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Some Considerations About Engineering Ethics

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Professional paper

Engineers and scientists today bear the responsibility for the quality of life of future generations more than ever before. Engineering is an important and learned profession, which has a direct and vital impact on the quality of life for all people. The decisions and actions of engineers have a profound impact on the world we live in, and society at large. Accordingly, engineers must provide their services on the basis of honesty, impartiality, fairness, and equity, and must be dedicated to the protection of public health, safety, and welfare. Engineering failures are often found to stem from deficiencies in engineering ethics, and engineers are responsible for their actions to the engineering community, to political and societal institutions as well as to their employers, customers, and technology users. Unfortunately, we are frequently witnesses to more and more negative consequences of scientific and technological advances markedly caused by neglect of moral principles in human activities. Engineers have to be aware of ethics in decision-making during their professional practice and they should not think only about profit, because when things go wrong, there is always an ethical dimension.

Nova razmišljanja o inženjerskoj etici

Strukovni članak

U današnje vrijeme inženjeri i znanstvenici nose teret odgovornosti za kvalitetu života budućih generacija više nego ikad prije. Inženjerstvo je važno i učeno zanimanje koje ima izravan i vitalan utjecaj na kvalitetu života svih ljudi. Odluke i aktivnosti inženjera imaju dalekosežan utjecaj na svijet u kojem živimo i na cjelokupno ljudsko društvo. Zbog toga, rad inženjera mora se temeljiti na ispravnosti, nepristranosti, pravednosti i poštenju, te mora biti usmjeren prema zaštiti javnog zdravlja, sigurnosti i opće dobrobiti. Pogreške u inženjerskom radu često su uzrokovane nedostatkom inženjerske etike. Inženjeri za svoj rad odgovaraju inženjerskoj zajednici, političkim i društvenim institucijama, kao i svojim poslodavcima, te kupcima, odnosno korisnicima inženjerskih proizvoda. Nažalost, često smo svjedoci sve negativnijih posljedica znanstvenog i tehnološkog napretka, uzrokovanih zanemarivanjem moralnih načela u ljudskom djelovanju. Inženjeri moraju biti svjesni etike u svom profesionalnom radu i ne smiju imati na umu samo profit, jer kad stvari krenu krivim putem, uvijek je u pitanju etička dimenzija.

Keywords

Codes of ethics
Engineering design
Engineering ethics
Responsibility
Technology

Ključne riječi

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1. Introduction

Ethics is the branch of philosophy dealing with values relating to human conduct, with respect to the rightness and wrongness of certain actions and to the integrity and falsity of the motives and intentions of such actions [1]. Thus, ethics is the study of moral characteristics, and involves the moral choices made by interacting individuals. The term ethics is derived from the Greek word "ethos", meaning "custom", "habit", and "way of living". Virtue, ethics and moral should be deeply rooted in the history, society and culture of human beings. In ancient China when moral values still prevailed, there was only one law for judging a person – virtue (de - in Chinese language). Ancient Chinese people stressed cultivation of one's xinxing (a Chinese idiom for the mind or heart nature, moral character and ethics). A Chinese proverb says, "A man without any virtue is no more than a beast." When a person does not have any virtue left, he is no longer considered worthy of being a human and should have no place in the human society. From this, one can see how highly virtue was regarded in ancient China.

Engineering ethics, as the field of applied ethics, is the application of philosophical and moral systems to the proper judgment and behavior by engineers in conducting their work, including the products and systems they design and the consulting services they provide. Thus, engineering ethics is defined as the rules and standards governing the conduct of engineers in their roles as professionals, and is concerned with determining the standards in engineering ethics and applying them to particular situations. Engineers need to be aware of ethics as they make choices during their professional practice of engineering. The decisions and actions of engineers have a profound impact on the world we live in, and society at large. Modern technology has profound impact on humankind and all life on Earth. Unfortunately we frequently are witnesses to many bad or even tragic consequences of scientific and technological advances markedly caused by neglecting moral principles in people's activities.

In the West, practical and theoretical Greek thought has been the basis of all later systems. Socrates is a personalized version of that tradition, an ideal philosopher and sage. Plato combines the theory of virtue with the theory of the state. He has established a canon of four virtues: wisdom, courage, prudence and righteousness. Plato considered that good served by virtues is acquired by knowledge, and that evil is the consequence of ignorance about what is good. Aristotle made the distinction between theoretical and practical philosophy in which he included ethics. Aristotle was the first to define ethics as an autonomous discipline and separated it from mythology and other theoretical disciplines such as metaphysics, logic, physics and mathematics. Aristotle's approach was to emphasize virtuous living. A good person will make good decisions, so what is important is to become a good person. The basis of morals and ethics in Christianity is the God's Ten Commandments. The Ten Commandments are a list of religious and moral imperatives that, according to the Judeo-Christian tradition, were authored by God and given to Moses on Mount Sinai in the form of two stone tablets. Since ancient era all societies have their codes of ethics and regarded them as being of the utmost importance.

