**Textbook Problem 3.3**

**Question**:

If there is a feasible and attractive concept for satisfying the requirements for a new system, state why it is important to consider other alternatives before deciding which to select for development? Describe some of the possible consequences of failing to do so.

**Response**:

At the beginning stages of the systems engineering life cycle, namely in the concept development phases, it is critical to consider different concepts prior to selecting one for full system development.

While it’s certainly an option to choose the first feasible and attractive concept that comes to mind, it is necessary to assess the implementation of other architectures prior to entering the engineering development stage of the systems engineering life cycle. The concept exploration and definition phases help define the key characteristics of a concept that will achieve the most favorable balance between items like relative performance, cost/schedule, and development risk. Once different concepts are established, a trade-off analysis is performed in order to help make an informed selection of the preferred approach for future development. Evaluations on each of the concepts are done against different measures of effectiveness (MOE) and developed system performance requirements in order to make a well-informed decision. In addition to the feasibility of the technical implementation, things like relative affordability and risk of accomplishment need to be taken into consideration as well. This relative analysis of different concepts against one another helps provide a strong, substantiated foundation for proceeding forward with a particular design implementation – this would not be possible if only one system concept was investigated. Proper use of the systems engineering method during this stage of the life cycle ensures the following:

1. All viable alternatives are considered.
2. A set of evaluation criteria (MOE, Key Performance Parameters, etc.) are established.
3. The developed criteria is prioritized and quantified when practicable.

Failure to properly evaluate and weigh different concepts prior to system development may result in the following consequences:

* Not selecting the “best choice” out of the possible options available for the system concept.
  + Critical items such as cost, operational performance, and schedule may not be optimal based on the needs analysis of the system to be designed.
  + This is particularly crucial to the defense industry, as many contracts are awarded to a contractor solely based on analysis from the concept development phases.
* No analysis of other options may result in a higher amount of technical problems or unknown unknowns (“unk-unks”) discovered much later in the systems engineering life cycle.
  + These have the potential of causing critical requirements changes late in the process.
* Unexpected expenses and impacts due to an insufficient, non-relative analysis of system MOE’s.

**Textbook Problem 3.5**

**Question**:

What steps can a systems engineer take to help ensure that systems components designed by different technical groups or contractors will fit together and interact effectively when assembled to make up the total system? Discuss in terms of mechanical, electrical, and software system elements.

**Response**:

One of the primary functions of a systems engineer is to ensure that proper communication channels exist between all technical groups and contractors, both during and in-between the different development phases of the system. Participation from specialized personnel (e.g. systems analysts/engineers, design engineers, engineering specialists) varies depending on the current phase of system development, and is at its highest during the engineering development stage.

With the responsibilities of the three engineering disciplines split across the different technical groups or contractors, the systems engineer should keep the following information in mind, pushing for information sharing and parallel testability between all parties:

*Mechanical*

* Mechanical component design elements may include the following: box level/container design, framework, material processing machines, kinetic parts, and actuators/motors.
* Conveyance of all electrical/software-related requirements to this team. Prior to full system production, the engineer can oversee the design of mechanical (physical) prototypes in order to assess the feasibility of the product and test the system under expected operating conditions.

*Electrical*

* Electrical component design elements may include the following: receivers, transmitters, data/signal processors, communication channels, and wiring elements.
* Conveyance of all mechanical/software-related requirements to this team. Prior to full system production, the engineer can oversee the design of breadboards and prototype circuits that will mimic the communication channels and electrical loads between different parts of the system.

*Software*

* Software component design elements may include the following: operating systems, application programs and processes, support software/firmware.
* Conveyance of all mechanical/electrical-related requirements to this team. Prior to full system production, the engineer can oversee the design of software simulations to model items like communication effectiveness, data interactions, and processing capabilities/limitations.

Understanding the responsibilities of the engineering disciplines, a systems engineer can take the following steps to help ensure that systems components designed by different technical groups or contractors will fit together and interact effectively when assembled to make up the total system:

* Setting up team meetings to discuss the current design and interoperability between the different groups. It is equally important to ensure that there are no discrepancies in technical and programmatic understanding between all parties involved, and that there are no inherent conflicts between the different engineering system elements.
* Clearly defining the interfaces that will exist within the system, along with external inputs/outputs. Understanding the interactions between the different mechanical, electrical, and software components and being able to effectively communicate that information to each team will provide a necessary bridge between the different engineering disciplines.
* Being proactively involved in the formulation of any test procedures which map back to requirements, along with the choice of instrumentation for that specific test. Testing should be done as the system evolves and not just at the end, with results communicated to all teams.

Equipped with a high-level overview of the system, these steps will help a systems engineer effectively lead the integration of systems components designed by different technical groups or contractors.

**Special Problem #1**

[Submitted via Assignments page in separate MS Word document]