U.S. Nuclear Power Plants as Terrorist Targets: Threat Perception and the Media

by

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Abstract

In recent history, nuclear engineers and the nuclear power industry have been primarily concerned with two things: safety and waste. In the past few years, a third concern has risen to join these two at the top: terrorism. This change occurred on September 11, 2001. Americans now realize that terrorists are willing and able to attack on their home soil and that terrorists have no qualms about attacking civilians.

This thesis examines in detail why people are especially afraid of nuclear power, from the standpoint of both safety and terrorist threats, more so than the other risks that we face everyday. This thesis then explores the role of the press in influencing and being influenced by public perception.

The conclusions of this thesis can be boiled down to these main points: (1) The public's fear of terrorism against a nuclear facility has the same roots as the fear caused by safety concerns over nuclear power, and the strongest of these roots is the association of all things "nuclear" with the threat of nuclear war. (2) Terrorism risk perception is largely influenced by proximity to a particular threat. That is, people see more risk in threats that are close to themselves or their loved ones. Likewise, authorities assume that the public perceives greater risk in their particular area of responsibility. (3) Since the purpose of terrorism is to incite terror, the public perception of nuclear power plants as tempting terrorist targets may be self-fulfilling. (4) Any public action by government or industry leads to increased media coverage, and any media coverage, positive or negative, increases public fear. Therefore, the nuclear establishment should take no action to lower terrorism risk with the hope that it will allay public concern. Instead, the establishment should take whatever reasonable actions it thinks will reduce the actual risk and make appropriate emergency response preparations, while avoiding additional media coverage.

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Chapter 1

Introduction

In recent history, nuclear engineers and the nuclear power industry have been primarily concerned with two things: safety and waste. The physics involved in releasing heat through nuclear fission are well established. The nuclear engineer's task is to design systems that control this process and convert the heat into usable electricity as safely as possible for those operating the plant, for the general population, and for the environment. In addition, the nuclear engineer endeavors to minimize the waste produced through this process and find reliable and economical methods for disposing of this waste.

In the past few years, a third concern has risen to join these two at the top: terrorism. Previously, we were concerned with mechanical failures, human error, and the effects of radiation and corrosion. Redundancy was built into any system to minimize damage in case of an accident. Now, we must also consider the dangers posed by intentional malicious acts. For example, we can design a containment system to limit radiation release in the event of a steam-line break, but can the containment withstand a commercial jet impact? We can design a pool to house spent fuel and carry away the decay heat, but will the cooling systems be adequate if an explosive is used to open a hole in the side of the pool? We can design a waste storage cask to withstand corrosion for a thousand years, but can the cask be protected from terrorists who want to combine the waste with conventional explosives to create a radiological dispersal device or 'dirty bomb'?

This change occurred on September 11, 2001. Americans now realize that terrorists are willing and able to attack on their home soil and that terrorists have no qualms about attacking civilians. Since the terrorists used methods that the public had not seriously considered previously (hijacking planes with box-cutters, using planes as kinetic missiles), the people of the United States initiated a nation-wide brainstorming session of what form the next attack could possibly take.

1.1 Statement of Problem

The September 11th attacks did not involve anything nuclear-related. No terrorist has yet succeeded in detonating a nuclear device or a 'dirty bomb.' However, at first glance, the fear of nuclear terrorism is intense in the American public perception. The risk of nuclear terrorism is always near the top of the list of possibilities for which we must plan. The government agencies responsible for nuclear energy, and the nuclear industry itself, have responded by beefing up security at nuclear plants and commissioning studies to demonstrate that the possible destruction in the event of an attack is not as great as the general public might fear.

Despite these efforts, the fear of nuclear terrorism persists unabated. What is the cause of this fear? What is the public's perception of the security changes that have been made? What more do they believe can be done? Should the government and the nuclear industry continue putting money into new efforts to assuage the public's fears, despite decreasing returns in actual security improvement? Or is it impossible to make people feel safe from nuclear terrorism, regardless of how much is spent?

This thesis explores this issue on two fronts: (1) by investigating the psychology behind the fear of nuclear power, the fear of terrorism, and their convergence; and (2) by documenting the public perception of nuclear terrorism as a threat through analysis of popular media sources, under the dual assumptions that the public is influenced by what it reads and that news editors print stories that the public wants to read.

Chapter 2

Perception of the Nuclear Terrorism Threat

It is obvious that the threat of nuclear terrorism exists, in that the probability of a terrorist using radiation to harm people or cause them fear is greater than zero. However, there is a difference between the actual risk of a terrorist threat (which cannot be precisely determined) and the risk as perceived by supposed targets and the people charged with protecting them. Since terrorism, by definition, is "the systematic use of intense fear...as a means of coercion"[8], the perceived risk can be just as effective as an actual attack in achieving a terrorist's goals.[1] Why does nuclear terrorism rank so high on the list of perceived risks? Why does this perception extend beyond nuclear weapons to commercial nuclear power plants? What is it about the

[1] At this point I should clarify some definitions for consistency's sake: A **threat** is any imaginable terrorist activity, whether vague (e.g. a suicide bombing of a military installation) or specific (e.g. stealing spent fuel rods from dry cask storage at the Maine Yankee nuclear power plant). A threat does not imply how likely a specific activity is or how much damage it could cause. A **probability** is the likelihood that a specific activity will occur in a period of time. The probability that there will be a terrorist attack at a particular mall in the next two months is very close to zero, while the probability that there will be some terrorist attack somewhere in the United States at any time in the future is very close to one. The **risk** of a particular activity combines the probability of occurrence with the probable damage caused, whether in human lives or property damage. A suicide bombing in a crowd could be relatively probable, but the risk to the average citizen would be low since the number of people killed would be relatively small; on the other hand, the probability of a terrorist successfully detonating a stolen hydrogen weapon on American soil may be low, but the risk would be greater since such an attack could kill thousands to millions of people, depending on where the bomb exploded.

word "nuclear" that inspires so much terror? These are the questions we will look at in this chapter.

2.1 Radiation Anxiety

Sigmund Freud defined anxiety as "something that rests upon helplessness and uncertainty, on the feeling that a threat cannot be escaped nor perhaps even comprehended before it is too late"[1, p.206]. This definition applies to public fear of radioactivity and nuclear power. The public's opinion of nuclear power is "that nuclear (and other) complex technology is unsafe, that expertise is inadequate, and that government and industry cannot be trusted to manage nuclear power safely"[9]. The inclusion of "other complex technology" in this assessment implies that the public's primary problem is the inability to understand the intricacies of a given technology. For example, we are not afraid of automobiles because we generally understand how they work and how things can go wrong. The logical conclusion is that educating people about nuclear power, the risks involved and the safety measures taken to minimize risks, should cause public anxiety to go away. However, the evidence does not back up this hypothesis:

> Nuclear experts often suggested that the antinuclear movement was based on ignorance of the facts, while the opponents too felt they would win support if only they could teach people the truth. Neither side was correct, for studies showed that the way people felt about nuclear power was mostly independent of how much they knew about it.[1, p.366]

So, there must be something more at work in the public mind that would lead to continued anxiety about radiation.

2.1.1 Risk Perception

The actual risk from a particular activity and the risk *perception* are not always the same. What is more, a relatively safe activity is not always preferred over an activity

with a greater perceived risk. The benefit of each activity also comes into play, so that people are constantly conducting spontaneous risk-benefit analyses for the activities in which they take part. For each activity, there is a perceived risk but there is also an *acceptable risk*. That is, the risk one would be willing to tolerate for a perceived benefit.[2]

Revealed Preference

So what is the acceptable risk of a given activity? One way of answering this question is to look at the *revealed preference*. This model borrows from the principles of free-market economics and is "based on the assumption that by trial and error society has arrived at an 'essentially optimum' balance between the risks and benefits associated with any activity"[4, p.128]. This method is "sensitive to the way in which measures of risk and benefit are computed from the historical data"[4, p.129], but it has revealed some important general trends:

> (1) The acceptability of risk is roughly proportional to the third power (cube) of the benefits; (2) the public seems willing to accept risks from voluntary activities roughly 1000 times greater than it would from involuntary activities that provide the same level of benefit; (3) the acceptable level of risk is inversely related to the number of persons exposed to that risk; and (4) the level of risk tolerated for voluntarily accepted hazards is quite similar to the level of risk from disease.[4, p.128]

This method is useful for showing what the acceptable risk of an activity has been in the past and might be in the future under similar circumstances. However, it implies a correlation between the perceived risk and the actual risk in that it "assumes that

[2]For instance, a child could eat the egg-salad sandwich packed in his school lunch box, but he would get much more pleasure from eating one of the chocolate chip cookies that the kid sitting next to him in the cafeteria has, even though he could get in trouble if he is caught stealing. If the neighbor is his friend who does not mind sharing, the risk is very low for the benefit of having the cookie. However, if the neighbor is the school bully, then getting caught may not be an acceptable risk, and the child may have to settle for the purely-nutritional benefit of eating the sandwich. This is a trivial example, but it portrays the principles of perceived risk, perceived benefit, and acceptable risk.

people not only have full information, but also can *use* that information optimally"[4, p.129].

The Psychometric Approach

Another method of determining acceptable risk is the *psychometric approach*, which looks at *expressed* preference rather than *revealed* preference:

> The psychometric approach to studying risk perception assumes that hazards can be characterized in terms of numerous characteristics or dimensions, analogous to the personality traits that characterize people.[9]

In other words, this method does not use any historical data directly, but instead asks people to give their estimation of risks, acceptable risks, and benefits of various activities. Each subject interviewed must use their own knowledge and perception when making these estimates. Risk perception is based on what individuals *believe* to be true as opposed to the actual facts. Fischhoff et al.[4] used psychometric methods with a group of seventy-six people in Oregon to rate thirty common activities and technologies. Table A.1 gives their results when the individuals were asked to rate the risk, the acceptable risk, and the benefit of each activity, with the numbers relative to each other (i.e. an activity with a perceived risk of 100 would be twice as risky as an activity with a perceived risk of 50.) Table A.2 gives the results when the subjects were asked to rate each activity on a scale of one to seven along nine different characteristics believed to influence risk perception. The characteristics are: voluntariness, immediacy of effect, knowledge about the risk to those exposed, knowledge about the risk to science, control over risk, newness versus familiarity, chronic risk versus catastrophic risk, common versus dread ("is this a risk that people have learned to live with and can think about reasonably and calmly, or is it one that people have great dread for, on the level of a gut reaction?"[4, p.133]), and severity of consequences (non-fatal versus fatal). Another study asked a similar pool of people to simply rank thirty activities in order of riskiness, and then compared that to the risk-rankings of a group of fifteen experts who use risk assessment professionally.

Table A.3 gives their rankings[5, p.191]. This study also asked the non-expert subjects to estimate the number of people killed annually by each of the thirty activities, both for an average year and for a particularly disastrous year. Table A.4 gives the results from that study, as well as actual fatality estimates gathered from statistical data for comparison[5, 6].

Nuclear power has the greatest perceived risk, greater even than automobiles, smoking, and handguns.[3] Also, the perceived benefit from nuclear power is about a fifth of the benefit from electric power in general. The subjects must have seen nuclear power as an unnecessary addition to the nation's electricity supply. Nuclear power provides about 20% of the electricity in the United States. The only larger source is coal, which provides about 50%. To say that nuclear power is unnecessary is to say that other energy sources could take its place and could be expanded to meet the increasing energy demand. Therefore, the subjects must have the opinion that nuclear power is not needed and is more risky than other methods of producing electricity. People normally fear two primary things about nuclear power: environmental contamination by the waste and catastrophic accidents at a power plant. While radioactive waste is carefully stored and protected, coal smoke, which is itself toxic, is released into the environment along with the many other toxic chemicals it contains, such as arsenic, lead, mercury, and even uranium. Not only is the smoke dangerous directly[4], but it can form crop-damaging and building-eroding acid rain. Just the mining of coal causes dozens of deaths and extensive environmental damage each year. So while people fear the *threat* of the worst case scenarios of nuclear power, other sources of electricity are continuously doing actual significant harm. Alternative, "environmentally safe" methods of electricity production are nice in theory, but until the technology exists to utilize them efficiently on a large scale, we will continue to rely almost entirely on fossil fuels, nuclear, and hydroelectric power. The point is

[3]Note that all of the studies cited in this section were performed before the incident at Three Mile Island in March of 1979. Such a well-publicized nuclear accident would surely have skewed the results even *more* against nuclear power, so these results, informative as they are, are still quite conservative

[4]In 1952, weather conditions allowed a smog of coal smoke to settle and persist over London for a week, killing around 4,000 people[1, p.333]. However, most of the people that die in such situations are the sick and elderly, those who are at higher risk of death in general.

that people expect the lights to come on when they flip the switch, and if the power does not come from nuclear energy it probably comes from burning fossil fuels, an activity that carries its own significant risks.

In addition, while nuclear power has the largest perceived risk, it also has the lowest level of acceptable risk. This means that, even if nuclear power were perceived to be a lot safer, it still would not be safe *enough* unless it became less risky than using home appliances, in the opinion of the study's subjects.

The results from the "characteristic" portion of the study are also revealing. Nuclear power scores the most extreme ratings for many of the categories. The risk from nuclear power is seen as the most involuntary, the most unknown to both the public and to science, the least controllable, and with the most delayed effects. It is also seen as the newest risk, the most catastrophic, the most linked to a gut feeling of dread, and the most likely to be fatal. The study found that only the characteristics of dread and severity correlated directly with the perceived risk, but when compared with acceptable risk, these correlations dropped away. Acceptable risk was instead correlated with the first six characteristics. This means that when a risk is deemed "acceptable" it causes little gut reaction of dread and its consequences are less likely to be fatal. Instead, "for any given level of benefit, greater risk was tolerated if that risk was voluntary, immediate, known precisely, controllable, and familiar"[4, p.143].

As noted in the rankings in Table A.3, non-experts rank nuclear power as the number one greatest risk. The experts rank it twentieth, well below such things as x-rays and non-nuclear electric power. Over-all, the experts' rankings correlate much more closely to the actual fatality estimates as shown in Table A.4. On the other hand, the non-experts' rankings correlate more to their estimates of the fatalities in a particularly disastrous year. This is perhaps the most important result from all the studies cited above. It indicates that the public realizes that nuclear power, for the most part, operates safely and that they are not particularly worried about nuclear power plants slowly poisoning their air or water supply under standard operating conditions. The high perceived risk is due to the possibility of large, catastrophic

accidents with widespread consequences.[5] In addition, Slovic et al. remind us that however much we focus on risk perception in the debate over nuclear power, we must remember that the issue lies in a "larger political context":

> While some nuclear opponents are motivated primarily by fears of routine or catastrophic radiation releases, others join the movement because they are disenchanted with growth, centralization, corporate dominance, technology, or government and its institutions. The latter individuals may argue questions of safety because they view the hazardousness of nuclear power as its "Achilles Heel".[6, p.229]

2.2 Radiation Imagery

The previous section identified several factors that set nuclear power (and radiation in general) apart in terms of risk perception: involuntary risks, unknowable and uncontrollable hazards, the menace of catastrophic and far-reaching threats, all adding up to a visceral, gut-reaction feeling of dread. But where does this dread come from? Is it based on the scientific and technical aspects of nuclear energy, or is it more primitive? In his book *Nuclear Fear*[1], Spencer Weart makes the argument that many of the images associated with nuclear technology represent ideas that have been present in society's consciousness for thousands of years, but which reach their fullest incarnation in the reality of nuclear energy.

2.2.1 Rays

In a previous section, the concept of anxiety was discussed. Radiation is not solely to blame for all of the anxiety in the world. People have anxiety about all kinds of things all the time. Several phenomena historically have caused anxiety in the same manner as radiation, although the anxiety may have eased as the they became

[5]See Appendix B.1.1 for an excerpt from Spencer Weart's book *Nuclear Fear* which in my opinion is a very succinct and eloquent explanation of the reality of the risks of a catastrophic accident at a nuclear power plant.

better understood and people felt that they were somewhat 'under control.' These include lightning and other weather events, disease, and electricity. These phenomena have many things in common that caused anxiety, namely the perception that they can kill from a distance unexpectedly, with the mechanisms of damage unknown, making it difficult to protect oneself. People often attributed such phenomena to malicious gods, such as Zeus hurling down his lightning bolts and the God of Israel striking the Egyptians with plagues. As science has come to understand many of these phenomena, we have developed methods for controlling them and minimizing the risk. Yet, they can still cause a feeling of dread when experienced by an individual.

