Lecture 1: Introduction

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Course Objectives

- Model a decision
- Make a value based decision
- Model uncertainty
- Make a decision under uncertainty
- Identify, prioritize, and manage risks

Congratulations!

You have just been named the technical lead for a newly won, high-priority project for a key customer.

If you deliver on this project, a major promotion is certain.

The product falls squarely into your area of technical expertise.

You know the technologies inside and out.

This project should be no problem, right?

Time to meet with the project manager…

The Situation

After meeting with the project manager and discussions with your engineering team, it turns out that:

- Several of the customer requirements are in direct conflict.
- The entire system concept is based on an experimental technology that is still in the lab.
- To meet the weight and strength requirements you would need to use a material that does not exist.
- The project has a very aggressive schedule and is understaffed.

After asking management why the company would agree to such terms, you are told:

"If we hadn't, we wouldn't have won the contract."

No Good Options?

You have reached the disconcerting conclusion the project, as it stands, is un-executable.

You consider your options:

- You could proceed with the project as it stands and hope for the best.
- You could advocate the use of more mature, available technologies that meet most, but not all, of the requirements. However, the customer plans to use your product as a component in its own products. Failure puts those customer products at risk.
- You could decline your position as technical lead and risk putting a halt to future career advancement in your company.
- You could keep working for now until you can find a job with another company.

What should you do? Are these really your only options?

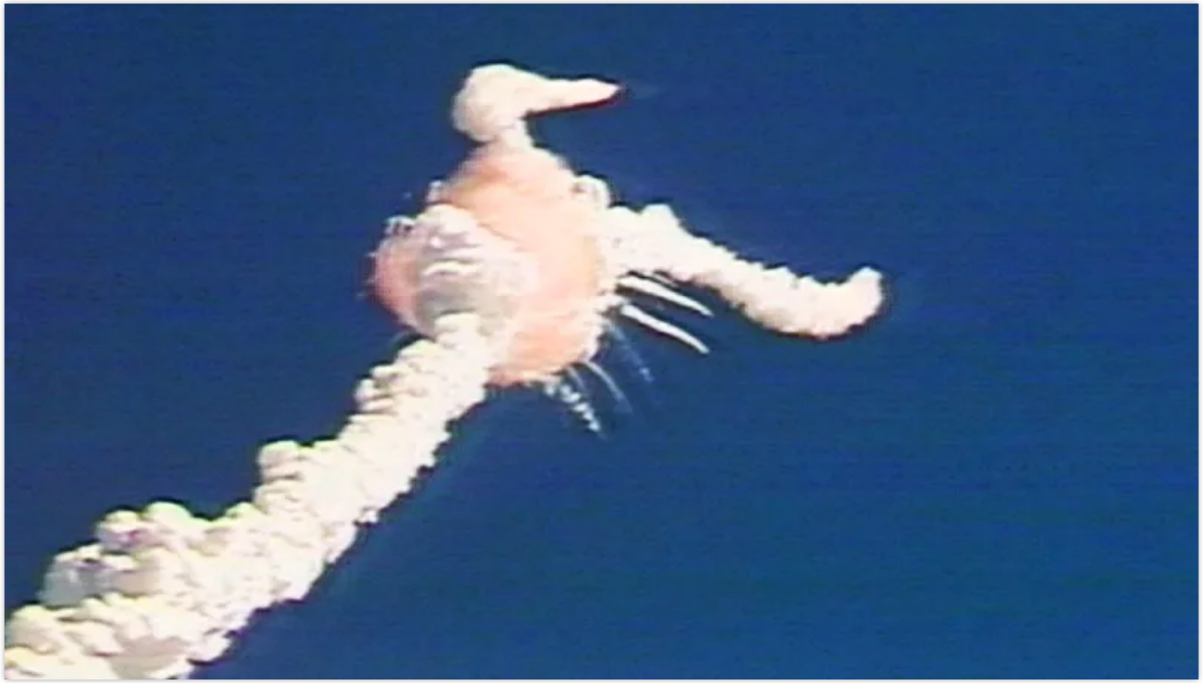
Why should engineers care about decision and risk analysis?

