12. A design principle for organizational information systems

The application of the function-support framework to the development of organizational information systems requires a careful evaluation of the ability of any proposed design alternative to meet the requirements of the information system. This is essential for the development of information systems that effectively support organizational function. But since contributing to the adaptability of the organization entails enhancing its ability to function, the contribution of the information system to the adaptability of the organization should be a basic, underlying design goal. The need of contributing to the adaptability of the organization is captured by the following principle of design for organizational information systems: \textit{In order to provide effective support to the functions of the organization it serves a computer-based information system must be compatible with the structure and the dynamics of these functions and with the adaptability of the organization. In particular, it must provide adequate support to the implicit (as well as to the explicit) control capabilities of the organization.}

Notice that the design principle emphasizes the need to support the implicit and the explicit control available in a system in an appropriate manner. Organizations have distributed control systems. Their control systems always have some degree of centralization as well as some degree of decentralization. The implicit control corresponds to their decentralized control capabilities while their explicit control corresponds to the centralized ones. Supporting the implicit control capabilities of organizations allows them to make adequate use of the self-regulation capabilities that exist in their own dynamics (Kampfner, 1992, 1997). The use of the implicit control available in an organization requires the use of the control mechanisms that exist, or can be built, at lower levels of control and function, that is, close to where the actions actually take place. The design principle also calls for an appropriate use of the explicit control mechanisms available in the organization. The appropriate use of the implicit and the
explicit control available in an organization is necessary for the vertical (control) information flows and the horizontal (operational) information flows of the organization to be properly maintained. This in turn ensures that the control and operational (organizational) units at all levels in the hierarchy and in all areas of function of the organization can achieve their goals.

*Making appropriate use of the implicit and the explicit control available in the organization.* Making appropriate use of the implicit control available in an organization is tantamount to achieving compatibility with its structure of the. It requires for the architecture of the information system to allow for the required degree of centralization of control and function in the organization. The degree of centralization/decentralization of control that is appropriate for a particular organization depends also on the characteristics of the environment it faces. An organization with a highly centralized control system, for example, would not generally be able to cope with a highly uncertain environment. Thus, a high degree of environmental uncertainty would in general call for a decentralized type of control. In any case, the compatibility with the structure of the organization requires an information system architecture that is consistent with its degree of centralization/decentralization of control. The compatibility of the information system with the adaptability of the organization is closely related to its compatibility with the structure, partly because the structure of the organization affects its adaptability. Since a new information system always introduces changes in the structure and the dynamics of the organization its designers must ensure that in addition to being compatible with the structure and dynamics of the organization, the new information system must not have a negative effect on its adaptability.


13.1 Introduction.

In agreement with the ASM and the function-support framework, the synthetic approach to design aims at the development of information systems that provide effective support to an organization’s functions in a manner consistent with the function of the organization as a whole. The synthetic approach to design contributes to this goal by providing a framework for the synthesis and evaluation of design alternatives, and the
selection of those that meet the requirements of the information system. Due to the flexibility of design it permits, and the criteria it uses for the evaluation and selection of design alternatives, the synthetic approach can help develop design alternatives that not only meet the requirements of the information system and therefore contribute to the adaptability of the organization, but also yield adequate tradeoffs between design objectives [Kampfner, 1989]. The synthetic approach to design can be used for the development and integration of information systems supporting all levels of organizational function and control. This includes applications associated with individual users, workgroups, and interdepartmental, enterprise-wide applications.

The effectiveness of the support provided by an information system to the functions of the organization it serves depends, to a great extent, on its compatibility with the structure and the dynamics of the organization. An information system that is compatible with the structure of the organization it serves must have an architecture that matches its structure of control and function. This means that the information system must generate patterns of information flow that are consistent with those induced by the structure of the organization. This is necessary in order to provide to each of the organizational functions it supports the kind of support it needs, which depends on its type (operational or control), its level in the organization's hierarchy and, of course, on the characteristics inherent to that particular function.

