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A CONCEPTUAL VIEW OF THE MANAGEMENT OF INDUSTRIAL PROJECT CONSTRUCTION IN DEVELOPING COUNTRIES 1/

by

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I. INTRODUCTION

During the last two decades a great number of developing countries have embarked on planning for economic and industrial development. Although the aims of planning, the planning techniques used and the results in terms of development vary from one country to the other, experience gained includes many useful lessons which are relevant to all countries.

One important lesson is that although planning alone does not result in development, it has frequently become an end in itself.

Planning, when it is not followed by adequate process of project implementation is an exercise of questionable practical value. The process of industrial development should be considered as a continuous whole where planning is only one part of it. The momentum should be maintained through all its stages; formulation of development strategy; preparation of the development plan or programme; setting of implementation policies; undertaking project feasibility and project appraisal studies for those projects that would eventually implement the plan or programme; constructing development projects, and finally project operation and post-audit.

Developing countries have devoted an immense amount of expertise to preparing comprehensive and consistent development plans and programmes without much attention given to the course of action necessary to implement and construct them. Failure to achieve targeted development has often been attributed to lack of good planners and inadequate planning techniques, while the real problem has frequently been the absence of well structured and organised plan implementation to follow plan formulation.

For a great part, implementation in developing countries has been approached at the aggregate or plan level rather than the micro or project level and this has been in the form of setting monetary, fiscal and employment policies for implementing the plan. There is no general procedure for considering analytically the various problems encountered in implementing and constructing individual projects which, in the final analysis, make up these aggregates nor for evaluating their impact on the intended development targets. Consequently developing countries

encounter a multitude of problems in the course of constructing development projects and project construction has fallen short of expectations with the consequences of costly delays and overrun of cost.

II. PROJECT CONSTRUCTION CHARACTERISTICS

In this paper a project is considered to be either a new or an expansion project. The first requires new construction, production and administrative facilities located on a new site. The second may involve the building of new production facilities at an existing or a new site, utilizing the existing overhead facilities. Project construction in this sense has a beginning and an end point. It is an assemblage of interrelated components and has an objective or a definite end result to achieve. Thus it may be considered as a system, and quite often a complex one.

It is characterized by:

1. a large number of component activities having definite relationships which are attributed to either physical or resource dependency;
2. a duration which extends over a number of years during which resources are immobilized and hence delays or interruption of work result in overrun of cost and waste of limited resources;
3. significant changes over time;
4. a high degree of uncertainty is involved, such as large technological and price risks;
5. a large number of agencies or parties, apart from the project management on which project construction depends and which are beyond the authority of the project management itself. These parties constitute the "project organization environment".

The situation in developing countries is further aggrevated by the fact that: -

1. industrial development projects are new in nature to most developing countries and hence a prior knowledge and experience in the type of work involved and at the order of magnitude required is frequently absent;

2. project management operates at a low efficiency;

3. resources are often in limited supply;

4. reliable information for project control is often not available. Follow-up information seldom reaches the right person at the right time.

III. PROJECT CONSTRUCTION DECISIONS

1. General

Bearing the aforementioned in mind and in order to cope with the different situations during the lifetime of a system, decisions have to be taken at various points in time. At the outset planning decisions are needed in order to develop the initial plan and schedules of project construction including objective netting, construction planning, time and resource scheduling to meet resource constraints, initial coordination between parties involved and budgeting. In the course of project construction since conditions inevitably change, actual performance varies from estimates and, hence, control decisions are necessary for taking corrective measures to alleviate deviations, reallocation of resources, updating of the initial plan or even modification of the strategy originally formulated.

Systems decisions are mainly strategic or tactical. Strategic decisions relate to policy measures and concern long-term plans. Decisions related to project cost-duration relationship, structure of necessary capital investment, major allocation of resources to achieve project goals, and additional funds required in the course of project construction, are examples of strategic decisions. On the other hand, tactical decisions are those involving operational problems which may be of a day-to-day nature such as allocation of resources to individual project activities within short time intervals, as for instance the allocation of manpower available with a view to minimizing hiring and firing of crews during the next reporting period as well as small schedule modifications. Put differently, strategic and

[illegible] and the latter are

[illegible] levels of the hierarchical [illegible] consideration of some [illegible] the characteristics of [illegible].

In [illegible], [illegible] or [illegible]. [illegible] both information and decision making techniques. Information needs vary with the technique used. For example, simulation and optimization techniques may be used in a variety of decisions, the information needs of the former are less than those of the latter. For tactical decisions, network techniques [illegible] and hence used. Again the information needs of the former are, for a great part, different in type and degree of detail from those of the latter. In developing countries [illegible] frequently [illegible]:

a) [illegible] are not well structured or not so. This is particularly true where the agency concerned is characterised by multi-organization, lack of clarity of organization objectives, [illegible] and inability to combine decisions at the appropriate decision points in the organization.

b) Information needed is inadequate.

c) The organization lacks well qualified personnel who can apply more effective decision making techniques, or the lack of decision-makers to be interested and motivated to scan an many alternatives as possible for finding the most favourable choice.

d) Even if well trained personnel in decision-making techniques, point (c) above, are available the absence of adequate computing facilities will render the application of most of those techniques not possible. For example, the amount of data and the complexity

of computation faced with the application of optimization techniques, simulation models and heuristic techniques necessitate the utilization of computers which renders any argument in this regard irrelevant.

e) Political pressure.

