Of Space Shuttles, Legal Logic, and Decisions

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It's a pleasure and an honor to have the opportunity to address this Decision Analysis Affinity Group (DAAG) meeting. At the first meeting in Indianapolis in 1995, the group didn't even have a name, and we had no idea at the outset that there would be any interest in an ongoing association. However, DAAG appears to have a powerful survivor instinct, as this is its ninth meeting and it appears to be going strong.

It's also a pleasure to return to Houston, where I was born. Lufkin, Texas, which is not far from here, has been the epicenter of an important recent news story. On February 1 of this year the Columbia space shuttle was descending for a landing in Florida, but fell apart in the skies over East Texas. For weeks and months afterwards, various agents have been vigorously attempting to recover all the debris from this horrible accident. We have all heard of citizens who have been arrested for trying to steal a bit of debris, and indeed a NASA employee is in jail at this time for such an attempted theft. The diligence of the search has lead to some humor, in that the satirical newspaper "The Onion" (www.theonion.com) ran a headline "Texan Unable to Trick NASA into Hauling Away Old Washing Machine Out of His Yard."

This recovery effort has been under the direction of FEMA, the Federal Emergency Management Agency. On May 5, just 10 days ago, FEMA issued a report describing the status of the debris recovery effort up to that time (http://www.fema.gov/diz03/e3171n71.shtm). Among other facts, they noted that more than 130 federal, state, and local agencies have participated in the search of approximately 2.28 million acres. Approximately 25000 people have taken part in the search, working about 1.5 million man-hours in the process. Those looking for debris in the waters of east Texas and western Louisiana faced murky water and other noxious conditions, while the ground crews faced wild hogs, snakes, and other vermin. In fact, during the course of the search there has been a helicopter crash in which two were killed, underscoring the fact that not only the shuttle flight, but also the search for debris is a risky venture. As of May 5, they had recovered about 82500 pieces of debris weighing about 84800 pounds, constituting about 40% of the shuttle by weight.

This gigantic effort to recover the debris of the Columbia was undertaken with no assurance that they would EVER discover what caused the disaster. Further, even

if they learned what caused the crash, and, perhaps more importantly, even if they KNEW that they knew, there was no assurance there would be any possible correction to be made to prevent it happening again. Therefore, it would be worthwhile to address the question: "Why make this debris recovery effort?"

Shortly after the Columbia accident, NASA appointed a blue-ribbon panel called the Columbia Accident Investigation Board to try to determine the cause of the crash. On April 17 the CAIB released a preliminary report containing their working scenario (http://www.caib.us/news/press_releases/pr030417.html). In this report they issue two recommendations. First, they recommend that NASA implement an improved method of inspecting the tiles prior to resumption of shuttle flight. Also, they recommend that NASA resolve to arrange in-flight imaging of any future shuttles so that any damage occurring during liftoff can be detected prior to re-entry into the earth's atmosphere.

What does all this have to do with Decision Analysis? I think it's interesting to look at it from the perspective of a decision analyst. First, we recognize all the foregoing for what it is. All the above, from recovery of debris, to pre-flight inspection of tiles, to in-flight imaging, represents DATA COLLECTION. We recognize these as manifestations of the human longing for more and more information. The discipline of decision analysis recognizes information as something that costs money (and even lives, in the case of the helicopter crash), and therefore we should be determined to collect information ONLY IF IT HELPS US TO MAKE SOME DECISION. The 18th century English painter Joshua Reynolds said "there is no experiment to which a man will not resort to avoid the real labor of thinking." So what should we think about? I submit we need to consider what is the decision we are trying to make in this case, and how does the information that is to be collected help us in doing that?

Think about this. It would be possible for NASA engineers to make a list of all the possible causes of a shuttle disaster resulting in loss of craft and human life. Obviously, such a list would always have a category called "other" to cater to the fact that humans can't think of everything. If you give them only an hour to do it, the "other" category of causes would be a very large category indeed. On the other hand, given ample time for the exercise, they could produce a useful list of possible causes of a shuttle disaster, and they could even arrange the list by descending likelihood of the accident happening.

Suppose the engineers have produced the list, and have ordered the causes by likelihood, so that possible cause A is the most likely, B the second most likely, etc., down to Z. Decision analysts make profitable use of the concept of the clairvoyant, an agent who can see perfectly into the unknown and report back faithfully, if we

only ask the question with sufficient care. Suppose the clairvoyant sees the list the engineers have produced, and offers to help. Suppose he says that the Columbia disaster happened because of cause D on the list, the fourth most likely. What should we try to fix? Should we try to correct cause D, because it happened in this case? Or should we work instead on cause A, because it is the most likely to cause an accident in the future? Note that this consideration begins framing the situation as a decision problem, in that we have created two alternative courses of action.

