CHAPTER VI

"At least when I get arrested it's only my personal self that is in danger.
With this launch, the whole world is at risk."
Beth Lavoie, 22, upon the occasion of her arrest during a Cassini protest October 4, 1997
(as reported by Reuters News Service)

CONCLUSION

Studies of risk perception have little or no value if they remain in the realm of the merely historical. Solutions for NASA will come in several forms. The social sciences can provide the contribution of reflexive interdisciplinarity[1] to improvement of NASA's risk assessment and technology policies. The choices that humans make are in many ways undeterminable.. However, human choices underlie not only the problem, but also the potential solutions. The social sciences can provide an understanding not only of future choices, but also provide a context for understanding past choices, i.e., "the existing social commitments that have set the world on its present course" (Rayner and Malone 1998; page xiv). Thus, an important goal of this study is to provide NASA a way to bridge the gap in understanding illustrated by the STOP CASSINI! campaign so as to build a future in which the dire predictions do not come true, and in which the future is not planet-bound–in other words–to find a way to Mars without bringing the "inevitability of nuclear destruction" with us.

The STOP CASSINI! campaign objected to the Cassini mission on the following counts:

1. NASA provided inadequate assessment that did not include multi-failure mode testing and had inadequate explanations of the risk.
2. The risk to the citizens and visitors to the region around the Kennedy Space Center, while low in probability, had very high consequence. Nor was the liability to be born by NASA alone—the public

[1] Reflexivity: applying one's theories to one's understanding. Interdisciplinarity: drawing from different disciplines, and applying synergy.

would bear the costs of the consequences. NASA was not perceived as trustworthy enough to provent accidents.

3. The risk to the global population was untenable for a scientific project. The protestors did not feel that the United States was truly responsible for the lives and well-being of all humans. No one asked global consent before increasing global risk.
4. The potential destructive capabilities that humans have created on Earth must not be carried into the future or onto other planets. The protestors based their opposition on strictly moral, strictly future terms and objected to NASA's counter proposition. An incommensurability of world views fueled the controversy.

NASA's response to the public risk perception has been shown to be incomplete with respect to such social values and goals. The future consequences of NASA's incomplete assessment may include significant social protest over the long-term social implications of nuclear technologies for space exploration. Such social protest has the potential to delay or stop future missions and thus comprises a significant element of programmatic risk to NASA's proposed human exploration of Mars.

Recommendations

The objections listed above span a considerable range of issues and concepts. First there is the objection to the method of risk assessment. NASA could respond by undertaking multi-failure mode testing, and if necessary, revising its assessment. Programmatically, this may be the easy part. NASA's assessment could also address the social issues inherent in the loss of livelihoods and environment in the event of a low-level launch accident. Well designed studies that assess public perceptions and values regarding risk and space exploration "can be helpful to policymakers" (Thompson and Rayner 1998, page 272).

The second objection, the high consequence in the event of a plutonium release during launch, could be countered by a long-term safety record and a demonstrated high level of concern for safety. However, arguments can be brought to play that no organization is ever safe enough to totally remove a risk (Heimann, 1997, page 175):

> "Can risky technologies be managed so as to achieve error-free operations for extended periods of time? Normal accident theorists claim the answer is no—major system failures are inevitable—according to these scholars. Ultimately, they are correct… Thus, we are left to conclude that major accidents will periodically occur despite our best efforts… Perhaps the real goal ought to be to reduce the frequency of accidents to as low a level as possible… Political viability may even ensure that some form of failure will eventually occur in even the most diligent agencies, but it is possible to limit the potential level of failure an organization experiences."

Is NASA in a no-win situation? The NIMBY acronym suggests that certain concerns about the risk will be reduced if the risk were removed to someone else's backyard. Perhaps a backyard that is less populated and with a less fragile environment would suffice. The Lockheed Martin SeaLaunch project with its floating launch platform represents a possible solution to these objections.

The third objection—to the possibility of plutonium vaporizing high in the atmosphere—is a moral concern that cannot be decided upon by one government or even a few governments. Nations seeking to protect themselves from threat of nuclear war have not sought the permission of other nations when testing nuclear weapons and nuclear test ban treaties have served as a deterrent not an end. However, is the peaceful exploration of space a different case? The Cassini protestors certainly thought so: the FCPJ insisted the risks resulting from scientific research should be approved by all nations.