2. Project Construction Planning Decisions

At the stage of project implementation, planning decisions are to be taken. For this purpose the relationships among the system inputs (various types of resources, information and time), objectives (practically the system outputs which in this case are a completed project confirming to the required specifications) are to be determined and clearly described in the form of a model. This is based on systems characteristics (the project activity procedence relationships) and decision parameters (such as allocations and schedules). Experience indicates that one of the most difficult aspects of project implementation in developing countries is the analysis of the project, the establishment of a list of its component activities and the determination of the sequential or precedence relations among these activities, which is a basic step for all following project work. It has been also found that time and resource scheduling of project activities is frequently an excruciating process for the implementation planner [illegible] entry.

This detailed project planning is a prerequisite for effective project control. Sometimes detailed planning is not appreciated by authorities in developing countries which may be attributed to a number of reasons.

Foremost are: -

a) Management may not be in a position to understand or assess the potential value of detailed planning as the cornerstone of project coordination, monitoring and control.

b) Detailed project planning may sometimes be looked at as costly and time consuming particularly when project management is under pressure, political for example, from some higher executives in the government, to proceed immediately with project execution.

In fact, [illegible] amount to twice or three times the [illegible] on the average between time to the work is to be completed, the benefits accrued from detailed planning will [illegible] this additional planning cost.

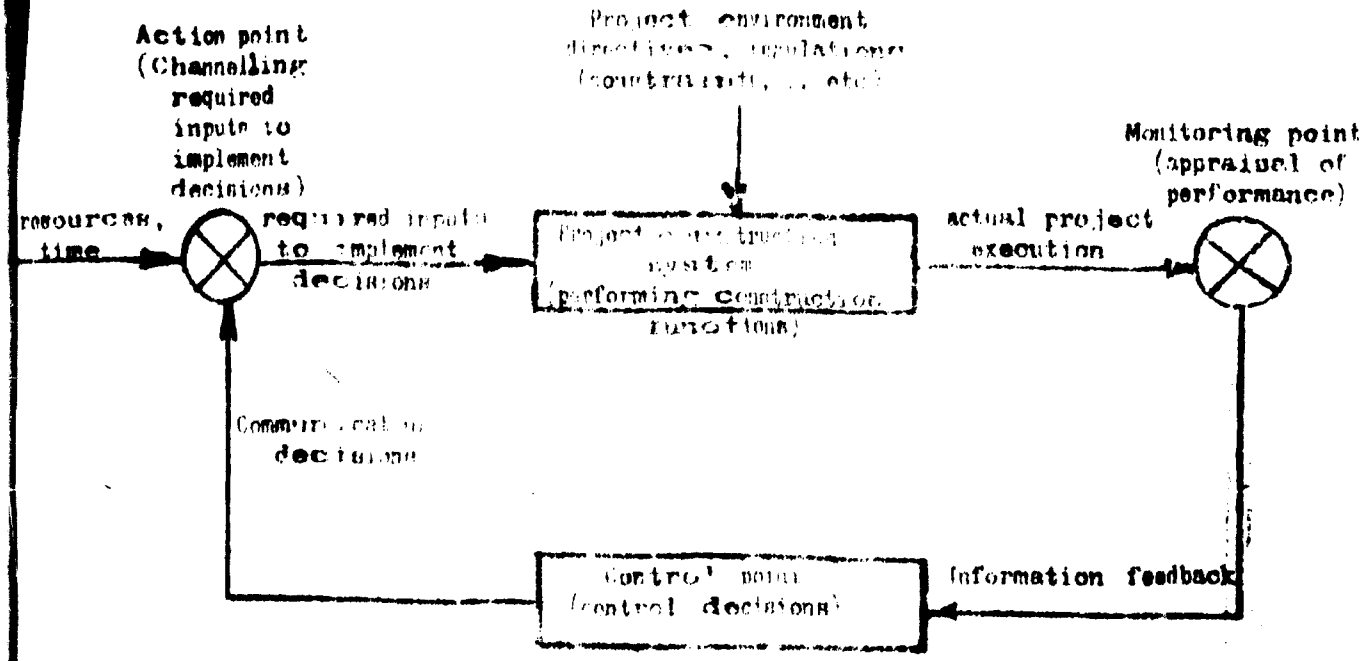
3. Project Construction Control Decisions

The control aspects of project construction are often overlooked in developing countries. Control decisions are, all too often, unsatisfactorily made with the consequence of lengthy delays and overrun of costs.

Project control involves, the coordination among parties participating in project construction, following up of project progress, detection of deviations from plan, making decisions to alleviate problems, detailed planning and scheduling, and updating of the plan in order to achieve objectives. Accordingly, control decisions serve two main functions. One is to alleviate problems when deviations from original plan are detected. The second, which is not related to performance deviations, is to enable those responsible to plan in detail and implementation and construction of that portion of the project which will be starting soon (such as detailed time and resource schedules) which they could not accomplish at the time the global or master project construction plan was prepared. This is particularly true as significant changes inevitably occur in the course of constructing a project, which make it impossible to plan and schedule, at the outset, those portions of the project which will be executed in the distant future to any degree of confidence, even if required data is available at this initial stage.

System control may conceptually be represented as in Figure 1.

Figure 1. System Control



Accordingly system control may be viewed as consisting of the following main steps which are illustrated in Figure 1: -

1. Collection of information and detection of deviations (based on appraisal of performance).
2. Feedback of information on deviations to decision-makers.
3. Decision-making for alleviation of deviations (taking corrective measures),
4. Communication of decisions to implementors.
5. Implementation of decisions.
6. Improvement of situation.

