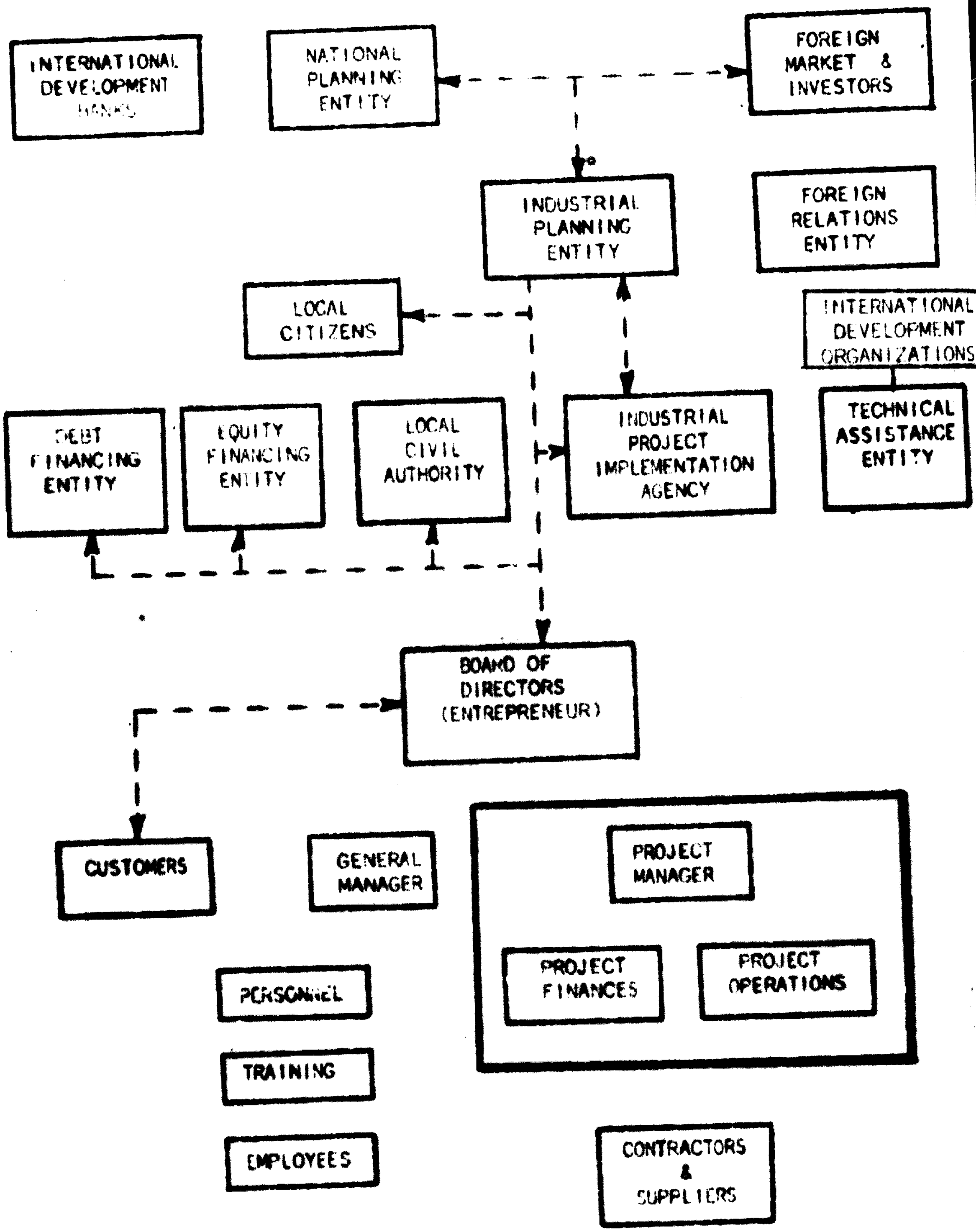

Figure 4.5 Information Flow in the Project Environment During Analysis.

