

## **ESD.33 Systems Engineering**

### **Exam 1 – Frameworks**

**Due Date:** Nominally, 22 June, 8:30AM- 10:30AM EST. However, for students unable to take the exam during class time, the exam may be taken in any two hour interval in the subsequent week.

**Deliverable:** Individual written assignment (no page limit, but concise communication is always valued).

**Time allotment:** You must do the exam in a single 2 hour block of time. You must submit the completed exam on line before 7:30AM Tues 29 June. Having tested this exam, I found it takes 30 minutes just to read and comprehend the questions (my test subject was not a native speaker of English but was proficient in English). There is enough time, but you will have to manager your time effectively.

**Grading:** This assignment represents 10% of your final course grade. The exam has 100 total points. Question 1 is 45 points, question 2 is 30 points, and question 3 is 25 points.

**Objectives:**

This assignment is intended to assess and reinforce your understanding of the frameworks for systems engineering.

**Exam Questions:**

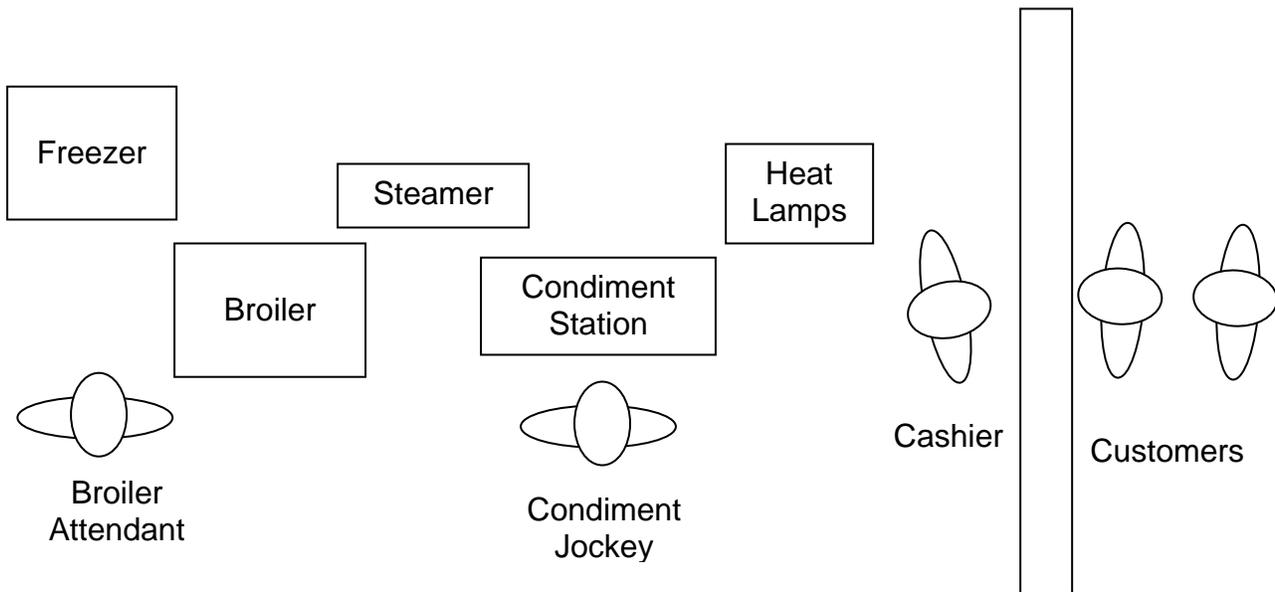
1. (45 points) This question is comprised of a series of 15 short answer questions based on the assigned readings. Each response should be about three sentences (you can also use simple graphics). Sub-questions (a through o) are worth 3 points each:

- a) (3 points) Argyris introduces the idea of a “theory-in-use”. What does he mean by a “theory-in-use”? How does it differ from an “espoused theory”?
  
- b) (3 points) Shön discussed the concept of “over-learning”. Briefly provide an example of Shön’s “over-learning” that might occur in an engineering organization.
  
- c) (3 points) According to the INCOSE systems engineering handbook, about how much of a program’s budget should be spent on the Systems Engineering function? According to the INCOSE, what are some of the consequences of underinvestment in Systems Engineering?

- d) (3 points) Given the definitions of Systems Engineering and System Architecture in the INCOSE systems engineering handbook, is Systems Engineering a subset of System Architecting, or vice versa? Briefly explain.
- e) (3 points) Provide an example of an “Acquisition and Supply relationship” as defined in the INCOSE systems engineering handbook.
- f) (3 points) A monopoly describes a market condition in which there is a single seller. What is the term for a market condition in which there is a single buyer?
- g) (3 points) What does the term “kaizen” denote? How is it related to “flow”?
- h) (3 points) What are the three major activities in the Lifecycle Value Creation Framework as defined by Stanke and Murman? Which of these three activities is most emphasized in Womak’s Lean Thinking framework?
- i) (3 points) Name three practices at Toyota (as documented by Ward et. al.) which would tend to give Toyota a low rating on the capability maturity model matrices in the appendices of Stanke and Murman’s paper.
- j) (3 points) What does Suh call a design with more DPs than FRs? What are the implications of this kind of design in light of Suh’s axioms?
- k) (3 points) Assume a projector’s function is to create an image which is the right size (fits the screen) and is properly focused. The projector has a lever which changes the image size and which also causes the focus to change. The projector also has a knob that changes the focus but leaves the image size essentially unchanged. According to axiomatic design, is this system uncoupled, coupled, or decoupled?
- l) (3 points) For the projector described in (k), what does axiomatic design say about the system and its operation? According to Axiomatic Design, is it acceptable? Does Axiomatic Design provide any insights about how to operate such a system?

