

of a system has meaning only when its presence is justified by requirements resulting from the definition of the function. Thus, it is possible that with one definition of the function, some element will be a part of the system; however, with a different definition, the same element is not included in the system.

Determination of a structure (i.e., the choice of necessary elements and the connections between them) assumes a transition to the next stage of creating the system, that is, to the *design stage*, during which each element of the system is developed. For example, in systems where the elements are processes, and all the processes are automatized with the help of a computer, one design stage is the development of an algorithm for each process. In technical systems, this stage can be the development of a concrete engine or a concrete transmission, for example. Obviously it is not always necessary to re-create all elements of a system. In some cases system creators can use previously prepared elements or subsystems. Suppose, for instance, that one had created a managerial system for a company. After determination of the structure of the system, for which one of the elements is a manager, the design stage becomes the selection of concrete candidates for managerial positions.

Designing each element of the system is followed by the *implementation stage*. In the examples presented earlier, this stage involves writing and debugging of the programs of the implementation algorithms, manufacturing and installing a developed motor, and hiring a selected candidate for a given position.

The final phase is the *evaluation stage*, during which the system's effectiveness is evaluated. This stage occurs when the goal for creating the system has been achieved. Quite often during this investigation significant difficulties arise. For example, it may be unclear as to how to evaluate the education system. Various evaluation criteria exist, depending on the goals and problems of the investigators. In addition, there are different methods of measurements, which may variously evaluate the subjective character of many estimates — often leading to diametrically opposed results. Therefore in many cases the investigation of a system's effectiveness becomes an independent scientific problem.

Thus, we sum up the stages of system creation.

1. *The goal definition stage.* The present need is studied and, on the basis of properties internally inherent to it, a goal for creating the system is formulated.
2. *The function determination stage.* The whole function of the system is determined and directed toward the achievement of the chosen goal.
3. *The structure creation stage.* The system's structure is created, enabling it to fulfill the previously determined function.
4. *The design stage.* A design is developed (methods, algorithms, etc.) to realize the created structure.
5. *The implementation stage.* Practical implementation of the investigations conducted at the design stage is carried out.
6. *The evaluation stage.* The effectiveness of the created system is studied.

Note that within the framework of the systems approach, the direction of systems analysis is developing. More than that, within the framework of systems analysis there exists extensive literature discussing the creation of computer-based information systems. Many practical recommendations on the creation of systems are available for each of the stages indicated, although the implementation stage is covered in the greatest detail.

## 1.9

### Conclusion

In the present chapter, we tried to show that the systems approach is one of the main tools for constructing complex objects of any nature. Viewing these objects as systems allows us to understand their function, structure, and character of interaction among different system elements. This understanding allows us to substantially simplify (and speed up) the practical realization of these systems, to reduce the cost of their development, and to avoid many mistakes. Another important advantage of the systems approach is the existence of standard methods for developing, analyzing, and controlling systems. As will be seen later, such controls as adaptation and optimization will play a significant role in the development and use of systems.

Because one of the important goals of this book is to analyze the method used to create information retrieval systems, almost all stages of systems creation will be considered in detail. We say "almost all stages" because in a book we can consider completely only the first four stages and can partially consider the sixth (even without implementation, we can discuss the method of investigation used to determine the effectiveness of information retrieval systems).

"Systems Everywhere" is the title of the first section of the introduction to Bertalanffy's book *General System Theory*, and in fact this is true. Our whole world is a system of systems. Therefore, in the present chapter we have tried to illuminate the basic ideas and methods characteristic to the modern systems approach.

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