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EECE 692 System Safety

Chapter 7

Foundations of System Safety

A Quote from Ralph F. Miles, Jr.

- “Underlying every technology is at least one basic science, although the technology may be well developed long before the science emerges. Overlying every technical or civil system is a social system that provides purpose, goals, and decision criteria.”

Safety Engineering Before World War II (7.1)

- During the Industrial Revolution (1750-1850) workers in factories were thought of as expendable and were treated worse than slaves often.
- Anyone injured in the work place would have to sue under common law, in which the employer almost couldn't lose.

Safety Engineering Before World War II (7.1)

- An employer would not have to pay injured employees if:

- 1) The employee contributed at all to the cause of the accident
- 2) Another employee contributed to the accident
- 3)The employee knew of the hazards involved in the accident before the injury and still agreed to work in the conditions for pay

Safety Engineering Before World War II (7.1)

- Terrible working conditions of the time led to social revolt by activist and union leaders
- The American Public Heath Association, the National Fire Protection Association, and Underwriters Laboratories were some of the first voluntary safety organizations formed in the late 1800's
- The first standards however, focused on health instead of safety

Safety Engineering Before World War II (7.1)

- In Europe, worker safety preceded the US in it's efforts. During the 1880's Otto von Bismarck (Creator of the German Empire) was the first to establish worker's compensation and security insurance paid for by employers. Soon other European countries started to create safety legislation.
- The U.S did not begin to change their laws until social revolt forced the gov't to act.

Safety Engineering Before World War II (7.1)

- Individual state laws preceded state laws, and eventually employers realized that it was in their best interest to keep their employers safe.
- Near the end of the 19th century engineers began to consider safety as well in functionality in their designs.

Safety Engineering Before World War II (7.1)

- In 1914 the first set of safety standards were published and stated that a safeguard should:

- 1) Afford all possible safety to the operator and surrounding workmen.
- 2) Be automatic in its action, application, or operation (if possible).
- 3) Be an integral part of the machine itself (if possible).
- 4) Not materially diminish the output or the efficiency of the machine to which it is applied.

Safety Engineering Before World War II (7.1)

- As engineers and others began to study safety as an independent study, Safety Engineering was born!
- In 1929 H.W. Heinrich published a study of industrial accidents which led to the Heinrich pyramid and established a statistical basis for eliminated hazards.
- Engineers started to take human error into account and designed machines that would not operate if one did not take appropriate safety measures.

Safety Engineering Before World War II (7.1)

- During the was statistics show that more people died in factories and in training accidents than on the battle-field. This was a driving force in improve safety.
- The rapid expansion and complexity of new technology cause the industry to think in terms of systems.

Systems Theory (7.2)

- System theory dates from the 30's in response to limitations with complexity.
- Ludwig von Bertalanffy is recognized as the founder of the general theory of systems.
- This theory is an approach that is taken along side reductionism, which include reduction, repeatability, and refutation.

Systems Theory (7.2)

- Reductionism makes three assumptions
- 1) The division into parts will not distort the phenomenon being studied.
- 2) The components of the whole are the same when examined singly as when they are playing their part in the whole.
- The principles governing the assembling of the components into the whole are straightforward.

Systems Theory (7.2)

- In a system, a problem is divided into distinct parts and examined piece by piece.
- Complexity of a system can be described as organized simplicity, unorganized complexity, or organized complexity.

Systems Theory (7.2)

- **Organized simplicity-** precise nature of interactions are known and component interactions can be examined pairwise. Systems can be separated into non-interactive subsystems for analysis without distorting the results.

Systems Theory (7.2)