Viewing ethics as core values of human life leaves us with many important questions. Real ethics or the values behind them cannot and should not change with time, although their expression or focus may change. But nowadays we can see that human morality has declined drastically and that the ethical standards in society are very low. Engineering really improves and enriches human life but also endangers it. We have to be aware of the fact that by using available engineering technologies it is possible to provide abundance for all human beings, but also to destroy all life on Earth. Therefore modern engineers have to study and apply ethical codes, doctrines and principles in their professional engineering practice.

2. Using case studies in engineering ethics

Case studies (also called "case histories") are descriptions of real situations that provide a context for engineers and others to explore problems. Case studies typically involve complex issues where there is often no single correct answer - engineers may be asked to select the "best" answer given the situation. A good case study, like a good story, should engage engineers' interest and they should explore and find a case study they are interested in.

Why use case studies? Case studies allow engineers to explore the nature of a problem and circumstances that affect a solution, to learn about others' viewpoints and how they may be taken into account, to define their priorities and make their own decisions to solve the problem, and to predict outcomes and consequences.

2.1. Case 1: The Ford Pinto

In the late 1960's, the Ford Motor Company designed a subcompact, the Pinto (Figure 1), weighing less than 910 kg and selling for less than $2000 [2]. Anxious to compete with foreign-made subcompacts, Ford brought the car into production in a little more than two years, in 1971. The regular time to produce an automobile is 43 months, it took Ford 25.

Figure 1. Ford Pinto [2]

Slika 1. Ford Pinto [2]

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 fuel tank was between the rear axle and the bumper (Figure 2).

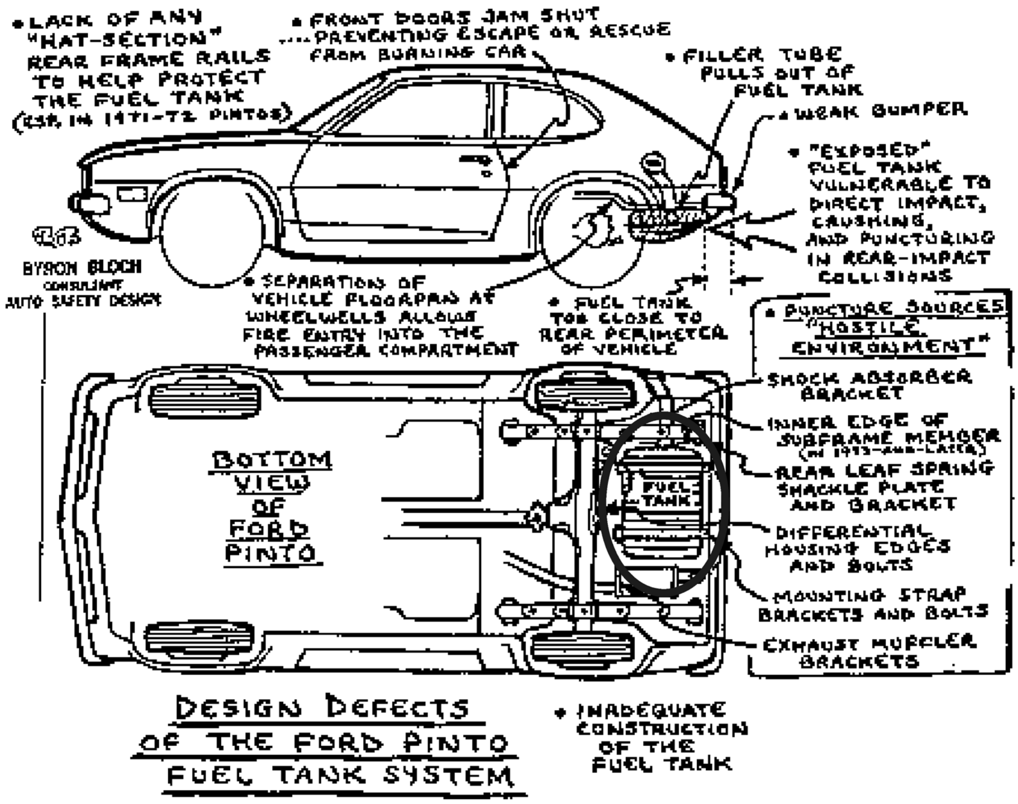

Figure 2. Ford Pinto - design defect of the fuel tank system (inside the ellipse) [2]
Slika 2. Ford Pinto - neispravna konstrukcija rezervoara goriva (unutar elipse) [2]

Before the production, however, Ford engineers discovered a major flaw in the car's design. In nearly all rear-end crash test collisions (at the speed of over 48 km/h) the Pinto's fuel system would rupture extremely easily (Figure 3). The differential housing had exposed bolt heads that could puncture the gas tank if the tank were driven forward against them upon rear impact. Now all that is needed is a spark from a cigarette, ignition, or scraping metal, and both cars would be engulfed in flames. If a Pinto was struck from behind at higher speed of over 65 km/h, its doors would possibly jam shut and its trapped passengers inside would burn to death. Because the assembly-line machinery was already tooled when engineers found this defect, top Ford officials decided to manufacture the car anyway in 1971, even though Ford owned the patent on a much safer fuel tank. A confidential company memo directed that the safety features would not be adopted at that time until required by law.