Also, the number of predicted global deaths from an increase in plutonium would be the result of a failure by the United States to protect the citizens of the Earth. NASA maintained that even if the plutonium were to disperse within the atmosphere, on a global basis the numbers of cancers generated by this new source would be "drowned out" by the frequency of all the other cancers that are expected to result in the next 20-50 years. The example, while putting the numbers in context, also implies a level of disregard for individual life that many find unacceptable, and leads to a situation in which "perception that the government tolerates risks to the public might be more damaging than the risks themselves" (Zeckhauser and Viscusi 1990, page 560).

The fourth objection—to the use of all nuclear technologies—is made more complex by the protestors willingness to take responsibility for all future generations. How will managers for an international Mars program—which also is responding to future generations—answer the challenge? The programmatic risk is significant, especially when other long-term intractable terrestrial environmental issues, such as global warming and the increasing scarcity of fossil fuels will also contribute to power debates in general. An anti-nuclear reaction to an increased demand for nuclear power (as a low to negligible CO_2 emitter) is a potential that has been addressed by the nuclear power industry (Wilson 1992).

In order to confront these last two issues, NASA's risk assessment ought to include not only the technical assessment which is coupled with a simple definition of the perception of the risk. It should also include a subjective assessment of the conceptual framework and values that are a part of the argument (Fischhoff 1994; Thompson and Rayner 1998). Reflexively questioning initial assumptions, not only about the risk, but also about the methods used to assess the risk and the perception of the risk by

society, may result in a synthesis of technological risk and social perception, or at least, forestall some conflicts by publicly identifying unacceptable solutions and concentrating attentions on critical and unsolved issues (Fischhoff 1994; Kunreuther and Slovic 1996). The Harvard Group on Risk Management Reform (1995, page 4) stated the case clearly:

> "Policy makers should… be influenced by important subjective factors such as whether risks are controllable by individuals through personal actions, whether risks are potentially catastrophic and irreversible in their consequences; and whether the risks and associated benefits are fairly distributed among citizens."

To the extent that assessment of risk, and disagreement about the risk, becomes a central issue in a political campaign or a source of contention between social groups, it will be vigorously brought to greater public attention by one side or the other, always imbued with value-based interpretations (Heimann 1997). The STOP CASSINI! campaign had local political impacts due to the Cassini mission's potential catastrophic effects on the economy of the region (60 Minutes). A nuclear-powered human mission to Mars will add considerable topics for debate, pro and con.

SOCIAL PROTEST AND MARS

Between the successful launch of Cassini and the beginning of a specific Mars program NASA has the opportunity to change policies that stimulate the anti-nuclear protest. By modifying its technical risk assessment techniques NASA can weaken the NIMBY argument. Risk assessments need not be "abstruse cabalistic exercises of incredible complexity" and ought to be reasonably straighforward attempts at communication (Goldstein 1996, page 67). By changing its mission design protocol to include public discussion in the creation of mission goals and requirements, NASA will begin to weaken

some NOPE arguments by strengthening the argument for Solar System exploration, even if nuclear energy is required as the enabling technology. Finally, the diffuse, moral threat from the NOSE argument can only be answered by a strong affirmation of the ultimate goal of space exploration, the release of humanity within the solar system. This mechanism will broaden the possible range of responses. Sarewitz notes that (1997, page 182-183):

> "At present, most citizens have only two options for involving themselves in decision making about science and technology—the diffuse mechanisms of voting, and the direct but often unmediated local action that is commonly associated with not-in-my-backyard sentiments. A middle ground that enhances opportunities for public participation, while also providing mechanisms for technical input and open dialogue between scientists and the laity remains to be defined… It does depend on the creation of avenues by which the public judgment can be brought to bear on important issues of science and technology policy, and on granting the public a stake in decision-making processes. The policy goal is not to substitute 'common sense' for technical knowledge but to allow democratic dialogue to play its appropriate role in decision making that is inevitably dominated not by authoritative data but by subjective criteria and social norms."

To some extent the issue at hand is part of a wider problem—"humankind's disturbed relationship with nature" (Thompson and Rayner 1998, page 273). It could become a precursor of social reaction to come if the basic perceptions underlying the protest are not better understood by NASA.

Will social discourse be beneficial? Understanding the context of the protest is valuable to understanding the political arena in which the argument will take place. The social sciences provide mechanisms for making explicit the complex framing of social responses to technology choice. The social sciences already supply an extensive body of research in understanding the processes by which societies perceive risk, and the public policy practiceswhich are impacted by those processes (Jasanoff and Wynne 1998). The social sciences can provide the context, the reflexive examination of assumptions, and the layered understanding that will enable NASA to fully inform its decisions. Discourse on space exploration will

inform the possible range of responses to choices of technology. As noted by Rayner and Malone (1998, page xvi) in analysis of global climate change:

> "the social sciences remind us to question assumptions and propositions that those who are already committed to a course of action may take for granted. For instance, the conscious choice of responses arises only after we have chosen which issues to take seriously."