As mentioned before, the main objectives of project construction are time, cost and adherence to specifications (technical performance or quality).

For progress evaluation, step 1 above, information collected has to be compared against standards of performance for time, cost and quality (completion dates, budgeted expenditures and engineering specifications of project components). Reliable performance standards are prerequisites for reliable decision-making.

According to the type of project at hand and its characteristics, performance standards should be based on the experience locally gained in a country which may be supplemented by reference country data of countries at comparable levels of development. Nevertheless, establishing

performance standards in developing countries is a problem due to lack of data and experience in the type of work involved. The milestones in project cost [illegible] diagrams or payment charts can be taken as examples for time and cost performance standards. These charts also show how performance standards can be graphically represented.

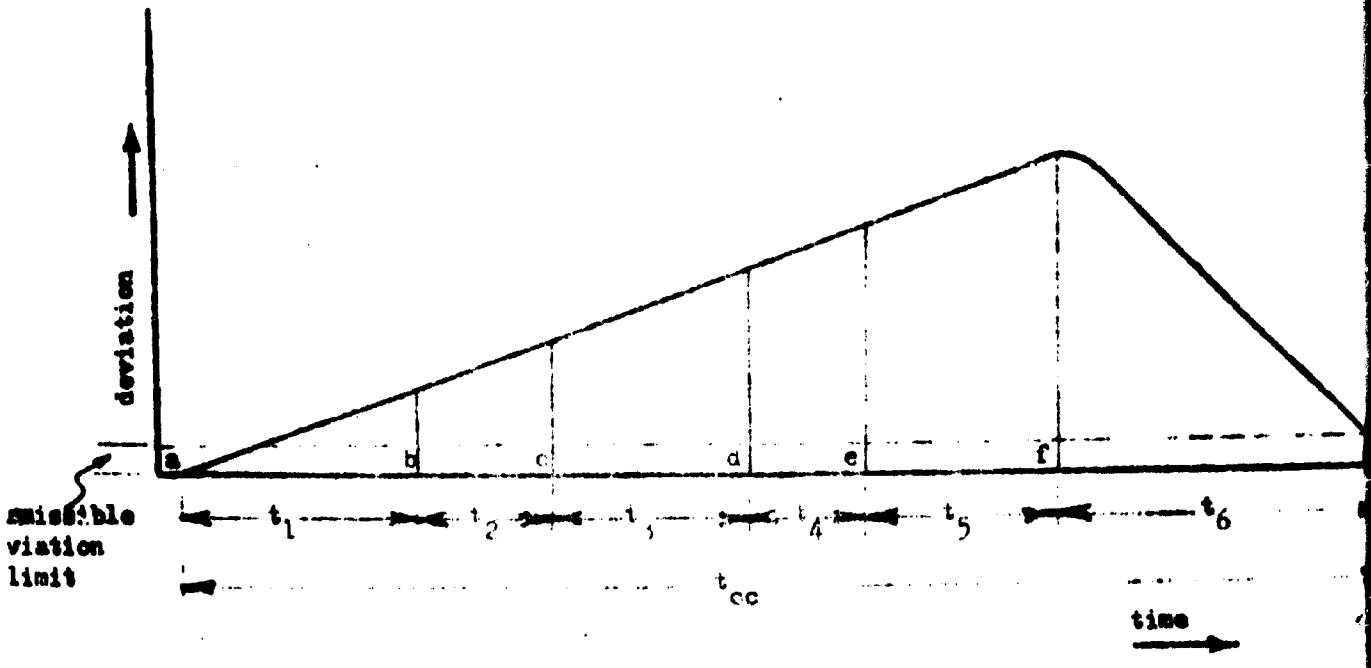


Figure 2. Control Cycle

The six control steps mentioned above are frequently labelled "the control cycle" and can be illustrated as in Figure 2. From the Figure it can be said that: -

a) the steps of the control cycle are of different time durations t_1, t_2, t_3, t_4, t_5 and t_6, which should vary from one organisation to the other according to the organizational, administrative, technic and financial problems prevailing in each;

b) deviation increases with any delay in the performance of one or more steps. In most developing countries, experience has shown, that for example, considerable time lapses between the time a deviation is detected and hence a need to make a decision and the time the decision is taken, i.e. the time up to point d in Figure 2;

c) effective control requires that the control cycle be of an appropriate time length, too. The time length of the control cycle should assist in exercising a "real time" or "in-time" control. This implies that the steps of the control cycle be performed in time so that in case of deviation it will be possible to go back to the plan and attain the original project objectives. This is clearly different from a case where a deviation is allowed to develop to the extent that no corrective measures can make it possible to go back to the plan and thus original objectives and strategies will be inevitably modified.

From the aforementioned, effective project control requires an adequate management information system (MIS), whose main functions are included in Figure 3.