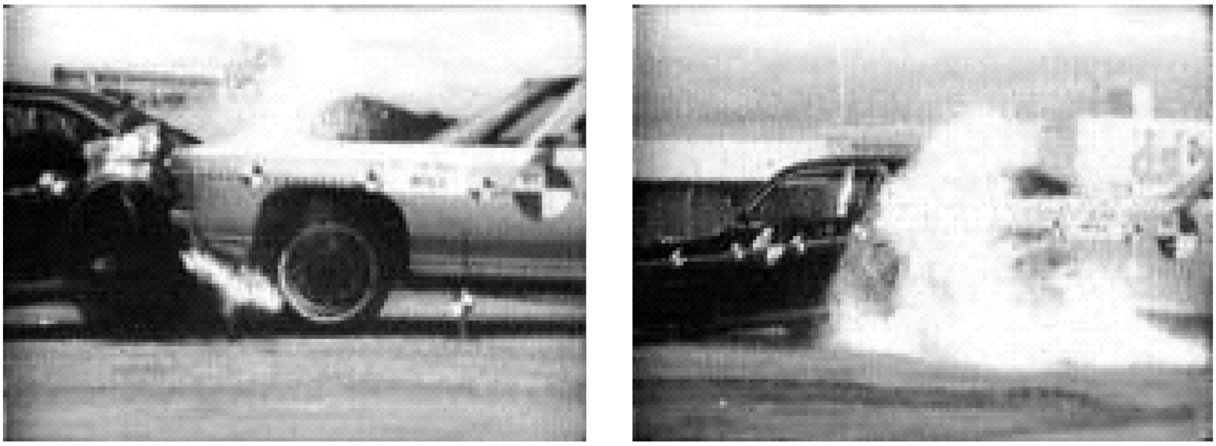

Figure 3. Rear-end crash test collision of the Ford Pinto [2]
Slika 3. Test udara odostraga u Ford Pinto [2]

The best method for improving the safety of the Pinto was to line the gas tank with a rubber bladder, to protect it from rupture. Ford alleged that it would cost $11 per car to add any sort of a fuel tank's fire prevention device. A confidential cost-benefit analysis prepared by Ford (Figure 4) concluded that it was not cost-efficient to add an $11 per car cost in order to correct the flaws. Benefits derived from spending this amount of money were estimated to be $49,5 million. This estimation assumed that each death, which could be avoided, would be worth $200000, that each major burn injury, that could be avoided, would be worth $67000 and that an average repair costs $700 per car involved in a rear-end accident. It further assumed that there would be 2100 burned vehicles, 180 serious burn injuries, and 180 burn deaths in making this calculation. When the unit cost was spread out over the number of cars and light trucks which would be affected by the design change, at a cost of $11 per vehicle, the cost was calculated to be $137,5 million, much greater than the $49,5 million benefit.

BENEFITS & COSTS ANALYSIS

Excerpt: Ford Inter Office Memo, September 18, 1973

BENEFITS		
180 burn deaths	$200,000 per death	$36,000,000
180 serious burn injuries	$67,000 per injury	$12,060,000
2,100 burned vehicles	$700 per vehicle	$1,470,000
		$49.5 Million

COSTS		
11,000,000 cars	$11 per car	$121,000,000
1,500,000 light trucks	$11 per truck	$16,500,000
		$137.5 Million

Figure 4. Confidential internal Ford's benefits & costs analysis

Slika 4. Povjerljiva Fordova interna analiza koristi i troškova

Analyses showed later that the total purchase and installation cost of the bladder would have been $5,08 per car. That $5,08 per car could have saved the lives of several hundred innocent people. Many such victims or their relatives filed civil suits against Ford Motor Company.

The Pinto disasters that were taking place did not go unnoticed by the government. The National Highway Traffic Safety Administration (NHTSA) began investigating the case shortly after the Pintos started rolling off the assembly line. It wasn't until May 1978 that the Department of Transportation (a division of the NHTSA) announced that the Pinto fuel system had a "safety related defect" and demanded a recall. Ford agreed, and on June 9, 1978 the company recalled 1,5 million Pintos. As deaths and injuries continued to occur, Ford stopped producing the Pinto after 1980, having sold about 3 million of the vehicles. By conservative estimates Pinto crashes have caused 500 burn deaths to people who would not have been seriously injured if the car had not burst into flames (Figure 5). The figure could be as high as 900.