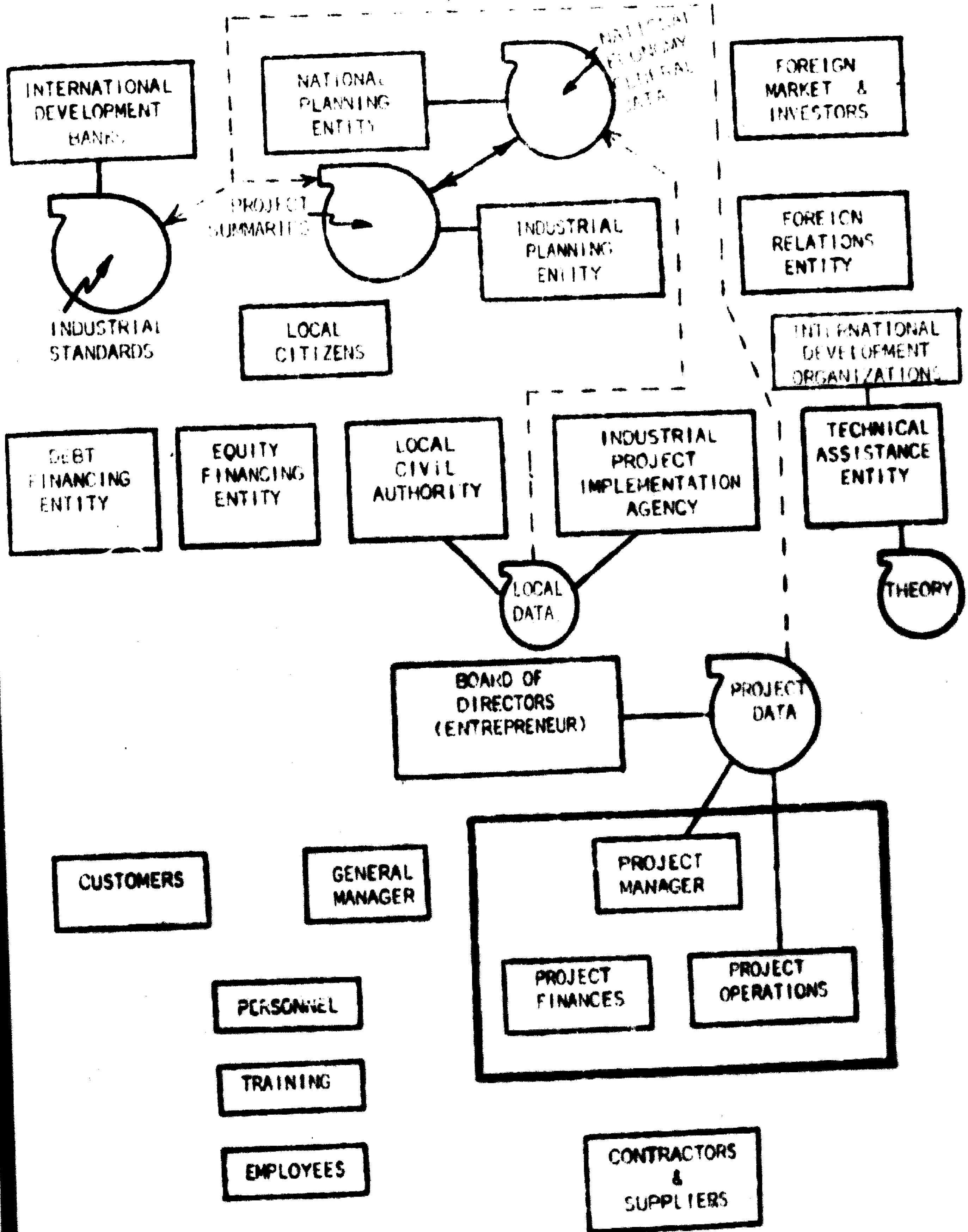

Figure 4.4 Location of Data Banks in the Project Environment.

organization, but made available to all entities. Such a data bank should also contain a bibliographical data bank containing references to appropriate publica- tions.