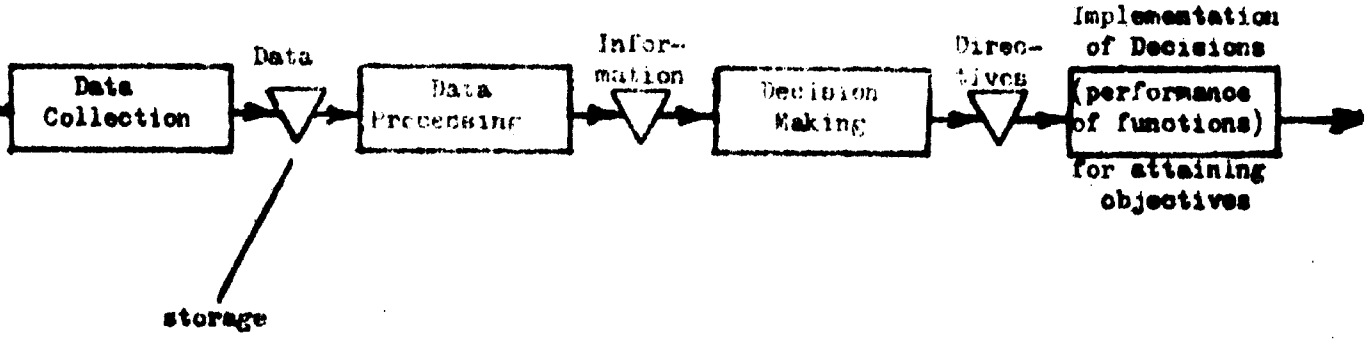


Figure 3. Information Handling

IV. MANAGEMENT INFORMATION SYSTEM FOR PROJECT CONSTRUCTION

A management information system for project construction may be viewed as having the following components: -

a) Information flows.

b) Data processing.

c) Data storage and information retrieval.

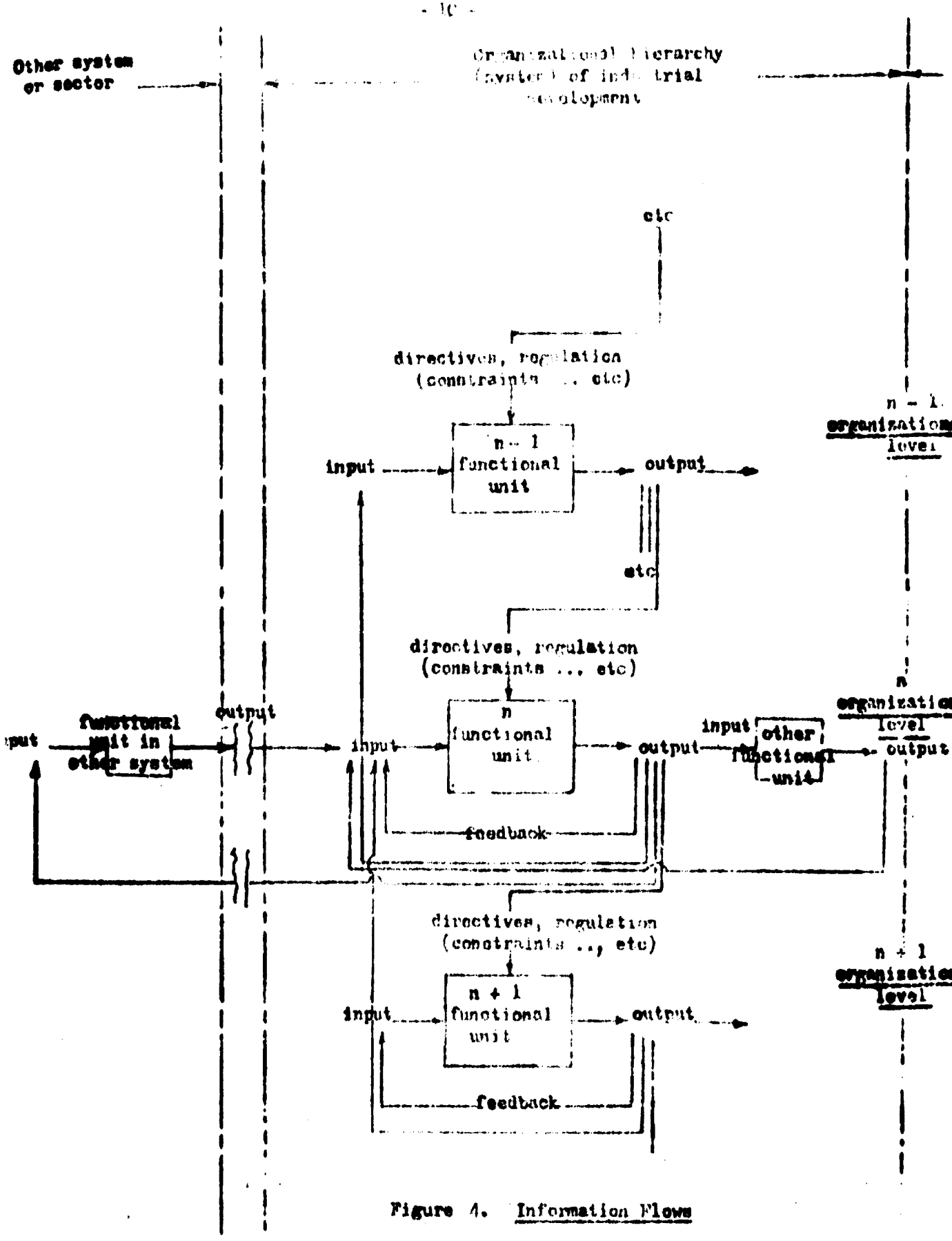


Figure 4. Information Flows

1. Information Flows

Information flows at the lowest level of an organization. Data is collected at the operating [illegible], summarized, processed into information in a form suitable for specific decisions. Information flows between the organizational units at various [illegible] shown in Figure 4. Information is needed for decisions to perform functions and thus to achieve objectives. One or more functions may be undertaken to attain one objective. Functions are carried out by various organizational units at the various hierarchical levels. The allocation of the responsibility and authority for performing functions to organizational units describes the organizational structure. Information flows or a reporting system within the organization ensures the availability of information to plan, construct and control projects. Consequently information flows cannot be considered separately from an organization structure. In fact, the design of an organization structure is the design of an information system. Unfortunately, this view point is not always given the emphasis it deserves and often the organization is designed on some other basis, the information flows being superimposed later. The result is more often a combined information and organization structure which fails to adequately serve decision-making and performance of functions and hence falls short of effectively supporting the attainment of the organization objectives.