Figure 5. Tragic consequences of design defect of the Ford Pinto gas tank [2]

Slika 5. Tragične posljedice neispravne konstrukcije rezervoara goriva Ford Pinta [2]

The Ford Pinto case is a classical ethics issue. If management of the Ford Motor Company really placed marketing considerations above safety, was that objective ethical and are members of management morally responsible for the preventable Pinto fire deaths? In Ford Pinto case, safety is obviously defined as acceptable risk. Although they had the foreknowledge of the hazardous flaw and anticipated the deaths of hundreds of innocent civilians, they still decided that it simply was not profitable to make the cars safer. This is a telling illustration of a corporation's mindset; the ethics and public good is of little concern unless it coincides with profits. Whether or not the Ford Motor Company is in business to make a profit, it should not be in business to kill people.

It seems that profit is the only god on Earth. There is a common saying: "In God we trust", which is the official U.S. national motto. But reality proved many times that: "In profit (i.e. in dollar) we trust". The Ford Pinto case strongly indicates that a clear understanding and application of engineering ethics is of utmost importance.

Not only the management but also the engineers involved in the Pinto's design, were very well aware of the design defect of the fuel tank system, but no one warned the public. Engineers gave in to pressure from superiors to keep quiet about the unsafe cars. But they are also morally responsible for the horrible deaths of so many innocent people. Obviously, loyalty to the Ford Motor Company was for them more important than ethics and moral obligations for the public good. Of course, they were also afraid of losing their jobs and careers, but when ethics issues are concerned, there should be no prerequisites and no fear. People with high ethical standards always have in mind care for other people, society and environment. They do not put themselves in the first place. These are the differences between the ordinary man and the man of high ethical standard and conduct.

2.2. Case 2: The Space Shuttle Challenger

On January 28, 1986, seven astronauts were killed when the space shuttle they were aboard of, the Challenger, exploded just over a minute (73 seconds) into the flight (Figure 6). The failure of the solid rocket booster O-rings to seat properly allowed hot combustion gases to leak from the side of the booster and burn through the external fuel tank. The failure of the O-ring was attributed to several factors, including a faulty design of the solid rocket boosters, insufficient low-temperature testing of the O-ring material and the joints that the O-ring sealed, and a lack of proper communication between different levels of NASA management.

The Space Shuttle Challenger disaster was a preventable tragedy and NASA tried to cover it up by calling it a mysterious accident. However, one man had the courage to bring the real true story to the eyes of the public and it is to Roger Boisjoly to whom we are thankful. Many lessons can be learned from this disaster to help prevent further disasters and to improve on engineering ethics.

Roger Boisjoly [3], the chief O-ring engineer, who worked for Morton Thiokol, the company which manufactured the booster rockets, knew the problems with the O-ring all too well (Figure 7). More than a year earlier he attempted to warn the panel of vice presidents of the inherent dangers involved in the launch. But despite his warnings and anxiety of some others Thiokol engineers and managers, Challenger was launched. The question was: Why, on the eve of the Challenger launch, did NASA managers decide that launching the mission in such low temperatures was an acceptable risk, despite the concerns of their engineers regarding problems with the O-ring? Possible answers could be: urgency due to the competition with Russians to be the first to observe Halley's Comet or some kind of political and/ or economical pressure from the USA government or Congress.

Roger Boisjoly, the Thiokol engineer, testified before the Congress and sued the Morton Thiokol Company under a federal whistleblowing statute, but he lost. Thiokol gave up on a ten million dollar incentive fee, but did not sign a document admitting to legal liability. After all the testimonials Biosjoly was taken off the project and subtly harassed by the Thiokol management. He left the company and underwent therapy for a post-traumatic stress disorder. For his honesty and integrity leading up to and directly following the shuttle disaster, Roger Boisjoly was awarded the Prize for Scientific Freedom and Responsibility by the American Association for the Advancement of Science. Roger Boisjoly now lectures on changing workplace ethics issues, a subject on which he has also spoken at MIT. Boisjoly said that this fatal accident could have been prevented. "The answer to preventing future catastrophes," he said, "lies in engineering ethics". The Challenger case is an excellent example showing that ethical issues involve confronting engineering responsibility against management decision-making.

