5. The Challenger launch decision

5.1. Role-play. The challenger launch decision

5.1.1. The accident with the Space Shuttle Challenger

On January 28th 1986, 11:38, Space Shuttle Challenger was launched from the Kennedy Space Centre, Cape Canaveral, Florida. It had a crew of seven persons, among which a school teacher, Christa McAuliffe, who was going to teach from space: hence the nickname of "Teacher in Space mission" for this launch. 73 seconds into the launch there was an enormous explosion; the Challenger disappeared into a cloud, and the remaining pieces fell into the ocean. All seven crew members died.

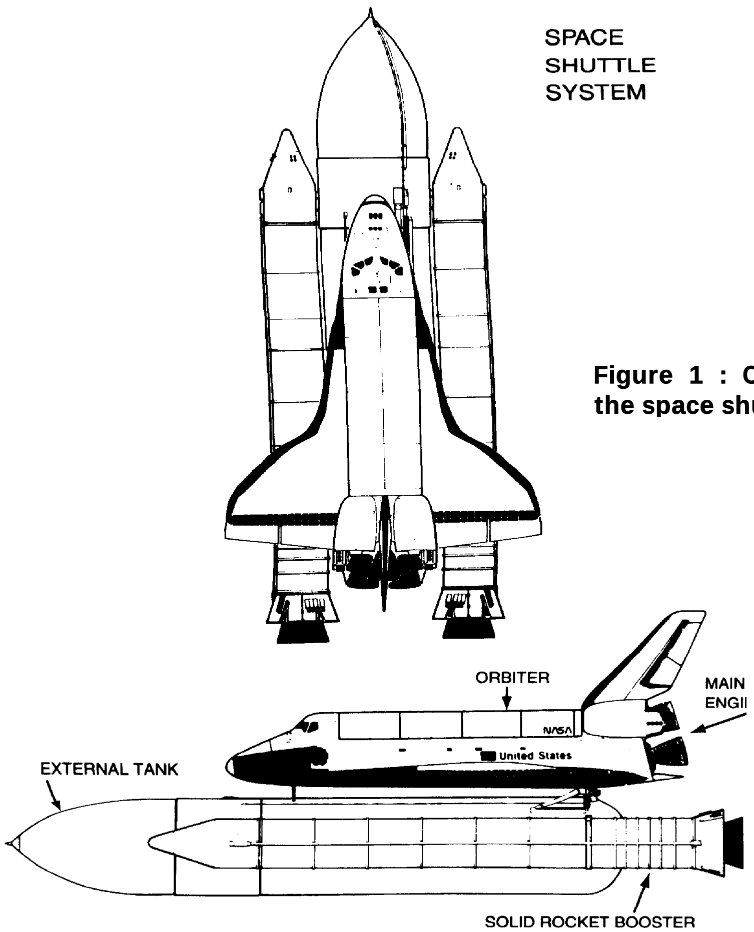

Figure 1 : Configuration of the space shuttle system

The prestigious space shuttle programme of NASA was immediately stopped, and a few days later the then president Ronald Reagan appointed a commission, led by senator William Rogers, with the assignment to research the causes of this disaster. Fairly soon after the accident there was a hypothesis what the cause could have been, in part from an analysis of the available video footage. In this footage it appears that a flame originates in the side of the right Solid Rocket Booster (SRB); it was then assumed that this flame burnt a hole into the external hydrogen tank leading to the explosion.

Soon also internal NASA memoranda came to light from which could be deduced that it had been known for some time that there was a problem with the O-rings sealing the joints between the parts of the SRBs. These SRBs are re-used in the space shuttle concept: when the fuel is spent they fall back to earth and are fished out of the ocean. In order to facilitate transport and re-fuelling, they are taken apart. However, on ignition the pressure difference between in- and outside of the SRB is enormous. The sealing thus has to perform a tough job, and it was known, from studying the seals of used SRBs, that with some regularity there was erosion of the O-rings. Morton Thiokol, the NASA subcontractor that had designed and produced these SRBs and that each time had to make them ready for launch, had even formed a taskforce to deal with the O-ring problem.