To be compatible with the dynamics of the organization, on the other hand, the information system must work in harmony with the processes that realize the functions of the organization. This requires, among other things, a computer-based information system that generates patterns of information flow that interact in a seamless manner with the processes that implement the function being supported. Clearly, to this effect, the users of the computer-based information system must be able to interact with it in a manner consistent with their working environment. In other words, the information system must provide its users and more generally the functions it supports with the information they need, at the time and in the form they need it. The interaction must also be seamless when the information system communicates directly with physical processes,
as it is the case, for example, in automatic process control, factory automation, data acquisition, and robotics.

Many other aspects of the compatibility of the information system with the functions of the organization should be taken into account in order to accomplish the function-support goal. This includes the timing patterns and the response times required by the information system users at each point of the user interface, as well as requirements for the interaction between the information system and its users. Among the latter are the amount of technical knowledge required from the users, the type of user interface (command based, graphical, menu based, natural language based, etc.) needed and many others. Clearly, these requirements must be met in order for the information system to provide its users with the information they need for the adequate performance of the organization’s functions.

The compatibility with the functions performed in the organization is essential not only to the effectiveness of the support provided by the computer-based information system, but also to its ability to contribute to the adaptability of the organization. This means that the computer-based information system should help the organization change in response to changes in its environment. At the same time, it must itself be able to adapt to changes in the structure and dynamics of organizational information processing. The ease with which the information system is able to adapt to such changes will help the organization to adapt to changes in its environment as well.

The changes to the structure and dynamics of the organization are sometimes designed to accommodate the information processing capabilities and requirements of new information technology. Especially in these cases, the ability of the proposed information system to contribute effectively to the adaptability of the organization must be carefully evaluated.

In the ASM, the requirements of the information system are determined on the basis of the information needs of particular organizational functions. Because of the
function-support orientation of the ASM, the goal of the information system requirements analysis activity is to translate the information needs specification into a set of characteristics that the information system must have in order to fulfill those needs. This correspondence between the information needs of the organization and its functions, and the requirements of the information system, clearly makes meeting these requirements a means of fulfilling the information needs of the organization. Moreover, since these requirements are determined in a manner sensitive to the need of compatibility of information processing with the structure of the organization, it follows that meeting these requirements is essential to the providing effective support to specific functions of the organization. The emphasis of the synthetic approach to design on meeting the requirements of the information system helps to avoid the problem of over-emphasizing specific design objectives at the expense of information system characteristics that are crucial to the support of organizational function.

A specification of the requirements of a computer-based information system on the basis of the information needed to support a specific set of organizational functions provides a solid basis for the design of function-supporting information systems. To this effect, the adoption of a particular design alternative for implementation must be based primarily on its acceptability, that is, its ability to meet these requirements and to contribute positively to the adaptability of the organization. Once a set of acceptable design alternatives has been found, design objectives that are not specific to the information system in question can then be pursued and characteristics specific to the information technology used can be exploited without jeopardizing the ability to provide effective function support.

Developing a computer-based information system that is compatible with a particular set of organizational functions, performed in a unique organizational environment, clearly requires a great deal of design flexibility. This flexibility is needed, since a solution to the design problem that provides a convenient degree of function support, is in general not likely to be found without considering a sufficient number of alternatives. Fortunately, as explained below, the synthetic approach to design capitalizes
on the design independence of the requirements specification, thus making the number of design alternatives that in principle can be considered potentially enormous.