Centering the discourse on social goals, and not on science goals, can change the frame of reference, and possibly change not only the motivations of the individuals and organizations performing research, but social perceptions as well. Studies that provide social models for how science works can help decisionmakers understand how science performs in a broader social context. Hopefully, this study provides one such example.

A socially-centered discourse, suggests Sarewitz, would need a new taxonomy to frame the debate, and STS can provide the analytical tools to fill in such a taxonomy. Sarewitz even provides a beginning taxonomy that might root the R&D enterprise, and NASA's mission more firmly to social goals (Sarewitz, 1998, page 77):

> "Science for:
> - Science (and culture)
> - Education (i.e., of the scientific work force)
> - Direct societal benefit (e.g., curing a disease)
> - Technology development
> - Economic development
> - Policy support (e.g., for environmental policy)"

According to this vocabulary, NASA's mission to Saturn, is primarily a mission of science for science. The mission would provide for the education of graduate students and a new generation of planetary

geologists, would provide economic support of existing aerospace companies and research institutions, and would support NASA's core mission to explore the solar system. The direct societal benefit? A diffuse but positive benefit from new knowledge.

To interpret the Cassini mission as a member of the FCPJ might: the Cassini mission was science for science, to educate graduate students, and to support the nuclear power and nuclear technology communities that advocate the use of SNP technologies. The direct societal benefit? None, *none* compared to the risks to be borne by future generations.

The NOSE argument (see Chapter V) includes future generations in its estimates of risk and harm. These generations may be resident on Earth, the Moon, Mars or elsewhere. The protestors placed a high value on these future generations by insisting that a dependence on nuclear technologies now would increase the risk and reduce the quality of life of generations yet to be born. Human exploration of the Solar System is rejected as unworthy of consideration by the protestors if that exploration must include nuclear technologies. Arguments regarding increased safety, higher power capability, and the like are ignored.

One alternative, favorable with the FCPJ, would be for NASA to wait until "other technologies have been developed" (Bruce Gagnon, personal communication). Alternative technologies will cost billions of dollars to develop for terrestrial or space use, and may never achieve the full potential required to carry out the missions envisioned by today's planners.

Two arguments articulated during the STOP CASSINI! campaign should be of special concern to NASA. First, the position that space nuclear power is the enabling tool for scientific research outside Earth orbit, limits NASA to a decision space that is bordered by a nuclear future on the one hand and a humankind that rejects space and the solar system to protect future generations on the other. What might the response to a serious accident be? Binary decision spaces limit the degrees of freedom of all parties. If NASA can encourage a dialogue in which the "uneasy coexistence of different conceptions of natural vulnerability and societal fairness" are maintained, then it will be rewarded with a richer understanding of the heterogeneity of the protest (Thompson and Rayner 1998) and of the desire for space exploration.

Second, NASA might benefit from understanding some reactions to the world it is predicting for the future human colonists of the Solar System. To many people, the world described by NASA is bleak, cold, and threatening. Colonists on Mars will live their lives in a totally technologically dominant world, where the simple enjoyment of taking a walk will be risky in the extreme. There will be no Luddites on Mars, because to reject technology in the Martian environment is to choose suicide. Citizens today grapple with the possibilities of global warming, and increasing social and environmental impacts of complex technological systems. Should any organization assume blindly that technology is the fix to social problems and that new technologies are always desirable? NASA should examine social reaction to long term and complete reliance on nuclear technologies. NASA should be aware that technological systems have unpredicted social affects, and social systems have unpredicted technological effects (Sarewitz 1996; page 9):

> "The value of science and technology is created at the interface between science and society…
> When a new product emerges from the lab, it undergoes a profound transition—from well-behaved,

> insular idea or object to a dynamic component of a complex interactive social system… An idea or a product in the lab often evolves rapidly into something entirely different once it moves into society. But society, too, will undergo change as it responds to and absorbs the knowledge and innovation transmitted from the lab."

However, must the future lives of Martian colonists be dominated by the risks and dangers of nuclear technologies; or conversely, will their existence be empowered and enriched through the use of nuclear technologies? The ability to place a reliance on nuclear technologies within a current, risk society world view will be an important pursuit for NASA.

