1.

Systems are created to solve problems. One can think of the systems approach as an organized way of dealing with a problem. In this dynamic world, the subject System Analysis and Design (SAD), mainly deals with the software development activities.

After going through this lesson, you should be able to:

- define a system
- explain the different phases of system development life cycle
- enumerate the components of system analysis
- explain the components of system designing.

A collection of components that work together to realize some objectives forms a system. Basically there are three major components in every system, namely input, processing and output. In a system the different components are connected with each other and they are interdependent. For example, human body represents a complete natural system. We are also bound by many national systems such as political system, economic system, educational system and so forth. The objective of the system demands that some output is produced as a result of processing the suitable inputs. A well-designed system also includes an additional element referred to as ‘control’ that provides a feedback to achieve desired objectives of the system.

System life cycle is an organizational process of developing and maintaining systems. It helps in establishing a system project plan, because it gives overall list of processes and sub-processes required for developing a system.
System development life cycle means combination of various activities. In other words we can say that various activities put together are referred as system development life cycle. In the System Analysis and Design terminology, the system development life cycle also means software development life cycle.
Following are the different phases of system development life cycle:

- Preliminary study
- Feasibility study
- Detailed system study
- System analysis
- System design
- Coding
- Testing
- Implementation.
- Maintenance

2.

Let us now describe the different phases and related activities of system development life cycle.

Preliminary system study is the first stage of system development life cycle. This is a brief investigation of the system under consideration and gives a clear picture of what actually the physical system is? In practice, the initial system study involves the preparation of a ‘System Proposal’ which lists the Problem Definition, Objectives of the Study, Terms of reference for Study, Constraints, Expected benefits of the new system, etc. in the light of the user requirements. The system proposal is prepared by the System Analyst (who studies the system) and places it before the user management. The management may accept the proposal and the cycle proceeds to the next stage. The management may also reject the proposal or request some modifications in the proposal. In summary, we would say that system study phase passes through the following steps:

- problem identification and project initiation
- background analysis
- inference or findings (system proposal).

In case the system proposal is acceptable to the management, the next phase is to examine the feasibility of the system. The feasibility study is basically the test of the proposed system in the light of its workability, meeting user’s requirements, effective use of resources and of course, the cost effectiveness. These are categorized as technical, operational, economic and schedule feasibility. The main goal of feasibility study is not to solve the problem but to achieve the scope. In the process of feasibility study, the cost and benefits are estimated with greater accuracy to find the Return on Investment (ROI). This also defines the resources needed to complete the detailed investigation. The result is a feasibility report submitted to the management. This may be accepted or accepted with modifications or rejected. The system cycle proceeds only if the management accepts it.

The detailed investigation of the system is carried out in accordance with the objectives of the proposed system. This involves detailed study of various operations performed by a system and their relationships within and outside the system. During this process, data are collected on the available files, decision points and transactions handled by the present system. Interviews, on-site observation and questionnaire are the tools used for detailed system study. Using the following steps it becomes easy to draw the exact boundary of the new system under consideration:

- Keeping in view the problems and new requirements
- Workout the pros and cons including new areas of the system.

All the data and the findings must be documented in the form of detailed data flow diagrams (DFDs), data dictionary, logical data structures and miniature specification. The main points to be discussed in this stage are:

- Specification of what the new system is to accomplish based on the user requirements.
- Functional hierarchy showing the functions to be performed by the new system and their relationship with each other.
- Functional network, which are similar to function hierarchy but they highlight the functions which are common to more than one procedure.
- List of attributes of the entities – these are the data items which need to be held about each entity (record).

Systems analysis is a process of collecting factual data, understand the processes involved, identifying problems and recommending feasible suggestions for improving the system functioning. This involves studying the business processes, gathering operational data, understand the information flow, finding out bottlenecks and evolving solutions for overcoming the weaknesses of the system so as to achieve the organizational goals. System Analysis also includes subdividing of complex process involving the entire system, identification of data store and manual processes.

The major objectives of systems analysis are to find answers for each business process: What is being done, How is it being done, Who is doing it, When is he doing it, Why is it being done and How can it be improved? It is more of a thinking process and involves the creative skills of the System Analyst. It attempts to give birth to a new efficient system that satisfies the current needs of the user and has scope for future growth within the organizational constraints. The result of this process is a logical system design. Systems analysis is an iterative process that continues until a preferred and acceptable solution emerges.

Based on the user requirements and the detailed analysis of the existing system, the new system must be designed. This is the phase of system designing. It is the most crucial phase in the developments of a system. The logical system design arrived at as a result of systems analysis is converted into physical system design. Normally, the design proceeds in two stages:

- Preliminary or General Design
- Structured or Detailed Design.

Preliminary or General Design: In the preliminary or general design, the features of the new system are specified. The costs of implementing these features and the benefits to be derived are estimated. If the project is still considered to be feasible, we move to the detailed design stage.

