Chapter 1 Outline

1.1 Systems and System Model

A *system* is a set of interacting or interdependent components forming an complex/intricate whole. Every system is delineated by its spatial and temporal boundaries, surrounded and influenced by its environment, described by its structure and purpose and expressed in its function. As system is a very broad concept, the nature, our human society, an enterprise, even a man can be viewed as a system. Each unit in a system can be viewed as a subsystem. The relationship between two systems is relative. One system might be the subsystem of the other larger one, and it can also be divided into smaller systems. From the definition of system, the following conditions should be met. Firstly, a system should have at least two or more elements and all of the elements should have certain objectives. Secondly, it should be inner correlated and comparatively stable. Thirdly, it should have certain structure and with exact order, thus ensuring specific functions.

A system has the following characteristics:

1. Integrality

A system is not a simple set of elements, but an organically formed entirety. In the system, each element must obey the whole, and the overall optimal should be the target, rather than the optimal of each element.

2. Correlation

All the elements in the system interrelate and interact with each other. Connection, mutual support and inhibition between the elements make the organic combination a specific social system with certain functions.

3. Hierarchy

The hierarchy of a system can be interpreted as each element of the system can be regarded as a system, which is known as “subsystem”. The traffic system, for example, can be divided into civil aviation system, highway system, railway system, and water system, etc.

4. Purposiveness

Any system has its goals and objectives. For example, the education system is to improve the teaching level and the quality of people. Its purpose is achieved through its function, and

every system has certain function.

5. Environmental adaptability

A system is within certain environment, and it is always affected and restricted by the environment. The system will response to the change of the related environment. The environment's influence on the system is called stimulation or shock, and the system's response to the environment is called reverberation. The adaptability of the system to the environment is manifested through the restrictions or influence of environment on the system and the system's feedback on and control of the environment.

Systems can be divided into two categories: *Engineering Systems and Non-Engineering Systems.* Engineering systems include aviation, aerospace, nuclear power, system analysis of industrial process control, system design, system testing, system function experiment and personnel simulation training, etc. Non-engineering systems include system prediction, control and decision making of society, economy, enterprise management, agriculture, ecological environment, etc.

System Model reflects the relationship among internal elements in the system, and it also reflects the essential feature of the system in some ways. Meanwhile, the relationship between internal elements and external environment is reflected. Models are divided into two categories, one is Model of Image, and the other is Abstract Model.

Model of Image is to set up a model by analyzing the physical or geometry characteristics of the system, and it can be a proportion, or entity, such as the building block model, the plane model with wind tunnel tests, etc. *Abstract model* includes the concept model, the simulation model, the graph model, and the mathematical model, etc.

The mathematical model can be divided into:

(1) Deterministic model or random model according to the variables;

(2) Linear model and nonlinear model according to the relationship between variables;

(3) Continuous model and discrete model according to the state variable;

(4) Dynamic model or static model according to the time;

(5) Evaluation model, design model and predictive model according to the structure model of function.

1.2 System Simulation Outline

System simulation is a comprehensive and experimental discipline which is based on systems theory, control theory, similarity theory, mathematical statistics, information technology and computing technology, etc. It makes decisions by using computer and other specialized equipment as physical effects tools, and the real or imaginary system test is done by using the system model with the help of expert experience, statistics and information

system analysis.

Two methods are usually adopted in studying a complex system: one is to directly conduct research on actual systems. Another is to study on the model of the system. Directly conducted research has the advantages of its confidence level, but in many cases, it is not appropriate or even impossible. The reasons are as follows:

1. Security

In the study of systems which are important, related to personal safety and equipment safety, it is not allowed to do the experiment in actual systems, such as aerospace, nuclear power system, air system, etc.

2. Irreversibility

There are a lot of irreversible systems, such as occurred disasters, and the ecological system, etc.

3. Highly investment risk

Some major projects and equipment systems are complex, and investment cost is extremely high, which does not allow the destructive experiment in actual system.

4. Long time span

In most cases, the research on actual systems often needs a long time. For example, the study of complex ecosystem needs decades. When researching on a transportation system, also we need to study the operations for at least some days or even a few months.

5. The real system has not yet been built

As the real system is not conducted, it is not possible for us to evaluate the scheme on the phase of system planning and design.

For the above reasons, using the simulation method to study the system is not only necessary, but also might be the only feasible method in some cases.

