



Managing Complex Problems Involving Technical and Social Challenges

An Online Continuing Education Course for Engineers

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Managing Complex Problems Involving Technical and Social Challenges

Steve Ackerlund, Ph.D.

Part 1: Recognizing the Special Needs of Complex problems

This course seeks to provide the reader with the tools needed to effectively manage complex problems. To do this, we must first recognize two fundamental aspects of problem-solving:

- Problem: What kind of problem do we have, and how should that influence my choice of a problem-solving process.
- Process: What is your own, innate (and possibly entrenched) way of solving problems, and how does this relate to a spectrum of possible problem solving processes including those most suitable to complex problems.

Part 1 of this course begins by explaining what a complex problem is, and places that definition within a typology of problem types so that we can begin to properly define the kind of problem this course addresses. Then the course explains why engineers, and others to be fair, struggle with complex problems – they are complex after all! An overview of the different kinds of strategies for solving different kinds of problems is provided, to give context for situating the approaches taught in this class as unique to complex problems. This sets the stage for then delving into complex problems more deeply in Part 2: Understanding Complex Problems.

1 What is a Complex PROBLEM?

This course focuses on complex problems, which is one type of problem. Herein, we define complex problems as **difficult to define and difficult to solve**. They are difficult to define because there are many influences on the problem, and they are similarly difficult to solve because the problem is poorly understood.

Complex problems involve significant uncertainty on what causes or influences the problem, and on the relative significance of each of the influences. There can even be disagreement on whether there is a problem at all!

Global warming is a contemporary complex problem with many possible ramifications to the world of engineering as we seek to reduce potential adverse effects and respond to the problem – if you’ll agree with me that there is a problem!? While some say climate changes are just part of normal cycles, others point to changes in solar flares and sun spots, and, of course, many point to anthropogenic greenhouse gases. But since greenhouse gases are also natural in origin, uncertainty pervades on just how significant the human related greenhouses really are. And on, and on. You have heard it before. Its complex. Beyond your own understanding of the topic, what’s important to recognize in trying to typify this kind of problem is that others have developed their own internally consistent rationality for thinking about the topic and filtering what they want to consider in terms of new information.

When it comes to solutions, it can be double hard to rally support for action on a complex problem. To really solve a complex problem means to address in some way each of the influences on the problem. Since there is poor agreement, or at least considerable uncertainty, on the influences on a problem, the benefits of any solution are also uncertain. Also, options may require coordinated action among stakeholders who may be confused, apathetic, or pulled into different fractions by different voices.

Again, climate change can be used to understand how solutions to complex problems are innately evasive. If cutting greenhouse emissions is needed, how do we find the personal, social and political will to act against such high implementation costs, uncertain benefits, and seemingly unfair

EXAMPLES OF COMPLEX PROBLEMS

Land Use Planning and Development:

Ideology divides those who appreciate central planning toward commonly shared goals and those who value independence or free enterprise.

Urban renewal in the 70’s was initially hailed to help inner city poor, but was later criticized as ethnic cleansing, as the poor became priced out of renewed areas.

Safety Culture: Is safety a matter of following procedure, or are there real or perceived issues about “real” expectations, mixed messages regarding performance metrics, culturally based differences in risk perception or risk tolerance, etc.?

Harbor Management: Dredging and maintaining harbors has become mired in regulatory complexity, stagnant budgets, political interferences, increased traffic, climate-change influences, and many more issues. Uncertainty permeates any course of action.

Boarder Control: Some see boarder control as needed to protect jobs, protect culture and other reasons, while others recognize the need for low-wage workers and the dire needs of illegal aliens. Would a wall work or is improved surveillance the answer – how can we know before trying?

distribution of benefits and costs? Without clarity and at least consensus of the problem, coordinated action on a solution seems futile.

This list can be extended to include pretty much the type of things you read about in the newspaper. These topics make the news because they involve ideologies that are important to shaping who we are and how we choose to think about problems. Such problems get “addressed”, for better or worse, over long periods of time within ongoing political discourse. But rather than let these problems evolve in whatever way the political winds blow, this course provides a structured approach to constructively advancing these issues as a structured management endeavor.

2 Problem Typology

As alluded to thus far, complex problems are one type of problem. Within the social sciences, and the fields of risk communication and conflict resolution more specifically, a three-fold typology is commonly used as a starting point for understanding the kind of problem you have and how it might be addressed.

Here is the point at which this course intersects with *Technical Communications for Controversial Projects*, which also presents this same typology. However, *Technical Communications for Controversial Projects* provides much more supporting information about causes and characteristics of controversy. Reviewing this information is recommended for those who are not comfortable with subjectivity and have little experience with the concept of problem framing. While *Technical Communications for Controversial Projects* uses the typology as the basis for describing how to address “controversial” projects, herein the same framework is used as a launching point for explaining how to address “complex” projects.

Table 1 presents a three-part typology developed by Alder and Kranowitz (2005). The typology is defined by yes or no answers to two questions:

- a) Is there a commonly accepted definition for the problem, and
- b) Is there a commonly accepted agreement on one or more possible solutions?