Ancient and medieval people associated such phenomena with mystical rays that could bring both life and death. The initial association came from the fact that sunlight is a necessary ingredient of plant growth, so people saw the rays of sunlight as bringing some sort of magical life force. They pictured benevolent gods sending rays to heal the sick, aid fertility, and cause crops to grow. Vengeful witch doctors could strike someone with disease from a distance or call down lightning to hurt them or rays to kill their crops. Originally, electricity was seen as another mystical ray that could bring life and death. It is easy to think of examples, such as Doctor Frankenstein using electricity to bring his pieced-together creation to life.

It was inevitable that radiation would become tied in with this historical context of images. It is a phenomenon that can in fact travel invisibly and cause effects at a distance. It can heal people; radiation cannot of course bring someone who is dead back to life, but doctors around the time of the discovery of radiation noted the therapeutic properties of x-rays and radium. We continue today to develop medical treatments based around radiation, especially cancer treatments. Early researchers quickly discovered that radiation could also do harm, that it could cause acute burns, radiation sickness, sterility, and even death. The point is that the public did not have to be told of these effects to imagine their existence. As soon as they were made aware that such a thing as radiation had been discovered, they immediately associated it with the ancient images of rays[1, Ch.3].

2.2.2 The "Legend"

As radiation and nuclear energy developed beyond curiosity to a phenomenon that held large-scale possibilities, the association with the ancient images of rays grew with it. As with other rays, it was often seen as a god-like power. As with all god-like powers it was seen by some as an ancient and forbidden secret that man was not meant to uncover, a kind of Pandora's Box. People began associating old stories of mad scientists experimenting with electricity and transmutation to nuclear energy. These 'legends' typically involve a wizard or 'mad scientist' probing forbidden secrets for the betterment of humanity. When things go out of control, as they always do, supreme destruction is released upon the world and few survivors are left to pick up the pieces and rebuild society.[6] This is the ancient imagery of the phoenix: horrible, violent death out of which comes renewal and rebirth[1].

2.2.3 Nuclear Energy—Two Paths

Although these legends of 'white cities' and apocalypse are ancient, in the discovery of nuclear fission they actually reach the realm of scientific plausibility.

There have always been stories and myths of some sort of civilization-ending destruction to come in the future, often with the idea that the 'wicked' would be destroyed while the 'righteous' would survive to rebuild society. Yet, mankind never possessed the means to produce such global effects. The closest thing in terms of widespread death and destruction were diseases and plagues, which definitely had their share of stories but were far from the immense battles and fiery devastation envisioned by many religious traditions. When the first atomic weapons exploded over Hiroshima and Nagasaki in August of 1945, humanity had its first glimpse of what such a world-ending battle could look like. In the hydrogen bombs, missiles, and huge nuclear stockpiles of the Cold War, the power to actually cause such total annihilation for the first time rested in the hands of man[1].

However, as described above in the 'legend,' there are usually two paths, one

[6]See Appendix B.1.2 where another excerpt from *Nuclear Fear* tells the legend in a version that contains a more complete fusion of the main elements of such stories

toward destruction but another in the direction of a glorious future society. Supporters of nuclear power used ancient imagery as much as their opponents did, describing the wonders that would be made possible by harnessing nuclear energy: if people would put all their trust and faith into nuclear power, there would be an unlimited supply of cheap, clean energy, making hard work a thing of the past as humanity entered a golden age of leisure and progress, along with a new renaissance of art and culture. While rarely stated so explicitly, nuclear advocates invoked images that resonated with ancient ideas of paradise and nirvana.

2.2.4 Displacement

Nuclear experts are always careful to separate these two aspects of nuclear power: the military versus the civilian, weapons of war versus instruments of growth and progress. These really are two separate fields, involving different properties of the materials and distinct engineering problems. It is impossible to make a nuclear reactor explode like an atomic bomb. It is just as difficult to turn a nuclear weapon into a steady source of electricity production. To the public, influenced by the thousands of years of imagery, these distinctions do not matter. These may be separate aspects, but they are two sides of the same coin: a dangerous technology that can be used either for enormous benefit or horrific evil. This is where these images have the most impact on the public's risk perception:

> Fear and hostility had been displaced from weapons onto civilian nuclear power. All the elements for classic displacement were indeed present. There was a persistent anxiety about nuclear war. There was an inability to dispel the anxiety in the only genuine way, by getting rid of bombs. Finally, there was a target toward which the frustrated feelings could redirect themselves, and all the more easily because of the many associations between bombs and reactors. If you had spent your life in a room with a grimacing Russian who kept a flamethrower pointed at your head, you might well feel upset when somebody struck a match.[1, p.322-3]

2.3 Trustworthiness of the Nuclear Industry

Looking beyond the symbolism of radiation and nuclear power and the feelings of anxiety that such things evoke from thousands of years of history and imagery, it can be said that another issue that society has with the nuclear industry is largely a lack of trust. The effect of distrust on risk perception is that it causes a person to believe that the actual risk is greater than the reported risk, if the source of the report is an untrustworthy authority figure.

2.3.1 Confirmability and Disconfirmability of Traits

Every person or group that we encounter in our lives has some traits assigned to them in our minds. When we see a friend walking down the street, we do not just see a body; we see someone who is dependable, temperamental, talkative, etc. If we were to define what it means to be one of these traits, then each person or group would either have that trait or not have it. However, as with nuclear terrorist risks, there is a difference between reality and our perception of reality. We use an analytical process to assign traits based on specific evidence. While a person's traits may not change over time, our perception of their traits may change because the evidence is not definitive, and we respond to evidence in different ways.[7]

Evidence takes two forms: actions that confirm a specific trait or actions that disconfirm a trait (or confirm an opposing trait). For example, if we see a friend not doing his homework when we know he should, we would take that as evidence that he *is* lazy or as evidence that he *is not* hardworking. Now, if we know that our friend is lazy, but we see him doing his homework one time, will that change our perception of him to hardworking? Or do we perceive this as just an exception to his normal trait? There are three measures to consider when determining how easy or difficult it is to change perception of a trait:

Frequency of confirming and disconfirming behaviors For example, we may

[7]This subsection is largely drawn from Rothbart and Park, "On the Confirmability and Disconfirmability of Trait Concepts"; see [7].

wish to find out whether someone is brave or cowardly. However, in this day and age when we are not confronted with life-threatening situations on a daily basis, there are few opportunities for behaviors that could confirm or disconfirm these traits. Therefore, if we once determine someone to be cowardly, there is small chance for this perception to change.

Imaginability of confirming and disconfirming behaviors Again, using the lazy versus hardworking example, it is easy to imagine behaviors that could confirm each, and it is easy to attribute each trait to specific actions, functionally increasing the frequency of relevant behavior.

Number of instances required to confirm or disconfirm a trait Some traits become ingrained in our perception more deeply than others, and therefore require more evidence to change. As stated above regarding laziness, it may take quite a few instances of seeing our friend being hardworking for us to change our mind about which trait he possesses.

To expound on this idea of the perception of different traits becoming ingrained more deeply, we can define three different implication structures between behaviors and traits[8] (that is, the evidence-to-inference relationship):

Fully restrictive This means that opposing traits are mutually exclusive; that is, our perception does not allow for a person possessing one trait to exhibit behaviors of the opposing trait. An example is again brave versus cowardly. When brave behavior is perceived, we say that person is brave; if he then acts cowardly, we say he is a coward. We allow that our perception of this trait can change, but not that he is still brave while acting cowardly or still cowardly while acting brave. Therefore, very little evidence is required to change trait perception.

[8]When I talk about a person or group having a specific trait, I am not talking in absolutes. Each trait pair defines a spectrum of behavior, e.g. very brave, somewhat brave, neither brave nor cowardly, somewhat cowardly, very cowardly.

Partially restrictive This structure allows for the possibility of opposing behavior while maintaining a certain trait. For example, if we think of a friend as messy, we know that he will sometimes be neat, and if he is neat he can still sometimes be messy. Therefore, a lot of evidence is required to change trait perception.

Hierarchically restrictive This is perhaps the most interesting structure. As described so eloquently by Rothbart and Park:

> The hierarchically restrictive structure implies a fundamental asymmetry such that individuals at one dispositional extreme are associated with a wider range of behaviors than individuals at the other extreme. For example, honest individuals are seen as engaging in honest behaviors almost exclusively, whereas dishonest individuals would be capable of engaging in both dishonest and honest behaviors. It follows, then, that observing a dishonest behavior allows for a dispositional attribution of "dishonest," whereas the observation of an honest behavior is less informative as to the corresponding dispositional inference.[7, p.131]

This structure is most relevant because this is the structure that applies to the trait examined in this report: trustworthiness. Just a few instances of being untrustworthy are enough to brand a person or group as such, while it may take a very long period of trustworthy behavior to regain the lost trust. Rothbart and Park note that in their results almost all of the traits that require little evidence to confirm and a lot of evidence to disconfirm are negative, leading them to this conclusion:

> We bias our decision criterion for ascribing traits in a way that minimizes loss rather than maximizes gain. That is, we have a lower threshold for deciding that someone is insulting than for deciding that they are courteous.[7, p.138]

Accordingly, a person or group seen as untrustworthy has great difficulty changing that perception.

This analysis has implications for stereotypes and other social beliefs. If a group is labeled incorrectly with a specific trait, there are several requirements for the trait to be disconfirmed for each perceiver. First, the perceiver must have some contact with a member of the group. That is, they must have some way of collecting behavioral evidence. If there is no contact, then the trait will remain as long as the social consensus persists. If there is contact, then the above criteria apply (the frequency of disconfirming behavior, the imaginability of such behaviors, etc.).

Table A.5 is an extensive list of traits with scores for ease of imagining confirming and disconfirming behaviors, the frequency of confirming and disconfirming behaviors, number of instances to confirm and disconfirm, and general favorability of the trait. Several traits particularly relevant to trustworthiness are highlighted. The scores are relative and centered on zero: a score of zero is neutral; the more negative a score, the fewer instances required to confirm or disconfirm and the less favorable; the more positive a score, the more instances required to confirm or disconfirm and the more favorable. Traits with a "favorable" rating require many instances to confirm and few to disconfirm, and vice-versa for "unfavorable" traits.

2.3.2 Distrust of Big Business

Of course, some of the public distrust of the nuclear industry is completely unrelated to nuclear power and radiation. The public is distrustful of big business in general. This distrust of business is due to evidence that profit is often more important than safety or ethics.

This does not mean that this is characteristic of most people involved in business. As discussed in the previous section, trust is a trait that is easily lost but very, very difficult to regain. While most businesses may operate safely and ethically most of the time, it only takes a couple of specific instances of evidence to the contrary to give big business the label "unethical" and "untrustworthy" for a long time. There have been several instances of this in the history of business that have made the public distrustful, a couple of notable examples of which follow:

- The filthy working conditions of the food processing and meat packing industries of the early-20th century inspired activists such as Upton Sinclair to expose the squalor. His book, "The Jungle" (published in 1906), appalled readers and helped pave the way for passage of the Pure Food & Drug and Meat Inspection Acts. When Teddy Roosevelt read the book, he agreed that "radical action must be taken to do away with the efforts of arrogant and selfish greed on the part of the capitalist"[10].

- The tobacco industry gained similar notoriety in the middle of the 20th century when scientists began noticing a statistical correlation between smoking and adverse health affects. The public became widely aware of the problem from the article "Cancer By the Carton," published in *Reader's Digest* in 1952. Although the industry fought back with studies of its own, the government responded with the Surgeon General's Advisory Committee on Smoking and Health report in 1964 and the Federal Cigarette Labeling and Advertising Act in 1965, which put the now familiar 'Surgeon General's Warning' on cigarette packaging[11].

- The 21st century began with more evidence of unethical behavior on the part of big business. Most of this revolved around exposure of deceptive accounting practices in some of the largest firms in the nation, such as the energy and communications conglomerate Enron and the telecommunications giant World-Com. While the first two items above involved threats to people's health and safety, the recent scandals have threatened people's investments and retirement accounts, yet have caused the same visceral reactions and resulting distrust.

2.3.3 The Nuclear Industry

The nuclear industry is different when compared to these other examples of distrust in big business. While these other scandals were instigated by disclosure of actual harmful behavior (i.e. unsanitary food processing, previously unstudied health effects, unethical accounting practices), distrust in the nuclear industry is largely based on the *perception* of risk and the *threat* of harmful behavior.

One of the problems the nuclear industry faces is that it is difficult to imagine specific instances of acting trustworthy. Trustworthiness is a trait that is usually defined as being *not un*-trustworthy. For the nuclear industry, trustworthy behavior can be imagined only as an accident *not* occurring. Therefore, evidence of trustworthiness is not a collection of specific instances but a period of time of accident-free operation. On the other hand, it is easy for the public to imagine instances of untrustworthy behavior, the most obvious example being an accident at a commercial reactor, throwing distrust on an industry that had claimed to be 'safe.'

Here is the evidence of safety and trustworthiness of the United States nuclear power industry:

- Through 2003, commercial power plants in the U.S. had accumulated 2,745 reactor-years of operating experience.[12]

- In the United States, "no nuclear workers or members of the public have ever died as a result of exposure to radiation due to a commercial nuclear reactor incident."[13]

However, the evidence of unsafe and untrustworthy behavior has often overshadowed this in public perception. This evidence is rarely directly related to the commercial nuclear power industry, yet as discussed above they are linked by the common bond of radioactivity. Some examples are listed here:

- Starting in World War I, a compound containing radium was painted onto dials to make them glow in the dark. The women who did the painting were told to "point" the brushes with their lips, causing them to ingest significant quantities of radium. Many developed serious radioactivity-related health problems, which the industry attempted to cover up. This was one of the first examples of the dangers of radiation becoming widely known to the public.[14]

- Fallout from nuclear weapons testing became a target of nuclear fear beginning in the 1950s. The public saw the government and the Atomic Energy Commission as untrustworthy when it tried to downplay the existence or scope of fallout, even though the risk to the average American was negligible.

2.4 Terrorism

Just from the discrepancies between public perceptions of risk and the opinion of risk-analysis experts (from Tables A.3 and A.4), it is clear that nuclear power is perceived as a greater risk than it actually is. We have explored thoroughly the reasons that this is the case with both psychological and historical explanations as well as technical reasoning. But this report is on nuclear terrorism; specifically, the fear of an attack against a civilian nuclear facility: Why is the idea of nuclear terrorism so strong compared to other terrorist threats? Why is the need to protect our nation's nuclear power plants always among the primary concerns? Is it actually among our primary concerns, or is that idea in itself a misperception held by the nuclear establishment?

2.4.1 Changing Assumptions

Nuclear terrorism was always considered a possibility as far back as the 1950s and 1960s, when pulp novels and James Bond movies showed evil villains (the "mad scientists" discussed above) using nuclear weapons to hold entire countries hostage. Experts were unwilling to say the idea was completely implausible because the consequences of a nuclear terrorist attack would be so grave. But governments did not consider the idea credible, as shown by the former lack of in-depth analysis of the problem, of contingency plans to counter a threat, or of detailed emergency response plans if such an attack occurred. The following quotation from 1996 reflects the conventional wisdom that persisted through the 1990s:

> ...No terrorist acts have been committed on a scale of truly indiscriminate mass murder—which, given the vulnerability of modern industrial societies, terrorists could achieve or try to achieve without nuclear weapons. (The poisoning of a big-city water supply with chemical agents is often cited as a potential terrorist act of such magnitude.)
>
> Why hasn't such an incident occurred? One explanation is that the terrorists' main objective is to attract as much attention as possible, not to create as many victims as possible. As Brian Jenkins noted in the

> Autumn 1985 issue of *Orbis*, "Terrorists want a lot of people *watching*, not a lot of people *dead*." [15]

This all changed on September 11th, 2001. The following statement from a scientist involved in non-proliferation work is characteristic of the new mindset:

> In the past, our main concern was that rogue nations or terrorist groups would develop nuclear weapons and that, by threatening to use those weapons, they would secure for themselves political and economic advantages that could drastically alter the world balance of power. September 11 changed this view of the threat facing us. Today we know that if a nuclear weapon were to fall in the hands of those who organized the September 11 attacks, there would be no threats and no negotiations. Millions of innocent victims would die in a flash, without warning, killed by people driven by a twisted ideology and devoid of any respect for human life, including their own.[16]

September 11th did not change that of which the terrorists are capable, but it changed the *perception* of their capabilities. Before, the reaction to the threat of nuclear terrorism could be somewhat passive: waiting for specific threats to emerge, waiting for a terrorist group to claim that they possess a nuclear weapon and make demands. Now, the perception is that the threat of nuclear terrorism must be confronted actively, with threats neutralized before they mature. Otherwise, we will get no warning before an attack. In October of 2002, when he was making the case for war against Iraq, President Bush explicitly articulated this (arguably inaccurate) perception:

> We have experienced the horror of September 11. We have seen that those who hate America are willing to crash airplanes into buildings full of innocent people. Our enemies would be no less willing—in fact they would be eager—to use a biological, or a chemical, or a nuclear weapon. Knowing these realities, America must not ignore the threat gathering against us. Facing clear evidence of peril, we cannot wait for the final

proof—the smoking gun—that could come in the form of a mushroom cloud.[17]

2.4.2 The Response

Counterterrorism tactics traditionally have been similar to established military strategy. When preparing for war, a combatant performs *target assessment* in which the enemy's assets are prioritized to determine which are the most strategically important for various goals and which are the most vulnerable to attack[18]. In addition, wise strategists would perform target assessments on their own assets to determine how defenses should be arrayed to minimize loss. These analyses reached their peak in the thermonuclear war and deterrence debates of the Cold War[1, p.231].