Furthermore it became known that on the evening before the launch there had been a teleconference between NASA Marshall Space Centre and Morton Thiokol Engineering in Utah. During this teleconference, Morton Thiokol had initially advised not to launch the shuttle. They were concerned about the behaviour of the O-rings at the extremely low temperatures that were being forecast. At such temperatures, the O-ring material would be harder and less elastic. However, after discussion Morton Thiokol withdrew their negative advice, resulting eventually in the disastrous launch. As soon as this emerged, the focus of the Rogers-commission became mainly concerned with the following question: why was the initial negative advice withdrawn and changed into a positive advice, and what roles were played in this process by the various involved individuals?

After the fact it is, of course, easy to denounce the decision taken in the teleconference as wrong. After all, the launch ended in catastrophe. Consider, however, that no absolute safety is (or even can be) claimed for space flight – as, indeed, for almost any large technological project. In other words, it may well be that the launch decision was very justifiable, and that this accident was imply a case of bad luck. The fact that things went wrong does not necessitate the conclusion that the risk that was taken was unacceptable.

Moreover, the launch decision was taken in a hierarchical organisation, and under political and commercial pressure. This is relevant for two reasons. Firstly, it is never only a technical (factual) question that is at issue: the question, "Is it safe to launch?" is a normative question, and therefore never answerable on purely technical grounds. Secondly – and this is what is emphasised by this role-play – there is a complex network of people that is involved in taking the decision, every one of them with their own competences and responsibilities, and as a consequence, own interests. Is it, in such a situation, exactly clear who is responsible for what? Whatever the answer may be to these questions: as a future engineer you would do well to ask the question, "could I have done a better job in that situation? A lot is to be learnt from this accident by taking this question as point of departure.

The above description of the Challenger disaster is of course not very detailed; in the context of this course we hardly have the time to do much better. Consider, however, that in your future professional practice also you will regularly have to take decisions without full knowledge of all relevant details, or even a full understanding of what all relevant details are. Furthermore, it is not the case that everybody has access to the same information; in part this is due to the hierarchical structure of, and division of labour within, organisations.

5.1.2. The role-play

At the tutorial we conduct the teleconference discussion about the launch advice, in the form of a role-play. Students are invited to crawl into the skin of an individual that was factually involved, and get a detailed description of this individual's position and tasks within the organisation, their worries, priorities and interests, and the information available to them. *Note: this means that (initially at least) not everybody has the same information.* The aim of the exercise is **not** to conduct exactly the same discussion as the one that actually took place, and to reach the same conclusion. Your assignment is to come to the best possible decision regarding a launch advice, within the limits of available information and time, and respecting the formal hierarchical relations between you.

The role-play extends over the following three episodes: (1) the preparation for the teleconference, (2) the teleconference itself, and (3) the aftermath of the teleconference (preceding the planned launch)*. Again, it should be stressed that you should try to abstract from your knowledge of the disastrous consequences of the actual launch.* (Those who want to know what actually took place during the teleconference should consult Diane Vaughan*, The Challenger launch decision: risky technology, culture, and deviance at NASA*, Chicago: 1996, chapter 8.) Not everybody gets a role; there are also impartial observers who will have the opportunity to ask questions about the actions and decisions of those who do have a role. These observers also have to check whether everybody communicates with each other in a way that is consistent with hierarchical structure; in the heat of the exercise it is easily forgotten that one is on a less equal footing than in real life. In order to really learn something from the role-play, and to keep it interesting, it is expected of the participants that they keep to their role and the rules and conditions attached to this role.

Involved individuals:
(In reality there were 34 persons at 3 locations involved in the teleconference, but we have to reduce this number for practical reasons)

<u>In the Marshall Space Centre</u>:
George Hardy, deputy director science and engineering directorate, NASA.
Lawrence Mulloy, manager solid rocket booster project, NASA
Stanley Reinartz, Shuttle projects office manager, NASA

<u>At Morton Thiokol, in Utah:</u>
Joe Kilminster, vice-president, space booster programs
Robert Lund, vice-president engineering
Roger Boisjoly, staff engineer
Arnold Thompson, engineer supervisor.

Each of these individuals receives their own information pack. Use name tags or similar to be able to correctly remember and identify your respective roles.
All those who have not been assigned a particular role are observer. See 1.3 below for your task and preparation.