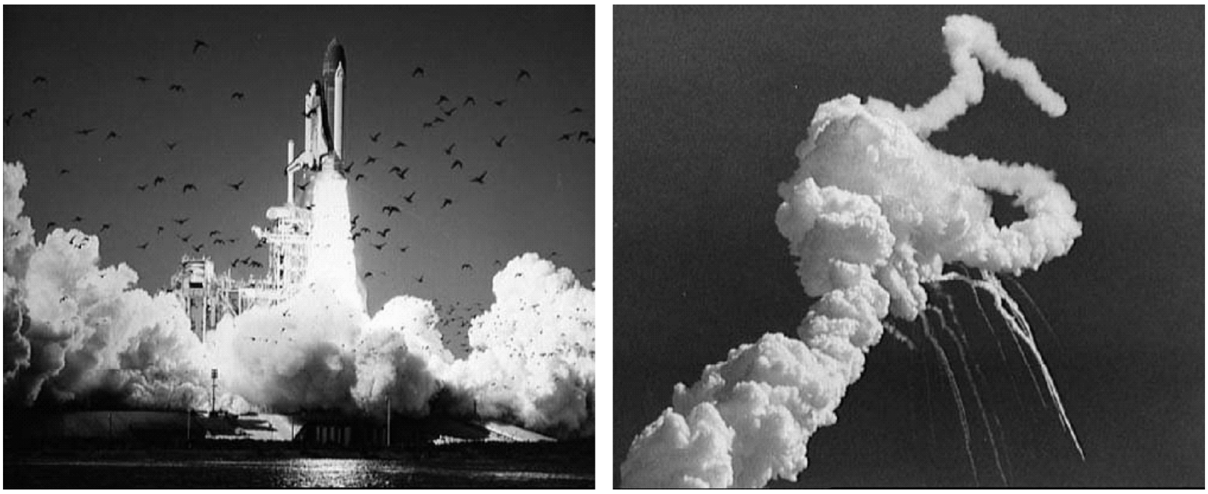

Figure 6. Launch (left) and explosion (right) of the Space Shuttle Challenger [3]

Slika 6. Lansiranje (lijevo) i eksplozija (desno) Space Shuttle Challengera [3]

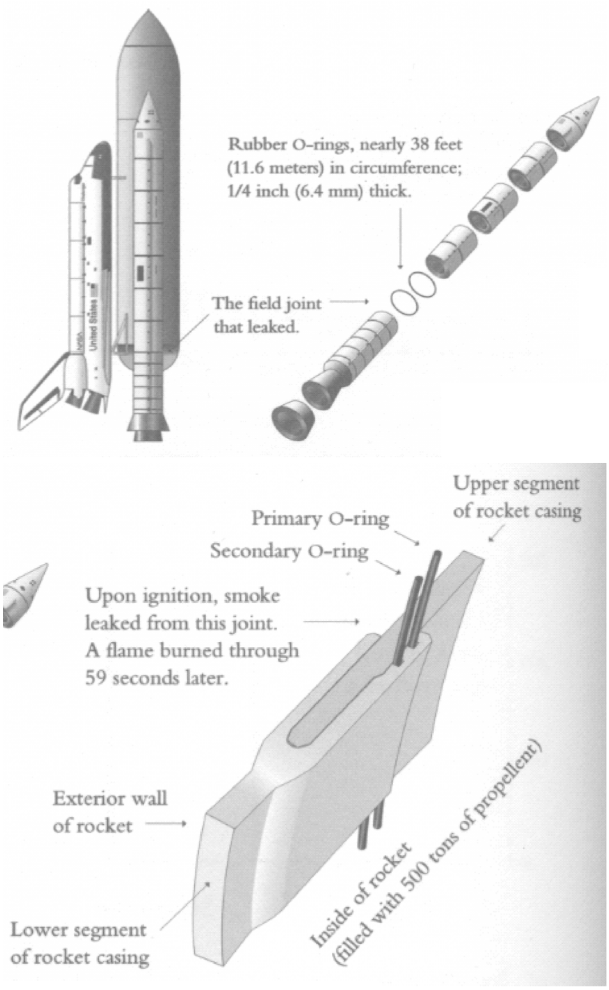

Figure 7. Design of the field joint with rubber O-rings [3]
Slika 7. Konstrukcija spojne plohe s gumenim O-prstenovima [3]

2.3. Case 3: The Space Shuttle Columbia

On January 16, 2003, Space Shuttle *Columbia* takes off on what will be its last mission. NASA engineer Rodney Rocha and others worried that a piece of foam that tore from the shuttle's external propellant tank and struck the left wing 81 seconds after lift-off could have damaged the craft, making it vulnerable to the high heat generated during reentry (Figure 8). But Rocha's superiors refused his request to try to confirm possible damage and that chance was tragically missed. While Columbia was still in orbit Rodney Rocha, who foresaw the accident, desperately tried to sound the alarm about *Columbia*'s potentially damaged condition. But he was ignored by NASA managers, which under pressure to meet launch schedules and cut costs, limited the investigation on the grounds stated that little could be done even if problems were found. Even while the damaged *Columbia* was still in orbit, there was a chance the crew could have been rescued by another shuttle if only the true state of *Columbia's* condition had been known. On February 1, 2003, the Space Shuttle *Columbia*, on its way to its landing site in Florida, blew apart in the skies of East Texas. Its seven-member crew perished. The $2 billion ship was lost; some destruction occurred on the ground, and considerable cost was incurred to recover debris scattered over several states. The Space Shuttle program was set back over two years by the disaster, a delay comparable only to that resulting from the Challenger disaster.