Two main characteristics of the ASM make a considerable flexibility of design possible. One is, of course, the design-independent nature of the requirements specification provided by the ASM, which does not prescribe the way these requirements are going to be satisfied, but confines itself to the description of the characteristics that a computer-based information system must have in order to support a specific set of organizational functions. The other is the nature of the synthetic approach to design that can be conceptualized as a search on the space of possible design alternatives. A design-independent specification of information system requirements describes the computations that the information system must perform in order to provide the required information, together with the performance targets that need to be met and the modes of interaction that need to be supported by the information system. Clearly, specifying these requirements in a manner free of design and implementation considerations leaves the designer a greater number of possible alternative designs open for consideration. The design independence of the specification of information system requirements clearly leaves the designer with a great deal of freedom as to the ways in which possible solutions can be designed and implemented. Since it does not eliminate, a priori, any design alternative, a design-independent specification of information system requirements allows the synthetic approach to design with the necessary flexibility, since practically all the designs that apply to a given situation can be considered.

Building information systems that effectively support the function of the organization they serve is an important goal of the information systems development process in the ASM. To achieve this goal is essential to enhance, or at least to preserve the adaptability of the organization. In this respect, the synthetic approach to design follows an adaptability-based principle for the design of organizational information systems. The design principle provides guidelines for the development of information systems that are compatible with the structure and dynamics of the organization and which also make a positive contribution to its adaptability. From the standpoint of
structural compatibility this principle provides guidelines for determining the degree of centralization/decentralization of information processing, as well as for the appropriate distribution of the various modes of information processing used in the organization. From the standpoint of dynamical compatibility, the design principle provides guidance for determining the algorithms and procedures to be used, the modes of information processing required for their implementation, and the characteristics that the user interface needed for the information system to work in harmony with the other processes that implement the organizational function it supports. The search for compatibility of the design alternatives considered must of course be carried out in an adaptability-conscious manner. In other words, the impact of any proposed information system design on the adaptability of the organization must always be considered for the purposes of the evaluation of its acceptability.

An important characteristic of the synthetic approach is the decision-making structure it uses for the evaluation and selection of design alternatives. In this approach, meeting the requirements of the information system has the highest priority. Of these, the logical requirements are considered first. Alternative designs that meet the logical requirements are referred to as valid alternatives. Since the logical requirements describe what the computer-based information system should ultimately do from a computational standpoint, there seems to be no reason to consider alternatives that do not perform the appropriate computations. The performance and user interface requirements are then considered in order to determine whether the synthesized design alternatives are acceptable. Meeting the requirements of the information system is thus essential in order to fulfill the information needs of the organizational functions to be supported by the information system. But once the requirements of the information system are met by a particular design alternative, its ability to achieve specific design objectives can also be considered. By design objectives we mean design characteristics that present specific advantages to the organization form the point of view of project management, information system operation and maintenance and, in general, from the point of view of the use and management of computer and information technology. Among these objectives we can mention maintainability, understandability and reusability of software,
economy, timeliness of delivery, efficiency, user friendliness, interoperability, and scalability of systems, among others. It is indeed convenient to pursue various combinations of these objectives, or adequate tradeoffs between conflicting objectives, in a particular design project. Because of its function-support orientation, however, the synthetic approach to design puts a strong emphasis on the ability of the information system to meet the requirements of the information system in an adaptability conscious manner.

All of the characteristics of the synthetic approach to design mentioned above contribute significantly to the function-support orientation of the ASM. Taken together, they offer a tremendous potential for the development of computer-based information systems that effectively support the function of their parent organization. We will explore this potential in the following section.

### 13.2 Overview of the Synthetic Approach to Design.

The goal of the synthetic approach is the design of computer-based information systems that effectively support the function of the organization. For this goal to be achieved, however, it is necessary to synthesize design alternatives that meet the requirements of the information system in an appropriate manner. This requires that the information processing functions incorporated into each component of the software system provide the necessary support to the organizational functions with which they interact. As the processing and user interface characteristics of the software system are defined through the design process, a specific relationship between the information processing functions incorporated into the information system and the organizational functions that make use of the information is established. This relationship must be established in a manner that is consistent with that implied by the information systems requirements specification.