Moments acted out in the role-play: (between brackets, the available time in the tutorial):

1. **<u>Before the teleconference</u>** *(15 minutes)*

The teleconference was scheduled at the request of Morton Thiokol, in reaction to next day's weather forecast. In what way do Morton Thiokol prepare for the teleconference? What conclusions can or must be drawn from available data? Do they agree in advance on the position they want to take during the teleconference? Consider that the motivation for your position is at least as important as the exact contents of it. The exact contents of a position leading to a negative recommendation for launch may vary; and a position that is in itself reasonable may succumb due to incomplete or plain bad motivation and argumentation.

At Marshall Space Centre as well it is important to assess the available data and conclusions that may be drawn from these data; moreover, it might be helpful to form a hypothesis about what position Morton Thiokol will take. To what extent is it possible, and are NASA willing, to postpone the launch because of a problem with the O-rings in the SRBs? Is NASA's aim to take a monolithic position vis a vis Morton Thiokol?

During this preparation stage you should only talk to people at the same location; you should consult them at length. Who is taking the lead in these preparations? Make a list of points to consider during the teleconference, or write down any argument that you want to present in a couple of lines. If applicable, prepare a visual presentation of your information (e.g. sheets) for the teleconference (this is recommended). Also, consider systematically: what is <u>my</u> responsibility here? What are my interests? What do I stand to gain or lose in each of the possible outcomes of the teleconference and, thereafter, the possible launch?

2. **<u>The teleconference itself</u>** *(max. 45 minutes)*

Be aware that a teleconference is in practical respects very different from a meeting at one location. The sheets, for example, were faxed and could therefore not be pointed at by the person who made them; it may not always be clear who is talking and who is present; and there is a tendency to talk between participants at the same location. Simulate this by sitting at opposite sides of the room. If needed, the teleconference may (as happened in reality as well) be paused in order to have (brief) local discussion. (This may be a good time for a coffee break – however, NASA and Morton Thiokol should not drink coffee together!)

Important matters that should be covered are: what is Morton Thiokol's recommendation, and what are the arguments supporting it? Is there a consensus within Morton Thiokol what the recommendation should be, and are the arguments for it consistent and cogent? Does it become clear what the ins and outs of the technical problem are, and how the seals might behave in case things go less well than perfect? What is NASA's reaction to Thiokol's recommendation? Which party has the burden of proof for the safety of the launch? Is there anybody whose opinion is decisive for which recommendation comes out of this teleconference? If so: who is it, and is it clear to everybody?

3. **<u>After the teleconference: the decision whether or not to launch</u>** *(10 minutes)*

After the teleconference, who are informed about its taking place and its outcome(s)? Is this (and the way things went during the teleconference itself) in accordance with the formal Flight Readiness Review procedure? If there is any doubt or lack of agreement at either Thiokol or NASA about the recommendation given, what does this lead to? Perhaps there are individuals that are inclined to blow the whistle, given the conclusions of the teleconference; what are their possibilities to do so, and how effective do you expect them to be?

This third moment should be distinguished from the **evaluation**, for which everybody abandons their role. Try to formulate common conclusions: Which decisions were taken, why, and (how) are they justifiable? Did the role-play diverge from what happened in reality; if so, why? Did this role-play make you change your mind about whether the actual launch decision was right? Has it become clearer how organisational structures have played a role in taking the decision? How well did the communication go, and have the technical arguments become completely clear? Can anyone be designated as ultimately responsible for the decision taken?

Sources:

Diane Vaughan, *The Challenger Launch Decision: Risky Technology, culture, and deviance at NASA*, Chicago (1996)
http://www.cwru.edu/affil/wwwethics/boisjoly/RB1-0.html

5.1.3. Observers

As interested outsider you don't know a great deal about the ins and outs of the Space Shuttle programme. NASA remains NASA, and the Cold War is still going on, so there is a fair amount of secrecy. It is clear, though, that the Space Shuttles are the pride of the nation. Within 8 years, there have already been 36 launches. With some regularity, launches are postponed, however safety margins in space flight are of a different order than those in public transport. On the other hand, though, tomorrow for the first time there will be a non-professional astronaut on a space flight: Christa McAuliffe, "teacher in space".