Counterterrorist experts do similar reverse target assessments, the logic being that "by identifying potentially attractive targets ahead of time, we are able to anticipate many of the major incident management problems which are unique to a particular target. Thus, we are able to determine in advance many of the response alternatives we will have if the attack takes place"[19]. This is a great idea in theory, but the problem is that reverse target assessments are based on an expert's perception of a terrorist's perception of a target's value, an analysis that is somewhat simpler for military targets in wartime. Nonetheless, it is clearly useful for certain high-priority, high-visibility targets, such as the Olympics, the Super Bowl, or a presidential appearance.

But where do nuclear power plants fall in these rankings? What are the criteria used to prioritize terrorist targets? These are questions that will be fleshed out as the field of terrorism risk assessment develops. Right now, the solution seems to be to focus all the attention on whatever is the hot topic of the moment, whether it be financial institutions in New York City or the national party conventions. In between such 'crises,' the government agencies try to maintain security in their specific spheres of influence: the Transportation Security Administration (TSA) over airport security, U.S. Customs and Border Protection (CBP) over the nation's borders and ports, U.S. Citizenship and Immigration Services (USCIS, formerly the INS) over entry of foreign

nationals, etc. Many such agencies have been gathered under the 'umbrella' of the new Department of Homeland Security (DHS) in order to facilitate communication and cooperation.

The U.S. Nuclear Regulatory Commission (NRC) is charged with licensing and regulating America's civilian nuclear facilities "to protect public health and safety, the environment, and the common defense and security"[20]. The NRC uses the idea of design basis threats (DBTs) to convey to licensees what level of physical security is required at each facility.[21] The DBT is the maximum threat which should be thwarted by plant security, and it is kept confidential for obvious reasons.

Since September 11th, the NRC has taken steps to increase security at licensed facilities. These measures were summarized in a report released in September of 2004 called, grandly enough, *Protecting Our Nation*:

> These actions include significant reinforcement of the defense capabilities for nuclear facilities, better control of sensitive information, and enhancements to security preparedness to further strengthen NRC's nuclear facility security programs.[22]

As with most counterterrorism efforts, the NRC measures focus on deterrence and emergency planning: deterrence by *target hardening* nuclear facilities, which is increasing defenses and defensive procedures to make the target less attractive and therefore stifling a potential attack before it occurs, and emergency preparedness by establishing communication paths with various government agencies at the local, state, and federal level, and establishing procedures to prepare for the consequences of an attack. In my opinion, deterrence is the more important of the objectives, since the consequences of an attack on a nuclear facility are not likely to be great in terms of death and destruction, due to the security measures in place, the robustness of the physical structures, and the complexity of the systems that must be disabled or bypassed to bring about significant radiation release to the environment. However, even an unsuccessful attack would do extensive damage to the public psyche and confidence. I draw this conclusion from a comparison in the industrial accident

realm: there was extensive public protest as a result of the nuclear "disaster" at Three Mile Island which destroyed the reactor but resulted in no documented deaths, while more common industrial accidents such as dam failures which actually kill a relatively large number of people cause no corresponding outcry. A terrorist attack on a nuclear power plant would at least cause significant economic damage, even if unsuccessful.[1, 23] However, target hardening has the side-effect of shifting the risk to more vulnerable targets. The conventional wisdom follows:

> As with burglar alarms, self-protection carries the unwitting externality of shifting criminal risk to one's neighbors. From a U.S. insurer's perspective, this is manifested in increased risk outside the government sector.[24]

2.4.3 Terror Perception

Why is nuclear terror so, well, terrifying? There have not been many psychometric studies done regarding terrorism risk perception as compared to other common risks, as there have been for nuclear power as cited in the studies above. There have been numerous polls taken which judge risk perception in a very vague manner, for example, "How worried are you that there will soon be another terrorist attack in the United States?"[25]; however, the results from such polls are still changing drastically as the memory of September 11th grows more distant and other issues take center stage. As the quotation that ends the previous section indicates, the most quantitative and realistic data on the risk of terrorism will probably be compiled and analyzed by insurance companies charged with underwriting the financial loss due to catastrophic, low-probability events.

Many studies conducted after September 11th on general terrorism risk perception looked at differences in perceived risk among different groups of people; for instance, terrorism risk perception for men versus women[26], for liberals versus conservatives and ethnicity[27], and in relation to distance from the site of the attacks[28]. These studies did not look at nuclear terrorism in particular, but they still have some revealing results. After finding that some groups were affected by distance while others

were not, Fischhoff et al. speculate that "members of the distance-sensitive groups might have greater feelings of personal control or trust in the social institutions managing risks"[28]. The study, which examines willingness to give up civil liberties for increased security (to some extent, a means of measuring acceptable risk), also acknowledges the importance of trust:

> Our account of the underlying reasons why citizens are willing to trade off certain civil liberties for greater security is complex. Threat and trust do not uniformly lead to favoring one set of values over another, but instead they interact with one another to determine the support for civil liberties over security. The effect of trust in the federal government on support for civil liberties is conditioned by a sense of sociotropic threat—concern that the country will come under another terrorist attack—as well as personal threat. However, at every level of trust in the federal government, increased sense of threat leads to a greater willingness to concede some civil liberties in favor of security and order.[27]

2.4.4 Nuclear Terror – Conclusion

From the analyses cited above, the reasons why a terrorist attack against a nuclear power plant is prominent as a threat in the public consciousness are the same reasons why nuclear power is perceived to be so risky from a safety standpoint. These reasons include the following:

- The unique nature of radiation, which invokes ancient imagery of godlike powers to bring life or death from a great distance;
- The resemblance between the 'mad scientists' of legend with current perceptions of terrorists as those who wish to bring about a new, better world by unleashing forces beyond their control to destroy the present one;
- The shortage of trust in governmental and business institutions to be both ethical and competent in their actions to protect the public;

- The perception that a nuclear threat is involuntary since it concerns forces not only beyond the control of the individual but beyond the control even of government or science, with potentially catastrophic consequences; and finally,

- The mental associations of military with civilian uses of nuclear energy (as people associate the risks of nuclear power with the risks from nuclear war, so people associate the threat of terrorism against nuclear power plants with other nuclear terror threats, namely exploding a nuclear weapon or a 'dirty bomb').

However, these questions of where risk perception comes from may be moot, in that perception of a terrorist risk may be self-fulfilling: the very basic purpose of terrorism is to provoke *terror*, which might be accomplished more effectively by striking at the greatest *perceived* risk as opposed to the target which would actually cause the most destruction. An attack on a nuclear power plant would undoubtedly prompt substantially more terror than an attack on a conventional facility which caused similar levels of destruction. Perception and imagery (the very reasons the terrorists on September 11th chose to strike the World Trade Center and the Pentagon) are central.

On a similar note, it is interesting to consider that some issues which might be tipping the scales of public perception back in favor of nuclear power are other concerns which may also be linked, at least to some extent, to irrational fears. An example of this is our current dependence on foreign (largely Middle Eastern) oil, and the idea of being held hostage by foreign governments who disagree with our policies. Another example is global warming, a phenomenon which has only recently gained scientific credibility. While the relationship (if any) between human action and global temperature change is still being argued, the public is already bombarded with images of melting ice caps and civilization-ending floods. Again, perception and imagery are central.

Chapter 3

The Media

The media affects public perception about the risks involved with various technologies. When people have extensive personal experience with a technology, the media's impact is small. However, "where very limited personal experience is available, the reporting of the media has a large influence on the perception of that technology and the risk"[29]. In this chapter, I will explore the media's role in shaping perception, including some input from current and former members of the media in how they see their own roles. Then, I will take a more quantitative approach in looking at how the media reflects public perception by looking at the ratio of topics reported in several popular publications.

3.1 Media and Perception

As stated above, the media's influence is greatest where other sources of information, especially personal experience, are lacking. This is similar to the tendency in trait perception discussed in the previous chapter; if there is limited opportunity for evidence-gathering on an individual level, then the individual's beliefs will remain largely dependent on social consensus. The media become the chief source for information on social consensus beyond an individual's personal experience.

Media and Imagery

The media, therefore, have two primary roles: reporting new information and communicating social consensus. A reporter has to write for his audience. That is, he has to shape his report in a manner that is understandable by those he expects to be receiving the information. When reporting on technological issues, this sometimes causes a reporter to bring in images that have additional, unintended connotations. For instance, soon after the discovery of radium, a well-known scientist was describing the amount of energy in radium, but his statements were interpreted by the press on the way to the public:

> Any physics teacher, asked to illustrate a quantity of energy, would be inclined to talk about lifting a weight. [Sir William] Crookes chose to lift the British Navy. The energy locked within one gram of radium, he calculated, could hoist the entire fleet several thousand feet into the air. The idea developed in a revealing way. From Crookes's scientific discourse the newspapers picked up the naval example as the stuff of headlines, adding helpful engravings of a cluster of battleships suspended in midair. The public quickly caught the image's latent meaning... that a gram of radium could "blow the British Navy sky high."[1, p.25]

So, even though the scientist intended to simply relate technical information, the media were already invoking images of radiation as a weapon.

Costs & Benefits

When reporting on technological issues, there are two categories of information that the media can present: the need that a new technology is attempting to meet, its benefit, and the risks involved with the new technology, its costs. The previous chapter has already gone into detail on costs and benefits and the resulting acceptable risk. However, which of these two aspects, the costs or the benefits, the media emphasize has a direct impact on public perception and therefore the acceptable risk. For instance, Germany has become an especially environmentally-conscious nation in the

last part of the twentieth century, as demonstrated by the influence of the minority Green Party. This has had an effect on the media's reporting:

> We can observe during this time that aspects of the benefits of technology are much less reported in the media, that most reporting by the media now is related to the consequences of technologies, such as negative environmental consequences. That development has led to a general opposition against new technological projects, in particular unusual and large. That trend is related not only to nuclear power, we see it also for new airports, trains, coal-fired plants. There is almost no new technological project in Germany where there is not very strong opposition against it.[29]

On the other hand, Japan is almost entirely dependent on foreign imports for its energy production. Because of their desire for self-sufficiency, "many people feel the need to increase their dependence on 'technology-intensive energy,' making full use of new energy technology, with nuclear power as one of the most important options"[30]. They still distrust their government and industry, and are fearful of radiation (perhaps more so than most, because of the lingering effects of the bombings of Hiroshima and Nagasaki). However, because of their limited natural resources, the Japanese people are forced to overcome these sentiments and focus more on the benefits of nuclear power than on the potential costs.

The United States lies between these two extremes. Many believe that we should reduce dependence on foreign oil, but this is more a desire than a need. As long as the need is not present, the media will continue to focus more on the costs than the benefits, influencing the very low acceptable risk numbers described in the previous chapter. Conventional wisdom is such:

> The U.S. has enough fossil fuels to take us through 2030 with ease. Coal supplies are sufficient to last far longer than that. Improved designs of fossil plants will allow substantial mitigation of acid rain and related artifacts without major cost penalty. The U.S. will not respond to global CO_2 considerations because exogenous sources such as China will domi-

> nate the global balance. This argument does not deny that nuclear power, properly deployed, is the least environmentally damaging of all near term prime movers. It is simply recognition of the fact that we do not "need" nuclear power for commercial or national security purposes.[31]

3.2 Media Analysis

There are several methods to ascertain public perception. The most obvious is by polling large numbers of people from across the geographic and economic spectra to determine a general consensus. This report focuses on nuclear power and terrorism. However, research has not revealed studies that have investigated relative risk perception for terrorist threats, nor are the resources available to perform such a survey myself. Therefore I have chosen a different method, building on the idea that news editors and reporters want to present stories in which their audiences will be interested. This idea, that media reflect public opinion, is often stated as a given, although the accuracy of this assumption is not at all clear. In addition, while the amount of media coverage on a topic may to a large extent reflect its importance in the public consciousness, it is likely that the actual content of the coverage would tend to be more negative than public opinion, especially in technical matters:

> After all, who could attract a big audience with a story about routine life at an industrial plant? Such a story would be far closer to the truth than, for example, the claim made in the movie *Silkwood* that a single flawed fuel rod could slay 2 million people, but without such claims there would be little excitement. It was a simple matter, this bias toward colorful talk of danger, but it gravely influenced the image of all technology.[1, p.363]

With that in mind, in this section I will present the results and my analysis of a study of several major print news sources and their coverage of "nuclear" and "terrorism" issues. The results will be in the form of how often these words are used and in what contexts, the relative frequency of different uses, and how this changes over time.

3.2.1 Method

Study Scope

Due to the prevalence in the news of terrorism and nuclear issues, it was necessary to limit the scope of my study to a single five year period, from two years before the events of September 11, 2001, to three years afterward. Therefore, I looked at articles appearing from October 1999 through September 2004. Obviously, by choosing this time frame, the intention is to investigate perception of nuclear power and terrorism before the attacks and the change in perception after the attacks. This is by no means a static measurement. Public perception will continue to change drastically as separation from the attacks grows with time and as new events occur. Public perception is heavily influenced by dramatic events (such as Three Mile Island, Chernobyl, and September 11th), so the utility of this study as a predictor of the future is severely limited.

Sources

I have chosen as my sources two major weekly news magazines, *Newsweek* and *Time*, and three major daily newspapers, *The New York Times*, *The Washington Post*, and *The Wall Street Journal*. The focus for this study is on perception in the United States, however I also studied the British news magazine *The Economist* for comparison.

Search Methods–Magazines

To perform my searches on the magazines, the Proquest Research Library[32] was used, with access licensed through MIT Libraries[33]. The Proquest interface allows multiple word searches of full text articles limited by date range and publication. I first searched for the word "nuclear" and read each article to determine the context of its use. I then performed the same search and breakdown for the word "terrorism." To limit the scope of my study and avoid redundancy, I did not perform similar searches for related words, such as "atomic" or "nukes" for "nuclear" and "terror" or

"terrorists" for "terrorism."

While I looked at any article or editorial that used the word "nuclear," I omitted from the results those that were not relevant to my investigation. These generally fell into three categories. First, I omitted those articles that used the word "nuclear" in a completely different context, such as "nuclear DNA" in articles about genetics, or "nuclear physics" being used to analyze astrophysical phenomena. Second, I omitted those instances where it is used simply as a symbolic or literary device. This occurred quite often. For example, articles saying that the recording industry wants to treat electronic music "like nuclear secrets," pro-marriage activists referring to "the stability of the nuclear family," etc. In addition, I omitted those instances where something nuclear-related was mentioned just in passing and had no significant relevance to the article or was used as an example in a list where non-nuclear examples could have been substituted without changing the intended point. Examples of this are obituaries of prominent scientists who participated in the Manhattan project or an analysis of election-year campaign strategies that said "it's nice for a candidate to say he has thought through nuclear proliferation..., but the more detailed your policies, the more ammunition you give to your opponent." While the references in these last two categories are not directly relevant to my investigation, the frequency of their use is further evidence of the impact of nuclear imagery on society.

Similarly, in searching for articles containing the word "terrorism," my purpose was to determine the relative representation of various domestic terrorist threats. Thus my results are made up of the number of mentions of specific terrorist threats, omitting generalized references to terrorism, which often made up a majority of the references.

Search Methods–Newspapers

For *The Wall Street Journal* I was again able to use the Proquest Research Library. For the other two newspapers, I made use of the archive searches available on their websites[34, 35], which allow the same search limiters as the Proquest interface.

The profusion of articles regarding terrorism and nuclear energy in the daily news-

papers I studied necessitated a different search approach. For instance, *Newsweek* and *Time* both had about 150 relevant articles using the word "nuclear" over the five year span, out of about 400 for *Newsweek* and 500 for *Time* total instances of the word "nuclear." In contrast, both *The Washington Post* and *The New York Times* each had over 9,000 articles containing the word "nuclear" in the same five year span.

Consequently, I was not able to read each individual article to determine the usage context. Instead I chose to perform multiple-word searches, counting the number of times each word appeared in conjunction with another word that would indicate into which category it should be placed. The drawbacks of this approach are that I was not able to eliminate the "noise" as described above for the magazine searches, and there are most certainly many instances of mis-categorization. For instance, an article about nuclear weapons proliferation that never actually used the word "proliferation" would be categorized just under "weapons." However, I believe that the large sample size of articles containing the relevant words minimizes these effects, especially since the results are only meaningful in relation to each other.