The local data bank is next containing the information pertaining to particular industrial sites. This may be either maintained by an implementation agency or by the local civil authorities.

The final data bank contains project information which is the responsibility of the entrepreneur or the project manager. It is useful in the project data bank to include a record of all decisions made so that they may be easily re- trieved and communicated to the various interested parties in the project.

4.4 Lessons of Experience Indicating Needs

It is often useful in design to survey past experience in a search for deficiencies in previous designs and to seek design changes that compensate for these deficiencies. This procedure has been formalised and could be used on design of information systems for the project environment.[1] For this study, however, it will suffice to point out some of the deficiencies that have been recognised and formulate them in various classes.

The classification system for troubles is shown in Table 4.6.

In a recently published survey of World Bank projects, Hirschman[2] finds a number of problems due to lack of information.

One is the Karnaphuli Pulp and Paper Mill in Pakistan which intended to make pulp and paper from bamboo. However, as soon as the mill became operational, the bamboo began to flower and die, rendering the mill's raw material unusable. The flowering occurs once in every 50-70 years and the lack of this information during the planning of this mill almost destroyed the project. Additionally, the mill had trouble in processing that bamboo that was not flowering because of the high silicon content, which is due both to the composition of the bamboo

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1/ Alexander, Christopher, Notes on the Synthesis of Form, Harvard University, 1968.

2/ Hirschman, Albert O., Development Projects Observed, The Brookings Institution, 1967.

Table 4.6 CAUSES OF DELAYS AND COST INCREASES[1]

PROCURING EQUIPMENT

- Vendor capacity limitations (when vendor is selected for cost reasons)
- Lack of foreign exchange

CHANGE OF ORIGINAL PLANS

- Changes in equipment specifications
- Changes in capacity
- Inadequate pre-design studies

ERRORS IN PLANNING

- Bids outside limits
- Lack of synchronization
- Errors in predicting equipment arrival lead time
- Worker training

CONTRACTOR INEXPERIENCE AND INEFFICIENCY

- Unrealistic schedules
- Erroneous productivity estimates
- Lack of controls

FORESEEABLE EXTERNAL CAUSES

- International lending organisations' processing time
- Customs delays
- Meeting contingent terms of loans
- Climatic conditions
- Inflation or devaluation and subsequent negotiation

PROBABILISTIC EXTERNAL CAUSES

- Climatic conditions
- Strikes
- Accidents
  - Damaged shipments
  - Lost shipments

FORESEEABLE INTERNAL CAUSES

- Diffusion of authority
- Owner interference

1/ Maurice D. Kilbridge and Robert B. Stobaugh, Design of an Empirical Study of Problems in Implementing Industrial Projects in Developing Countries, The United Nations Industrial Development Organisation, UNIDO, 1968 and contamination during travel to the plant. Both of these can be attributed to lack of investigation of the raw material.

In addition, he talks about other uncertainties, which are, in fact, lacks of information. There are political uncertainties, technological uncertainties, uncertainties in demand, uncertainties in finance, etc.

It is interesting to note that Hirschman develops an argument for lack of information in the project analysis phase. The essence of this view is expressed in the following quotes:

> "Hence, the only way in which we can bring our creative resources fully into play is by misjudging the nature of the task, by presenting it to ourselves as more routine, simple, undemanding of genuine creativity than it will turn out to be."1/

and

> "The idea that failure to fully visualize prospective internal costs can be growth-promoting is, in a sense, an extension of the more familiar and more obvious thought that disregard of the costs of a project or industry will inflict on third parties - that is, failure to internalize external costs - can serve as stimulus to enterprise."2/

The idea is that if we knew the difficulties and costs of some projects they would not be undertaken, but having decided to undertake them and having become committed to them, we will extend extraordinary effort to make them successful and do so at net positive benefit.