Because of some twist of fate you have the opportunity to attend a teleconference between NASA and subcontractor Morton Thiokol (manufacturer of the solid rocket boosters), at the eve of the launch of the "Challenger". It appears that they are worried about the low temperatures that are being forecast, and the behaviour of some kind of seal at these temperatures. Of course you are not expected to take part in the discussions during the teleconference, but should there be any major unclarities – either about technical details, or about anybody's motives – then you can of course pose questions about that.

Information:

- Organisation structure of NASA, and of Morton Thioko, available at Blackboard.

Preparation: study the organisation structure in order to understand where exactly the individuals in this role-play are. Who according to you should be the one deciding what launch recommendation is given after the teleconference?

5.2. The Space Shuttle tragedy and the ethics of engineering

By Steven Goldberg[3]

In the aftermath of the Space Shuttle Challenger accident individual villains were hard to find. Most observers, including the Presidential Commission investigating the matter, criticized instead the process that resulted in a launch despite concerns about O-ring seals that ultimately failed.

But if villains in the Challenger tragedy were scarce, heroes did emerge. They were the engineers at Morton Thiokol who, we were told, "objected to the launching,"[4] but were ignored both by company management highly pendant on the National Aeronautics and Space Administration (NASA) and by NASA officials under outside pressure to launch.[5]

Yet a close examination of the role of one of the most prominent engineer "resisters"[6] in the Space Shuttle case suggests that in fact heroes may be as scarce as villains. That examination, based on the report of the Presidential Commission, reveals an honest, competent engineer performing his work well, but it reveals as well an individual limiting himself strictly to his engineering, careful not to infringe on management prerogatives. In short, we have someone playing to perfection his

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[4] Kruglanski, *Freeze-think and the Clallenger*, 20, PSYCHOLOGY TODAY 48, 49 (1986).
[5] Editorial, *The Challenger Report*, Washington Post, June 10, 1986, at A18.
[6] GIazer & Glazer, *Whistleblolwing*, 20, PSYCHOLOGY TODAY 37 (1986).

assigned role in the decision making process; not a villain to be sure, but not a hero either.

Roger Boisjoly, at the time of the Challenger launch, was a member of the Seal Task Force at Morton Thiokol.[7] Unlike some of the other engineers involved in the decision to launch, Boisjoly did not have management responsibilities.[8] The night before the launch, in a teleconference involving Morton Thiokol and NASA officials, Boisjoly expressed "deep concern,"[9] as he had on previous occasions, about launching at low temperature.[10] The concerns were important because low temperatures were forecast for the next day. Boisjoly argued that at low temperatures, if erosion damaged the primary O-ring seal, "there is a higher probability of no secondary seal capability."[11] Boisjoly conceded that he had no data to quantify his concerns,[12] but initially his arguments led to a Morton Thiokol recommendation during the teleconference that the launch be postponed.[13] After further discussion, Morton Thiokol requested to break off the teleconference for a caucus.[14] At the caucus, Boisjoly continued to press his concerns. Morton Thiokol officials then said "we have to make a management decision."[15] Management, without including non-management personnel such as Boisjoly, reviewed the engineering facts as they knew them, concluded it was "a judgment call and therefore a management decision," and decided to recommend a launch.[16] The teleconference was resumed and NASA was informed that in Morton Thiokol's view if the primary seal did not succeed the secondary seal would and the launch could go forward.[17]

In hindsight, of course, Morton Thiokol's decision was wrong. But at the time, what was Boisjoly's attitude toward being excluded from the management caucus? Was it outrage? Far from it:

> I must emphasize, I had my say, and I never [would] take [away] any management right to take the input of an engineer and then make a decision based upon that input, and I truly believe that. I have worked at lot of companies, and that has been done from time to time, and I truly believe that, and so there was no point in me doing anything any further than I had already attempted to do.
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> I did not see the final version of the chart until the next day. I just heard it read. I left the room feeling badly defeated, but I felt I really did all I could to stop the launch.[18]

There is a name for Boisjoly's approach. It is not heroism, it is separatism: the notion that scientists and engineers should supply the technical inputs, but appropriate management and political organs should make the value decisions.[19]

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[7] Presidential Commission on the Space Shuttle Challenger Accident, Report to the President, Vol. I, pp. 92, 107 (1986). Morton Thiokol, Inc. was the contractor for the shuttle's dolid rocket motor. *Id.* at 9.

