Technology failures were caused by managers not listening to engineers

Sir — I do not agree with Sheila Jasanoff's point in her Millennium Essay "Knowledge élites and class war" about the dangers of technology[1]. Of the three technological disasters mentioned by Jasanoff — Bhopal, Chernobyl and Challenger — the last two (and perhaps even the first) had a common root cause, in that the advice of expert engineers and risk analysts either was not sought or was overruled by management.

In the Challenger case, for example, the 'expert assessments' of the engineers were not incorporated into a proper risk analysis by NASA; engineers' recommendations were overruled by less expert management; and the astronauts were not made aware of the engineers' worries or of the disagreement. (See Richard Feynman's account[2].) NASA management procedures have much improved since then, but not to the extent of having an external expert safety review. In1989, for example, an interagency safety review committee for the Galileo space probe was not informed about concerns expressed by a scientist at a lower level. This disagreement surfaced when the scientist wrote a letter directly to the president.

Chernobyl arose because the design assumed perfect operation. It was the compartmentalization of Soviet society and a politically based management that prevented information about design faults from reaching the operators.

It now seems clear that Bhopal arose from intentional sabotage by a disgruntled employee. Neither Union Carbide management nor the Indian government seems to have required a proper expert safety review of the plant by modern risk-assessment standards. Why, for example, was such an easily sabotaged plant designed and allowed to operate? Why were the operators not trained in the obvious remediation measures? This was a failure of management, not of the experts.

I do agree with Jasanoff that compartmentalizing society is dangerous, but that is becoming less prevalent. The crucial divisions are not those between workers and management or between expert and layperson, but those between management and experts — and between different experts, in societies in which management keeps them apart in order to control them.

The problem is compounded by politicians' refusal to recognize that the knowledge of scientific and technical experts must be at the heart of every scientific and technical decision they make.

There is no simple rule as to what defines an expert. But their role in judicial issues has recently been clarified in three landmark decisions: Daubert[3], Joiner, and Kumho[4]. The first two of these were on admissibility of evidence of causation in medical situations, and the last on causation in engineering.

In Daubert the Supreme Court stated some non-exclusive criteria by which the court may judge the testimony being proffered. Has the theory been tested, or can it be tested? (In other words, is it falsifiable?) Has the theory been peer-reviewed and published? What is the known or potential risk of error? Has the theory been generally accepted in the relevant scientific community? Is the theory based on facts or data of a type reasonably relied upon by experts in the field? And, most importantly, does the testimony have probative value that is greater than, or not outweighed by, a danger of unfair prejudice, confusion of issues, or misleading the jury?

In Kumho the court declared that these criteria apply with greater force to situations in which an expert relies more on experience than on clearly defined theories.

DNA fingerprinting, despite being a relatively new technique, was not successfully challenged during the O. J. Simpson trial — though whether the jury accepted it is, of course, another matter.

It is important to incorporate expert knowledge into societal decisions. But a "conversation between science and society", as suggested by Jasanoff, is a peculiar recommendation. Science is an integral part of society, whether non-scientists like it or not. Some segments of society (including many non-scientists) understand the role science and technology play within society. That is the understanding that should be enhanced.

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1. Jasanoff, S. *Nature* **401,** 531 (1999).
2. Feynman, R. *What Do You Care What People Think? Further Adventures of a Curious Character* (Norton, New York, 1988).
3. Daubert v. Merrell Dow Pharmaceuticals (92-102), 509 U.S. 579 (1993): http://supct. law.cornell.edu/supct/html/92-102.ZS. html.
4. Kumho Tire Co vs Carmichael (97-1709). 131 F.3d 1433, reversed (1998–1999): http://supct.law.cornell.edu/supct/html/97-1709.ZS.html.

No conflict between SLAC and Japan's KEK

Sir — In the News profile on B-factories, my statements and those of others at Stanford Linear Accelerator Center (SLAC) were distorted (*Nature* **403,** 586; 2000). It is damaging to the relationship between our laboratory and the Japanese KEK B-factory, and to me personally, to have my words made to appear competitive and inflammatory when that was not my intention.

Accelerators are complex machines that cannot be expected to operate perfectly as soon as they are turned on — reaching design performance is a process of gradual improvement.

I did say to your reporter that SLAC's machine worked very well in its first months and that everyone was surprised and pleased at how the performance had improved so quickly. I doubt that I used the word "debugging" with reference to this process.

I did not tell your reporter that there was any indication of whether the US or the Japanese experiment was ahead. I do not believe that it is possible to know this at the moment. Both projects have shown significant successes and both need much more work before the important physics results can be obtained.

One point not made in your article is the value of having two projects working on this same physics.

It is not true that only the first measurement will matter. In science, replicability of results is essential, and as a theoretical physicist I will be much more confident in the results if both experiments make similar findings.

On the same page, your reporter makes similar mistakes in commenting on the absence of the Fermilab director from the celebration honouring Burton Richter. The article implies this is because of bad blood; in fact it was simply because the Fermilab director was out of the country for personal matters that could not be rescheduled, a fact that could easily have been checked.

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Colin Macilwain replies — The opening paragraph of my story erred in stating that SLAC was "poised to win" its race with KEK to obtain significant measurements of charge-parity violation, but I stand by the rest of it, which accurately reflects the views of several scientists I interviewed at SLAC. The SLAC researchers believe themselves to be ahead at this early stage.

The director of KEK declined to be interviewed on this matter when I met him at SLAC on 21 January, but my colleague Robert Triendl obtained a response from Japan that confirmed my story's perspective, and was included in it.

Both of the quotes that I attributed to Dr Quinn in my story were accurate: her charges of distortion are not supported by the facts.