Categorizations

Each article I examined containing either the word "nuclear" or "terrorism" was classified as to the context of its usage, either by actually examining the text of the article or by searching for additional words as described above. Some articles were scored in multiple categories if they mentioned multiple aspects of nuclear energy or domestic terrorist threats.[1] Below are brief descriptions of the categories I used.

For articles containing the word "nuclear," the possible categorizations were as follows:

Terrorism: Any article mentioning any form of nuclear terrorism, whether with stolen weapons, dirty bombs, against nuclear plants, etc.

Weapons: Anything related to nuclear weapons, including arms control treaties, missile defense, and nuclear weapons development in India and Pakistan.

[1]For instance, mention of crashing an airplane into a nuclear reactor building would be categorized as both terrorism against a nuclear plant and terrorism using an aircraft as a cruise missile. Similarly, suggestion of the threat of a chemical weapon being released at the Super Bowl would be scored in both the chemical weapons and crowds/gatherings categories.

Security: *Not* national security in terms of weapons forces, but security measures at plants, weapons storage facilities, and the security of nuclear secrets at the national labs.

Proliferation: Nations or groups developing nuclear weapon capabilities or related technology, usually referring to North Korea and Iran.

Safety: Articles or editorials regarding the safety of nuclear energy, in fuel cycle and government facilities as well as commercial plants.

Energy: Any mention of the commercial, economic, or political aspects of nuclear power as an energy source, including industry dealings and future energy demands.

Iraq: Any mention in relation to possible weapons programs specifically in Iraq.

For articles containing the word "terrorism," the possible categorizations were the following:

Biological weapons: Any mention of an attack with a biological organism.

Chemical weapons: Any mention of an attack with a chemical compound.

Nuclear weapons: A terrorist threat involving a nuclear explosive, whether a stolen warhead or a bomb constructed by the terrorists, including inefficient, low-yield devices.

Dirty bombs: The detonation of a conventional explosive that disperses radiological material of any kind, such as spent fuel, other high level waste, or medical or industrial isotopes.

Crowds/Gatherings: Any terrorist threat against public places where people gather (such as restaurants or malls) or specific 'events' (such as the Super Bowl or a movie premier).

Government: A threat against government buildings or facilities, or against members of the government.

National landmarks: Any threat to a symbolically-important site, such as a monument or other tourist attraction (the Statue of Liberty, the St. Louis Arch, the Golden Gate Bridge, etc.).

Nuclear plants: A threat against a nuclear power plant or other fuel-cycle facility, such as fuel enrichment or fabrication facilities.

Chemical plants: Any mention of an attack against a chemical facility, including chemical plants, chemical storage tanks, and oil refineries.

Infrastructure: A threat against any aspect of infrastructure, including transportation (tunnels, bridges, airports, etc.), electrical (transfer stations, power lines), and economic (credit card companies, banks, stock exchanges, etc.).

Water supply: A threat against the public water supply, such as by poisoning or otherwise contaminating a reservoir.

Aircraft as cruise missiles: An aircraft used as a kinetic weapon against another site, as was done on September 11th.

Border security: Any discussion of terrorism involving the nation's borders, including terrorists sneaking into the country as well as smuggling in other materials, such as using shipping containers to transport nuclear weapon components.

For the newspaper searches, when I was searching for specific words in addition to "terrorism," it would not have been meaningful to search for all these categories. For instance, an article containing both "terrorism" and "water" would not necessarily have anything to do with a threat against the water supply. Therefore, I only searched for words that would give useful data, which amounted to eight of the above categories: "terrorism" in conjunction with "biological," "chemical," "nuclear," "dirty bomb," "nuclear plant," "chemical plant," "landmarks," and "borders."

3.2.2 Data and Trends

All the data I collected are found in Appendix A, Tables A.6 thru A.17. The data in each table are broken down first by quarter, starting in the last quarter or 1999 and going to the third quarter of 2004, and then by year, although the years are shifted by a quarter to reflect that the study is focused around September of 2001.

All of the analysis I have done with the data were just my broad impressions as to meaningful trends and significant departures from those trends. When you look at the data the first time it is a mess of meaningless numbers. I have already discussed above the limited value of the data due to the tenuous relationship between media coverage and public perception.

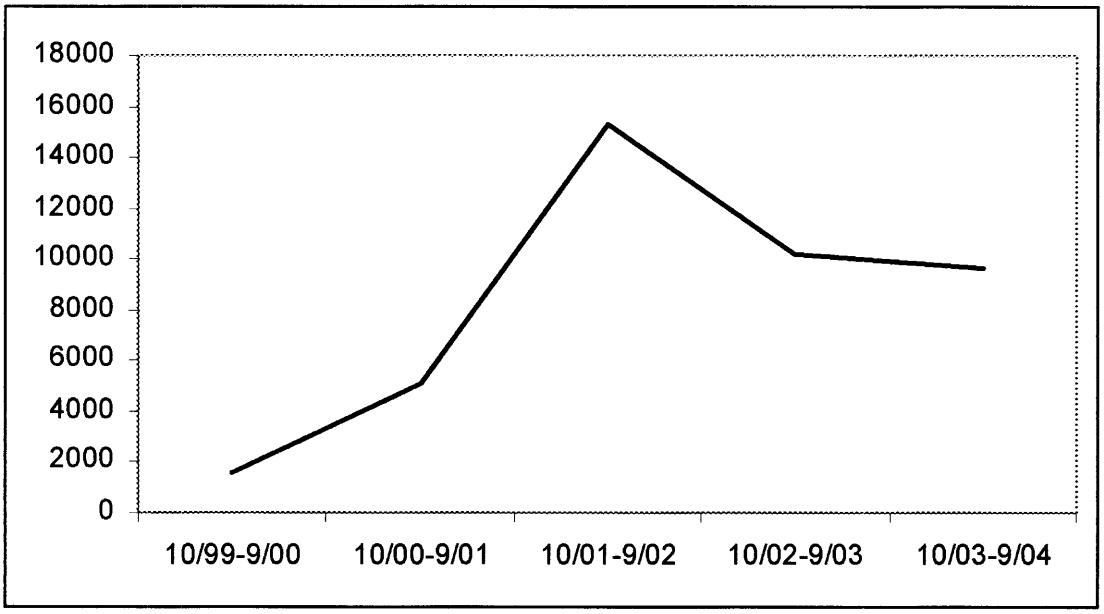
The first and most obvious trend is the impact of the September 11th attacks on mentions of both "nuclear" and "terrorism" across sources. Figure 3-1 shows

the total number of articles containing the word "terrorism" in the five years.[2] One would expect a great change, but the increase is further emphasized by the relative absence of coverage of terrorism before the attacks, resulting in a factor of nearly ten from the first year to the third year in the study. In addition, there is a significant fall-off of about a third after the first year immediately following the attacks, but the coverage remains significantly elevated relative to pre-attack levels. There is also a consistent increase in the mentions of "nuclear" after the attacks, as shown in Figure 3-2. However, the increase is much less than for terrorism, and the peak does not occur until the fourth year of the study, which corresponds more with the build-up to and first few months of the war in Iraq.

In the different categorizations for "nuclear," it is notable that even after September 11th, the focus remained on nuclear weapons. In some of the publications, terrorism eclipsed weapons for the year immediately following September 11th, but even in these, weapons regained prominence in the subsequent years. This could be seen to support the idea that fears of all things nuclear retain their root in the latent fear of nuclear war. In the other categorizations, mentions of nuclear safety and nuclear power as an energy source remained relatively steady through the study period and did not seem to be affected by the September 11th attacks. This seems to indicate that the public is able to separate the increased perceived risk from terrorism and the safety risks of nuclear power, and that the terrorism risk is not seen as significant in determining the future of the nuclear industry from an economic standpoint. In addition, a general increase was seen in the mentions of proliferation, but not until the fourth year of the study. This demonstrates that the increased fear of proliferation was not due directly to September 11th, but to events and circumstances that developed later, such as the situations in North Korea and Iran.

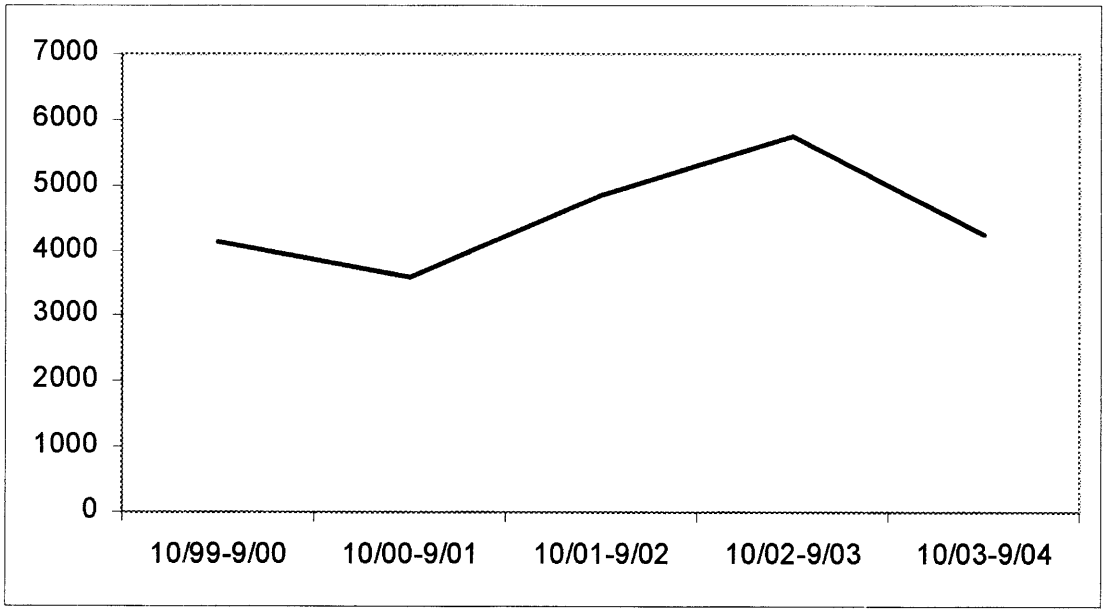
[2]Unless otherwise noted, these figures do not include data from *The Economist* since it is not a U.S. publication.

Figure 3-1: **Media Coverage of 'Terrorism'**



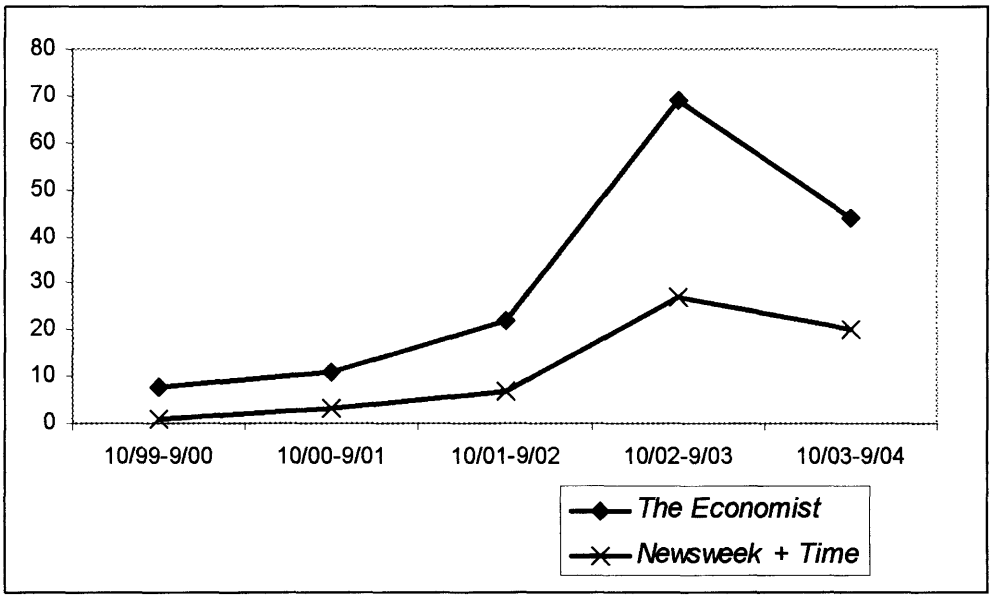
This graph shows the number of articles containing the word "terrorism" in each time period in all the publications except *The Economist*.

Figure 3-2: **Media Coverage of 'Nuclear'**



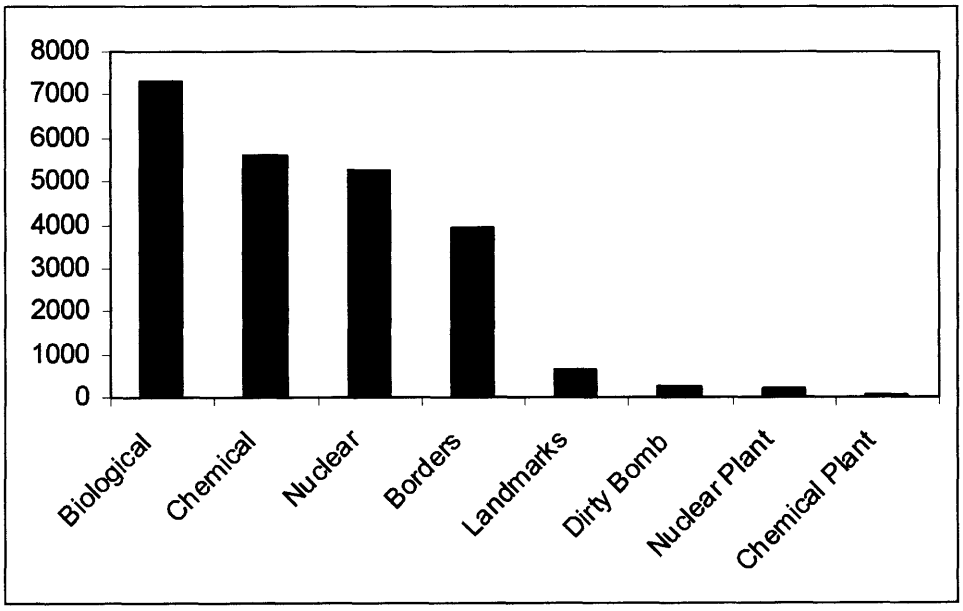
This graph shows the number of articles containing the word "nuclear" in each time period in all the publications except *The Economist*.

Figure 3-3: **Media Coverage of 'Nuclear Proliferation'**



This graph shows the number of articles in each year of the study concerning nuclear proliferation in *The Economist*, compared to the total number of articles concerning nuclear proliferation in both *Newsweek* and *Time*.

Figure 3-4: **Total Mentions of Terrorist Threats**



This chart shows the total number of articles referencing specific terrorist threats in the three daily newspapers studied, of the over 40,000 total articles containing the word "terrorism".

There were also some informative trends in the different categorizations for "terrorism." In the weekly magazines, biological terrorism was by far the chief concern. However, most of the articles about biological terrorism were concentrated in the period right after September 11th, during the anthrax scare when several prominent people received contaminated letters. This is evidence that could largely undermine the theory of the relationship between media coverage and public perception: that the media is largely reactionary, reporting on specific events that have occurred, only occasionally speculating on other possible threats. While the speculations were definitely present, they may not be frequent enough to have a large impact on public opinion.

However, there is still significant evidence for the opposing view. For instance, in the daily newspapers, biological terrorism received comparable coverage to chemical and nuclear threats, even though of the three, only biological attacks have actually occurred in the United States. In addition, in all three sources mentions of "borders" were substantial, revealing that the public acknowledges the importance of entry into the country as a necessary first step in a terrorist attack. This clearly shows that the threat is perceived to be largely a foreign one, as opposed to the fear of domestic terrorism caused by the Oklahoma City bombing and the spread of militias in the 1990s.

While the news sources are generally consistent in how they represent the various threats, there are some significant disparities. For instance, in *The Washington Post* and *The Wall Street Journal*, the mentions of terrorism against a nuclear plant and against a chemical plant were comparable. Even in the news magazines, the two threats were pretty evenly covered. However, in *The New York Times*, mentions of terrorism against a nuclear plant occurred an order of magnitude more often, 154 articles compared to 18 for chemical plants. Again this is related to nuclear safety, as discussed in the previous chapter. Much of the concern with terrorism against nuclear plants in *The New York Times* is specifically concerned with the Indian Point power plant, located about 30 miles north of New York City. This facility has also been a major target for anti-nuclear advocates from a safety basis since the early days of

the nuclear industry. As evidence of this point, Table A.15 shows that there were 72 mentions of "terrorism" and "nuclear plant" in *The New York Times* from October 2001 through September 2002; in that same period there were 87 articles containing the words "terrorism" and "Indian Point."[3]

To a large extent, the trends in *The Economist* were similar to the other media sources. However, there were some notable differences. For instance, in the second half of the study period, *The Economist* focused much more on nuclear proliferation than did the other publications, even surpassing mentions of nuclear weapons. Figure 3-3 shows the number of articles containing "nuclear" and "proliferation" in *The Economist* compared to the number of articles containing the same words in both *Newsweek* and *Time*. This reflects the more global perspective of *The Economist* compared to the U.S. publications, since proliferation is a more widespread and longterm threat. Similarly, in regards to terrorist threats, *The Economist* focused much more on general threats, such as nuclear, chemical, and biological weapons, and less on attacks against specific targets such as power plants and landmarks.