Figure 1: Technical, Value and Intractable Problems

	TYPE-1 ("Technical/Convergent")	TYPE-2 ("Value/Divergent")	TYPE-3 ("Wicked/Intractable")
Agreement on Problem Definition	Yes	Yes	No
Agreement on Possible Solutions	Yes	No	No

Source: Alder and Kranowitz, 2005.

Of course, the typology is a simplification of the real world. Many factors can influence clear answers to the questions that frame this typology, and accordingly the typology should be considered more in terms of a spectrum of problem types. Situations can change over time and across different stakeholders, and as they do, the communication strategies may also need to be fluid. Moreover, the yes or no answers within the matrix need to be considered from the perspective of the stakeholders who are in some way part of the problem you seek to manage. With these application considerations in mind, the characteristic types of problems are defined as follows:

1. **Technical - Convergent**: When people readily agree on the cause of the problem and the kinds of solutions that may be brought to bear, then the problem is bounded to a factual or technical problem. People commonly recognize a given set of facts that are applicable to the problem and apply these facts to converge upon similar conclusions. How to design stack emission controls to meet air quality permit limits is one example of a purely technical problem.
2. **Controversial - Value/Divergent**: People can agree on the cause of a problem but not agree on the range of possible solutions. These problems may involve a large degree of technical complexity, but they are not restricted to technical issues – different values, perspectives and competing interests are involved. When presented with a common set of facts, different ways of interpreting the facts lead people to divergent conclusions. In the case of stack emission controls, a Type 2 problem might be said to exist if there is disagreement about the basis for the permit limits. Should the permit limits protect just human health and at what level of protection, or should the environment also be considered? How does one judge the uncertainty in the toxicological data that supports the development of the standards? To what extent should costs or industrial process changes that might reduce emission be considered? Is emissions trading over broad geographies inherently fair to those living near a

facility? While there is agreement on the need to establish pollution control limits, there is little agreement on the facts that should be used to assess the problem, how the facts are interpreted and applied to the problem, and what the range of solutions to the problem should be.

3. Complex - Wicked/Intractable: Complex problems are also often called intractable problems, indicating that they are not easily controlled or directed; not docile or manageable; stubborn; obstinate. As we have described, these are problems that are typically hard to define, much less solve. There may be little agreement that a problem even exists. An understanding of a Type 3 problem is often heavily influenced by social values that influence the interpretation of scientific facts. Teen pregnancy or women's rights and discrimination more generally are examples where belief systems can take precedent over measurable facts. Deep value differences, deeply vested interests, and long histories of dispute can create dramatic situations that are unmanageable and lead to violence in the most extreme case. People's identities are involved. In the engineering world, other examples of Type 3 problems may be found within various risk management frameworks that seek to efficiently manage infrastructure. In the case of dams and levees for example, allocation of resources to maintain aging infrastructure is made complex by competing ideas of what causes failure. The interplay between purely technical considerations, such as hydrologic trends or structural integrity becomes enmeshed with various human performed operational concerns that can give risk to the "perfect storm" scenario, where multiple intersections of human and technical factors become considered in a highly ambiguous and uncertain manner. The BP Deepwater Horizon disaster in the Gulf of Mexico has become the contemporary poster child for the realization of these kinds of complex problems.

3 Why Engineers Can Struggle with Complex Problems

With Table 1 as a tool to characterize different types of problems, we can begin to appreciate why engineers, and technical people more generally, can have trouble in working effectively within such environments. Engineers, and technical people more generally, are well trained in efficiently applying a given set of facts to determining an optimal solution. However, social science methods must be woven into the problem-solving process when social factors are important to perceiving and defining the nature of the problem. **An appreciation must be gained for the different ways in which different people think about a problem, and to understand methodologies for elucidating these different ways of thinking.** This becomes

critically important for understanding what people are prepared to listen to and how they will interpret the facts.

It is also important to recognize that complex problems are not generally “solvable” in the traditional sense, but rather tend to evolve over time as discrete opportunities emerge by which attention and dialogue are given to the matter. This is in sharp contrast to a Type 1 Technical problem, where defined schedules and budgets to solve the problem are the norm.

It’s no wonder that engineers get frustrated, or worse yet, experience failure with their products, when they conflate complex problems into Type 1 technical problems, offer up a technical solution, only to see it fail.

That said, Type 3 Complex problems are not solvable in the traditional sense. They are often the result of multiple stakeholders with conflicting interests and goals. These problems are often solved through a process of stakeholder engagement and negotiation, but these goals are often not mutually exclusive. In some applications, the goal is to reach a consensus through deliberative processes, while in others, the goal is to reach a decision through a manager or managing team, or a stakeholder perspective, and then move forward with implementation.

This course overcomes these challenges by providing a structured approach to problem-solving that is different from traditional engineering. While the problem-solving approach is different, the goal is the same. And the value of this approach is not limited to engineers or technically-inclined people. This approach all the way through, including the social scientist; although experience is helpful. It is a social risk communication, and the value of this approach is not limited to engineers or technically-inclined people.

To view the remainder of the course material and to take the quiz for PDH credit, you must purchase the course.

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