NASA (or an external agency like the National Science Foundation or the National Research Council) could undertake a study to examine the social contexts and values embodied within the Cassini protest, at the same time as it examines the social contexts and values embodied within the pro-Mars exploration community. For example, an open-ended survey could be performed to discover the value systems in cultural context within the following communities:

- the membership of the STOP CASSINI! campaign
- the membership of the Mars Society
- the membership of the American Institute for Aeronautics and Astronautics (AIAA)
- and the Sierra Club (or other diffuse green society).

There are four perspectives represented by the above groups that could contribute to a rich understanding of U.S. value systems as they pertain to space exploration, the sociocultural dynamics inherent in those systems, and the possible ranges of response. The STOP CASSINI! members could show a range of values illustrated in this thesis; while the members of the Mars Society (5,000 members at last count) are strongly dedicated to getting to Mars as soon as possible and by whatever means necessary. The members of the AIAA embrace the aerospace professions (the received NASA point of

view, if you will); and the Sierra Club, also dominated by professionals in many different groups, could provide a diversity of perspective and opinion that could enrich the discourse. Of course, there are other methodological options, including a random sample of U.S. citizens. However, solidarity in groups refines and confirms opinions and perception of risk so that examining the range of perception and values of established groups (or cultures) would generate a better understanding of the groups as actors in the policy world (Thompson and Rayner 1998).

Such a study could allow NASA to understand its place in the social fabric of the United States. It could enable NASA to start a dialogue that would expose its internal assumption to derive more realistic goals. The study could also enable NASA to actively increase pro-space support while reducing technology concerns.

AFTERWORD

My perspective on what NASA ought to do is based, in part on who I am , on what I learned in doing this study, and on my personal goals.

I have worked for the space program for a significant part of my adult life. Much of my technical expertise is in the field of space human factors, and on cataloguing the risks to humans from exposure to microgravity. Technical risk assessment is a field that I understand – at least regarding human factors. In the last ten years, I have read with increasing frequency about proposed human missions to Mars, and was skeptical. I felt that Mars was too risky for the astronauts, and so considered a Mars mission out of

the question because of the programmatic risk to NASA should it lose an astronaut on that type of mission. In 1996, three events happened to cause me to examine my position:

- NASA announced that a Martian meteorite may have evidence of ancient fossilized pre-bacterial life, from Mars, exponentially multiplying the reasons to go there;
- I heard a talk by a Mars mission designer in which nuclear technologies were considered "on the shelf" and were built into his otherwise very rational mission design; and
- My daughter announced that she wanted to become an astronaut and go to Mars.

Today, in late 1999, the debate over whether or not the evidence in the meteorite signified life is still raging, and I do not care to speculate on what may resolve the controversy. I have had the chance to study several proposed Mars mission architectures and while they won't be easy on the humans, I do believe the trip may be survivable. However, the attitude that space nuclear reactors are "on the shelf" is still prevalent and still quite irritating in regard to the fact that there are no expected expenditures in the foreseeable future that would allow NASA to push the technology to the testing stage, and there are still laws in effect in the United States that strictly prohibit live tests of nuclear devices for propulsion. As for nuclear reactors for power generation on Mars, I believe that without significant social input and high public opinion for a Mars expedition, the designs will never get past the drawing stage.

I learned during this study that NASA's risk assessments are technically well done and that the blind spots are fixable. I learned a great deal about social protest and that social discourse is more critical to social goals than are technical analyses. But, most importantly, I have learned that other persons—of like background, education, tastes in music, and general political sympathies—do not share my passion for space, do not believe that we can successfully "conquer" space, and moreover do not believe that it

should be attempted because the money could be better spent curing other important social ills. These persons, in fact, are all around me, pay taxes, and read books. They are as ubiquitous as the person that believes in Star Wars (the nuclear war deterrent or the movie – take your pick).

How, in this age of litigation, AIDS, and trillion-dollar military budgets, do we rationalize a space program of basic research that does not have any application to bettering human life – much less a program that is nuclear-powered? I believe, like Sarewitz, that the rationalization will come when we more closely examine our social goals. Understanding social goals will allow space advocates like myself to couch our discourse in more socially acceptable terms—or to at least find a way to express clearly what is meant by the term "acceptable risk," to create stronger advocacy for the idea of space exploration, and to be honest, to create in other hearts that which has caught my daugther's passion: "to go to Mars and find out the questions." And, to be reflexive about it, maybe society's goals do not reflect mine, and such a study will show that the space program is a technologically driven dinosaur. However, I would much rather ask the hard question, than to not have it asked and the space program crash and burn in a storm of anti-nuclear protest that does not adequately reflect the will of the people.

"If we cease to explore, we cease to be human."
Sir Arthur C. Clarke,
in his address to the
United Nations Committee on the Peaceful Uses of Outer Space
July 23, 1999