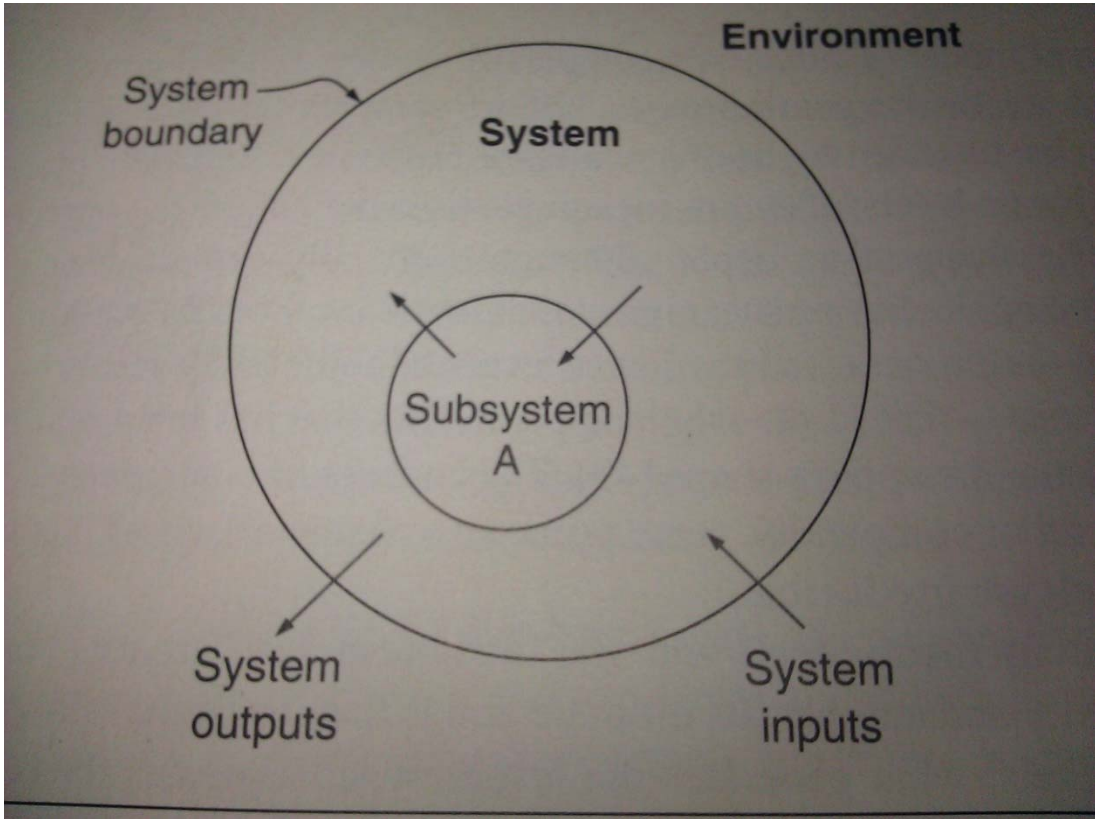
- **Unorganized Complexity** – lacks the underlying structure that allows reductionism to be effective. These systems are complex but regular and random enough to be studied statistically. The law of large numbers is often used because the larger the population, the more likely observed values follow the average.

Systems Theory (7.2)

- **Organized Complexity** – systems are too complex for complete analysis and too organized for statistics: averages are deranged by the underlying structure. This describes many of the complex systems which are the subject of systems

Systems Theory (7.2)

- System Diagram



Emergence and Hierarchy (7.2.1)

- A model of organized complexity can be expressed in terms of levels, which grow in complexity with each step. Each level has emerging properties
- Emergent properties are ones which do not exist at lower levels. They are meaningless in the language appropriate for lower levels. This property will surface at the appropriate level. (Ex: cells in an apple and its shape)

Emergence and Hierarchy (7.2.1)

- Hierarchy theory deals with the fundamental differences between one level of complexity and another. Its goal is to explain the relationships between the different levels.

Communication and Control (7.2.2)

- Having constraints on activity on a level of the hierarchy is a form of control. These constraints define the “law of behavior” for that level.
- Control in an open system requires communication between its components, incase its environment throws them out of equilibrium.

Systems Engineering (7.3)

- During and after WWII, technology expanded rapidly and engineers were faced with creating more complex systems than ever.

- These systems were:
- -Large
- -Complex
- -Semi-Automatic
- -Unpredictable

Systems Engineering (7.3)