The relationship between information processing and function that is implied by the specification of information system requirements begins to be established in the information needs analysis phase when the information flows between the organizational
units performing the functions to be supported by the information system and between them and their environment are identified with the help of the OCSM. Information about this relationship is contained in the informational interactions diagrams as relations between the information flows and the organizational units where they originate, in the one hand, and between these information flows and the organizational units that require the information in order to perform their functions.

The relationship between information processing and function is further defined in the information system requirements analysis activity, where the information processing functions needed to sustain these flows are identified. The relationship between information processing and function is an important characteristic of adaptive systems including, of course, organizations. Information about this relationship must therefore be included in the documentation of the information system as is developed. In the ASM this is done in the information system requirements analysis process by noticing and documenting the correspondence that naturally exists between the information processing functions (IPFs) producing the information, the organizational units that need the information to perform their functions, and the information flows that interconnect them.

In order to guarantee that the design of the information system preserves this function-support capability, the relationship between information processing and function previously established must be maintained throughout the design process. This can be achieved, once it is decided which of these IPFs will be incorporated into the information system's computational repertoire, by indicating in the documentation of each component of the software system the IPFs such a component incorporates. The documentation of such relationships must be maintained and updated throughout the life of the information system.

Essentially, the synthetic approach to design consists of the synthesis and evaluation of design alternatives, followed by the selection of one of them for implementation. The requirements of the information system define the characteristics
that any acceptable design alternative must have. In the ASM, these characteristics are described in terms of three main types of information systems requirements: *logical*, *performance*, and *user interface* requirements. The logical requirements determine the computational contents of the computer-based information system and provide a basis for the determination of its basic architecture. The performance requirements specify information-processing targets that the information system must meet. The speed, capacity, and other performance characteristics of any acceptable design alternative must therefore be consistent with these requirements. Finally, the user interface requirements provide a basis on which the characteristics of the human-machine interface must be designed. Any acceptable design alternative must, therefore, also meet the user interface requirements of the information system.

The design process starts with the synthesis of design alternatives and the evaluation of each of them as to its ability to meet the requirements of the information system. Consistency with the logical requirements of the information system is a primary concern, since this ensures that each design alternative will produce precisely the information needed to provide the necessary function support. *Valid* design alternatives, that is, those that meet the logical requirements of the information system, are subsequently evaluated with respect to the performance and user interface requirements. Only the design alternatives that meet all the requirements of the information system are considered *acceptable*. To be acceptable, a design alternative must be *valid*, that is, consistent with the logical requirements of the information system and must also meet the information system’s *performance* and *user interface* requirements and must be compatible with its adaptability. The acceptable design alternatives can be further required to meet specific design objectives, or adequate tradeoffs between conflictive design objectives, before it can be selected for implementation.

The distinctive feature of the synthetic approach mentioned above makes it fit nicely within the ASM and the function-support framework. It provides the designer with a decision-making structure that guarantees the consistency of a design alternative with the information needs of the organizational function being supported. In the ASM, the
requirements that the information system must meet are determined on the basis of the information needs of the organizational functions to be supported. Meeting these requirements is therefore essential to the ability of the information system to provide the required support. This explains the emphasis of the synthetic approach on meeting the requirements of the information system, and why only design alternatives that satisfy these requirements are considered acceptable. In the synthetic approach, whether a design alternative yields an adequate tradeoff between design objectives is considered only after the information system requirements are met. In contrast, many current approaches to information systems design do not distinguish clearly between design objectives (such as the strong module cohesion and loose coupling between modules pursued in connection with structured design approaches, the pursue of usability, interoperability or other similar objectives) and information system requirements that are based on specific information needs of the functions to be supported. Confusing information system requirements with design objectives clearly brings with it the danger of sacrificing the information system’s ability to fulfill the information needs of particular organizational functions. In the synthetic approach, on the other hand, only design alternatives that have been found acceptable are evaluated as to their ability to achieve specific design, or project objectives. Since design or project objectives do some times conflict with each other, a convenient tradeoff or compromise between them is usually accepted. Meeting the requirements of the information system must, of course, have the highest priority.