Structured or Detailed Design: In the detailed design stage, computer oriented work begins in earnest. At this stage, the design of the system becomes more structured. Structure design is a blue print of a computer system solution to a given problem having same components and inter-relationships among the same components as the original problem. Input, output, databases, forms, codification schemes and processing specifications are drawn up in detail. In the design stage, the programming language and the hardware and software platform in which the new system will run are also decided.

There are several tools and techniques used for describing the system design of the system. These tools and techniques are:

- Flowchart
- Data flow diagram (DFD)
- Data dictionary
- Structured English
- Decision table
- Decision tree

The system design involves:

i. Defining precisely the required system output
ii. Determining the data requirement for producing the output
iii. Determining the medium and format of files and databases
iv. Devising processing methods and use of software to produce output
v. Determine the methods of data capture and data input
vi. Designing Input forms
vii. Designing Codification Schemes
viii.Detailed manual procedures
ix. Documenting the Design.

The system design needs to be implemented to make it a workable system. This demands the coding of design into computer understandable language, i.e., programming language. This is also called the programming phase in which the programmer converts the program specifications into computer instructions, which we refer to as programs. It is an important stage where the defined procedures are transformed into control specifications by the help of a computer language. The programs coordinate the data movements and control the entire process in a system.

It is generally felt that the programs must be modular in nature. This helps in fast development, maintenance and future changes, if required.

5.

Before actually implementing the new system into operation, a test run of the system is done for removing the bugs, if any. It is an important phase of a successful system. After codifying the whole programs of the system, a test plan should be developed and run on a given set of test data. The output of the test run should match the expected results. Sometimes, system testing is considered a part of implementation process.

Using the test data following test run are carried out: Program test; System test.

Program test: When the programs have been coded, compiled and brought to working conditions, they must be individually tested with the prepared test data. Any undesirable happening must be noted and debugged (error corrections).

System Test: After carrying out the program test for each of the programs of the system and errors removed, then system test is done. At this stage the test is done on actual data. The complete system is executed on the actual data. At each stage of the execution, the results or output of the system is analyzed. During the result analysis, it may be found that the outputs are not matching the expected output of the system. In such case, the errors in the particular programs are identified and are fixed and further tested for the expected output.

When it is ensured that the system is running error-free, the users are called with their own actual data so that the system could be shown running as per their requirements.

After having the user acceptance of the new system developed, the implementation phase begins. Implementation is the stage of a project during which theory is turned into practice. The major steps involved in this phase are:

- Acquisition and Installation of Hardware and Software
- Conversion
- User Training
- Documentation.

The hardware and the relevant software required for running the system must be made fully operational before implementation. The conversion is also one of the most critical and expensive activities in the system development life cycle. The data from the old system needs to be converted to operate in the new format of the new system. The database needs to be setup with security and recovery procedures fully defined.

During this phase, all the programs of the system are loaded onto the user's computer. After loading the system, training of the user starts. Main topics of such type of training are:

- How to execute the package
- How to enter the data
- How to process the data (processing details)
- How to take out the reports

After the users are trained about the computerized system, working has to shift from manual to computerized working. The process is called 'Changeover'. The following strategies are followed for changeover of the system.

(i) Direct Changeover: This is the complete replacement of the old system by the new system. It is a risky approach and requires comprehensive system testing and training.

(ii) Parallel run: In parallel run both the systems, i.e., computerized and manual, are executed simultaneously for certain defined period. The same data is processed by both the systems. This strategy is less risky but more expensive because of the following:

- Manual results can be compared with the results of the computerized system.
- The operational work is doubled.
- Failure of the computerized system at the early stage does not affect the working of the organization, because the manual system continues to work, as it used to do.

Pilot run: In this type of run, the new system is run with the data from one or more of the previous periods for the whole or part of the system. The results are compared with the old system results. It is less expensive and risky than parallel run approach. This strategy builds the confidence and the errors are traced easily without affecting the operations.

The documentation of the system is also one of the most important activity in the system development life cycle. This ensures the continuity of the system. There are generally two types of documentation prepared for any system. These are: User or Operator Documentation and System Documentation.

The user documentation is a complete description of the system from the users point of view detailing how to use or operate the system. It also includes the major error messages likely to be encountered by the users. The system documentation contains the details of system design, programs, their coding, system flow, data dictionary, process description, etc. This helps to understand the system and permit changes to be made in the existing system to satisfy new user needs.

7.

Systems science is an interdisciplinary field of science that studies the nature of complex systems in nature, society, and science. It aims to develop interdisciplinary foundations, which are applicable in a variety of areas, such as engineering, biology, medicine and social sciences.

