than 5,000 slave laborers lost their lives and were buried in the foundations of the canal.

Palchinsky's planning studies for what was to be the world's largest dam and supplier of electricity in Dneprostroi opposed the government's final plan. All of his engineering and humanitarian warnings were ignored, and the dam never met its objectives. Palchinsky was next asked to do a planning study for a complex of blast furnaces and steel finishing mills in Magnitogorsk, designed to be the largest such facility in the world. Again, he called attention to many government engineering and humanitarian shortcomings. These warnings were ignored, and Palchinsky was sent back to Siberia. Slave labor was used to build the steel mill, which never came close to meeting its objectives.

In 1929, on Stalin's orders, Palchinsky was secretly taken from his prison and shot. In secret files uncovered as the result of the *glasnost* policy in Russia in the early 1990s, Palchinsky wrote that no government regime could survive the Bolshevik's inhumanity. He predicted that the Russian government would fall before the end of the 20th century (which it did). During the 1920s, the number of engineers decreased from approximately 10,000 to 7,000, with most simply disappearing. Peter Palchinsky sacrificed his life during this time fighting for the engineering and humanitarian concerns in which he believed.

Loren Graham's *Ghost of the Executed Engineer* portrays Palchinsky as a visionary and prophetic engineer. The ''ghost'' of Palchinsky, Graham suggests, can be seen in the Soviet Union's continued technological mistakes in the 60 years following his death, culminating in the 1986 Chernobyl nuclear disaster and the dissolution of the Soviet Union in 1991.

Ironically, although praising Palchinsky for his integrity, forthrightness, and vision, Graham concludes his book with a mixed verdict:[73]

> It is quite probably that Palchinsky's execution resulted from his refusal, even under torture, to confess to crimes he did not commit. Palchinsky always prided himself on being a rational engineer. One can question whether his final act was rational, but one cannot question its bravery.

Discuss whether it can be rational to be willing to die rather than confess to crimes to which one has not committed. (Those familiar with Plato's *Crito* might compare Palchinsky's situation with that of Socrates, who also gave up his life rather than compromise his integrity.) How much personal sacrifice should one be willing to make to maintain one's professional integrity?

CASE 27

Pinto[74]

In the late 1960s, Ford designed a subcompact, the Pinto, that weighed less than 2,000 pounds and sold for less than $2,000. Anxious to compete with foreign-made subcompacts, Ford brought the car into production in slightly more than 2 years (compared with the usual 3½ years). Given this shorter time frame, styling preceded much of the engineering, thus restricting engineering design more than usual. As a result, it was decided that the best place for the gas tank was between the rear axle and the bumper. The differential housing had exposed bolt heads that could puncture the gas tank if the tank were driven forward against them upon rear impact.

In court, the crash tests were described as follows:[75]

> These prototypes as well as two production Pintos were crash tested by Ford to determine, among other things, the integrity of the fuel system in rear-end accidents. . . . Prototypes struck from the rear with a moving barrier at 21-miles-per-hour caused the fuel tank to be driven forward and to be punctured, causing fuel leakage. . . . A production Pinto crash tested at 21-miles-per-hour into a fixed barrier caused the fuel tank to be torn from the gas tank and the tank to be punctured by a bolt head on the differential housing. In at least one test, spilled fuel entered the driver's compartment.

Ford also tested rear impact when rubber bladders were installed in the tank, as well as when the tank was located above rather than behind the rear axle. Both passed the 20-mile-per-hour rear impact tests.

Although the federal government was pressing to stiffen regulations on gas tank designs, Ford contented that the Pinto met all applicable federal safety

standards at the time. J. C. Echold, director of automotive safety for Ford, issued a study titled ''Fatalities Associated with Crash Induced Fuel Leakage and Fires.''[76] This study claimed that the costs of improving the design ($11 per vehicle) outweighed its social benefits. A memorandum attached to the report described the costs and benefits as follows:

Benefits	
Savings	180 burn deaths, 180 serious burn injuries, 2,100 burned vehicles
Unit cost	$200,000 per death, $67,000 per injury, $700 per vehicle
Total benefits	180 × $200,000 plus
	180 × $67,000 plus
	2100 × $700 = $49.15 million
Costs	
Sales	11 million cars, 1.5 million light trucks
Unit cost	$11 per car, $11 per truck
Total costs	11,000,000 × $11 plus
	1,500,000 × $11 = $137 million

The estimate of the number of deaths, injuries, and damage to vehicles was based on statistical studies. The $200,000 for the loss of a human life was based on an NHTSA study, which estimated social costs of a death as follows:[77]

Component	1971 Costs
Future productivity losses	
Direct	$132,000
Indirect	41,300
Medical costs	
Hospital	700
Other	425
Property damage	1,500
Insurance administration	4,700
Legal and court	3,000
Employer losses	1,000
Victim's pain and suffering	10,000
Funeral	900
Assets (lost consumption)	5,000
Miscellaneous accident cost	200
Total per fatality	$200,725

Discuss the appropriateness of using data such as these in Ford's decision regarding whether or not to make a safety improvement in its engineering design. If you believe this is not appropriate, what would you suggest as an alternative? What responsibilities do you think engineers have in situations like this?

CASE 28

Profits and Professors

A *Wall Street Journal* article reports:

> High-tech launches from universities frequently can't get off the ground without a steady supply of students, who are often the most talented and the most willing to toil around the clock. But intense schedules on the job can keep students from doing their best academic work. And when both student and teacher share a huge financial incentive to make a company a success, some professors might be tempted to look the other way when studies slip or homework gets in the way.[78]

In some instances, the article claims, students seriously consider leaving school before completing their degrees in order devote themselves more fully to work that is financially very attractive.

In 1999, Akamai won the MIT Sloan eCommerce Award for Rookie of the Year, an award to the startup company that seems most likely to dominate its field. The article comments,

> No company has been more closely tied to MIT. The firm has its roots in a research project directed by Mr. Leighton [Computer Systems Engineering professor at MIT] about 3 years ago. Daniel Lewin, one of Mr. Leighton's graduate students, came up with a key idea for how to apply algorithms, or numerical instructions for computers, to Internet congestion problems.[79]

Soon, Mr. Leighton and Mr. Lewin teamed up to form Akamai, hiring 15 undergraduates to help code the algorithms.