The loss of *Columbia* was a result of damage sustained during launch when a piece of foam insulation the size of a small briefcase broke off the Space Shuttle external tank (the main propellant tank) under the aerodynamic forces of launch. The debris struck the leading edge of the left wing, damaging the Shuttle's thermal protection system, which protects it from heat generated with the atmosphere during re-entry. As demonstrated by ground experiments conducted by the Columbia Accident Investigation Board, this likely created a 15 to 25 cm diameter hole, allowing hot gases to enter the left wing when Columbia later reentered the atmosphere and causing the disintegration of the left wing and then the Shuttle, just as Rodney Rocha predicted.

In both Space Shuttle cases individual engineers played significant similar ethical roles trying to prevent the accidents (Roger Boisjoly in the case of Challenger, Rodney Rocha in the case of Columbia), but without success, because unfortunately profit is usually above the concern for the human life and public good [4].

2.4. Case 4: McDonnell Douglas DC-10 plane

On June 12, 1972 American Airlines Flight 96 DC-10 left Detroit with 67 passengers. After reaching 3658 meters over town of Windsor in Canada, Ontario province, the bulk aft cargo door blew off, collapsing the floor and disrupting all hydraulic controls to tail section (Figure 9). Fortunately the pilot, Captain McCormick, had trained on a simulator how to handle loss of control over the rear engine and wings, and he was able to land the plane safely in Detroit. It was now clear that there was a problem. The problem was first recognized in August 1969. The same thing had also happened in a ground test in 1970.

There were several errors in the design of the fuselage for this plane: the bulk aft cargo door had to be secured from the outside, and there was no way for those inside the plane to check that this had been done correctly. If it was not done correctly, the door could blow out during flight. Once this happened, the cargo hold would depressurize. The passenger compartment would remain pressurized, so there would be an immense differential pressure on the passenger floor. The floor would collapse, rupturing the hydraulic control lines to the rear engine and control surfaces on the rear wings. The plane would then most probably crash.

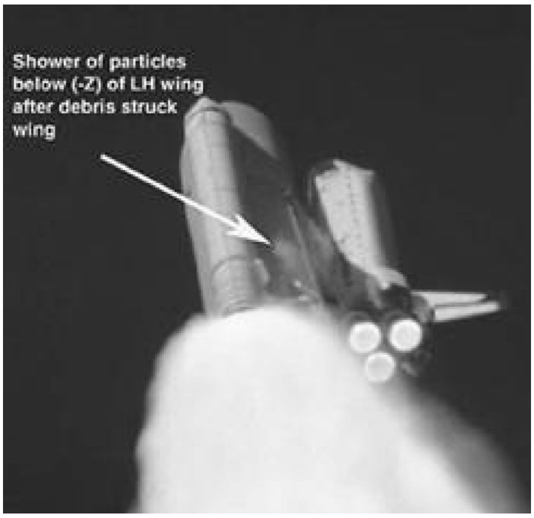

Figure 8. The Space Shuttle Columbia's last launch (arrow points the cause of damage of the left wing) [4]

Slika 8. Posljednje lansiranje Space Shuttle Columbije (strelica pokazuje uzrok oštećenja lijevoga krila) [4]

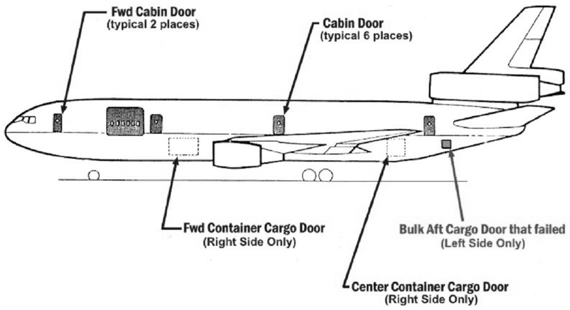

Figure 9. Position of the DC-10 plane's bulk aft cargo door that failed [5]

Slika 9. Pozicija stražnjih vrata za teret avionu DC-10 koja su zakazala [5]

Daniel Applegate, the director of project engineering at Convair, the company that designed the fuselage, wrote a memo to his supervisors detailing potential problems of cargo door, saying "It seems to me inevitable that, in the twenty years ahead of us, DC-10 cargo doors will come open, and I expect this to usually result in the loss of the plane."

After the Detroit near-disaster, NTSB (National Transportation Safety Board) investigation revealed several problems and recommended immediate design changes. FAA (Federal Aviation Administration) did not follow NTSB recommendations. FAA director John Shaffer and McDonnell Douglas President Jackson McGowan reached a gentleman's agreement to voluntarily fix the problem, but no further official action was taken.

In July 1972, three inspectors at Long Beach plant certified that DC-10 plane no. 29 (Ship 29) had been modified to fix problems. Each affixed a stamp to the Ship's paperwork confirming the modifications. The modifications, in fact, had not been made.

The only change made to the aircraft was to install a one inch peephole overlooking the locking pins. It would have been possible to provide further protection, by, for example, installing vents between the cargo hold and the passenger compartment so that the pressure differential would equalize before crushing the floor, but this would have involved major design changes.