A development project is not implemented and constructed in a vacuum. There are a number of organizations and agencies influencing it which are called the project environment and which require certain information on its progress in a form compatible to their information systems. This is true, since in a country there must be a system of organizations responsible for performing the various industrial development functions: preparing an industrial development plan, compatible with the development of other sectors of the economy as well as the national goals; implementing and constructing industrial projects and starting their operations satisfactorily, and feeding back information from the construction process to the planning and construction machinery for better planning, replanning, priority selection, and more effective controls and incentives. Thus to designing a project construction MIS, all information requirements have to be considered in order to have a system generating the information required at all levels. Accordingly consideration of all organizations interesting with the project as well as their functions is essential.

For [illegible] which is a hierarchical organization connected with the planning agency (government) at the top, the management of industrial development projects at [illegible], in the organization to be set up between at the various levels from the site. Each organization or body has to report to the one above it and may require sending information to other agencies at the same or higher hierarchical levels inside as well as outside the industrial system. The latter are those agencies participating or interested in the implementation and construction of the project which belong to other sectors of the economy. Among these agencies are local or foreign financing institutions and government departments such as departments of labour, construction and housing, and public works which require receiving information on the progress of the project for their own decisions and functions.

As developing countries exhibit a variety of characteristics it would be senseless to attempt to put forward an "ideal" national hierarchical organization for implementation and construction, for a workable organizational set-up would vary from one country to another. However, some generalization could be made which can be based on the steps of the process of industrial development. Accordingly, five hierarchical levels of agencies may be considered. These levels together with their responsibility and main information needs are shown in Table 1.

Follow-up information moves from the bottom to the top in the hierarchy. As information moves upwards from one level to another it must be summarized and be of less detail as shown in Table 1. Some information, such as that concerning technical performance or quality of project components is not included in the reporting system beyond a certain level, for instance level 4 in Table 1. Figure 4 shows the information flows between the main elements of the organizational hierarchy of industrial implementation and construction, of which the project is a part.

Table 1. Responsibility and information needs by level of the organizational hierarchy for industrial planning, implementation and construction.

Level	Agency	Responsibility	Information needs
1	<u>National planning agency:</u> could be also the Ministry of Planning.	- Formulation of strategy of development; preparation of national development plans giving different importance to various economic sectors; allocation of resources among sectors; setting policies for plan implementation. - Follow-up plan implementation by sector.	a) Population census; labour force and its productivity [illegible]; consumption, imports, exports; technological coefficients and [illegible] techniques for national [illegible] [illegible] as well [illegible] international [illegible] by economic sector; [illegible] policy measures; past and current national, regional and [illegible] development plans. b) Follow-up information on the implementation by economic sector.
2	<u>Industrial planning agency:</u> is often attached to the Ministry of Industry if it is not the Ministry itself.	- Preparation of industrial development plans: elaboration of the industrial part of the national plan giving different importance to different sub-sectors or branches of industry; allocation of resources within the industrial sector. - May plan large and important individual projects. - May be responsible for promotional work (promotion of local industrial opportunities for foreign investors). - Follow-up industrial plan implementation by branch of industry. May follow-up implementation and construction of large and important individual projects.	a) Same as [illegible] above [illegible] information is concerned [illegible] industrial sector [illegible] various branches. b) Follow-up information by branch of industry and perhaps [illegible] large and important individual industrial projects.

Level	Agency	Responsibility	Information needs
3	**Industrial Development Agency:** at level 3 of the organizational hierarchy there are also other agencies such as industrial development banks and other financial institutions.	- May be also known under other names such as industrial implementation and constructing agency. It is usually an [illegible] organization except if it is established to deal with one [illegible] project. - Studies and analysis of [illegible]. - Implementation and [illegible] of [illegible] all of the industrial projects included in the [illegible] allocation of resources [illegible] process. - May be responsible for [illegible] and/or [illegible] as well. - Follow-up of the implementation and construction of projects [illegible] public sector projects. - Regarding private sector [illegible] it applies [illegible] through licensing and allocation of resources. - May delegate authority for individual projects to individual boards of directors.	- Policies set for project planning and construction by levels 1 and/or 2. - Project information: - - [illegible] - [illegible] resource [illegible] techniques; resource [illegible] factor prices and control [illegible]. - Periodic follow-up information on time and cost of the project and significant bottlenecks. This information may be also needed for each project component.