The emphasis of the ASM on the development of information systems that effectively support organizational functions makes the need of appropriate criteria for the evaluation of alternative designs critical. The design principle mentioned earlier provides suitable criteria for making design decisions at all levels. This includes decisions concerning the software systems architecture, network design, decisions concerning the type of user interfaces, the use of batch or on-line processing, file and database design, the design of systems controls, the structure of the programs, and detailed aspects of the system’s output, input, process design, and module design and implementation. All the techniques used normally in connection with each of these design aspects can be advantageously used in connection with the synthetic approach. In all these cases,
however, the basic criterion for acceptability, that is, the ability to meet the logical, performance, and user interface requirements should take precedence over more specific design objectives if effective function support is to be achieved.

The synthetic approach views design as a process involving the synthesis, evaluation, and selection of design alternatives, as illustrated in Figure 13.1. First, a design alternative must be evaluated as to its validity, that is, its consistency with the logical requirements of the information system. The validity of a design alternative must be determined first, since a design alternative that is not valid would not provide a correct solution and, clearly, would not be useful. In order to provide effective support, however, producing the correct information is not enough. Valid design alternatives must also be evaluated as to their ability to meet the information system's quantitative and user interface requirements. Any potentially negative effect that a design alternative might have on the adaptability of the organization must be noticed and properly documented. This of course includes cases in which the lack of adaptability of the software system itself is found to be important. Ultimately, however, the concern should be with the way in which the information system is perceived as affecting the adaptability of the organization. Obviously, a design alternative that is thought to affect negatively the adaptability of the organization should not be considered acceptable. All the acceptable design alternatives are capable of meeting the requirements set for the information system and, consequently, of fulfilling effectively a specified set of information needs. They therefore become candidates for implementation. If more than one acceptable design is found, the selection of one for implementation can be done on the basis of the advantages it provides with respect to specific design objectives.

The design process can be seen as a search on a space of possible design alternatives. The design space concept provides a representation of design alternatives where the search can be guided toward those regions in which the information system requirements are met and, in addition, particular objectives can be sought. To describe this space we can consider dimensions such as hardware, systems software, and applications software. The way in which this space is actually searched depends strongly
on the methodology used to develop the information system. Some methodologies confine themselves to specific regions of this space. Data, or database oriented approaches, for example, tend to emphasize the design of data models and to base the architecture of the information system on the use of a particular, usually pre-specified database management system, that will control the creation, maintenance, querying, and updating of databases. Clearly, in these cases, data modeling and data base design are emphasized, possibly at the expense of process design. Process-oriented approaches, on the other hand, typically based on the principles of structured design, tend to emphasize maintainability of systems through the use of evaluation criteria such as strong module cohesion and loose inter-module coupling. In this case the emphasis is on the development of the necessary functionality while reducing maintenance and development costs. The problem in this case is that process design is overemphasized at the expense of database design. This may result, among other things, in a lack of control on redundancy of data and, consequently, on the integrity and consistency of the data.

Newer versions of the systems development life cycle (SDLC), on the other hand, try to balance the aspects of data- and process-orientation of the design process and, therefore, put less constraints on the search of the design space. Typically, these approaches aim at gradually developing a feasible solution to the development problem, while checking for the feasibility of the system at specified points in the development process [Powers et al., 1990; Burch, 1992]. In Burch’s SDLC [1992] the development process starts with a systems planning phase, followed by systems analysis, general design, systems evaluation and selection, detailed design and systems implementation phases. Powers et al.’s SDLC [1990] includes investigation, analysis and general design, detailed design and implementation, installation and review phases. Both approaches try to balance data and process modeling, but by focusing on a basic design solution that is successively refined, these approaches focus in the particular region of the design space defined around the basic solution.