- The systems engineering process can be viewed as a phased risk reduction process.
- Each phase in the process provides an opportunity to reduce the risks to the final realization of the system.
- It is generally cheaper to address problems on paper than after the system is built.
- Engineers are constantly making technical decisions under uncertainty that directly impact the successful delivery and operation of the system.
  - Making tradeoffs among potential requirements and design alternatives.
  - Determining whether or not to mitigate the impact of risky requirement.
  - Determining whether or not implement a costly system test.

Why should engineers care about decision and risk analysis?

- Many of these decisions are made informally using expert judgment or back of the envelope calculations (informal trades).
- For the countless low impact decisions that must be made on a daily basis on a major technical project, this is okay.
- However, as the impact of a decision increases, the more is needed to avoid them.
- Some customers will require documentation of major trade studies as part of milestone reviews.
- This course will cover methods and tools that can be used to support decision making under uncertainty for these high-impact situations.

The Challenger



Examples of Engineering Decisions

- Should we select a mature, proven, low-risk technology that will sacrifice a little bit of the performance or should we select a more advanced but risky technology that has the promise to deliver the performance our customer wants?
- Should we select a server model that is inexpensive to purchase but is less reliable or one that is more expensive but extremely reliable?
- Our users are demanding a robust, user-friendly interface with lots of built-in training, but our customer says that meeting the minimum functional requirements at minimum cost is the priority.
- Should we build our flood mitigation system to withstand a 100 year flood, a 1000 year flood, or a 10,000 year flood?

Examples of Engineering and program Risks

- If our vendor discontinues support for the selected server model in the next three years, then we could be forced to make expensive upgrades sooner than expected
- If the experimental engine doesn't meet requirements by PDR, we will be forced to redesign much of the system
- If we do not hire a qualified database administrator within three months, we will not meet our delivery schedule
- If we do not meet this requirement, then the sponsor will reduce funding for future versions of the system
- If this new pharmaceutical drug causes too many side effects, the company will subject to class-action law suits

Course Philosophy

- Despite their age and extensive history of use, many of the standard methods for decision and risk analysis are still debated and sometimes controversial.
- There are competing paradigms (e.g., MAUT vs MCDA).
- Consequently, in this course we will take a critical approach to each topic and discuss their strengths and weaknesses.
- The tools and techniques covered can be valuable if one understands their limitations.

Overview of Course Topics

1. Consider the elements of a decision and discuss means for structuring them, particularly when there are conflicting objectives.
2. Learn how to make tradeoffs under certainty.
3. Introduce uncertainty with a refresher on basic probability theory.
4. Consider subjective probability and how it can be updated with new information.
5. Introduce utility theory as a means to capture risk attitudes.
6. Learn how to make tradeoffs under uncertainty using multi-attribute utility theory (MAUT).

Overview of Course Topics

7. Discuss alternative ways to make tradeoffs besides MAUT.
8. Discuss the human biases with regard to uncertainty and human perceptions of risks.
9. Learn about the makeup of the broad domain of risk management.
10. Learn about typical approaches to project risk management on engineering programs.
11. Gain a high-level understanding of how financial risks factor into project decisions.
12. Learn about the risk of extreme events.
13. Learn about model risk.

Relevance for Practitioners

- Formal decision analysis techniques enable managers to explore options even if the decision isn't (and probably shouldn't be) made on the numerical utility values.
- Most of the value is in the exercise.
  - The key is the exploration of tradeoffs not the actual utility values.
  - Many times the very act of trying to structure a decision and collect the associated data makes the best option immediately apparent.
- Risk management is pervasive in both program management and engineering.
  - If it weren't for risk, managers wouldn't have much to do.
- Formal techniques can aid in the allocation of scarce resources for risk mitigation.

Relevance for Researchers

- Utility theory is pervasive in economics and human decision making.
- Classical economic theory assumes individuals are utility maximizers.
- Utility theory will likely come into play if you are developing any models or simulations that involve human behavior.
- Understanding utility theory is critical to understanding the deviations from it (e.g. prospect theory)
- Understanding human responses to risk are also relevant for understanding social and political decision making. (e.g. people will likely have a stronger response to the risk of dying in a terrorist attack versus the risk of dying in a car accident even though the probability of dying in a car accident is substantially higher.)

Before Lecture 2:

- Read Chapters 1 and 2 from Clemen.
- Watch the “Alaskan Pipeline” from your Canvas under Module 1.