- m) (3 points) Restate the following Functional Requirement into more nearly solution neutral terms: “Scrape ice from the surface of the car’s windshield”
  
- n) (3 points) Euclidean geometry is based upon a set of axioms including “all right angles are equal to one another.” Is this axiom more aligned with the use of the term “axiom” by Suh or the use of the term “axiom” by Hazelrigg? Explain briefly.
  
- o) (3 points) The course calendar lists many tools we plan to learn. Name the most important SE tool that we are not currently planning to cover. Justify your choice briefly.

2. (30 points) Your goal on this question is to evaluate a system as described in text and graphics below. Sub-questions (a through h) are worth 5 points each.



Burger Czar (a fast food restaurant), operates in two different ways depending on time of day. Let’s call these modes “NORMAL” and “BUSY”.

NORMAL mode is used from 2PM to 4PM. During NORMAL mode, a hamburger is made the following way. When a customer places an order, it cues an employee (the broiler attendant) to take a meat patty and a bun from the freezer and place them in broiler that automatically cooks them and ejects them (this takes about 2 minutes). A different employee (the condiment jockey) is cued by the patty being ejected to catch the cooked patty and toasted bun. Based on the customer's specifications, the condiment jockey places condiments on the hamburger, wraps it in paper, and gives it to the cashier (this takes about 0.5 minutes). The cashier then puts the hamburger in a bag with other items and delivers it to the customer (this takes about 0.5 minutes). The whole process takes about three minutes from order placement to delivery and completely bypasses the steamer and heat lamps. No new order is taken until the customer has their food. There is only one employee at each station (one cashier, one condiment jockey, and one broiler attendant).

BUSY mode is in place from 4PM to 6PM. Five regular sized hamburgers are made in the standard condiment configuration and placed under heat lamps. In addition, five hamburgers are held in a steamer between the broiler and the condiment table (these are cooked but have no condiments on them). The condiment jockey seeks to maintain the stock of items under the heat lamp at the prescribed level. The broiler jockey seeks to maintain the stock of items in the steamer at prescribed level. No new order is taken until the customer has their food. There is only one person at each station (one cashier, one condiment jockey, one broiler attendant).

During BUSY mode, there is a quality control function in place. Any item under a heat lamp or in a steamer for more than 10 minutes is generally too stale or soggy to sell to the customer. Therefore, items placed under the heat lamp or in the steamer are "time stamped". The person who draws a hamburger from under a heat lamp or steamer does so under a "first in first out" rule drawing the oldest one available. If that item is over 10 minutes old, it is discarded.

- a) (5 points) State whether NORMAL mode is a push or pull mode. Also state whether BUSY mode is a push or pull mode. Explain your reasoning briefly.
  
- b) (5 points) At 3 PM, seven people arrive simultaneously each wanting one hamburger. Estimate how long before the 7<sup>th</sup> person has a hamburger. Explain your reasoning and assumptions briefly.
  
- c) (5 points) At 4:05 PM, seven people arrive simultaneously each wanting one hamburger. Estimate how long before the 7<sup>th</sup> person has a hamburger. Explain your reasoning and assumptions briefly.

- d) (5 points) On an unusual day, there are no customers at all from 4PM to 5PM. Identify “muda” in the system under these conditions. Explain your reasoning briefly.
- e) (5 points) Evaluate the overall system (which includes two different modes of operation) from the perspective of the “Lean Thinking” framework. As a minimum, state whether you think that having two modes of operation is a good idea (you may have to state some assumptions about the system and the demands on the system not given explicitly in the problem statement).
- f) (5 points) Suggest changes to the system that might be made if you discover that customers are very picky about quality (e.g., soggy and staled) and are willing to wait up to five minutes for their food.

3. (25 points) Fred Brook's paper *No Silver Bullet* discusses several software engineering processes / tools. Brooks evaluates each according to how it addresses the "accidents" or the "essence" of the software engineering challenge. Brooks then attempts to quantify how much improvement one might expect if a particular process / tool is developed and implemented.

a) (15 points) Select a framework you think is useful for your field of professional work. Discuss how that framework addresses the "essence" or the "accidents" that make good systems engineering difficult.

b) (10 points) Select a framework which you do think is not useful for your field of professional work. Discuss how that framework addresses (or fails to address?) the "essence" or the "accidents" that make good systems engineering difficult.