Elisabeth Pate-Cornell is the President of the Decision Analysis Society, and by coincidence, has co-authored an award-winning paper on the reliability of the tiles of the space shuttle (M. Elisabeth Pate-Cornell and Paul S. Fischbeck, 1994, "Risk Management for the Tiles of the Space Shuttle," INTERFACES 24:1 January-February 1994 (pp. 64-86)). In the March 2003 Newsletter of the Decision Analysis Society she remarks that she has been working on the assessment of risks associated with terrorism. She notes that "our primary conclusion is that it is essential to look forward and set priorities based on ever changing intelligence signals instead of focusing to a large extent on protection against the last attack. It can be done, and the challenge now is to explain how it should be done to those who make these decisions." The Columbia disaster is obviously the "last attack" that Dr. Pate-Cornell mentions, and I submit that we should focus not on that but on possible FUTURE accidents.

A professional decision analyst would be finished with the Columbia situation by now. Rather than to focus on the collection of data, the decision analyst would bring a decision perspective to the problem. What are we going to DO? It is worthwhile to revalidate the objectives of the exercise, but it seems clear that they must be to increase safety, and the costs of any interventions must be weighed against that. Without regard to what happened to the Columbia, a decision analyst would help the NASA engineers to generate some alternative courses of action that we might follow. Then, he would use the standard tools of decision analysis to evaluate the performance of each of the alternatives on the objectives. This analysis would permit the NASA decision makers to judge the possible consequences, including costs, on future flights, and they could take the appropriate action, which of course might be none.

A focus on the decision to be made allows one to turn away from the past and instead look into the future, because that is where we find the consequences of current decisions. In so doing, we focus on what has happened in the past only insofar as it helps to understand those future consequences, and we do not devote our time and energy to the collection of data without a profound understanding of how valuable it would be to have it. Indeed, just before lunch this morning we

enjoyed a session on the value of information, a key concept of decision analysis. I suspect that my tone today has betrayed the fact that I have been displeased with the entire Columbia debris recovery effort. I'm willing to admit that the recovery might have been worthwhile (though my hunch is that it is not), but my principal annoyance has been that I have heard absolutely nobody in a position of authority, or even a news reporter, even consider the possibility of NOT trying to collect the debris. Why can't we at least consider that alternative?

The Columbia disaster is only one of many, many situations in our world where I think a focus on decisions to be made can clarify our thinking to a great degree. For example, in my local newspaper last week there was a report of concern about the growing incidence of dog bites. It stated that, under state law, the owner of a dog that bites another person can be charged with a misdemeanor. If the dog kills a person, then the owner can be charged with a felony. One can easily imagine a scenario in which a dog attacks another person and causes severe, even life-threatening, injuries. The decision as to whether to charge the owner with a misdemeanor or with a felony hinges on such extraneous factors as how long it takes to summon help, the skill of the medical team providing care, the general health condition of the victim before the attack, etc. All of these things can be lumped together as "luck" from the perspective of the animal owner. Certainly, the owner has a responsibility to restrain his animal, but is it right that his punishment be based on the combination of his negligence and his luck, rather than just on his negligence? A similar owner who committed the same negligence but has better luck receives less punishment.

The critical distinction between action and outcome in the preceding paragraph is one of which decision analysts are acutely aware. The dog bite situation is one of many examples where our legal system has dangerously blurred the distinction and imposes consequences on the basis of outcomes, rather than actions. Otherwise why would we distinguish murder from attempted murder? Murder is just a successful attempt, and as such luck is a factor.

I believe it was Ron Howard who said "wisdom lies in the ability to make distinctions." Look at some other important distinctions that our legal system glosses over. There is a very important distinction between being guilty of a crime and being convicted of it. The legal system pays lip service to this by demanding only evidence beyond a reasonable doubt to convict. Given that, though, if somebody is convicted of a crime, why should they stop looking for the culprit? There might be other people for whom there is evidence beyond a reasonable doubt of their guilt as well.

Decision analysts are also aware of the errors humans make in evaluating evidence. Decision analysts are cognizant at all times of the possibilities of false positives and false negatives, and help their clients in the proper updating of knowledge in light of new evidence. DNA evidence in violent crimes is an interesting case in point. This evidence is considered so reliable, for example, that many convicted felons have been released from long prison sentences because newly available DNA evidence suggests they were not involved in the crime. These persons have been released without a new trial, simply because of judicial order. Why is it, then, that DNA evidence is presented to a jury for consideration in cases being tried today? If the DNA evidence is as strong as people would like, then why involve a jury?