On March 3, 1974, Turkish Airlines DC-10 (just the one previously mentioned as plane no. 29, i.e. Ship 29) took off from Paris. At the height of 3658 meters the bulk aft cargo door blew out and all 346 people on board were killed, including 12 crew members.

In Aircraft Accident Report [5] it is stated that the accident of the Turkish Airlines DC-10 was the result of the ejection in flight of the aft cargo door on the left-hand side (Figure 9 and 10). The sudden depressurization which followed led to the disruption of the floor structure, causing six passengers and parts of the aircraft to be ejected, rendering no. 2 engine inoperative and impairing the flight controls (tail surfaces) so that it was impossible for the crew to regain control of the aircraft. The underlying factor in the sequence of events leading to the accident was the incorrect engagement of the door latching mechanism before take-off due to the characteristics of the design of the mechanism and the absence of any visual inspection, through the viewport to verify that the lock pins were effectively engaged. It should be noted, however that a view port was provided so that there could be a visual check of the engagement of the lock pins, although at the time of the accident inspection was rendered difficult by the inadequate diameter of the view port. Finally in the report it is concluded that all these risks had already become evident earlier, at the time of the Windsor accident (on June 12, 1972), but no efficacious corrective action had followed.

The question is why the needed changes to ensure safety were not made earlier. McDonnell Douglas, the manufacturer of the aircraft, was in a time-critical situation: they needed to get the DC-10 onto the market before its rival, the Lockheed Tri-Star. Convair, the engineering company that McDonnell Douglas had subcontracted to do the fuselage design, was unwilling to argue too strongly that the problem needed to be fixed, since they would almost certainly be held to blame for the existence of the problem - and could expect to be stuck with the million-dollar costs of the design changes, such as: fitting a support plate on the door, installing a big enough window in the door so that a ground-crew member could clearly tell if the latch hooks were properly engaged and posting locking instructions clearly in English. Tragically, as French investigators discovered, the ground crewman who sealed the door on the Turkish Airlines craft could not read!

Engineers pressed the matter through normal channels to the highest levels within both companies, but did not take it any further. Standard operating procedure at McDonnell Douglas and Convair was for engineers to defer to upper management, even though they were aware of serious design flaws. Were the engineers negligent? What about the three (obviously corrupted) inspectors who false certified that changes had been made? What responsibility rests with the ground crew members who actually closed and latched the door? Were these people negligent?

This DC-10 bulk aft cargo door case is another example of unethical behaviour, where profit was above the concern for the human life. This is another illustration of a corporation's mindset where the ethics and public good is of little concern unless it coincides with profits.

3. Importance of engineering ethics in contemporary society

Engineers often face the dilemma of loyalty to their company and employer versus their responsibility to the society and environment. The dilemma is whether a product presents an enormous hazard, whether engineers have a duty through their individual consciousness to make the problem public or whether they have to protect their company.

The question is, whether it is enough to act according to technical standards and canons. The answer is that they cannot cover the whole field of engineering design and responsibility. Engineers should not have a profit in mind in the first place. They always have to strive to design products that are, not only profitable, but also user-friendly and safe to a customer and environment [6]. They should take into account environmental aspects and safety of their design, i.e. possible pollution and necessity of product's recycling. When a new technology is introduced, its potential unintended consequences are unknown until decades later. Engineers should be committed to improving the environment to enhance the quality of life and to sustain the balance in nature. They shall hold the safety, health and welfare of the public as the paramount and shall strive to comply with the principles of sustainable development [7]. Engineers also have a responsibility to share technical knowledge and professional development, not only with younger members and colleagues but also with the public.

Engineers have obligations to future generations that could be harmed by irresponsible engineering activities, because it may take decades and generations for products and facilities to have adverse effects. Engineers who draw attention to problems against the wishes of their superiors are known as whistleblowers. They can expect that being a whistleblower will have serious