[8] Rober Lund, for example, was an engineer who also was a vice president of Morton Thiokol. *Id.* at 92, 93, 107.

[9] *Id.* at 88.

[10] *Id.*

[11] *Id.*

[12] *Id.* at 89.

[13] *Id.* at 89,90

[14] *Id.* at 90.

[15] *Id.* at 93.

[16] *Id.* at 93.

[17] *Id.* at 96.

[18] *Id.* at 93.

[19] The term separatism was used prominently in a 1980 symposium on administrative law. See Yellin, *Sience, Technology and Administrative Government: Institutional Designs for Environmental Decisionmaking*, 92, YALE L.J. 1300, 1309 (1983); Carter, *Separatism ans Skepticism*, 92 YALE L.J. 1334 (1993). The idea of course is much older: much of the literature is discussed and analyzed in McGarity *Substantive and Procedural Discretion in Administrative Resolution of Science Policy Questions: Regulating Carcinogens in EPA ena* OSHA, 67 GEO. L.J. 729 (1979).

I use the term separatism in this piece simply lo refer to the attempt to separate out technical from policy decisions, not to suggest that technical decisions must be made by some new institution such as a science cour. *Cf.* Yellin, supra, at 1307.

Roger Boisjoly was not the only engineer at Morton Thiokol who adopted the separatist approach.

Separatism is the dominant approach today to policy problems of this type, and it is an approach that has been explicitly applied to engineers:

> As a class, engineers have neither the power nor the right to plan social change. If they did, we might be well on our way to George Orwell's 1984. Fortunately, engineers are no more agreed upon how to organize the world than are politicians, novelists, dentists, or philosophers. Should we risk oil spills and increase our reserves by off-shore drilling? Accept the hazards of pesticides in order to feed hungry people? Stop building a dam and thus protect an endangered fish? These are political questions; it is pathetic and a little frightening to see citizens abdicate their responsibilities by assigning them to the realm of engineering ethics.[20]

The Challenger accident is a case where the engineer was more cautious than management, but separatism operates, of course, in both directions. A nuclear engineer might believe that a one in a thousand chance of an accident over forty years of reactor operation is an acceptable risk, but, under the separatist approach, that is not the engineer's decision to make. The question of how much risk is acceptable is not an engineering question.

This is not the place to debate the pros and cons of separatism. It would be unfair, of course, to argue that the Challenger example alone proves that separatism is flawed. Surely engineers, left to their own devices, would sometimes make decisions that proved disastrous. But Boisjoly's experience is a dramatic example of separatism at work, and thus it does raise valid questions about what more, if anything, Boisjoly could have done consistent with the separatist model. As we noted, Boisjoly testified that there "was no point in . . . doing anything any further"[21] once management began its caucus. Is it true, however, that any further action would have run afoul of the idea that technicians should not usurp social judgments?

Separatism has always included the idea that experts can participate in public debates concerning value choices, but they do so as citizens, not experts. Yet surely there are also cases where even a devout separatist would agree that an individual scientist or engineer should speak, as an expert, outside of the usual chain of command. If, for example, an engineer believes his or her technical judgments are being suppressed or distorted, and lives are at risk, few would doubt that a dramatic public statement was justified. Indeed, such a statement would serve the separatist goal of informed public opinion. The issue ultimately becomes one of individual moral choice: to use the currently fashionable parlance, at what point does "whistleblowing"' become justified?

In Boisjoly's case whistleblowing might have included midnight phone calls to national news media or top NASA officials with the stark warning that if the launch took place, critical seals would fail and disaster would follow. Of course that effort might not have stopped the launch, but would it have been morally justified?

On the current record, it is impossible to know. It is unclear whether Boisjoly believed his technical arguments were improperly ignored or whether management simply disagreed with him on a policy matter. In addition, it is unclear to what extent Boisjoly was aware that his concerns were not fully passed along to NASA officials who had to make the final decision on the launch.

Even apart from the specific facts of Boisjoly's case, there are three general problems that hinder efforts to assess when whistleblowing is appropriate for an

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Rober Lund, an engineer and vice president, *see* note 5, *supra*, was skeptical about the launch at first, but when asked by company officials "to take off his engineering hat and put on his management hat." het supported the launch. PRESIDENTIAL COMMISSION, *supra* note 4, at 92-94.