There are a variety of classification methods for system simulation technology. According to the types of models, it can be divided into Successive System Simulation, Discrete Event System Simulation, Hybrid System Simulation and Qualitative Simulation. According to the realization of the simulation method and means and types of model, it can be divided into Physical Simulation and Mathematical Simulation. According to the validity extent of people and equipment, it can be divided into Real Simulation, Virtual Simulation and Structural Simulation.

Successive System Simulation refers to the system simulation where the state of the system changes continuously with time. *Discrete-event System Simulation* refers to the system simulation where the state of the system changes at some certain points. With the continuous

development of management science and the advanced manufacturing system, *Discrete Event System Simulations* has developed gradually. At present, discrete event system simulation theory research in the transportation management, urban planning and design, inventory control, manufacturing logistics, and other fields are conducted.

Physical Simulation is to establish a physical model of the system. The earliest simulation originated in physical simulation, such as aviation flight with empty experiment to study the effect of airflow on the plane flight. *Mathematical Simulation* is to study a model through the establishment of mathematics of the system. Mathematical Simulation is divided into Simulation and Digital Simulation. *Digital Simulation* is to establish a digital model of the system. Because of its dependence on computer digital simulation and fast calculation, Digital Simulation is therefore formed and matured with the development of the computer science. Meanwhile, Digital Simulation of the research and application in system simulation takes an increasingly large proportion.

In the late 1980s, Japanese companies used system engineering in management and decision-making. At present, the percent of using system simulation is more than 80%. British manufacturing system simulation method is used to solve the material control, manpower allocation and scheduling problem such as assessment, investment strategy and balanced production. According to foreign application statistics, system simulation can reduce about 30% investment by optimizing the design of the system and inventory control can reduce the inventory by about 15%.

1.3 The Characteristics of System Simulation

System simulation technology is the process of establishment, validation, and test of a model (physics, mathematics or mathematics).

The characteristics of modern simulation technology can be summarized as follows:

(1) The system simulation technology is a general supporting technology. When making decision in the face of some big, intractable problems, you can get key insights and innovative ideas from it.

(2) The development of system simulation technology is relatively independent, and it develops with the development of sound, light, machine, electric, especially information, etc. Therefore, the system simulation technology has a wide subject area, and it is comprehensive, nondestructive, controllable, repeatable, safe, and economical. And it is not restricted by the conditions of the climate and site space, which is its unique technique.

(3) The development of system simulation technology is closely related to its application. The relationship between application and development of system simulation is dialectical. The application requirements are the initializing power to promote the development of system simulation technology. The benefit of system simulation technology application is related to

not only its level of technology, but also the application in the field of development. A large number of examples show that the effective application of system simulation technology must rely on the advanced simulation system. Only the simulation system servicing the application developed, the development of system simulation technology can be promoted.

(4) The system simulation technology application developed to “complete system”, “total system life cycle”, “system management”, and these are all based on the development of simulation technology.

1.4 Logistics System Simulation and Technology

The essence of simulation is a process of knowledge processing. A typical system simulation process, involving the knowledge and experience of multi-disciplinary fields, includes system modeling, simulation modeling, simulation programming, simulation and data analysis processing. With the rapid development of current information technology, urgent needs of military and civilian fields for simulation technology and system simulation technology have been developed rapidly simultaneously.

With the development of system simulation technology, it has been increasingly integrated into the decision-making of important operation. System simulation technology is widely used in the automotive, tobacco, medicine, chemical, military logistics, machinery, third party logistics, food, electronics, electrical appliances and other industries, and it is used throughout the product design, production, sales and distribution, until the end of product life, waste and recovery stage. The discrete event system simulation has occupied an irreplaceable position in logistics management and even all walks of life.

Early logistics system simulation is mainly processed through the establishment of mathematical model, which is a type of general simulation technology called mathematical simulation. Therefore, the mathematical simulation process of the logistics system is similar to the establishment of the logistics system model.

Modern distribution and production process emphasize much on the overall benefits. As a multi-factor, multi-target complex system, logistics is a complex system pursuing integrated optimization when analyzing problems. Modern logistics is increasingly emphasizing systematization and comprehensive logistics. The essential difference between modern and traditional logistics has been gradually revealed. Because of the characteristic of modern logistics, it is particularly necessary to use the systems analysis methods to analyze the logistics.

Studies on logistics system with simulation method can be divided into the following categories:

(1) The simulation study of logistics process. Logistics process refers to the process of transportation, storage, loading and unloading, packing and the related function of the