Any discussion of media's relation to perception must acknowledge the fact that coverage of nuclear energy and nuclear terrorism still constitutes a very small fraction of the current "barrage" from all forms of media: print, radio, television, and the internet, not to mention word of mouth and personal experience. I believe this lends support to the idea that the media affect public perception, but from a different angle. Because of the media bombardment, only those articles or reports that resonate on some deeper level with the audience actually get noticed. Therefore, the media do not shape public perception so much as they reinforce perceptions already held. For example, people that worry about the safety of their children are likely to respond emotionally to articles that trump up the dangers of nuclear power, while those who are more concerned with their stock portfolios are likely to take interest in reports that discuss the economics of the energy market.

[3]Appendix B.2 contains a *New York Times* article from this time which revealingly combines Indian Point with all these other ideas and images: nuclear plant safety, terrorism, catastrophic consequences, irrational fear, distrust of authority, comparisons to nuclear war, ineffective attempts to 'do something about it,' etc.

Chapter 4

Analysis and Conclusions

4.1 System Dynamics

As alluded to in the previous section, the relationship between media coverage and public perception is not well understood. To help clarify that relationship somewhat, we can use a method called system dynamics, where a network is made by connecting various elements of a system, and then working to define the characteristics of specific links within that network. On the simplest level, this means defining whether specific links have a positive or negative relationship (in other words, identifying whether an increase in one element causes an increase or decrease in subsequent elements). One feature of this method is the ability to identify loops that cause positive or negative feedback in a system.

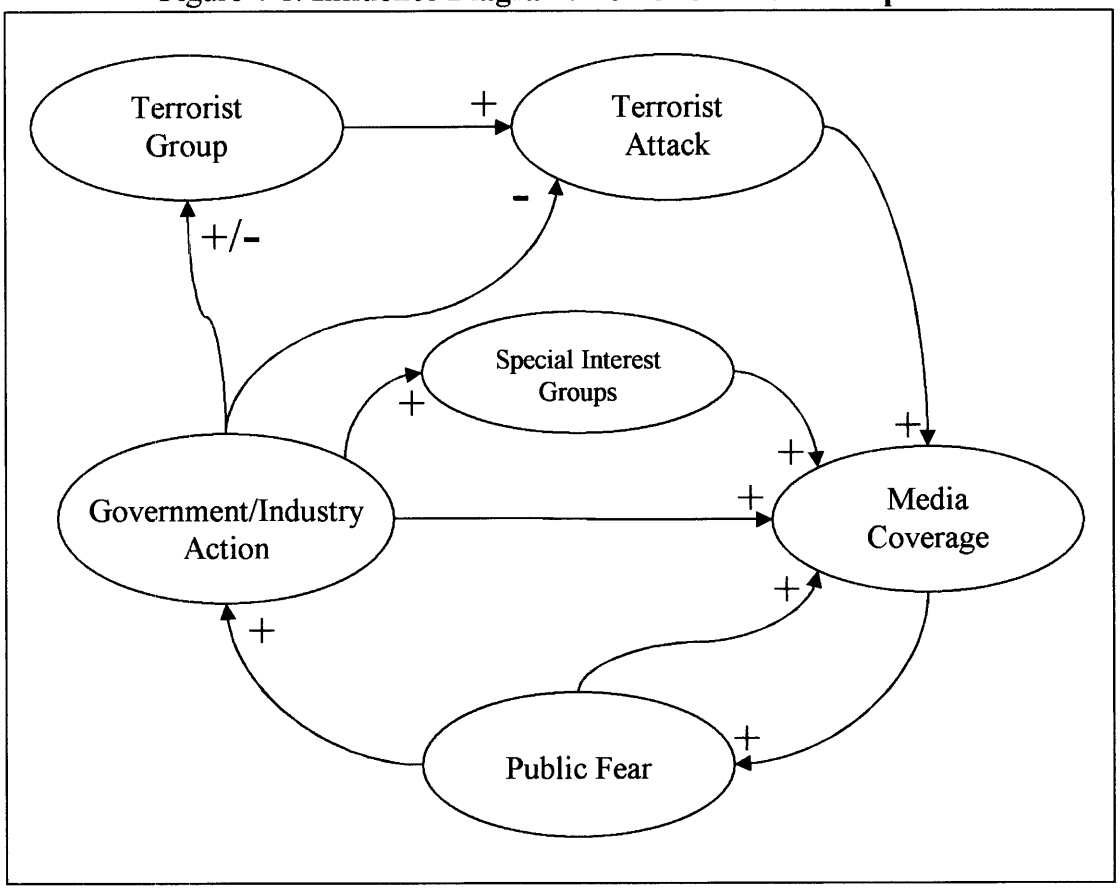
Figure 4-1 shows a basic system dynamics model of terrorism and public perception. A terrorist group carries out an attack and news of this is relayed to the public through the media. Prompted by public outcry, the government and other responsible parties take action against terrorist groups and to protect against another terrorist attack. The media now reports on the actions being taken by the authorities, and on the response by special-interest groups that may oppose government action or policy. Public fear is also a stimulus to media coverage, which is the primary reasoning behind the study described in the previous chapter. Government and industry actions take two forms. Actions against a possible terrorist attack are defensive in

nature, such as target hardening and security screenings. I assume that any such action has a decreasing influence on the possibility of a terrorist attack, although this assumption does not determine whether the benefit of a specific action is worth its cost. Government action against terrorist groups, on the other hand, are offensive in nature, and include everything from intelligence gathering and infiltration to attacks on terrorist training camps. The relationship in this area is difficult to determine, in that an action can have some benefit in reducing the resources and effectiveness of a terrorist group, but offensive action can cause anger and resentment, which fosters the conditions that motivate terrorism in the first place.

Figure 4-2 gives more detail of a portion of the system shown in Figure 4-1. In this figure, two kinds of terrorist attacks are given: a nuclear-related attack (either explosion of a nuclear device, a dirty bomb, or an attack against a nuclear facility) and all other non-nuclear attacks. The distinction is not perfect, since there are aspects of biological and chemical attacks that are similar to nuclear attacks, and the magnitude of a conventional attack will have a huge influence on its coverage and perception. In this figure, the difference between nuclear attacks and the other attacks is in the amount of media coverage, which is a result of the numerous additional elements associated with a nuclear attack. "Consequences" refers to widespread effects and longterm consequences, such as contamination by radiation and radiation dispersion to other areas. Such things would undoubtedly lead to extensive media coverage beyond the immediate effects of the attack. "Speculation" refers to the speculation by experts and analysts as to the possible consequences, such as increases in "statistical deaths" and public radiation dose. People who want to talk about these things seem to always find their way to a media source that will let them share their opinion, regardless of their scientific reputation or accuracy.[1] "Imagery" has been discussed at length in this report.

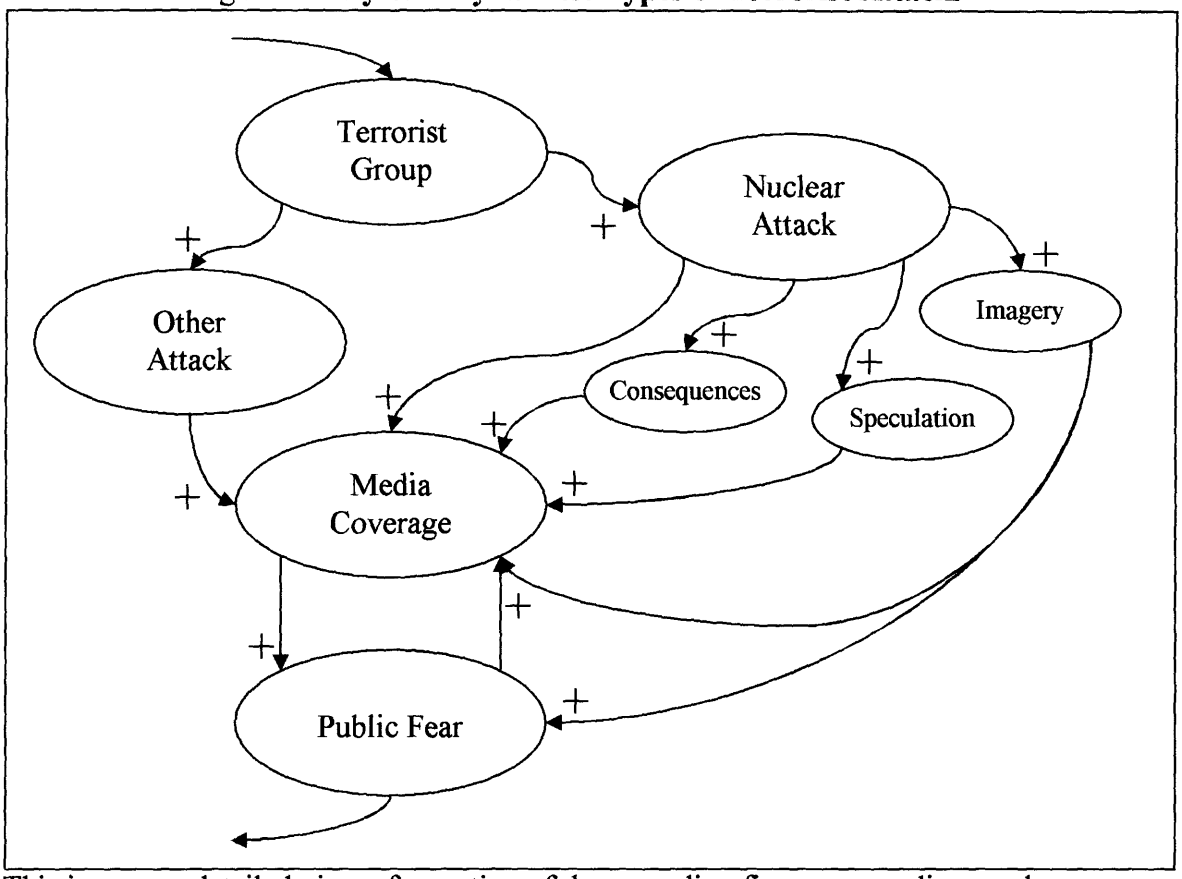
[1] "Statistical deaths" means the number of excess cancer deaths due to radiation exposure if the dose to a large population were concentrated in a fewer number of people so as to maximize cancer deaths. A handy analogy can be made to alcohol consumption: "Twelve lawyers stop at a bar in the commuter train station and each has a martini in the 1/2 hour before the train leaves. If 1 lawyer drank 12 martinis in a 1/2 hour, he might die, and he surely would get sick and pass out. The [statistical death model] says that 1 of the 12 lawyers is just as likely to die as the drunk."[36]

Figure 4-1: **Influence Diagram: Terrorism Risk Perception**



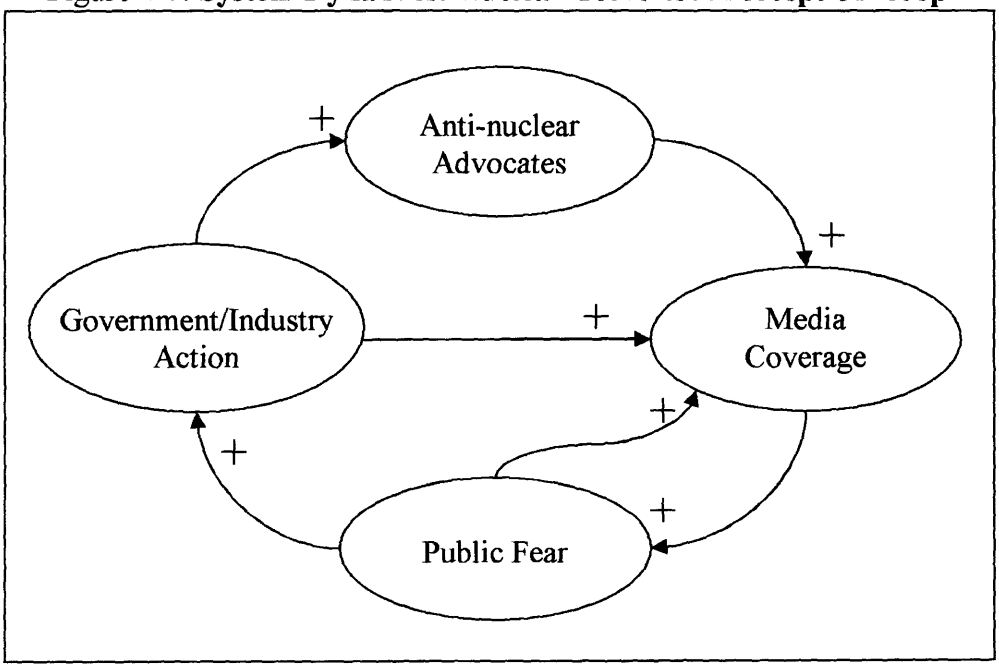
This is a basic system dynamics model of terrorism and public perception. A link indicates that a change in one element influences the state of the downstream element. A "+"means that an increase in the first element results in an increase in the downstream element, while a "–" indicates that an increase in one element results in a decrease in the next element.

Figure 4-2: **System Dynamics: Types of Terrorist Attacks**



This is a more detailed view of a portion of the preceding figure, expanding on the "Terrorist Attack" element.

Figure 4-3: **System Dynamics: Nuclear Terrorism Perception Loop**



This is a simplified influence diagram that more closely reflects current reality.

However, the above two paragraphs bring an element into the equation that does not actually exist yet: an actual nuclear terrorism attack of this kind has never occurred in the United States. Figure 4-3 shows a more accurate, albeit simpler, model of the system which is in fact currently in place. Note that every single relationship in this system is positive, so that any action or event at any element creates positive feedback, which eventually leads to an increase in public fear.

4.2 Perception

In Chapter 2, I examine in detail why people are especially afraid of nuclear power, more so than other risks that we face everyday. The reasons for this sometimes irrational fear boil down to a few major points: the history of images that nuclear energy evokes; a distrust of government and other authorities; feelings of unfamiliarity and loss of control; and, above all, the association between nuclear power and nuclear war. I then go on to explain how fear of terrorism has moved into the forefront of the public consciousness, including fear of nuclear terrorism, either in the form of a nuclear device or as an attack against a nuclear facility. With these two aspects in mind, I come to the conclusion that the reasons a terrorist attack against a nuclear power plant is so prominent as a threat are the same reasons why nuclear power is perceived to be so risky from a safety standpoint.

4.3 Media Analysis

In Chapter 3, I briefly explore the role of the press in influencing and being influenced by public perception. A media analysis is performed on six popular print media sources. The appearances of the words "nuclear" and "terrorism" are catalogued, as well as their various contexts, for a five year period from two years before to three years after September 11, 2001. The purpose of this study is to see how media coverage changed as a result of the attacks, under the assumption that (at least to some extent) media coverage reflects public interest and perception. This study

reveals several meaningful trends: fear of nuclear war persisted as the most prominent fear, in spite of the increase in the fear of terrorism; the public was able to detach the new perceived terrorism risk of nuclear power plants from the old perceived safety risk, although both were substantial; to a large extent, the media are reactionary in their coverage, focusing on actual events and news; on the other hand, the media do speculate considerably, devoting significant coverage to postulated threats that have never actually taken place; the current terrorist threat is perceived to be almost entirely foreign in origin; and proximity to a possible terrorist target greatly influences the perceived risk for that target.[2]

4.4 State of the Nuclear Industry

One question still remains: How relevant is all of this for the current state and future development of the nuclear power industry? It is often said that the nuclear industry has been stagnant since the late 1970s, since there have been no new reactors ordered or construction permits granted since then. Table 4.1 shows how electricity generation has changed and how the nuclear industry has adapted to shoulder more of the load. While the number of operating reactors has only increased from 71 in 1980 to 104 in 2000, nuclear power in the U.S. has nearly doubled its share among electricity generators (from 11.0% to 19.8%) and more than tripled its total electricity generation (from 251 to 754 billion kilowatt-hours) in that same time.