Level	Agency	Responsibility	Information needs
4	**Board of Directors:**	- Is mainly responsible for the implementation and construction of one project. - Is responsible to the industrial development agency for implementing, constructing and controlling the project according to the guidelines and policies set out by the agency.	- Policies set for project planning and construction by the levels listed above. - Its functions are based on the work and analysis done and provided by the project management which requires detailed information, same as mentioned under level 3 above. - Periodic follow-up information on time, cost and quality status of construction by project components; critical bottlenecks impeding project construction and pertinent project management recommendations.
5	Project management: This level includes the project manager and project personnel. At the level of project personnel main follow-up information is generated as data on time and cost (by resource and activity) as well as on quality and pertinent problems are collected, manipulated and inputed in the MIS.	- The project manager is responsible to the board of directors for constructing the project. - Channelling all resources to complete the project in time, within the resources available and cost limits stipulated and according to specifications, and hence coordination of the efforts of all parties engaged in constructing the project. - Selection of project personnel. - Negotiation with suppliers of equipment and contractors and placing orders and awarding most of the contracts. - Follow-up and control of project construction. Taking up major problems with the board of directors and up-dating project plans and schedules.	- Same information as listed under the three first items of level 3. However, more detail is required regarding the project construction information. This should be by each project activity. - Follow-up information on time, cost and technical performance by project activity as well as critical path(s) and problems impeding project construction. This information can be provided periodically or at any time a serious problem occurs.

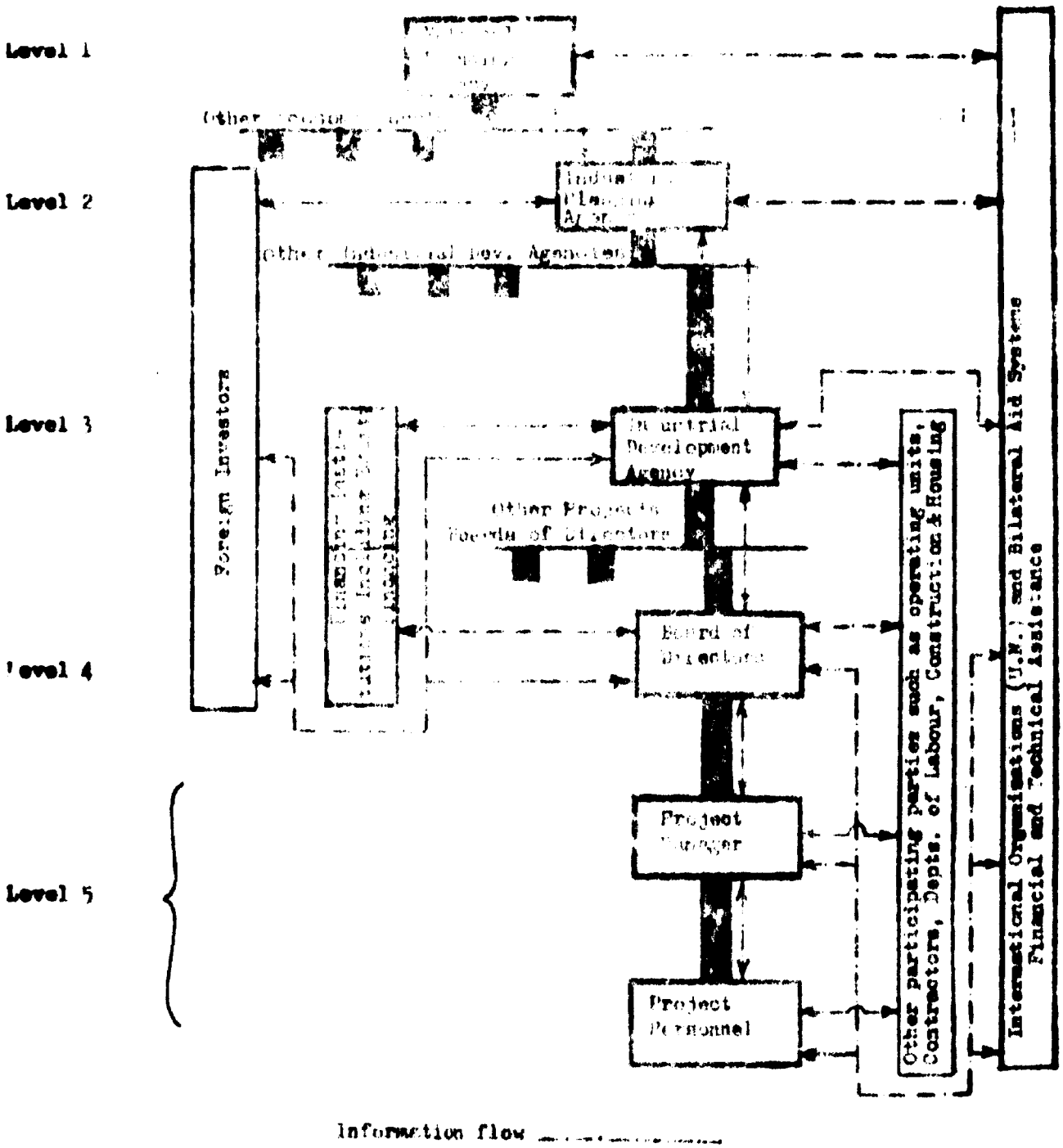


Figure 5. Information flows in the hierarchical organisation for industrial planning, implementation and construction.

Finally, in designing the information flows of reporting system, a balance should be drawn between cost and value of information. Value of information is related to:

(i) the necessary type(s) of information needed to make specific decisions; its coverage and degree of detail,

(ii) reliability of information,

(iii) cost of accessibility of information,

(iv) the need for real time control.

2. Data Processing

Processing of data mainly comprises: -

(i) Simple manipulation through simple processing functions such as organizing and summarizing.

(ii) More complicated manipulation dealing with analysis of information, such as when analytical models are used which abstract the real world.