Systems sciences covers formal sciences fields like complex systems, cybernetics, dynamical systems theory, and systems theory, and applications in the field of the natural and social sciences and engineering, such as control theory, operations research, social systems theory, systems biology, systems dynamics, systems ecology, systems engineering and systems psychology.

Since the emergence of the General Systems Research in the 1950s systems thinking and systems science have been developed into many theoretical frameworks. The following overview will only show the most basic types.

Systems analysis is the interdisciplinary branch of science, dealing with analysis of systems, often prior to their automation as computer systems, and the interactions within those systems. This field is closely related to operations research.

In computing systems design is the process or art of defining the hardware and software architecture, components, modules, interfaces, and data for a computer system to satisfy specified requirements. One could see it as the application of systems theory to computing. Some overlap with the discipline of systems analysis appears inevitable.

System dynamics is an approach to understanding the behavior of complex systems over time. It deals with internal feedback loops and time delays that affect the behavior of the entire system. What makes using system dynamics different from other approaches to studying complex systems is the use of feedback loops and stocks and flows. These elements help describe how even seemingly simple systems display baffling nonlinearity.

Systems Engineering (SE) is an interdisciplinary field of engineering that focuses on the development and organization of complex artificial systems. Systems engineering has emerged into all kinds of sciences, and universities nowadays offer all kinds of specialized academic programs.

There are several types of Systems Methodologies, that is, disciplines for analysis of systems. For example:

§ Soft Systems Methodology (SSM): in the field of organizational studies is an approach to organizational process modeling and it can be used both for general problem solving and in the management of change. It was developed in England by academics at the University of Lancaster Systems Department through a ten year Action Research program.

§ System Development Methodology (SDM) in the field of IT development is a general term applied to a variety of structured, organized processes for developing information technology and embedded software systems.

8.

Systems theory is an interdisciplinary field of science. It studies the nature of complex systems in nature, society, and science. More specifically, it is a framework by which one can analyze and/or describe any group of objects that work in concert to produce some result.

Systems sciences are scientific disciplines partly based on systems thinking such as Chaos theory, Complex systems, Control theory, Cybernetics, Sociotechnical systems theory, Systems biology, Systems ecology, Systems psychology and the already mentioned Systems dynamics, Systems engineering and Systems theory.

General systems scientists can be divided into different generations. The founders of the systems movement like Ludwig von Bertalanffy were all born between 1900 and 1920. They all came from different natural and social science disciplines and joined forces in the 1950s to establish the general systems theory paradigm. Along with the organization of their efforts a first generation of systems scientists rose.

Among them were other scientists, who popularized the systems concept in the 1950s and 1960s. These scientists inspired and educated a second generation, who wrote about systems theory in the 1970s and 1980s. Others got acquainted and started studying these works in the 1980s and started writing about it since the 1990s. Debora Hammond can be seen as a typical representative of these third generation of general systems scientists.

The International Society for the Systems Sciences (ISSS) is an organization for interdisciplinary collaboration and synthesis of systems sciences. The ISSS is unique among systems-oriented institutions in terms of the breadth of its scope, bringing together scholars and practitioners from academic, business, government, and non-profit organizations. Based on fifty years of tremendous interdisciplinary research from the scientific study of complex systems to interactive approaches in management and community development. This society was initially conceived in 1954 at the Stanford Center for Advanced Study in the Behavioral Sciences.

In the field of systems science the International Federation for Systems Research (IFSR) is an international federation for global and local societies in the field of systems science. This federation is a non-profit, scientific and educational agency founded in 1981, and constituted of some thirty member organizations from various countries. The overall purpose of this Federation is to advance cybernetic and systems research and systems applications and to serve the international systems community. The best known research institute in the field is the Santa Fe Institute (SFI) located in Santa Fe, New Mexico, United States, dedicated to the study of complex systems. This institute was founded in 1984. SFI's original mission was to disseminate the notion of a separate interdisciplinary research area, complexity theory referred to at SFI as complexity science.

Contemporary ideas from systems theory have grown with diversified areas, exemplified by the work of Béla H. Bánáthy, ecological systems, organizational theory and management, interdisciplinary study with areas like Human Resource Development. As a transdisciplinary, interdisciplinary and multiperspectival domain, the area brings together principles and concepts from ontology, philosophy of science, physics, computer science, biology, and engineering as well as geography, sociology, political science, psychotherapy (within family systems therapy) and economics among others. Systems theory thus serves as a bridge for interdisciplinary dialogue between autonomous areas of study as well as within the area of systems science itself.

In this respect, with the possibility of misinterpretations, von Bertalanffy believed a general theory of systems "should be an important regulative device in science," to guard against superficial analogies that "are useless in science and harmful in their practical consequences." Others remain closer to the direct systems concepts developed by the original theorists. For example, Ilya Prigogine, of the Center for Complex Quantum Systems at the University of Texas, Austin, has studied emergent properties, suggesting that they offer analogues for living systems. The theories of autopoiesis of Francisco Varela and Humberto Maturana are a further development in this field.