- Standard Control Loop

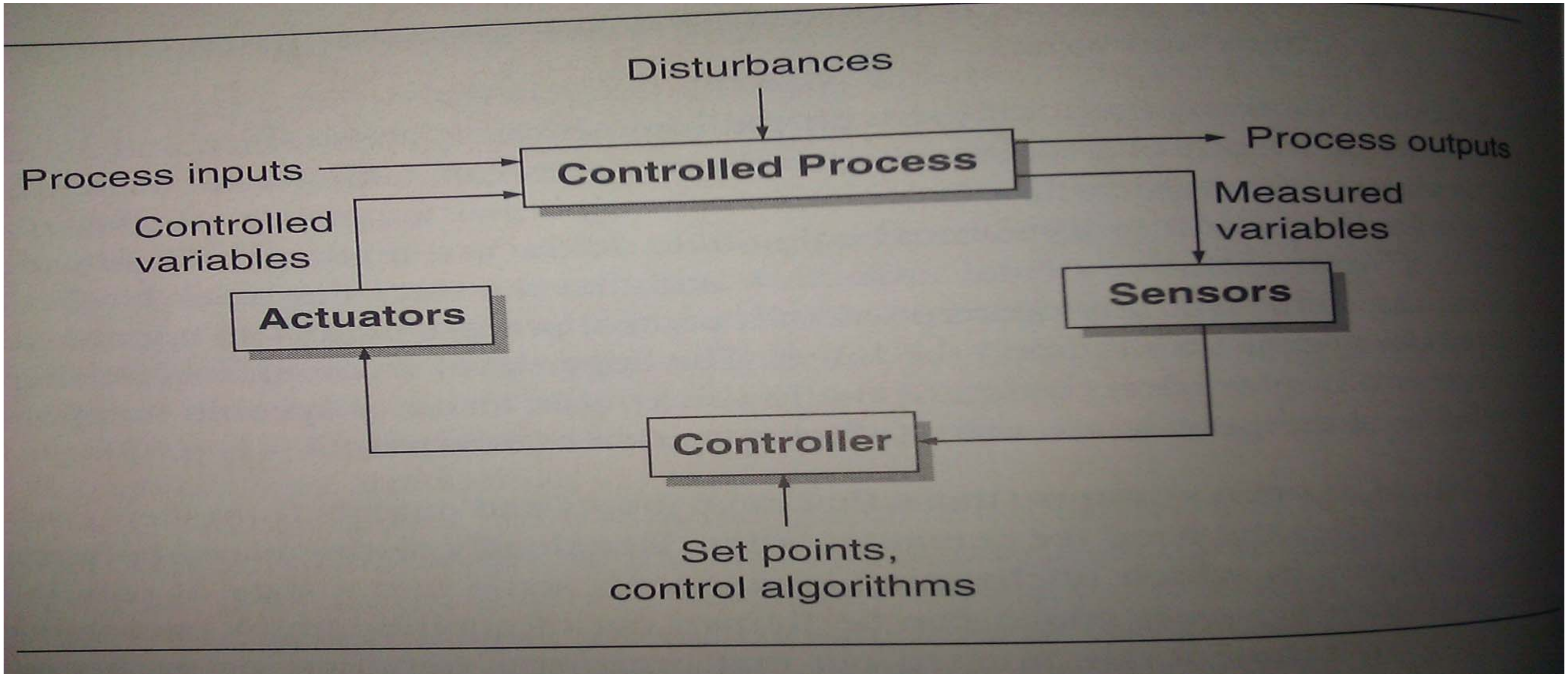
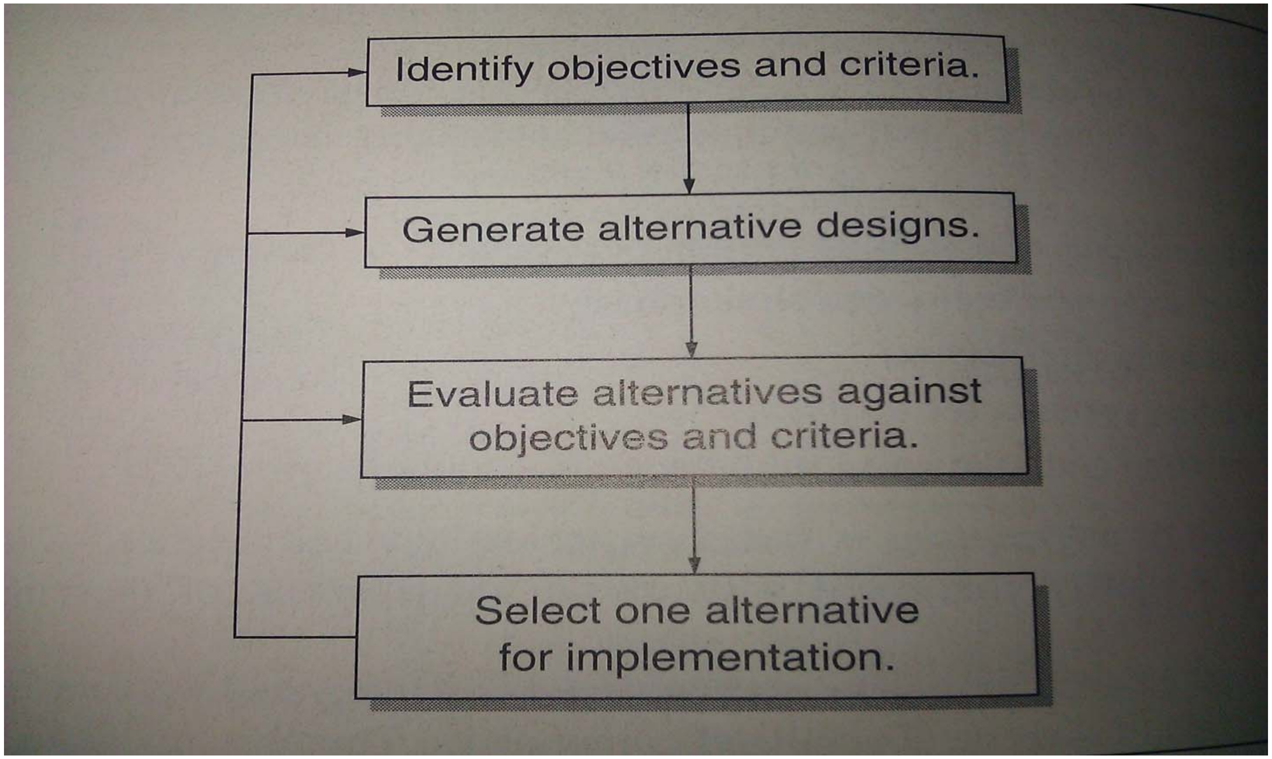


FIGURE 7.2
A standard control loop

Systems Engineering (7.3)

- Problem-Solving Model



Systems Analysis (7.4)

- A rational way to evaluate alternatives facing a decision maker.
- A method for broad economic appraisal of the costs and consequences of the various ways to satisfy a particular goal.