IENG/MANE112

Systems and System Engineering

The central notion of IENG/OR/MANE is ***system***.

A ***system*** is a set of ***elements*** which

- interact among each other,
- behave as a *single unit*, and this unit is the system itself, and
- the interactions of the elements create new properties *on the level of the system*.

The objective or purpose of a system is the desired state or outcome which the system is attempting to achieve.

Consider the air-conditioning system in a home. Assume that the system uses a heating pump for both heating and cooling, depending on the need. The *components* of this system include the house (walls, ceiling, floors, furniture, etc.), the heat pump, the thermostat, the air within the system, and the electricity that drives the system. The relationships between the system components are as follows:

(1) The *air temperature* depends on:
   (a) Heat transfer through the walls, ceiling, floor, and windows of the house.
   (b) Heat input or output due to heat pump action.
(2) The *thermostat* action depends on:
   (a) Air temperature.
   (b) Thermostat setting.
(3) The *heat pump* status depends on:
   (a) Thermostat action.
   (b) Availability of electricity.

Although there are other relationships in this system, the ones listed above serve to give physical meaning to the terms we are using.

System Classifications

Systems may be classified in a number of different ways. We discuss a few classification that illustrate the similarities and dissimilarities of systems.

- *Natural vs. Man-Made System—Natural systems* are those that exist as a result of processes occurring in the natural world. A river is an example of a nature system. *Man-*

made systems are those that owe their origin to human activity. A bridge built to cross a river is an example of a man-made system.

- *Static vs. Dynamic Systems*—A *static system* is one that has structure but no associated activity. The bridge crossing a river is a static system. A *dynamic system* is one that involve time-varying behavior. The U.S. economy is an example of a dynamic system.
- *Physical vs.* Abstract Systems—A *physical systems* is one that involves physically existing components. A factory is an example of a physical system, since it involve machines, buildings, people, and so on. *Abstract systems* are those in which symbols represent the system components. An architect's drawing of a factory is an abstract system, consisting of lines, shading, and dimensioning.
- *Open vs.* Closed Systems—An *open system* is one that interacts with its environment, allowing materials (matter), information, and energy to cross its boundaries. A *closed system* operates with little interchange with its environment.

1. Modern history

around 1945: Ludwig von Bertalanffy (biologist), Norbert Wiener (mathematician) and Ross Ashby (psychiatrist and cybernatist)

Examples

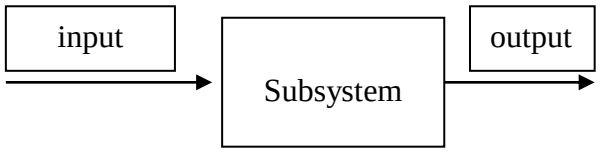
- **Human being.** A human being is more than just brain plus heart plus kidney plus skin plus etc.
- **Production system.** It consists of
  - **a.** machines to produce the products,
  - **b.** workers (human being) controlling the machines,
  - **c.** raw material from which the products are produced,
  - **d.** transportation equipment and personnel,
  - **e.** storing equipment,
  - **f.** information,
  - **g.** ***decisions,*** and
  - **h.** energy supply.

  New property on the level of the system: *production, capacity.*

  Behavior as a single unit: *supplies customers and/or other production units.*

2. Black box approach

- One component of a system can be another system. Then it is a subsystem. For example the blood system of human beings.
- Sometimes the structure of the subsystems is not known.
- For the description of the system it is enough to know that what is the answer of the subsystem for the possible inputs.



3. Systems in production environment

Warning: the list of elements in the example may not contain all components.

3.1 Workshop

Elements				
room/hall	raw materials	transportation equipment	storing equipment for tools	information collecting equipments
machines	workers	storing equipment for finished and semi-finished	technological instructions	decision procedures
tools	energy supply	storing equipment for raw material	schedules	safety equipments
inspection				

3.2 Facility

Elements				
location	rooms	heating	inside transportation possibilities	connection to airports
plot	energy supply	cooling	connection to roads	connection to harbor
building(s)	water supply	internet	connection to railways	parking lot
production/service equipment				

3.3 Production control system

Elements			
information collection	database for technology	distribution control	Capacity Requirement Planning (CRP)
forecasting	Bill-Of-Materials (BOM)	purchasing	budget planning
customer contracts	daily schedule: Shop Floor Control (SFC)	Master Production Schedule (MPS)	long term planning
supplier contracts	inventory control	Material Requirement Planning (MRP)	

4. Line and staff

- expressions taken from military organization
- ***Line***: superior-ordinate, belongs of the main duty of the organization
  For example: CEO, director of a factory, foreman, and worker.
- ***Staff***: advisors in special areas.
- For example: accounting, finance, and maintenance.