Some approaches to structured analysis, such as the project life cycle [Yourdon, 1989] and the Yourdon systems method [Yourdon Press, 1997] emphasize the use of an
essential model from which the implementation is derived. Since the essential model is a logical model it allows in principle for the consideration of a greater number of alternatives, hence for a potentially large region of the design space. A limitation of this approach and in general of structured analysis and design methods is that they do not address the support of function in an explicit manner.

The synthetic approach to design takes advantage of the fact that, in the ASM, the design-independent character of the requirements specification, especially the specification of logical requirements, allows for a considerable flexibility of design. This means that a great many alternative designs can be considered which obviously results in a correspondingly greater ability of finding a design that provides an acceptable degree of function support. This flexibility allows for the consideration of all kinds of design options, including the use of integrated packages as in the case of enterprise resource planning (ERP) systems, and different kinds of make-or-buy-software decisions.

In the ASM, the requirements of the information system specify conditions for the compatibility of information processing with the structure and dynamics of organizational function. However, a design alternative that provides the necessary compatibility and, consequently, a convenient degree of function support, is in general not likely to be found without considering a sufficient number of alternatives. A great deal of design flexibility is clearly needed to achieve this purpose. Fortunately, two main characteristics of our approach make this flexibility of design possible. One, of course, the design-independent nature of the requirements specification provided by the ASM; the other is the nature of the design process in the ASM, that can be conceptualized as a search on the space of possible design alternatives.

A design-independent specification of information system requirements specifies the computations that the information system must perform in order to provide the required information, the volumes of information involved and the processing patterns required, and the modes of interaction that need to be supported by the information system. Clearly, by specifying these requirements in a manner free of design options and
implementation considerations, the designer has a greater number of possible alternative designs open for consideration. On the other hand, the view of the design process as a search on a design space is essential in order to take advantage of the potential flexibility provided by the design-independent character of the specification of requirements. As it can be easily seen, these two characteristics of the synthetic approach to design complement each other.

The synthetic approach to design thus helps to capitalize upon the potential for flexibility provided by the design-independence of the specification of requirements. Design flexibility is considerably useful, especially when the requirements of the information system impose heavy demands on the information processing system. In such cases, a sufficiently large set of alternatives might need to be considered. The cost of considering a considerable number of alternatives, on the other hand, might exceed the benefits rendered by the selected one. Therefore, the resulting tradeoff needs to be considered carefully. Key aspects of this design tradeoff will also be discussed in this chapter.

As mentioned above, a distinctive feature of the synthetic approach is that it provides the designer with a decision-making structure that emphasizes the consistency of the design with the information needs of the organizational function being supported. This is accomplished by first verifying the validity of a design, then its acceptability with respect to information system requirements, and then considering possible advantages that can be obtained by achieving specific design objectives. In contrast, many current approaches to information systems design do not distinguish clearly between design objectives of a general, technical, or economic character, and information system requirements such as providing a specific kind of information, a particular type of interface with the user, or the ability to account for specific performance targets. Although the latter approach may work well in many cases, brings with it the danger of sacrificing the ability of the system to fulfill the information needs of the organizational functions being supported.
The requirements of the information system being developed are determined on the basis of the information needs of the organizational functions being supported. This clearly implies that meeting these requirements amounts to fulfilling such information needs. This goal, in turn, is facilitated by the flexibility of design that the synthetic approach provides. The reason is that a design-independent specification of information system requirements allows for the consideration of all possible solutions to the design problem, since it does not eliminate, a priori, any design alternative.

The characteristics of the synthetic approach to design mentioned above offer a tremendous potential for the development of function-supporting information systems. Taken together, they help achieve the underlying objective of building computer-based information systems that effectively support the function of the organization and contribute positively to its adaptability.

References


Figure 13.1 The Synthetic Approach to design. Information systems design as a Synthesis-Evaluation-Selection process.