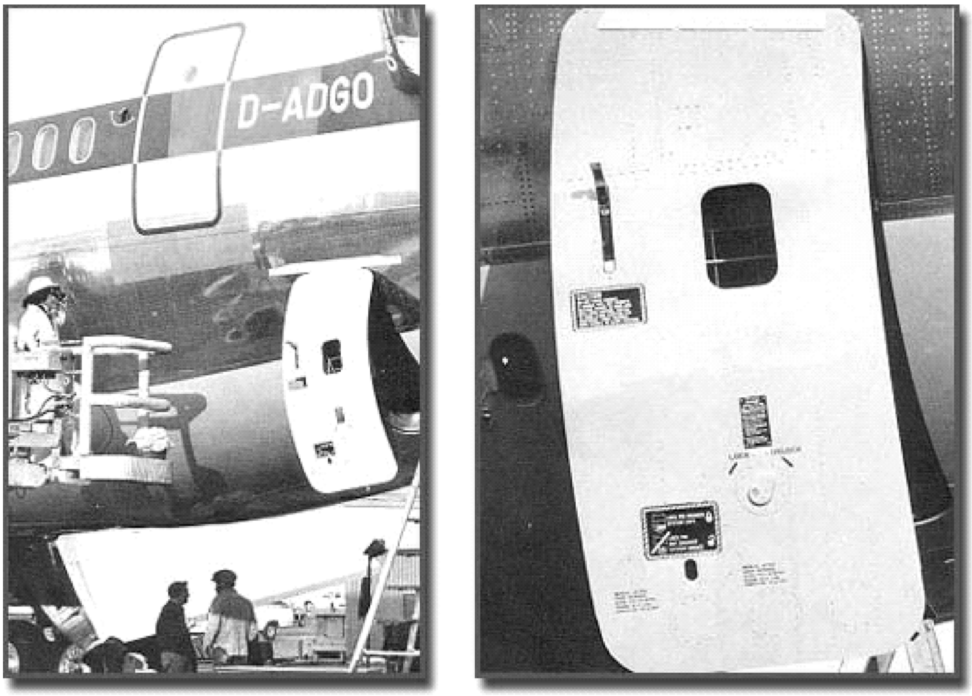

Figure 10. Turkish Airlines DC-10 bulk aft cargo door [5]

Slika 10. Stražnja vrata za teret na avionu DC-10, avio-prijevoznika Turkish Airlines [5] consequences for their job, and perhaps for the rest of their career - even when the problem they are drawing attention to is real and important. But if an engineer's superior, manager or colleague does not act to undo, curb or mitigate dangers of serious personal or social damage, it is necessary to offer honest criticism or even "blow the whistle", so as to reduce the risk, to acknowledge and correct errors, violations or negative consequences as much as possible.

Engineers should always, in their engineering practice, ask themselves: Who will be affected by my decision? What general rules or principles underlie my decision? What are the implications of my decision for the Company and the public? What does my decision say about my moral values? (We all know people who say one thing and do another.)

It is necessary here to point out how ancient people practically applied ethics, for example in the Hammurabi Code in Babylon, 1758 B.C.: "If a builder has built a house for a man and has not made his work sound, and the house he has built has fallen down and so caused the death of the householder, that builder shall be put to death. If it causes the death of the householder's son, they shall put the builder's son to death ..." Maybe Hammurabi Code seems cruel in our contemporary society, but the cruel truth is that, although great changes have taken place in human society, today's human morality has declined drastically, ethical standards in society are very low and profits have become the sole motivation.

Engineers should not act using immoral and unethical rules and laws. They should not be bribed and corruptible. Engineers should always keep in mind the moral responsibility and obligations toward society as a whole. Their professional ethical standards have to transcend commonly accepted morality. An engineer of the high ethic behaviour should always be truthful, benevolent and tolerant. Ancient Chinese people summarized all these highest virtues in three Chinese words: Zhen (truth, truthfulness), Shan (kindness, benevolence, compassion) and Ren (endurance, forbearance, tolerance) [8].

Engineers of high ethical standards should not be involved in design of weapons for mass destruction i.e. chemical, nuclear and biological weapons. They also should not be involved in so called researches, which are in reality paid by various companies to advertise their products.

Engineering ethics is of the utmost importance for society as a whole. It is necessary to teach ethics in engineering education. Engineering ethics is one of the most important concepts engineering students must become familiar with. Students have to study the basis of ethics, i.e. philosophy, and history of ethics as well as contemporary engineering ethical canons and codes. Engineering ethics could be classified as microethics and macroethics. Microethics is concerned with ethical decision making by individuals and the internal relations of the engineering profession. Macroethics refers to the collective social responsibility of the engineering profession and to societal decisions about technology. Students should discuss the canons of ethics for engineers and general standards or principles by which the engineering profession is judged. Students have to recognize the importance of ethical and professional standards of conduct and the sociological and cultural context of the engineering profession [9].

If engineers will not respect ethics in their profession, it will directly affect the quality of life on Earth, i.e. bring more environmental pollution, affect welfare of humankind as well as the future of our children and the future of our unique home in the universe, our blue planet, the Earth.

4. Conclusion

Engineers have to be aware of ethics as they make choices during their professional practice and they should not think only about profit [10]. Therefore, a clear understanding and application of engineering ethics, especially in transport of people as well as various material goods (which includes environmental ethics) is needed like never before. It is of utmost importance to teach ethics in engineering education, because students have to recognize the importance of their ethical and professional standards of conduct. Engineers must perform under a standard of professional behavior that requires adherence to the highest principles of ethical conduct including honesty, impartiality, fairness, and equity, and do so in the absence of bribe and corruption [11]. They should also contribute to environmental protection and to sustaining the balance in nature. To be an engineer of a high quality one has to study, not only engineering, but also ethics and philosophy in order to understand relationships between man, nature and the universe and thus to become a humanist who respects, protects and welcomes all life on Earth.

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