Apparently, no one thought to inform the industry itself that it is stagnant. The industry has been very busy the past 25 years increasing generating capacity through such things as power uprates and improved capacity factors, not to mention the recent license-extension program allowing older reactors to remain in operation. Many would argue that the absence of new orders over the past 25 years has more to do with economic and regulatory uncertainties than with any public relations problems. Even though the fear of terrorism is at an all time high, nuclear advocates and regulators are

[2]This is reflected in the opinion of one reporter I interviewed: When asked whether fear of terrorism has overshadowed concerns about waste or safety, he replied, "It depends what part of the public you're talking about. At Indian Point, yes. In Las Vegas, no."

Table 4.1: **State of the U.S. Nuclear Industry**[3]

	Net Electricity Generation (Billion Kilowatt-hours)		Net Capacity (Gigawatts)		Nuclear Share of Total Generation		Average Capacity Factor
Year	All sources	Nuclear	All sources	Nuclear	(%)	Operating Units	(%)
1970	1535	22	336	7	1.4	20	N/A
1980	2290	251	579	52	11.0	71	56.3
1990	3038	577	734	100	19.0	112	66.0
2000	3802	754	786	98	19.8	104	88.1

expecting new reactor orders in the next few years. This is not due to some large shift in public opinion. Instead, this optimism by industry is due to a new environment of "transparent and predictable regulation" (from such programs as early site permitting and design certification), and the foreseeable need for electricity producers to add new baseload generating capacity to keep up with growing demand[37].

4.5 Suggestions for future research

As discussed above in the system dynamics section, the relationship between the media, public perception, and government action is not well-defined. Many believe that media coverage is actually a very poor indicator of public perception[38]. I recommend further study in this area, such as analysis of media coverage compared to public opinion polls to determine what correlations exist. In addition, it would be useful to explore what impact public perception has on action by the authorities. It is obvious that public perception influences the government, since our government is democratically elected. However, the influence of special-interest groups and lobbyists cannot be discounted. Therefore, it would be useful to do historical studies of how government action correlates with contemporary public opinion.

In the specific realm of terrorism, this question remains relevant. It is simple to show that the perceived risk of terrorism has increased greatly since September 11th, but research has not revealed any psychometric studies comparing perceived

risks of various terrorism threats, as there have been for other risks as referenced in this report. In addition, government agencies and corporations have put considerable resources into "combating terrorism" since September 11th. It would be informative to investigate how the resource allocation compares to public perception. In other words, we can study what people think and we can study what the media cover, but we must also study what the people in charge of the industry are actually doing in response, and how effective these actions have been in reducing the real risk of terrorism.

On a similar note, there seems to be an overall disparity between perception and action. In this thesis I have made the case that fear of nuclear power is largely a displaced fear of nuclear war. Yet the United States still maintains a sizeable nuclear arsenal to act as a deterrent against threats which no longer exist, and someone can speak out against nuclear power, but they still expect the lights to come on when they flip the switch. It would therefore be extremely useful to find some way to measure the public's opinion when the consequences for that stance are more apparent. One way could be to examine the results from referenda on nuclear power from around the world, when people must actually go and vote in support of their position. Another method would be to construct a polling system which took consequences into account, such as asking questions like, "Would you still be against the proposed nuclear power station if it meant your electricity bill would double?", etc. This could perhaps encourage the nuclear industry to focus their education campaigns on increasing perceived benefit rather than decreasing perceived risk.

All of the above suggestions are well beyond my expertise as a nuclear engineer, even more so than the various fields covered in this report. From a strictly nuclear engineering perspective, we must continue to be diligent in making our reactors and facilities as robust and resilient as reasonably achievable to deter potential terrorists, to mitigate the effects if an attack were to occur, and to maintain safe and efficient day-to-day operation. To this end, the work that has begun in applying risk assessment to terrorist threats should continue so that reactor designers and operators can focus their limited resources on the greatest risks, not just the worst-case scenarios.

4.6 Conclusions

All of the above conclusions can be boiled down to these main points:

1. The public's fear of terrorism against a nuclear facility has the same roots as the fear caused by safety concerns over nuclear power, and the strongest of these roots is the association of all things "nuclear" with the threat of nuclear war.

2. Terrorism risk perception is largely influenced by proximity to a particular threat. That is, people see more risk in threats that are close to themselves or their loved ones (people that fly often view airport security as most important, people that live near a nuclear power plant identify that as a principal target, etc.). Likewise, authorities assume that the public perceives greater risk in their particular area of responsibility (the TSA thinks people are most worried about air safety, the NRC thinks people are most worried about security at nuclear plants, etc.).

3. Since the purpose of terrorism is to incite terror, the public perception of nuclear power plants as tempting terrorist targets may be self-fulfilling.

4. The media coverage–public perception–government action cycle, as it applies to fear of nuclear terrorism, is a closed positive-feedback loop, so that any public action by government or industry leads to increased media coverage, and any media coverage, positive or negative, increases public fear. Therefore, the nuclear establishment should take no action to lower terrorism risk with the hope that it will allay public concern. Instead, the establishment should take whatever reasonable actions it thinks will reduce the actual risk and make appropriate emergency response preparations, while avoiding additional media coverage.

Appendix A

Tables

A.1 Risk and Perception

Table A.1: **Judgements of Relative Risk and Benefit**[4]

	Perceived Benefit	Perceived Risk	Acceptable Risk
Alcoholic beverages	41	161	36
Bicycles	82	65	43
Commercial aviation	130	52	40
Contraceptives	113	50	25
Electric power (non-nuclear)	274	52	50
Fire fighting	178	92	84
Food coloring	16	31	10
Food preservatives	44	36	13
General (private) aviation	53	114	56
Handguns	14	220	13
H.S. and college football	35	37	22
Home appliances	133	25	24
Hunting	30	82	33
Large construction (dams, bridges, etc.)	142	91	55
Motorcycles	29	176	33
Motor vehicles	187	247	42
Mountain climbing	28	68	69
Nuclear power	52	250	9
Pesticides	87	105	11
Power mowers	30	29	19
Police work	178	111	66
Prescription antibiotics	209	30	23
Railroads	185	37	30
Skiing	38	45	43
Smoking	20	189	12
Spray cans	17	73	9
Surgery	164	104	56
Swimming	68	52	50
Vaccinations	194	17	20
X-rays	156	45	28

These numbers represent the perception of a group of non-experts. All numbers in this table are relative to each other (i.e. an activity with a perceived risk of 100 would be twice as risky as an activity with a perceived risk of 50).

Table A.2: **Mean Ratings for Nine Characteristics of Risk**[4]

Characteristics[a]:	V–I	I–D	K–U:e	K–U:s	U–C	N–O	Ch–C	C–D	NF–F
Alcoholic beverages	2.10	5.34	3.77	1.98	5.57	6.61	1.79	1.92	4.40
Bicycles	1.90	2.82	3.27	2.80	4.99	5.19	1.30	1.74	3.77
Commercial aviation	2.80	1.85	3.24	2.12	2.18	4.24	6.09	3.39	5.72
Contraceptives	2.74	5.69	4.66	3.88	3.11	2.25	1.49	3.14	4.08
Electric power (non-nuclear)	4.40	2.82	3.98	2.68	4.25	5.09	2.66	1.72	4.52
Fire fighting	2.40	2.33	1.98	2.25	4.03	6.01	2.84	2.62	4.42
Food coloring	5.86	6.26	6.40	4.77	2.70	2.66	2.82	3.24	3.59
Food preservatives	5.65	6.18	6.39	4.76	2.70	2.73	2.82	3.32	3.66
General (private) aviation	2.20	1.66	2.62	2.64	4.45	4.08	3.40	3.15	5.63
Handguns	3.42	1.65	2.64	2.41	4.05	5.69	2.10	4.40	5.67
H.S. and college football	1.90	3.52	3.66	3.11	4.15	4.78	1.40	1.95	3.15
Home appliances	3.61	2.97	4.47	2.90	4.85	4.39	1.38	1.43	3.08
Hunting	2.01	1.66	2.62	2.64	4.45	6.14	1.59	2.79	4.91
Large construction	3.07	2.23	2.77	2.51	3.91	5.04	3.04	2.61	4.77
Motorcycles	1.87	1.73	2.69	2.17	4.08	4.31	1.59	3.02	5.19
Motor vehicles	4.04	2.33	3.14	2.31	4.19	4.73	3.28	3.04	4.57
Mountain climbing	1.15	1.78	1.83	2.49	4.98	5.63	1.32	2.57	4.80
Nuclear power	6.51	5.08	5.85	4.83	1.36	1.35	6.43	6.42	5.98
Pesticides	5.77	5.57	5.50	4.41	2.14	2.22	4.75	5.21	4.87
Power mowers	2.23	2.99	3.31	2.60	5.13	3.70	1.16	1.75	2.75
Police work	2.44	2.14	2.05	2.25	3.76	5.50	2.07	3.05	4.35
Prescription antibiotics	4.44	4.33	5.40	3.91	2.77	2.87	2.35	2.19	3.82
Railroads	3.42	2.91	3.66	2.68	3.22	5.49	4.49	1.75	3.60
Skiing	1.28	2.45	2.47	2.51	4.73	4.69	1.06	1.92	3.15
Smoking	1.85	6.11	2.86	2.15	4.43	5.04	1.68	2.89	5.01
Spray cans	3.80	6.06	5.43	4.16	3.60	1.89	3.82	3.62	4.27
Surgery	4.28	2.71	3.84	2.86	2.39	4.95	1.14	4.04	4.68
Swimming	1.64	1.76	2.87	2.68	5.17	6.50	1.16	1.89	4.78
Vaccinations	3.82	3.71	4.84	2.82	2.53	4.50	1.88	2.03	3.62
X-rays	4.38	6.15	5.05	3.28	2.37	4.02	1.99	2.58	4.20

[a]V–I= voluntary vs. involuntary; I–D= immediate vs. delayed; K–U:e= known vs. unknown to the exposed; K–U:s= known vs. unknown to science; U–C= uncontrollable vs. controllable; N–O= new vs. old; Ch–C= chronic vs. catastrophic; C–D= common vs. dread; NF–F= non-fatal vs. fatal

All characteristics are ranked on a scale of one-to-seven by a group of non-experts.

Table A.3: **Ranking of Perceived Risk**[5]

	Non-experts	Experts
Nuclear power	1	20
Motor vehicles	2	1
Handguns	3	4
Smoking	4	2
Motorcycles	5	6
Alcoholic beverages	6	3
General (private) aviation	7	12
Police work	8	17
Pesticides	9	8
Surgery	10	5
Fire fighting	11	18
Large construction	12	13
Hunting	13	23
Spray cans	14	26
Mountain climbing	15	29
Bicycles	16	15
Commercial aviation	17	16
Electric power (non-nuclear)	18	9
Swimming	19	10
Contraceptives	20	11
Skiing	21	30
X-rays	22	7
H.S. and college football	23	27
Railroads	24	19
Food preservatives	25	14
Food coloring	26	21
Power mowers	27	28
Prescription antibiotics	28	24
Home appliances	29	22
Vaccinations	30	25

The study subjects were asked to rank these activities from 1-to-30, with 1 being the most risky and 30 being the least risky. The "experts" are fifteen people who use risk assessment professionally.

Table A.4: **Fatality Estimates and Disaster Multipliers**[5, 6]

	Statistical Fatality Estimates	Non-expert Perception	
		Average Year Fatalities[a]	Disastrous Year Multiplier
Smoking	150,000	6,900	1.9
Alcoholic beverages	100,000	12,000	1.9
Motor vehicles	50,000	28,000	1.6
Handguns	17,000	3,000	2.6
Electric power (non-nuclear)	14,000	660	1.9
Motorcycles	3,000	1,600	1.8
Swimming	3,000	930	1.6
Surgery	2,800	2,500	1.5
X-rays	2,300	90	2.7
Railroads	1,950	190	3.2
General (private) aviation	1,300	550	2.8
Large construction	1,000	400	2.1
Bicycles	1,000	910	1.8
Hunting	800	380	1.8
Home appliances	200	200	1.6
Fire fighting	195	220	2.3
Police work	160	460	2.1
Contraceptives	150	180	2.1
Commercial aviation	130	280	3.0
Nuclear power	100	20	107.1
Mountain climbing	30	50	1.9
Power mowers	24	40	1.6
H.S. and college football	23	39	1.9
Skiing	18	55	1.9
Vaccinations	10	65	2.1
Food coloring	–[b]	38	3.5
Food preservatives	–	61	3.9
Pesticides	–	140	9.3
Prescription antibiotics	–	160	2.3
Spray cans	–	56	3.7

[a]Geometric mean of responses – this reduces the impact of extreme responses
[b]Technical estimates unavailable for these last 5 items.

A group of non-experts were asked to estimate the number of people killed by each activity in an average year and then in a particularly disastrous year. The disaster multiplier is how many times more deaths in the disastrous year than in the average year. The statistical fatality estimates are a combination of statistical data and expert opinion.

Table A.5: **Confirmability and Disconfirmability of Traits**[7]

Trait	Ease of Imagining Confirming Behaviors	Ease of Imagining Disconfirming Behaviors	Frequency of Confirming Behavior	Frequency of Dis-Confirming Behavior	# of Instances to Confirm	# of Instances to Dis-Confirm	Favorability
Alert	0.67	0.70	1.64	1.07	0.60	-0.55	0.99
Ambitious	1.16	0.38	1.07	-0.85	0.60	0.35	0.89
Arrogant	1.73	-0.81	-0.54	1.11	-1.75	0.53	-0.96
Brilliant	-0.14	1.03	-1.19	0.33	0.89	0.08	1.31
Conventional	-1.64	-0.38	0.19	0.01	0.70	-0.10	0.01
Cowardly	-0.54	1.03	-1.43	-2.56	-1.34	-0.82	-1.10
Deceptive	-1.04	-0.92	-0.38	-0.52	-2.12	2.42	-1.01
Dependable	0.46	0.38	1.88	0.97	1.29	-1.72	1.54
Efficient	0.46	-0.16	0.51	0.65	0.89	-0.10	1.13
Faithful	-0.84	1.03	0.19	-0.30	2.55	-1.81	1.45
Gluttonous	1.05	1.11	-0.62	-0.60	0.11	0.71	-1.11
Greedy	0.26	0.82	-0.78	-0.95	-1.64	1.16	-1.52
Honest	-0.14	0.70	1.72	-0.42	2.36	-2.50	1.68
Hostile	0.16	0.49	-0.70	-0.21	-1.45	1.43	-1.34
Humorless	0.06	0.27	-0.86	0.97	-0.18	-0.46	-1.38
Impulsive	0.66	0.38	0.43	-0.74	-0.18	0.53	0.24
Industrious	0.86	-0.48	0.83	0.55	1.09	-0.37	0.99
Innocent	-1.84	0.17	-0.22	-0.31	1.77	-0.71	0.10
Intelligent	0.26	0.60	1.48	1.72	1.18	-0.82	1.36
Kind	0.16	1.68	1.96	1.40	0.89	-1.72	1.59
Lazy	1.26	1.36	0.19	1.29	0.41	0.98	-1.20
Meticulous	1.60	1.03	-0.03	-0.74	1.57	-1.27	0.03
Musical	1.18	0.06	-0.78	-1.70	-0.86	0.98	0.66
Naive	-0.44	0.17	-0.46	0.01	-0.76	0.08	-0.73
Neat	1.68	1.25	1.80	2.26	1.39	-0.10	0.99
Open-minded	-0.74	1.36	1.48	1.29	1.09	-1.00	1.54
Perceptive	-0.74	-0.70	0.91	-0.21	0.41	-0.91	1.31
Persistent	0.46	0.70	0.75	-0.74	0.80	-0.82	0.34
Phony	-0.34	-1.57	0.19	-0.21	0.02	1.52	-1.57
Polite	1.48	1.89	1.88	2.04	0.80	-1.18	1.22
Quiet	1.48	2.01	0.43	2.15	1.18	-0.55	0.24
Reserved	-0.14	-0.27	0.43	1.08	-0.46	-0.82	0.01
Romantic	0.26	-1.45	0.19	-0.95	0.51	-0.28	0.80
Rude	2.48	1.36	0.51	0.33	-2.02	1.52	-1.66
Selfish	-0.73	0.38	-0.22	0.01	-0.46	0.62	-1.34
Sensitive	-0.54	0.92	1.56	0.65	0.21	-1.18	1.08
Shallow	-0.44	-1.14	-1.27	-0.31	-0.37	0.35	-1.34
Sincere	-0.14	-1.02	0.59	0.97	1.39	-1.36	1.40
Skeptical	-0.64	-1.02	-0.14	0.44	-0.67	-0.01	0.01
Sly	-1.34	-2.30	-0.86	-1.38	-1.15	1.43	-0.64
Smug	-0.74	-1.57	-1.02	-0.21	-1.61	1.16	-0.95
Stupid	-1.04	-0.81	-1.27	0.55	-0.27	-0.46	-1.06
Talkative	2.08	1.79	1.31	1.83	1.09	0.26	0.29
Thoughtful	-0.34	0.06	1.80	1.08	0.11	-1.63	1.22
Tough	-0.54	-0.59	0.19	-0.52	-0.27	-0.91	0.01
Trustworthy	-0.54	0.70	1.23	-0.63	1.68	-1.81	1.54
Truthful	-0.54	0.60	1.88	0.97	2.06	-2.44	1.45
Unethical	-2.44	-2.11	-0.30	-0.63	-1.93	2.06	-1.15
Unreliable	-0.44	0.82	-0.14	-0.09	-1.54	1.52	-1.52

The scores are relative and centered on zero: a score of zero is neutral; the more negative a score, the fewer instances required to confirm or disconfirm and the less favorable; the more positive a score, the more instances required to confirm or disconfirm and the more favorable.