Although, no doubt, this view describes a real actual phenomenon, it is an argument for a kind of irrationality that is difficult to accept.

1/ Op. cit., pp. 13.

2/ Op. cit., pp. 15.

APPENDIX A

A GUIDE TO ASSESSING AN INFORMATION SYSTEM

This Appendix contains a number of questions to be answered by any individual at anly level of the project environment in order to assess the effectiveness of the information system which cupports him.

There are three sets of questions used. The first type, Table A-1, assesses the general management system from an information point of view. These questions deal with general managerial issues, but they allow assessment of management's communication system, which is a part of the information system. They can be answered yes or no because they deal with the existence or absence of some piece of information.

The questions are phrased so that a no answer is a sign of a defficiency. A second set, Table A-2, is designed to evaluate the general information system and requires an estimate of frequency of happenings according to the following scale:

1. Almost always: occurs 80 per cent of the time;
2. Often: more than 50 per cent of the time;
3. Occasionally: about 30 per cent of the time;
4. Infrequently: less than 15 per cent of the time;
5. Never: less than 1 per cent of the time.

A third set of questions, Table A-3, deals with the adequacy of the reporting system in support of functions that the respondent must perform. These are rated according to the following characteristics:

1. Excellent: is never a bottleneck to performance of the function;
2. Good: is seldom a bottleneck or detriment to performance of the function;
3. Fair: is rather frequently the bottleneck or detriment to performance of the function;
4. Poor: is more often the impeding factor than any other single cause;
5. Bad: is more often the impeding factor than all other causes.

Respondents are allowed four additional answers which are not used in the analysis described subsequently. They are:

A. Saturated: better or more than required, but good for general information,

B. Superfluous. better or more than required and serves no purpose;

C. Distracting. so much better or more than required that it acts as a detriment to actual performance.

D. Upsetting: better or more than required and serves to disturb morale.

Analysis

Responses from users can be represented in the form of frequency distributions which show the relative frequency of the various answers to questions asked on the questionnaire. One such frequency distribution will exist for each question from Table A-2 and for each combination of function and reporting system characteristic from Table A-3.

These distributions are presented in the form of bar graphs (Figure A-1). To interpret this data, two concepts must be kept in mind. First, the characteristic of the shape of the distribution is more important than any particular class of answers. Second, one must account for biases as a result of the phrasing of the question or viewpoints of the response.

There are two characteristics of the shape of the distribution that provide analysis information. The first is the spread, or the disparity of user opinion, and the second is the displacement of the distribution from the central category which, in statistical parlance, is called the skew.

The skew indicates, in some sense, the goodness of information. The questions are designed so that answers to the left of the scale are most likely characteristics of a good information system, while answers to the right are typical weaknesses. Therefore, if one is willing to accept the numerical assignment to each answer and take an average overall questions, a strong information system would result in a pattern, as shown in Figure A-1(a).

The spread, however, is an indication of the uniformity of the goodness among all users. For example, a large spread could be indicative that there is a great diversity of opinion among users as to goodness of a portion of the information system, as in Figure A-1(b).

Table A-1. Assessment of Management Communications

Please answer each question either yes or no, but feel free to comment if a yes or no does not convey all the information you wish to transmit.