The data processing system to be used has to be capable of coping with the processing functions required during project planning and control so that only the required information in the required form will reach the right person at the right time. The choice of the system would be mainly among these three classes; manual, punched card and electronic data processing (EDP) systems. The latter, provide automatic control and high speed processing.

Regarding project implementation, EDP systems are capable of sorting the output in a variety of orders as required, as for example, sorting project activities by total float according to their degree of criticality in ascending positive float order, which can be excruciating work if it is done manually, Results of resource and cost scheduling can also be obtained on additional lists. This information can be shown in bar chart or histogram forms. For departmental control, follow-up reports should only contain the information needed by the recipient of the report since not every agency participating in constructing a project nor every manager of a portion of a project is interested in following-up the progress of the entire project. In this respect computer output can be given by function or

de[illegible] [illegible] reliably [illegible] periodic [illegible] different degree of detail [illegible] the [illegible] organizational environment [illegible] organization.

With large [illegible] critical hierarchical level [illegible], which might not be based on sufficient [illegible] portions. [illegible], which [illegible] policy, may have detrimental effect [illegible] speed or cost of completing the project as a whole. Accordingly computers can be of great value in determining rapidly and reliably the impact of individual decisions on the various activities of the project. Furthermore, alternative solutions to problem [illegible] which are behind schedule can be more easily and rapidly [illegible] and [illegible], than by any other computing system.

Although [illegible] advantages of using computers [illegible] systems, there is no definite answer to the question [illegible] a computer? This of course depends [illegible] of the project and the financial and technical [illegible] the project. However, in this respect the following [illegible] may be considered as guidelines: -

1. Number of project activities [illegible] in the network.
2. Number of the [illegible] in project construction, in other words the [illegible] of the project organizational environment.
3. Duration of the project and the frequency of progress reporting for project control.
4. Availability of computers and computational costs incurred.

It is needless to over emphasize the importance of performing a cost-effectiveness analysis for determining the appropriate system for an organization. This is often overlooked in developing countries and hence a limited use of the system established and a high cost per unit of information provided. This frequently presents a problem in developing countries. Therefore, in substituting EDP systems for manual systems,

utilization of the former should not be limited to the computational functions that were manually performed before. Further applications and additional functions [illegible] to process control and system simulation which [illegible] cost should be studied and included. [illegible] interpreted as shown in the hypothetical diagram shown in Figure , which relates the marginal costs of providing additional [illegible] information to the number of processing functions provided. "Area B" in the diagram indicates the area beyond which the [illegible] will involve a sharp rise in marginal costs of additional units of information. This is particularly true as increasing the data processing functions beyond the capacity of the data processing operators will affect their produc ivity, and the necessary supervision on the work they perform and may, in addition, require overtime work at: higher cost and less efficiency. This limits the system in coping with additional processing functions for meeting pressing needs.

The diagram also shows that in case of EDP systems, marginal costs are definitely higher than in the case of manual systems when a small number of data processing functions will be carried out. As the number of data processing functions increase, marginal costs sharply decline.

3. Data Storage and Information Retrieval

Data and information storage or "data banks" must be user-oriented. Briefly, data banks should be established to provide the users of information at the various hierarchical levels of the project organizational environment with their information needs, as shown in Table 1 before. In this respect, a trade-off should be made between the cost of access to information (including communication costs) and the cost of its storage and, hence, the appropriate degree of automation in a given situation. Similarly, a decision should be also made regarding the degree of centralization versus duplication of files of information.