A.2 Media Analysis

Table A.6: **'Nuclear' in *Time***

By Quarter	Nuclear+	Terrorism	Weapons	Security	Proliferation	Safety	Energy	Iraq
4/4 1999	7	0	4	1	0	2	0	0
1/4 2000	6	0	2	1	0	1	3	0
2/4 2000	9	0	7	1	1	0	1	0
3/4 2000	4	1	1	1	0	0	1	0
4/4 2000	0	0	0	0	0	0	0	0
1/4 2001	2	0	2	0	0	0	0	0
2/4 2001	4	0	1	0	0	0	3	0
3/4 2001	6	3	1	1	0	1	1	0
4/4 2001	17	14	3	8	2	0	0	0
1/4 2002	8	2	3	2	2	0	2	0
2/4 2002	15	5	5	2	0	2	2	2
3/4 2002	11	5	2	4	0	1	2	3
4/4 2002	12	4	4	3	2	0	0	4
1/4 2003	8	1	3	1	3	0	0	3
2/4 2003	5	1	2	0	2	0	0	2
3/4 2003	8	1	3	1	2	1	2	1
4/4 2003	6	0	2	1	3	0	1	1
1/4 2004	6	1	0	1	2	0	1	1
2/4 2004	4	1	3	0	1	0	0	0
3/4 2004	5	3	2	3	2	0	0	0

By Year	Nuclear+	Terrorism	Weapons	Security	Proliferation	Safety	Energy	Iraq
10/99–9/00	26	1	14	4	1	3	5	0
10/00–9/01	12	3	4	1	0	1	4	0
10/01–9/02	51	26	13	16	4	3	6	5
10/02–9/03	33	7	12	5	9	1	2	10
10/03–9/04	21	5	7	5	8	0	2	2
Total	143	42	50	31	22	8	19	17

The data in this table represent the number of articles in *Time* in a given time period that contain the word "nuclear" and in what context. For example, from October to December of 2001, there were 2 articles that mention nuclear proliferation.

Table A.7: **'Nuclear' in *Newsweek***

By Quarter	Nuclear+	Terrorism	Weapons	Security	Proliferation	Safety	Energy	Iraq
4/4 1999	8	0	6	0	0	2	0	0
1/4 2000	4	2	3	0	0	0	1	0
2/4 2000	4	0	3	1	0	0	0	0
3/4 2000	8	0	1	6	0	1	0	0
4/4 2000	3	2	0	1	1	0	0	1
1/4 2001	3	1	1	1	2	0	0	0
2/4 2001	4	0	3	0	0	0	1	0
3/4 2001	3	0	1	1	0	0	1	0
4/4 2001	9	8	0	4	2	0	0	0
1/4 2002	9	6	3	4	0	0	0	0
2/4 2002	9	5	5	3	0	0	0	0
3/4 2002	8	3	1	3	1	0	0	4
4/4 2002	7	4	1	1	3	0	0	2
1/4 2003	16	3	12	2	9	0	0	4
2/4 2003	12	5	4	2	4	0	0	4
3/4 2003	6	1	4	0	2	0	0	1
4/4 2003	3	1	0	1	2	0	0	0
1/4 2004	13	7	4	2	6	1	0	3
2/4 2004	5	3	1	1	1	0	0	1
3/4 2004	10	2	2	2	3	0	3	0

By Year	Nuclear+	Terrorism	Weapons	Security	Proliferation	Safety	Energy	Iraq
10/99–9/00	24	2	13	7	0	3	1	0
10/00–9/01	13	3	5	3	3	0	2	1
10/01–9/02	35	22	9	14	3	0	0	4
10/02–9/03	41	13	21	5	18	0	0	11
10/03–9/04	31	13	7	6	12	1	3	4
Total	144	53	55	35	36	4	6	20

The data in this table represent the number of articles in *Newsweek* in a given time period that contain the word "nuclear" and in what context.

Table A.8: **'Nuclear' in *The Economist***

By Quarter	Nuclear+	Terrorism	Weapons	Security	Proliferation	Safety	Energy	Iraq
4/4 1999	16	0	6	0	1	6	5	0
1/4 2000	17	2	8	0	2	5	3	0
2/4 2000	16	0	9	1	3	2	0	1
3/4 2000	9	0	5	1	2	1	1	0
4/4 2000	9	0	4	0	2	1	2	0
1/4 2001	20	0	10	0	4	2	4	0
2/4 2001	19	0	8	0	4	1	5	1
3/4 2001	20	4	6	4	1	2	1	1
4/4 2001	25	10	6	6	0	2	1	0
1/4 2002	21	2	8	2	6	0	2	1
2/4 2002	38	8	13	2	10	2	2	1
3/4 2002	24	2	1	1	6	3	2	9
4/4 2002	32	3	1	1	14	0	2	11
1/4 2003	45	2	3	1	25	1	4	9
2/4 2003	33	2	6	1	16	1	3	4
3/4 2003	33	2	1	1	14	3	8	4
4/4 2003	23	3	2	1	10	2	2	3
1/4 2004	37	4	3	1	21	2	1	5
2/4 2004	17	3	3	1	6	1	1	2
3/4 2004	28	2	4	2	7	4	6	3

By Year	Nuclear+	Terrorism	Weapons	Security	Proliferation	Safety	Energy	Iraq
10/99–9/00	58	2	28	2	8	14	9	1
10/00–9/01	68	4	28	4	11	6	12	2
10/01–9/02	108	22	28	11	22	7	7	11
10/02–9/03	143	9	11	4	69	5	17	28
10/03–9/04	105	12	12	5	44	9	10	13
Total	482	49	107	26	154	41	55	55

The data in this table represent the number of articles in *The Economist* in a given time period that contain the word "nuclear" and in what context.

Table A.9: **'Nuclear' in *The New York Times***

By Quarter	Nuclear+	Terrorism	Weapons	Security	Proliferation	Safety	Energy	Iraq
4/4 1999	533	31	257	197	34	77	114	68
1/4 2000	394	41	167	130	10	52	113	45
2/4 2000	433	21	195	165	17	60	127	48
3/4 2000	446	16	200	179	28	75	152	43
4/4 2000	346	27	116	115	9	48	91	33
1/4 2001	399	17	163	141	20	65	131	61
2/4 2001	414	27	154	128	21	58	164	36
3/4 2001	391	119	169	155	12	46	89	38
4/4 2001	620	381	292	281	23	128	136	75
1/4 2002	440	199	218	179	16	67	143	93
2/4 2002	520	237	225	190	12	97	147	54
3/4 2002	448	185	246	192	25	76	126	181
4/4 2002	617	217	412	295	24	68	195	320
1/4 2003	780	369	493	410	37	126	205	436
2/4 2003	526	220	334	207	28	60	140	274
3/4 2003	490	170	253	197	41	73	165	188
4/4 2003	420	137	226	153	35	41	140	167
1/4 2004	507	183	303	205	75	45	154	204
2/4 2004	362	114	178	147	28	37	111	146
3/4 2004	455	161	249	224	31	52	149	208

By Year	Nuclear+	Terrorism	Weapons	Security	Proliferation	Safety	Energy	Iraq
10/99–9/00	1806	109	819	671	89	264	506	204
10/00–9/01	1550	190	602	539	62	217	475	168
10/01–9/02	2028	1002	981	842	76	368	552	403
10/02–9/03	2413	976	1492	1109	130	327	705	1218
10/03–9/04	1744	595	956	729	169	175	554	725
Total	9541	2872	4850	3890	526	1351	2792	2718

The data in this table represent the number of articles in *The New York Times* in a given time period that contain the word "nuclear" both by itself or in conjunction with the other keywords. For example, from October to December of 2001, there were 23 articles containing both the words "nuclear" and "proliferation".

Table A.10: **'Nuclear' in *The Washington Post***

By Quarter	Nuclear+	Terrorism	Weapons	Security	Proliferation	Safety	Energy	Iraq
4/4 1999	464	29	227	215	42	69	119	38
1/4 2000	355	41	160	161	27	50	109	39
2/4 2000	393	16	173	170	35	49	112	44
3/4 2000	393	22	171	189	26	63	118	47
4/4 2000	277	16	106	104	7	31	70	25
1/4 2001	376	20	138	134	26	66	82	48
2/4 2001	396	25	147	144	37	52	150	36
3/4 2001	403	113	158	180	27	47	104	32
4/4 2001	533	327	243	309	31	90	116	69
1/4 2002	448	161	212	225	25	56	122	87
2/4 2002	511	173	206	235	30	60	119	59
3/4 2002	479	152	253	245	24	49	94	192
4/4 2002	590	160	386	333	39	49	184	327
1/4 2003	705	170	472	392	68	85	169	431
2/4 2003	519	116	333	258	57	41	133	274
3/4 2003	487	107	276	231	46	42	147	209
4/4 2003	434	103	253	232	51	47	136	173
1/4 2004	481	119	284	248	69	51	156	175
2/4 2004	387	91	203	188	47	31	114	143
3/4 2004	385	106	201	215	37	54	124	143

By Year	Nuclear+	Terrorism	Weapons	Security	Proliferation	Safety	Energy	Iraq
10/99–9/00	1605	108	731	735	130	231	458	168
10/00–9/01	1452	174	549	562	97	196	406	141
10/01–9/02	1971	813	914	1014	110	255	451	507
10/02–9/03	2301	553	1467	1214	210	217	633	1241
10/03–9/04	1687	419	941	883	204	183	530	634
Total	9016	2067	4602	4408	751	1082	2478	2591

The data in this table represent the number of articles in *The Washington Post* in a given time period that contain the word "nuclear" both by itself or in conjunction with the other keywords.

Table A.11: **'Nuclear' in *The Wall Street Journal***

By Quarter	Nuclear+	Terrorism	Weapons	Security	Proliferation	Safety	Energy	Iraq
4/4 1999	209	4	66	31	5	16	45	7
1/4 2000	133	2	34	11	3	6	21	3
2/4 2000	161	3	54	27	4	3	44	4
3/4 2000	148	0	47	26	5	7	40	4
4/4 2000	118	3	26	10	1	3	30	2
1/4 2001	152	3	47	24	5	9	29	4
2/4 2001	148	1	28	16	4	8	44	4
3/4 2001	161	22	46	25	6	9	23	11
4/4 2001	249	66	105	41	6	7	16	16
1/4 2002	144	18	55	21	3	3	28	23
2/4 2002	212	32	70	33	8	10	30	17
3/4 2002	172	24	80	31	1	8	30	57
4/4 2002	200	23	107	50	12	7	29	82
1/4 2003	299	17	138	95	16	6	48	127
2/4 2003	256	20	106	54	31	11	44	71
3/4 2003	201	11	75	33	11	5	37	60
4/4 2003	218	16	72	51	13	5	42	48
1/4 2004	189	15	93	34	27	4	36	33
2/4 2004	171	11	49	30	11	1	32	24
3/4 2004	183	20	61	38	12	9	40	30

By Year	Nuclear+	Terrorism	Weapons	Security	Proliferation	Safety	Energy	Iraq
10/99–9/00	651	9	201	95	17	32	150	18
10/00–9/01	579	29	147	75	16	29	126	21
10/01–9/02	777	140	310	126	18	28	104	113
10/02–9/03	956	71	426	232	70	29	158	340
10/03–9/04	761	62	275	153	63	19	150	135
Total	3724	311	1359	681	184	137	688	627

The data in this table represent the number of articles in *The Wall Street Journal* in a given time period that contain the word "nuclear" both by itself or in conjunction with the other keywords.

Table A.12: **'Terrorism' in *Time***

By Quarter	Terrorism+	Biological	Chemical	Dirty Bomb	Nuclear	Nuclear Plant	Chemical Plant	Land-marks	Borders	Crowds/ Gatherings	Govern-ment	Water Supply	Infra-structure	Aircraft
4/4 1999	4	0	0	0	0	0	0	1	0	2	1	0	0	0
1/4 2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/4 2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/4 2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/4 2000	1	0	0	0	0	0	0	0	0	0	1	0	0	0
1/4 2001	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/4 2001	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/4 2001	7	1	1	0	1	0	0	1	0	0	1	1	0	1
4/4 2001	46	18	4	1	5	4	1	1	2	4	1	2	2	1
1/4 2002	14	3	1	0	1	1	0	0	3	1	0	1	0	3
2/4 2002	13	2	0	3	0	2	0	0	1	3	0	1	1	0
3/4 2002	5	1	0	2	0	0	0	1	0	0	0	1	0	0
4/4 2002	9	3	1	2	1	0	0	0	1	0	0	0	1	0
1/4 2003	23	3	4	3	1	4	2	0	2	2	1	0	1	0
2/4 2003	2	0	0	1	0	0	0	0	0	0	0	0	1	0
3/4 2003	5	1	0	1	1	0	0	0	1	0	0	0	1	0
4/4 2003	2	0	0	1	0	0	0	0	0	0	0	0	1	0
1/4 2004	14	1	1	1	1	0	0	1	1	1	0	1	3	3
2/4 2004	1	0	0	0	0	0	0	0	0	0	0	0	1	0
3/4 2004	8	1	0	0	0	0	1	1	1	1	0	1	2	0

By Year	Terrorism+	Biological	Chemical	Dirty Bomb	Nuclear	Nuclear Plant	Chemical Plant	Land-marks	Borders	Crowds/ Gatherings	Govern-ment	Water Supply	Infra-structure	Aircraft
10/99–9/00	4	0	0	0	0	0	0	1	0	2	1	0	0	0
10/00–9/01	8	1	1	0	1	0	0	1	0	0	2	1	0	1
10/01–9/02	78	24	5	6	6	7	1	2	6	8	1	5	3	4
10/02–9/03	39	7	5	7	3	4	2	0	4	2	1	0	4	0
10/03–9/04	25	2	1	2	1	0	1	2	2	2	0	2	7	3
Total	154	34	12	15	11	11	4	6	12	14	5	8	14	8

The data in this table represent the number of articles in *Time* in a given time period that contain the word "terrorism" and in what context.

Table A.13: **'Terrorism' in *Newsweek***

By Quarter	Terrorism+	Biological	Chemical	Dirty Bomb	Nuclear	Nuclear Plant	Chemical Plant	Land-marks	Borders	Crowds/ Gatherings	Govern-ment	Water Supply	Infra-structure	Aircraft
4/4 1999	3	0	0	0	0	0	1	1	0	0	0	0	1	0
1/4 2000	8	1	1	1	1	0	0	1	0	2	0	1	0	0
2/4 2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/4 2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/4 2000	4	1	1	0	1	0	0	0	0	0	1	0	0	0
1/4 2001	2	0	0	1	1	0	0	0	0	0	0	0	0	0
2/4 2001	1	0	0	0	0	0	0	0	0	0	1	0	0	0
3/4 2001	7	1	1	0	0	0	0	1	0	1	1	0	0	2
4/4 2001	24	11	2	3	3	1	0	1	0	1	0	0	0	2
1/4 2002	13	3	2	3	0	1	1	0	0	1	1	0	0	1
2/4 2002	4	1	0	0	0	2	1	0	0	0	0	0	0	0
3/4 2002	7	1	1	0	1	1	0	1	0	0	0	0	1	1
4/4 2002	10	2	1	1	1	1	1	0	1	0	0	0	1	1
1/4 2003	9	2	2	1	0	0	0	0	0	2	1	1	0	0
2/4 2003	7	1	0	1	0	0	1	1	0	0	0	1	2	0
3/4 2003	2	0	0	0	0	0	0	0	1	0	0	0	1	0
4/4 2003	1	1	0	0	0	0	0	0	0	0	0	0	0	0
1/4 2004	8	1	0	0	0	0	0	1	0	1	0	0	2	3
2/4 2004	5	1	1	0	2	0	0	0	0	0	0	0	1	0
3/4 2004	5	0	0	0	1	0	0	1	0	1	1	0	1	0

By Year	Terrorism+	Biological	Chemical	Dirty Bomb	Nuclear	Nuclear Plant	Chemical Plant	Land-marks	Borders	Crowds/ Gatherings	Govern-ment	Water Supply	Infra-structure	Aircraft
10/99–9/00	11	1	1	1	1	0	1	2	0	2	0	1	1	0
10/00–9/01	14	2	2	1	2	0	0	1	0	1	3	0	0	2
10/01–9/02	48	16	5	6	4	5	2	2	0	2	1	0	1	4
10/02–9/03	28	5	3	3	1	1	2	1	2	2	1	2	4	1
10/03–9/04	19	3	1	0	3	0	0	2	0	2	1	0	4	3
Total	120	27	12	11	11	6	5	8	2	9	6	3	10	10

The data in this table represent the number of articles in *Newsweek* in a given time period that contain the word "terrorism" and in what context.

