

ESD 71 -- Engineering Systems Analysis for Design

UNCERTAINTY ASSIGNMENT

Last updated: September 2009

Learning objective:

The overall purpose of this exercise is to introduce you to the fundamental concept underlying this course. This is the fact that the future is uncertain. Specifically, designers cannot expect to know the future loads and requirements for a system accurately. The development and use of a system over time almost inescapably takes place in the context of changing technical, economic, political, industrial and regulatory conditions. These factors will generally disrupt initial forecasts, and make the actual outcomes be quite different from the best original estimates. In short, the general rule is that the "forecast is always wrong".

Part 1 provides you with a current example of how changing technical, economic, political, industrial, and regulatory conditions have affected forecasts. It is one of many that we could have chosen; the recent and past experience is full of parallel examples. In this case, we give you the ways current loads on a system turned out to be different from forecasts, and invite you to investigate the sources of the disruptions to the forecasts, according to a general checklist we provide. We would like you to

- appreciate the kinds of significant contextual changes that disrupt forecasts, and
- take-away a checklist of issues that you could use to anticipate the possible uncertainties that may affect a design issue you may be working on.

Part 2 gives you the opportunity to apply what you have worked on in Part 1, to reinforce and generalize that learning.

PART 1

The purpose of Part I is for you to understand some of the sources of uncertainty in engineering projects and the ways in which they can impact forecasts, by considering a specific example.

In the aviation industry, the development of infrastructure and equipment can take a long time. As a result, large-scale investment decisions must be made in anticipation of transportation behavior ten or more years in the future. As this example demonstrates, future trends (in this case in transportation) are highly dependant on unpredictable or uncertain events.

Between 1995 (when the nearly-complete US \$4B¹ upgrade project for Boston-Logan International Airport was initiated) and 2006, air traffic into and out of the Boston metropolitan area changed significantly. This means that airport designs based on earlier forecasts may be inappropriate for current conditions. For example, the plan to construct a massive new passenger terminal for Delta Airlines, did not anticipate that this airline would go bankrupt just before the opening of the terminal (and may not be able to pay for it!).

Figure 1 indicates the total traffic, in passengers and aircraft, which departed from Boston Logan airport in 1999 and the actual and US Federal Aviation Administration (FAA) forecast for annual passenger and aircraft traffic in Boston in 2004².

¹ http://www.massport.com/logan/about_histo.html, (1 Sept. 2006)

² http://www.nerasp.com/Tech_Paper_2.pdf, (1 Sept. 2006)

	1999	2004	
	Base Year	Forecast	Actual
Passenger Emplanements	13,531,330	14,500,000	13,074,190
Domestic Jet	10,325,619		9,681,745
Regional Carriers	1,059,355		1,291,626
International	2,146,357		2,100,819
Aircraft Operations excl. Mil.	494,816	529,129	409,066
Mainline Jet	255,953	265,058	236,758
Regional Carriers	189,680	222,949	128,972
All-Cargo	11,267	13,180	12,100
General Aviation	37,916	27,942	31,236

Figure 1: Actual and forecast annual total passengers and flights, Boston-Logan International Airport, 1999 and 2004 [Source: Massport, 01 Sept. 2006; FAA 01 Sept. 2006 / Logan ESPR]

Task: Use online resources (such as Google, Wikipedia, and media available through the libraries) to identify possible sources for the differences between forecasts and actual results. There is no secret “right answer” for you to discover. The purpose of the exercise is for you to demonstrate an understanding that forecasts are subject to many unforeseen risks. Include a citation or online source for each potential cause. Your answer on 1page should be sufficient, but in any case should not be more than 2 pages in Word.

The following general categories of uncertainty that affect the accuracy of forecasts may help your thinking:

- **Technical change:** The introduction of new technology may change conditions significantly. For example, regional jets (RJs) became important elements of the airline fleets. As smaller aircraft need larger separations during the landing approach when sequenced behind larger aircraft, their presence at an airport can lower its capacity, measured both in number of operations and of passengers.
- **Economic/Financial:** Periods of boom and recession affect demand, as do absolute or relative prices (as for jet fuel, the value of the Euro, or the comparative fares by rail or on airlines through nearby cities).
- **Regulatory:** Regulatory changes can change what can (or cannot) be done. Thus, new security regulations since 2001 made air travel less attractive compared to rail, car, or video conferencing (where these are substitutes). They also changed the space needs in passenger buildings.
- **Industrial:** The composition of the industry can change the availability and supply of service from a system. For example, the sale of TWA to American Airlines drastically reduced service to St Louis, as American moved flights to its hubs in Dallas and Chicago. Similarly, the expansion a of low cost carrier (Southwest) into cities near Boston (Providence and Manchester) increased the attractiveness of these airports to travelers.
- **Political:** Changes in international relations may alter the system. Thus, the implementation of the North American Free Trade Alliance (NAFTA) means that US and Canadian airlines can change their route patterns.
- **Other:** Of course, this is not an exhaustive list. You can think of other uncertainties that impact engineering projects.

PART 2: Uncertainty in Agricultural Products

Background: The World Bank and other institutions often finance large-scale projects – such as flood control and irrigation projects -- to develop agriculture. They justify these loans based on the prospective value of the commodities that will be produced. To carry out this calculation, they thus need to estimate the future prices of these products. How easy is that?

Task 1: Pick Wheat, Rice or some other food as the agricultural commodity you will focus on.

Task 2: Use a search engine (such as <http://indexmundi.com/commodities/>) or other source to obtain the variation of price of your commodity. Of course, properly reference your sources.

Task 3: Think about the changing

- technical,
- economic,
- political,
- industrial and
- regulatory conditions

that may have caused the fluctuations that you can observe.

Task 4: Prepare a **1-page** memorandum, addressed to your hypothetical boss in an international lending agency

- providing an Excel table and graph showing how the actual prices over the past years compare to some fixed price that might be used to value some development,
- suggesting what developments might affect the future price of the commodity, and
- indicating what kind of price, or what kind of distribution of prices, the lending agency should use to evaluate a major project now under consideration.

SPECIAL INSTRUCTIONS

- Turn in your answers in Word and Excel.
- Each Page should have a footer with your name and the date of turn-in.

BEST WISHES!