A system from this frame of reference is composed of regularly interacting or interrelating groups of activities. For example, in noting the influence in organizational psychology as the field evolved from "an individually oriented industrial psychology to a systems and developmentally oriented organizational psychology," it was recognized that organizations are complex social systems; reducing the parts from the whole reduces the overall effectiveness of organizations. This is different from conventional models that center on individuals, structures, departments and units separate in part from the whole instead of recognizing the interdependence between groups of individuals, structures and processes that enable an organization to function. Laszlo explains that the new systems view of organized complexity went "one step beyond the Newtonian view of organized simplicity" in reducing the parts from the whole, or in understanding the whole without relation to the parts. The relationship between organizations and their environments became recognized as the foremost source of complexity and interdependence. In most cases the whole has properties that cannot be known from analysis of the constituent elements in isolation. Béla H. Bánáthy, who argued—along with the founders of the systems society—that "the benefit of humankind" is the purpose of science, has made significant and far-reaching contributions to the area of systems theory. For the Primer Group at ISSS, Bánáthy defines a perspective that iterates this view.

Whether considering the first systems of written communication with Sumerian cuneiform to Mayan numerals, or the feats of engineering with the Egyptian pyramids, systems thinking in essence dates back to antiquity. Differentiated from Western rationalist traditions of philosophy, C. West Churchman often identified with the I Ching as a systems approach sharing a frame of reference similar to pre-Socratic philosophy and Heraclitus. Von Bertalanffy traced systems concepts to the philosophy of G.W. von Leibniz and Nicholas of Cusa's *coincidentia oppositorum*. While modern systems are considerably more complicated, today's systems are embedded in history.

An important step to introduce the *systems approach*, into (rationalist) hard sciences of the 19th century, was the energy transformation, by figures like James Joule and Sadi Carnot. Then, the Thermodynamic of this century, with Rudolf Clausius, Josiah Gibbs and others, built the *system* reference model, as a formal scientific object.

Systems theory as an area of study specifically developed following the World Wars from the work of Ludwig von Bertalanffy and others in the 1950s, specifically catalyzed by the cooperation in the Society for General Systems Research. Cognizant of advances in science that questioned classical assumptions in the organizational sciences, Bertalanffy's idea to develop a theory of systems began as early as the interwar period, publishing "An Outline for General Systems Theory" in the *British Journal for the Philosophy of Science*, Vol 1, No. 2, by 1950. Where assumptions in Western science from Greek thought with Plato and Aristotle to Newton's *Principia* have historically influenced all areas from the hard to social sciences (see David Easton's seminal development of the "political system" as an analytical construct), the original theorists explored the implications of twentieth century advances in terms of systems.

Subjects like complexity, self-organization, connectionism and adaptive systems had already been studied in the 1940s and 1950s. In fields like cybernetics, researchers like Norbert Wiener examined complex systems using mathematics. John von Neumann discovered cellular automata and self-reproducing systems, again with only pencil and paper. Aleksandr Lyapunov and Jules Henri Poincaré worked on the foundations of chaos theory without any computer at all. At the same time Howard T. Odum, the radiation ecologist, recognized that the study of general systems required a language that could depict energetics, thermodynamic and kinetics at any system scale. Odum developed a general systems, or Universal language, based on the circuit language of electronics to fulfill this role, known as the Energy Systems Language. Between 1929-1951, Robert Maynard Hutchins had undertaken efforts to encourage innovation and interdisciplinary research in the social sciences, aided by the Ford Foundation with the interdisciplinary Division of the Social Sciences established in 1931.

Numerous scholars had been actively engaged in ideas before (Tectology of Alexander Bogdanov published in 1912-1917 is a remarkable example), but in 1937 von Bertalanffy presented the general theory of systems for a conference at the University of Chicago.

The systems view was based on several fundamental ideas. First, all phenomena can be viewed as a web of relationships among elements, or asystem. Second, all systems, whether electrical, biological, or social, have common patterns, behaviors, and properties that can be understood and used to develop greater insight into the behavior of complex phenomena and to move closer toward a unity of science. System philosophy, methodology and application are complementary to this science.[2] By 1956, the Society for General Systems Research was established, renamed the International Society for Systems Science in 1988. The Cold War affected the research project for systems theory in ways that sorely disappointed many of the seminal theorists. Some began to recognize theories defined in association with systems theory had deviated from the initial General Systems Theory (GST) view.[14] The economist Kenneth Boulding, an early researcher in systems theory, had concerns over the manipulation of systems concepts. Boulding concluded from the effects of the Cold War that abuses of power always prove consequential and that systems theory might address such issues.[15] Since the end of the Cold War, there has been a renewed interest in systems theory with efforts to strengthen an ethical view.