Table A.14: **'Terrorism' in *The Economist***

By Quarter	Terrorism+	Biological	Chemical	Dirty Bomb	Nuclear	Nuclear Plant	Chemical Plant	Land-marks	Borders	Crowds/ Gatherings	Govern-ment	Water Supply	Infra-structure	Aircraft
4/4 1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/4 2000	3	2	1	0	0	0	0	0	0	0	0	0	0	0
2/4 2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/4 2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/4 2000	2	1	0	0	0	0	0	0	0	0	1	0	0	0
1/4 2001	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/4 2001	7	1	1	0	1	0	0	0	0	1	3	0	0	0
3/4 2001	28	2	3	0	1	3	0	2	2	4	3	0	1	7
4/4 2001	49	20	7	2	5	2	1	0	2	0	3	0	2	5
1/4 2002	15	5	2	1	2	1	0	0	2	1	0	1	0	0
2/4 2002	24	5	3	3	7	0	1	0	3	0	0	0	0	2
3/4 2002	13	2	0	1	0	1	1	0	3	1	0	1	1	2
4/4 2002	14	3	2	1	2	1	0	0	0	1	0	1	2	1
1/4 2003	15	4	4	2	1	0	0	0	1	1	0	1	1	0
2/4 2003	7	2	0	0	0	0	0	1	0	1	1	0	1	1
3/4 2003	16	3	1	1	1	0	1	2	1	1	0	1	3	1
4/4 2003	1	0	0	0	0	0	0	0	1	0	0	0	0	0
1/4 2004	20	2	2	1	2	1	0	1	3	1	0	1	2	4
2/4 2004	4	2	1	0	1	0	0	0	0	0	0	0	0	0
3/4 2004	8	0	0	0	0	0	0	1	0	3	2	0	2	0

By Year	Terrorism+	Biological	Chemical	Dirty Bomb	Nuclear	Nuclear Plant	Chemical Plant	Land-marks	Borders	Crowds/ Gatherings	Govern-ment	Water Supply	Infra-structure	Aircraft
10/99–9/00	3	2	1	0	0	0	0	0	0	0	0	0	0	0
10/00–9/01	37	4	4	0	2	3	0	2	2	5	7	0	1	7
10/01–9/02	101	32	12	7	14	4	3	0	10	2	3	2	3	9
10/02–9/03	52	12	7	4	4	1	1	3	2	4	1	3	7	3
10/03–9/04	33	4	3	1	3	1	0	2	4	4	2	1	4	4
Total	226	54	27	12	23	9	4	7	18	15	13	6	15	23

The data in this table represent the number of articles in *The Economist* in a given time period that contain the word "terrorism" and in what context.

Table A.15: **'Terrorism' in *The New York Times***

	Terrorism+	Biological	Chemical	Dirty Bomb	Nuclear	Nuclear Plant	Chemical Plant	Landmarks	Borders
10/99–9/00	745	40	53	0	112	2	0	9	51
10/00–9/01	1905	78	99	0	191	1	2	41	116
10/01–9/02	4450	1089	1089	54	1013	72	9	119	525
10/02–9/03	4431	3560	1487	41	976	65	4	78	318
10/03–9/04	4184	501	556	42	600	14	3	36	246
Total	15715	5268	3284	137	2892	154	18	283	1256

The data in this table represent the number of articles in *The New York Times* in a given time period that contain the word "terrorism" both by itself or in conjunction with the other keywords.

Table A.16: **'Terrorism' in *The Washington Post***

	Terrorism+	Biological	Chemical	Dirty Bomb	Nuclear	Nuclear Plant	Chemical Plant	Landmarks	Borders
10/99–9/00	653	32	44	0	108	0	2	13	137
10/00–9/01	2240	92	116	0	174	0	1	47	282
10/01–9/02	7622	885	939	42	813	22	9	144	984
10/02–9/03	4230	461	555	33	553	7	10	65	493
10/03–9/04	3965	245	297	16	419	3	3	47	429
Total	18710	1715	1951	91	2067	32	25	316	2325

The data in this table represent the number of articles in *The Washington Post* in a given time period that contain the word "terrorism" both by itself or in conjunction with the other keywords.

Table A.17: **'Terrorism' in *The Wall Street Journal***

	Terrorism+	Biological	Chemical	Dirty Bomb	Nuclear	Nuclear Plant	Chemical Plant	Landmarks	Borders
10/99–9/00	168	10	9	0	9	0	0	2	15
10/00–9/01	912	27	35	0	29	1	1	4	57
10/01–9/02	3082	217	222	17	140	5	6	12	153
10/02–9/03	1463	55	72	10	71	1	4	6	64
10/03–9/04	1416	31	33	8	62	3	2	5	59
Total	7041	340	371	35	311	10	13	29	348

The data in this table represent the number of articles in *The Wall Street Journal* in a given time period that contain the word "terrorism" both by itself or in conjunction with the other keywords.

Appendix B

Excerpts from Other Publications

B.1 Excerpts from *Nuclear Fear* by Spencer Weart

B.1.1 On the risk of a catastrophic accident at a nuclear reactor[1, p.336-7]:

In my opinion, this excerpt represents a very succinct and eloquent explanation of the reality of the risks of a catastrophic accident at a nuclear power plant. This contrasts with the public perception of the risk of catastrophic accidents discussed in Chapter 2.

"...Every industry suffers hundreds of minor mishaps each year. A valve would get stuck, an instrument would give a false reading, an operator would make a mistake. By itself one such failure was trivial. But what if two or three of them happened one on top of another? Such coincidences were much less likely than a single failure, of course, but from time to time a valve would stick, an instrument fail, and an operator make a mistake all at once, especially since one problem might provoke the next. Given that there were hundreds of individual failures, such a cluster of failures might be expected to happen a few times a year, and experience with reactors confirmed this. Such incidents were still not enough to melt down a reactor's fuel, but even more elaborate chains of failure could also be expected, if more seldom. That sort of chain could lead to partial melting of the reactor's fuel, as had happened in 1957 at Windscale and in 1966 at Lagoona Beach.

"These possibilities were little noted. Nuclear engineers and their critics continued to focus single-mindedly through the 1970s on the spectacular events of the China Syndrome. Meanwhile the hundreds of little mishaps each year and the occasional double or triple coincidences kept on happening. In 1979 came an elaborate chain of failures, any one of which would have been harmless by itself but which all came together to cause a medium-sized accident: partial melting of the fuel in the Three Mile Island reactor near Middletown, Pennsylvania. Although nobody was injured, the reactor was ruined and the public for many miles around was alarmed almost to the point of panic.

"Later, calculating from the detailed analyses buried in the Rasmussen Report, engineers found that some such accident might have been expected somewhere in the world, with fair probability, before the end of the 1970s. Even back in 1957 members of the WASH-740 study group had predicted that a medium-sized accident could happen within their lifetimes. The exact types of failures that came together to wreck the Three Mile Island reactor had been

occurring at one or another reactor for years without happening all at the same time, but reports on those failures had been overlooked amid the storms of debate over maximum disasters and the blizzard of regulatory paperwork. Taken aback by the Three Mile Island accident, American officials and engineers at last began to pay less attention to imaginary vast catastrophes and more to the real problems of reactor safety.

"The accident could have been worse. A runaway heating explosion was not possible in this type of reactor, but another one or two coincidental failures might have melted the rest of the fuel; there remained the containment shell, but even more coincidences might somehow have breached it, releasing radioactivity to threaten the public. The fact that coincidences had to keep piling up before the worst could happen brought a crucial, poorly understood type of safety.

"Just as hundreds of minor individual failures had been observed for each troublesome incident, and hundreds of those for each serious accident like Windscale or Three Mile Island, so among reactors with containment shells there should be many such cases of partly melted fuel for each great disaster where a still longer chain of failures let a radioactive cloud break into the open. Before such a cloud dispersed it might kill a few hundred people in the vicinity, reaching the level of commonplace disasters like dam failures. Finally – and here the calculation became entirely reliable, for it depended only on weather statistics – there would be hundreds of these ordinary disasters for each one in which the wind was exactly wrong and a radioactive cloud settled on a city to slay tens of thousands. In short, for typical American and Western European reactors, a great many accidents like Three Mile Island could be expected before the first dreadful catastrophe. Long before then the owners would either make reactors more reliable or abandon them, if only because each ruined reactor would cost them billions of dollars."

B.1.2 The 'Legend'[1, p.3-5]:

With the discovery of radiation, people began associating old stories of mad scientists experimenting with electricity and transmutation to nuclear energy. These 'legends' typically involve a wizard or 'mad scientist' probing forbidden secrets for the betterment of humanity, opening a kind of Pandora's Box. When things go out of control, as they always do, supreme destruction is released upon the world and few survivors are left to pick up the pieces and rebuild society. This excerpt is a retelling of these legends in a version that contains a more complete fusion of the main elements of such stories.

"Once there was a man who sought after hidden knowledge. The story says that he hoped to make human civilization more noble, and if there was an ugly, mad streak in him, as in all of us, he controlled it strictly. This man arduously studied not only modern science but also alchemy, and it was after pondering the arcane philosophers' stone that he discovered the most prodigious secret of physics: the release of vast energy from within atoms. He knew at once that this energy would change the world. He feared vast explosions, but at the same time he hoped that atomic energy would save civilization, which he believed was otherwise destined to collapse when its fossil fuels ran out. A vision came to him of white towers rising from gardens, a peaceful and prosperous future city centered upon gleaming atomic power plants.

"Up to here the story is historical fact, but the rest becomes increasingly like a dream.

The man built a shining cylindrical device that could project atomic rays. He was pleased but not surprised to find that, among various remarkable effects, the radiation could cure cancer and other ills. However, in his experiments the rays sometimes did not cure people but gave them cancer, or horribly deformed their flesh, or changed their very genes so that their children were monsters.

"The destructive power of atomic rays might be useful, the man thought, for his nation was under deadly threat from enemies. If he could make an all-powerful weapon, surely nobody would dare to start a war. He went to a laboratory hidden down a shaft deep in the earth, and there he used his rays to construct a weird creature, a sort of living robot armed with irresistible energies.

"In this story there was also a woman who might have been the scientist's lover. He had found little time to court her when all his efforts were going after knowledge and power, but she nevertheless visited his workroom. Just then he had been thinking of a ray that might possibly render living creatures immortal. As the woman approached he aimed a ray device toward her and proposed an experiment; she fled in horror. Rage exploded in the man's overtaxed brain, and he screamed that everyone had abandoned him, leaving him alone in the world. Climbing into a recess in his robotic creature, he rode it to the surface of the earth. But when he emerged his enemies were frightened and attacked him, which automatically activated his weapons. Enormous clouds mushroomed into the sky; radioactive poisons swept the planet. In the ashen landscape lay the robot, blackened and deformed.

"From the underground room where she had taken shelter, the woman emerged. When she tried to lift the ruined creature it cracked apart like a shell and the man crawled out, his madness purged away. The pair joined hands. A new world would rise on the ashes of the old, a purified and wiser race, perhaps with a white city after all..."

"There are some curious things about this legendary tale, which I have constructed as a composite of numberless stories familiar to every citizen of the twentieth century. A close look will show that such tales included divergent and even contradictory ideas. Yet in some odd fashion the ideas fitted neatly together. Still more remarkable, the images were plausible. Atom-powered city, potent ray, strange creature, blasted plain—each could happen. Images so plausible, and also so impressive, might have been expected to exert some kind of influence on the people who made the political, economic, and military decisions that determined the history of nuclear energy.

"The most curious and unsettling thing is that every theme in such tales was already at hand early in the twentieth century, decades before the discovery of nuclear fission showed how to actually release the energy within atoms. The imagery, then, did not come from experience with real bombs and power plants. It came from somewhere else.

"Legends conceal grave truths, but not truths about nuclear physics. Such tales are really about more important matters: the forces of human history, social structure, and psychology."

B.2 *New York Times* article, June 30th, 2002[2]:

This post-September 11th editorial piece revealingly combines Indian Point with many of the other ideas and images discussed in this thesis: nuclear plant safety, terrorism, catastrophic consequences, irrational fear, distrust of authority, comparisons to nuclear war, ineffective attempts to 'do something about it,' etc.

"Nuclear Stockpiling" by Lisa Belkin

I have the pills. At the moment, they are in my kitchen cabinet, where I keep the Tylenol and the Mylanta. I am thinking, though, of moving them to the locked drawer in my bedroom, or maybe even carrying them wherever I go. I will send a supply to camp with the boys, but I haven't yet brought myself to inform the camp nurse. I think that's because I tend to lower my voice when I talk about these pills, as if they were illegal, which they are not, or valuable, which they one day might be, or discomforting, which they definitely are.

They come in blister packs of 14, accompanied by directions that sound like something out of an overly wordy science-fiction film. "Thank you for your order of IOSAT brand of potassium iodide," the leaflet says, explaining that those in the know call it by its scientific shorthand, KI. It's the first FDA-approved "radiation blocking agent" being sold to the general public for protection in an emergency; it prevents the absorption of radioactive material that can cause cancer, particularly in children. "Nuclear plants make tempting targets," it continues. "The destruction of one would spread radiation for hundreds of miles, threatening cancer to anyone without immediate access to KI. Millions of people would need it but would be unable to get it in time."

Odds are I would be one of those millions. The Indian Point nuclear power plant, in Buchanan, N.Y., is about 20 miles from my house, and data from Chernobyl show that a radiation plume can cause thyroid cancer much farther downwind than that. Chernobyl also taught us that potassium iodide, taken just before or shortly after radiation exposure, can sharply decrease the odds of thyroid cancer. (It does nothing to prevent other risks of radiation, but I've chosen not to dwell on that.)

If I lived 10 miles closer to Indian Point the government would have given me my first pill free—one "starter" dose per person, with instructions to swallow it when they give me the go, then get the hell out of town. Instead I paid $14 per person for a two-week supply, assuming I was also buying some emotional comfort.

I was wrong.

What I bought instead was a ticket to a surreal fun house, a cascade of unthinkable thoughts, each leading to another that is even more bizarre. Crossing the line between suppositions and preparation means journeying through some mental portal into a place so absurd it would be funny, but for the fact that it's dead serious, and where everyone would be paranoid, except that the bad guys are really out there.

Take my call to the local pharmacy. When I asked if there was any potassium iodide in stock, the clerk put me on hold and then returned to say he could add me to the waiting list. "Will you be needing them before Thursday?" he asked. Umm. Good question. When will I be needing them? That depends, of course, on when terrorists choose to attack the local nuclear power plant, and they won't call ahead.

"How many packages will you need?" he continued. How many indeed. One each for

my two sons. Two more for my husband and myself. One for the baby sitter. Do I give one to the dog? Is it reaffirming or troubling that, with the specter of nuclear terror looming, I am worrying about Riley? What if there are house guests from out of town? What is the etiquette for a radioactive event? What if the children have friends over who can't get home because the roads are clogged with panicked hordes looking for pills of their own? I ordered seven packets—one each for the four of us plus the baby sitter and two more for whoever else might need it.

Back when I was a child—back when the Russians were expected to blow up my Long Island elementary school, back when we practiced standing in the halls with our fingers laced behind our necks—I saw an episode of "The Twilight Zone". If memory serves, it told the story of a family who had built a nuclear shelter in their yard and ran to it when word came that Russian bombs were falling. The neighbors pounded on the door, demanding safe shelter, but the family would not or could not let all of them in. Guns were drawn, shots were fired and then, as neighbors stood facing down neighbors, word came that it was a false alarm. They all crawled home, knowing what they were capable of.

I want to be able to look my neighbors in the eye. I can't control the doings of Al Qaeda, but I can influence the contents of local medicine cabinets. So I've taken to knocking on doors along my block, chatting up potassium iodide.

"If the world blows up and you don't have any pills, I would feel... conflicted," I confessed, with carefully wrought flippancy, to a friend.

She replied, "If the world blows up, your pills will, too." But I'm fairly certain she has since bought a supply of her own.

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