1. Do you know exactly how higher levels of management evaluate your work?

YES ________ NO ________

COMMENTS:

2. Do you have a clear written statement of your functions, responsibilities and authorities?

YES ________ NO ________

COMMENTS:

Table A-2. General Assessment of Information System

1. How often do you have trouble finding a document that crossed your desk previously? ______

2. How much time do you spend in completing reports on progress? ______

3. How much time in answering specific requests for information that exists within the organization? ______

4. Do you find that you are often involved in crash programmes to meet deadlines? ______

5. What percentage of jobs are completed according to schedule? ______

6. What percentage of jobs are completed within budget? ______

7. How often do you find that you cannot schedule your work because higher levels of management are imposing ad hoc demands? ______

8. How often do you generate requests to other organization levels for information (excluding normal searches such as library searches, etc.)? ______

9. How often do you find that there is more than one study on the same topic going on independently within the organization? ______

Table 3

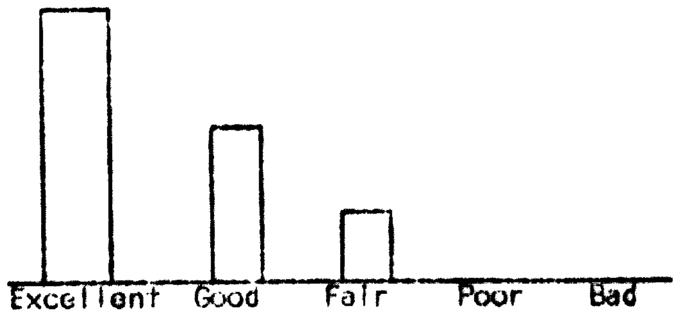
ASSESSMENT OF THE REPORTING SYSTEM

There are several characteristics of a reporting system which define its usefulness. Please rate the information according to the following criteria for each function you perform. List your own functions in the left most column. Rank according to the following scale (definitions of terms are given in the instructions).

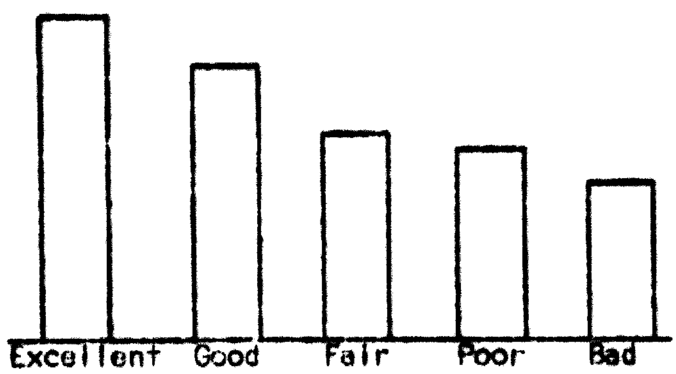
1. EXCELLENT 2. GOOD 3. FAIR 4. POOR 5. BAD A. Saturated B. Superfluous C. Distracting D. Upsetting.

Write the appropriate number or letter in the box below:

FUNCTIONS	QUANTITY		TIMELINESS		CONTENT		AVAILABILITY	QUALITY
List all your functions which require information.	BREADTH Coverage of aspects required.	DEPTH Level of detail.	INTERVAL Time between reports.	LAG Time between collection and reports.	TECHNICAL LEVEL Relative to the individual's professional training.	PRESENTATION Clarity, conciseness, ease of comprehension.	Ease of obtaining.	Freedom from errors.



(a) Highly skewed, small spread



(b) Highly skewed, large spread

Figure 4-1(a)/(b).
Frequency Distributions Illustrating Degrees of Spread and Skewness.

The combination of skewness and spread yields some important information. For example, a strongly skewed and small spread of the type indicated in Figure A-1(a) indicates a very good and uniformly designed information characteristic. On the other hand, a combination of the type shown in Figure A-1(b) indicates that, in general, the component is good, but there are some areas where it is poor.

This entire analysis must be tempered by the fact that the questions are generalised to apply to a wide variety of functions and in individual cases may not be appropriate. For example, question 7 of type B (Table A-2) deals with the ability to schedule one's work, yet the responder may have a job whose nature is responding to ad hoc work requests from supervisors (such as executive assistances, etc.). Moreover, obviously, cardinal numerical assignments to answers implicitly assumes some comparability among answers to different questions when, in fact, there is none.

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