There are numerous other examples in the legal system, in particular those associated with the weighing of evidence. The Governor of Illinois was so concerned with what he interpreted as "mistakes" in the capital punishment system that he commuted the sentences of all the prisoners on Illinois's death row. How are we to interpret our fabled "presumption of innocence" until proven guilty? If the defendant is truly presumed innocent, then why does he wear shackles and prison orange while the judge wears black robes? How should a juror interpret the fact that THIS PARTICULAR PERSON is on trial, as opposed to the juror sitting to his left?

Society is in need of clear thinking about how to evaluate evidence. The Columbia case showed an example of people collecting evidence for no reason that I can discern, and the examples from the legal system suggest that humans make grievous errors in the interpretation of evidence. Decision analysts are people who have the training, and the inclination, to recognize these errors and to correct them. Decision analysts can roll out the extremely powerful tool of value of information to help clients judge whether to collect information, and then they use their understanding of the weighing of evidence to help people interpret it properly.

These views of decision pathology in society at large are indicative also of the problems existing in the companies represented by the members of DAAG. It is not uncommon for companies to wrestle interminably with difficult problems, never really reaching a suitable conclusion, because they lack the structure for thinking about the problem. It's ironic that many of these people say they don't use decision analysis because it takes too long! In my experience, one of the reasons people struggle so long, and so unsuccessfully, is that they focus on trying to collect ever more information. Decision analysis, of course, helps them understand what kind of information they need.

Another common decision weakness is the tendency of people to fail to generate good alternative courses of action. The decision focus fostered by decision analysts makes it clear that without alternatives there is no progress to be made. I believe the Columbia situation needs pretty urgently to generate some possible courses of action for consideration. And by "courses of action" I mean something other than data collections.

And decision analysts are all attuned to the threat of bias in evaluation. We see it in our clients all the time. Sometimes it presents as overzealous promotion of a course of action, other times it is simply overconfidence in an alternative (or underconfidence, on the part of detractors). Richard Feynman, a Nobel Laureate in Physics at Cal Tech University, evaluated the "risk climate" at NASA in 1986 after the Challenger accident (http://www.uky.edu/~holler/msc/roles/feynrept.html). He concluded that NASA engineers rated the likelihood of a failure with loss of vehicle and of human life at about 1/100, while NASA management rated it near 1/100,000. He concludes that

> "Official management … claims to believe the probability of failure is a thousand times less. One reason for this may be an attempt to assure the government of NASA perfection and success in order to ensure the supply of funds. The other may be that they sincerely believed it to be true, demonstrating an almost incredible lack of communication between themselves and their working engineers."

All of these decision weaknesses I have cited succumb to the sort of thinking that decision analysts bring to a problem. Nevertheless, a few words of warning to the analysts are in order, I believe.

One of my hobbies is fishing, and I found a fishing magazine which claimed to present a "decision tree" for the various judgments that anglers need to make if they hope to catch the big one. It began with the decision how deep to fish, followed by the choice of bait, etc., extending to the right for several such decisions. But it was just branches and words; there were no outcomes or likelihoods. All the things that make decision trees useful were missing. I take this as an example of the way in which the discipline of decision analysis can be, and often is, trivialized. If we allow it, people will believe that a decision tree is an analysis, and the analyst is acting as a graphic artist. Influence diagrams are subject to the same problem. Decision makers need what my friend Dave Kutoloski calls good decision hygiene, leading to insights. That, in my opinion, is the job of decision analysts, to foster that good hygiene.

Customers will resist the efforts. They find the "decision analysis way of thinking" foreign to their nature. (Well of course it is, and we all know many, many examples

of how "natural" thinking leads us astray.) Many customers are uncomfortable with a decision process that promotes transparency. I find this odd, because one would think that decision makers would value a process that helps them to teach decision making skills to their younger subordinates. And of course analysis might lead to an alternative that is not preferred.

I challenge decision analysts, and especially those of DAAG, to make it their mission to "clean up" the decision situations wherever they see problems, and the examples I have cited suggest that I believe they are ubiquitous. They can perform this service not only in their companies, who can hardly imagine the competitive advantage that better decision hygiene would give them, but also in society as a whole. Decision analysts are uniquely suited to do this, and they derive their strength, in my view, from their tendency to focus on decisions, and not get swept up in data collection exercises, etc. But we have to take a hard line. If we try to win popularity contests, I don't believe we will have managed to improve the decision climate. Push hard on your clients, and hope to move them at least a little bit in the right direction.

Thank you.