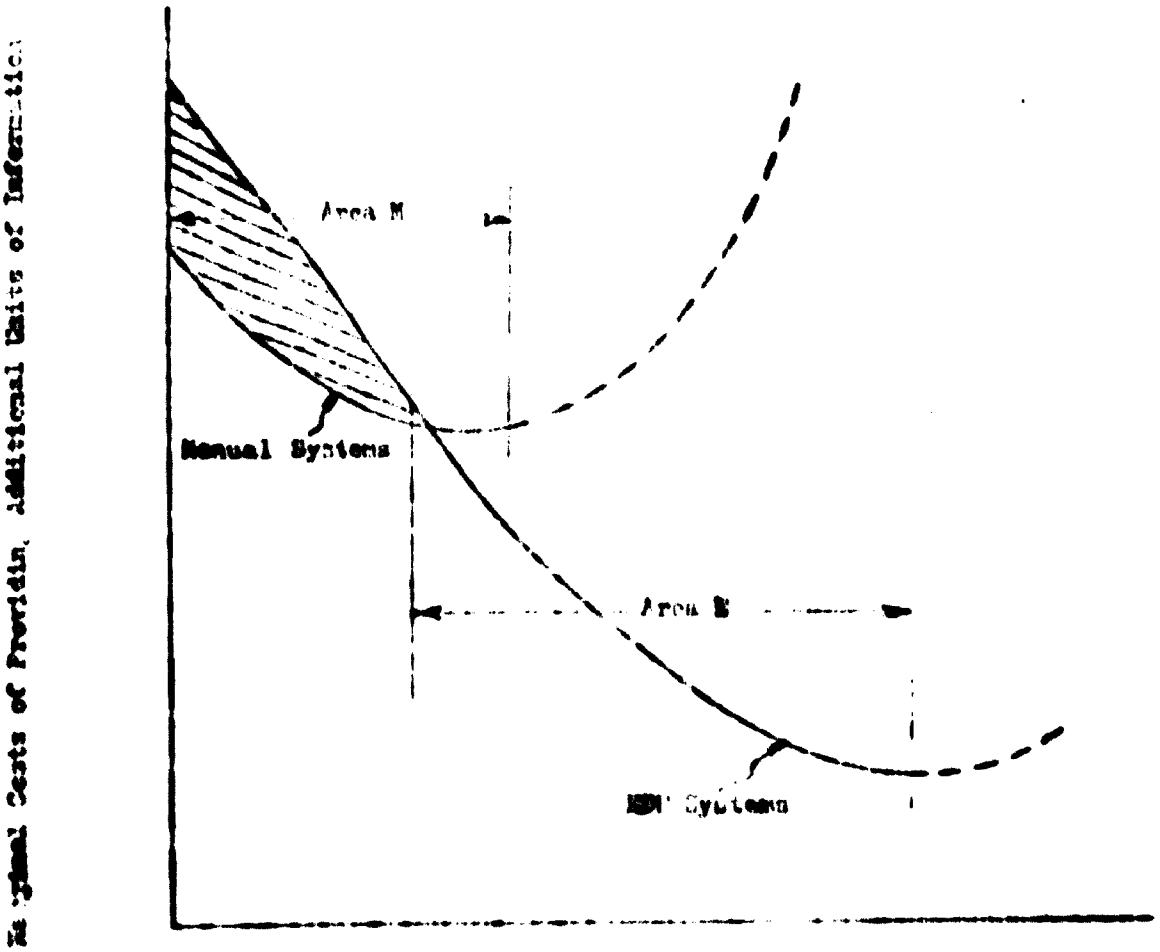
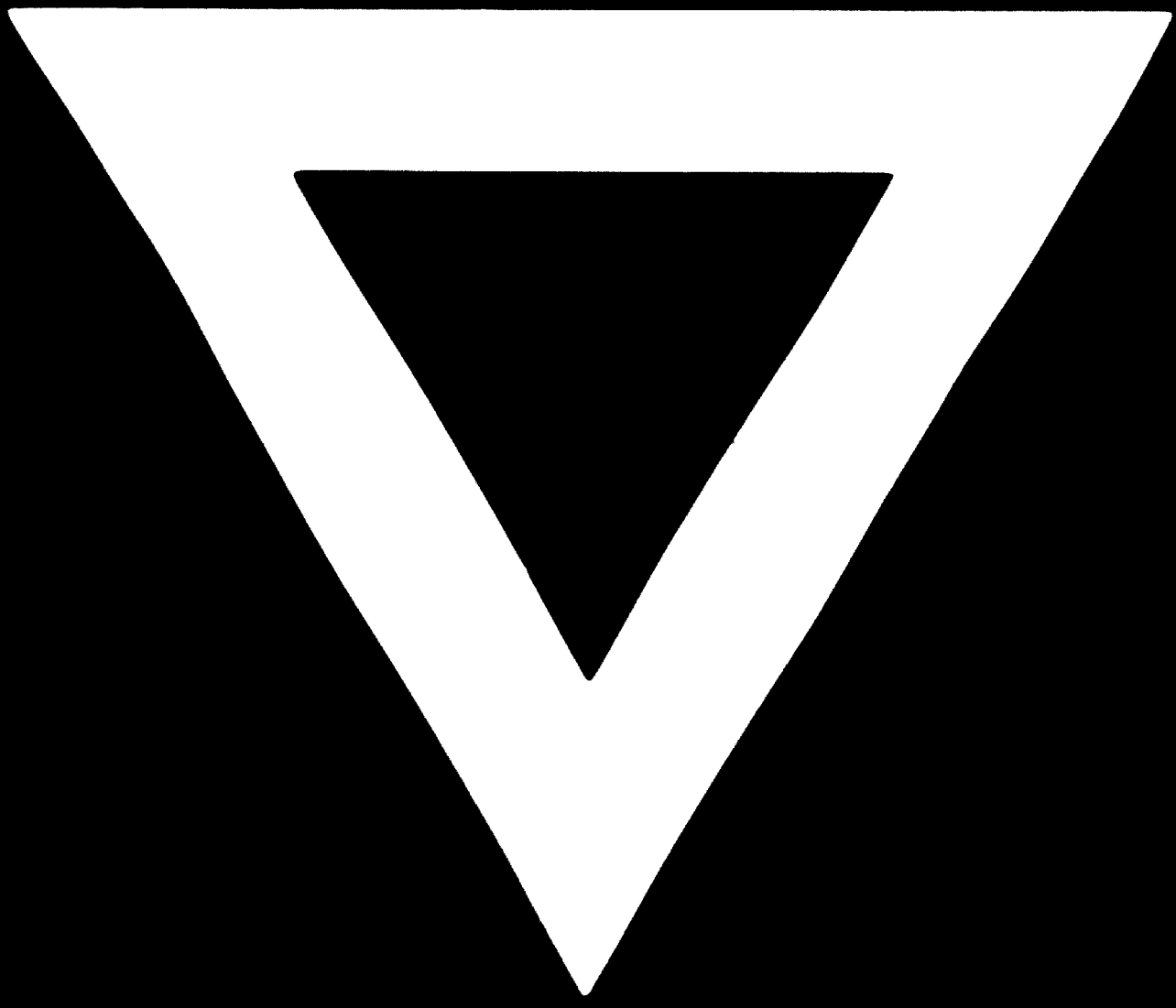


Figure 6. Hypothetical curve relating marginal costs of providing additional units of information to the number of processing functions provided.



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