[20] Florman, *Moral Blueprints: On Regulating the Ethics of Engineers*, HARPERS, October 1978, at 30, 32. Samual Florman is a prominent author in the field of engineering and engineering ethics. *See e.g.,* SAMUAL FLORMAN, THE EXISTENTIAL PLEASURES OF ENGINEERING (1976). For criticisms of portions of his work, *see* ROBERT J. BAUM, ETHICS AND ENGINERING CURRICULA 9-10 (1980); MIKE W. MARTIN & ROLAND SCHINZINGER, ETHICS IN ENGINEERING 159-160 (1983).

[21] *See* text accompanying note 15, *supra*.

engineer. First, the applicable ethical and professional standards for engineers working in large enterprises are surprisingly murky. There are difficult questions of professional responsibility when loyalty to an employer comes into conflict with concerns for the public.[22] Engineering, where employment in large corporate or government bureaucracies is the norm, has long been marked by an unclear and poorly-enforced set of professional norms monitored weakly by a fragmented collection of professional societies.[23] While some modern codes of conduct for engineering groups now say that "engineers shall hold paramount the safety, health and welfare of the public,"[24] enforcement of this idea has been extremely limited.[25]

Second, even if whistleblowing is called for, it is unclear what audience the engineer should alert. Most discussions assume, as we have to this point, that the media or bureaucratic higher-ups are the appropriate target. But are those groups always in the best position to assess the information the engineer has to offer? One alternative would be to alert precisely those who will suffer if an accident occurs. Often in engineering that is not realistic, since a large and undefined public will be affected by the proposed bridge or reactor. But if there is a more specifically definable public, why not alert them? The analogy, of course, would be informed consent, and while it is rarely invoked in discussions of engineering ethics,[26] it is worth considering whether the analogy is appropriate where, as here, the "subjects" of the engineer can be identified. In short, a phone call from an engineer to the astronauts themselves might have been the proper channel for whistleblowing here.

The final difficulty that prevents a fair assessment of what a dissenting engineer in the Challenger case might have done is an intensely practical one. Whistleblowers get fired. Put more cautiously, there are inadequate mechanisms in place to protect private sector whistleblowers from retaliatory discharge.[27] Boisjoly himself, who spoke out to the public only after the launch and after complete vindication, was temporarily transferred, perhaps in retaliation.[28] A government whistleblower has said, "If you have God, the law, the press and the facts on your side, you have a 50-50 chance of winning."[29] For an engineer in the private sector, those odds are optimistic.

In short, if Roger Boisjoly had spoken out the night before the launch he would have been a hero, risking everything for the sake of his obligations to others. As it was, he was a capable engineer in a separatist system who at least had the courage to speak out after the fact. An examination of his role reveals separatism at work, without the safety-valve of a workable system for bringing forth suppressed or distorted technical views. Under that system it is predictable that quite often if we do not have heroes we will have disasters.

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[22] This conflict is presented as the initial and central "engineer's dllemma" in STEPHEN H. UNGER. CONTROLLING TECHNOLOGY: ETHICS AND THE RESPONSIBLE ENGINEER 1 (1982). *See generally* MARTIN & SCHINZINGER, supra note 17.

[23] The classic study of the American engineering profession from its origins through the New Deal is EDWIN T. LAYTON, JR., THE REVOLT OF THE ENGINEERS (1971). For more recent developments, *see* BAUM, *supra* note 17, at 8-10.

[24] Kultgen, *The Ideological Use of Profesional Codes*, 1, BUS. & PROFESSIONAL ETHICS J. 57-59 (Spring 1982).

[25] *Id.*

[26] For a notable exception, *see* MARTIN & SCHINZINGER, *supra* note 17, at 59-60; *see also* Long, *Informed Consent and Engineering: An Essay Review*, 3 BUS. & PROFESSIONAL ETHICS J. 59 (Fall 1983).

[27] *See, e.g.,* BAUM, *supra* note 17, at 61-62.

[28] *See e.g.,* Isikoff, *NASA Probes Thiokol's Treatment of Two Engineers*, Washington Post May 14, 1986, at A4.

[29] Glazer & Glazer, *supra* note 3, at 42.