

Introduction

The DC-10 case is a complex story of persons, machines, accidents, laws, policies, organizations, and institutions. An acquaintance with the major features of that story is essential for an ethical evaluation of key policies and actions. This introduction provides an outline of the events and issues in the case and brief descriptions of the articles.

The selections that follow develop specific parts of the story in more detail or examine the ethical responsibilities of individuals, corporations, and the Federal Aviation Administration (FAA). The former selections include excerpts from government investigations of DC10 crashes, and studies of the DC-10 and of the aviation industry. Each develops an important part of the story, describing accidents, DC-10 design features, policies, decisions, and events. The latter include articles on the professional and moral responsibilities of engineers, whistleblowing and ethical obligation, and critiques of the FAA and the aviation industry. Together they provide the material needed for a detailed ethical analysis of the DC-10 case.

HISTORY AND EARLY WARNINGS

The history of the aviation industry really begins with the establishment of the U.S. Air Mail Service in the early 1920s. Companies were established to provide mail service and many of them grew into today's airlines. Federal regulation of safety also began in that period, and its structure and orientation reflect the historical events that shaped the industry and its regulation. "Regulatory and Institutional Framework" traces the history of federal regulation of air safety and outlines some of the ongoing concerns about its ability to carry out its responsibilities.

The Douglas Aircraft Company was the leading U.S. aircraft

manufacturer for many years, but it was late in making the transition from propeller to jet aircraft, allowing Boeing to take the lead first with its 707 and later with the popular 727. In an attempt to attract buyers, Douglas offered many customized versions of its DC-8 and DC-9 jet aircraft. This customizing of the production process caused problems which were compounded by shortages of technically proficient employees and critical materials during the Vietnam war. In 1967 Douglas was experiencing severe financial difficulties and was purchased by the McDonnell Corporation, a manufacturer of military aircraft based in St. Louis. Douglas became a division of McDonnell Douglas.

Still trying to catch up with Boeing, the new company belatedly entered the jumbo jet market, where Boeing again held the lead with its highly successful 747. McDonnell Douglas found itself in a cruel race for second place with Lockheed, which was re-entering the commercial market with a similar wide-body jet with three engines. Because the market at that time would not support three manufacturers of jumbo jets, there would be no third place. Thus the DC-10 began its existence in an atmosphere of change and urgency.

In the aircraft business the financial risks and corresponding stresses are very high. The commitment to build a plane like the DC-10 requires virtually all of the company's net worth: they call it "betting the company." Lockheed lost \$2.5 billion before it stopped making its jumbo jet, the L-101 1, and withdrew entirely from the commercial aircraft business. Boeing, in the words of one of its managers, was a "gnat's whisker" away from bankruptcy at one point in the development of its famous 747. Douglas has not yet reached the break-even point for its DC-10, and may never do so. When survival cannot be taken for granted, the pressures on individuals, corporations, and oversight agencies are immense and pervasive. All are aware of playing in a high-stakes game and respond accordingly. John Newhouse describes this dimension of the aircraft business in "High Risks, Sinking Fortunes."

Even before the DC-10 had its first test flight, there were warnings of design problems that would later claim many lives. The first DC-10 produced (Ship 1) was being tested on the ground in 1970 when the forward cargo door blew open, causing part of the floor in the passenger cabin to collapse. Because the floors of jumbo jets are designed to function with roughly equal air pressure from the passenger cabin above and the cargo hold below, sudden depressurization of either (which would result from a door opening) will cause the

floor to buckle. Control systems that actuate movements of flying surfaces run through the floor, and any damage to it threatens the pilot's ability to fly the aircraft. John Fielder's chapter, "Floors, Doors, Latches, and Locks," explains the design of the floor and the cargo doors of the DC-10 and shows why the airplane was especially vulnerable to loss of control resulting from inadvertent opening of the cargo door in flight.

The discovery of this weakness in 1970 led to revisions of the cargo doors and created a financial and design dispute between Convair, a subcontractor, and McDonnell Douglas over what changes should be made and who should pay for them. "The 1970 Ground Testing Incident" details the concerns of individuals in the Convair organization about the door and how the legal relationships among McDonnell Douglas, Convair, and the FAA complicated their response to this difficulty. Although the problem was being addressed by the manufacturers, a complex network of financial, technical, and legal considerations made effective action more difficult.

A number of ethical issues emerge here concerning the policies of the FAA. Before an aircraft can receive a certificate of airworthiness, its legal right to be flown, it must undergo many inspections, tests, and analyses. For financial and proprietary reasons, most of those inspections are done by the manufacturer's employees called "designated engineering representatives" (DERs). They make inspections for the FAA on their own aircraft, a clear conflict of interest. Many persons have claimed that this arrangement and other FAA policies are ethically doubtful if not unacceptable.

In June 1972, less than a month after the DC-10 had been put into service, American Airlines Flight 96 out of Detroit suffered loss of a rear cargo door over Windsor, Ontario. Because the plane was only lightly loaded (only 67 passengers and crew in an airplane that can hold 350), there was only a partial collapse of the floor. Some control lines running through it were rendered inoperable, but owing to the skill of the pilot, the damaged aircraft was brought down in a harrowing but safe landing. "National Transportation Safety Board Report on the Windsor Incident" analyzes the control system damage and reveals how the design changes initiated after the 1970 ground test accident were inadequate to protect the aircraft. It also suggests that the DC-10 should not have been certificated with a control system that could be disabled by the loss of a door. Critics believe that the FAA did not meet its ethical obligation to make sure that the DC-10 was adequately safe.

Shortly after the Windsor incident, Dan Applegate, director of product engineering for Convair's part of the DC-10 project, wrote a memo which clearly set out the design faults of the cargo door latch and lock system and urged his superior to take action. It is one of the most powerful documents in this case study, clearly describing his grave doubts about the safety of the aircraft. Applegate's immediate superiors, J. B. Hurt and M. C. Curtis, decided not to act on Applegate's recommendation about a solution to the problem with the cargo door. When Hurt received Applegate's memo, McDonnell Douglas and its subcontractor Convair were already disputing over who should pay for earlier fixes to the plane. By contract, Convair was forbidden from contacting the FAA directly about problems with the aircraft. The only legal option open to them was to recommend a better fix of the problem to McDonnell Douglas. Hurt and Curtis may have felt that Convair's recommendation of a radical fix to Douglas might lead to Convair being held liable for paying for that alteration. For whatever reason, they failed to act on Applegate's memo and he apparently accepted their decision and did not pursue the matter. Applegate's memorandum and Convair's response to it are described in "The Applegate Memorandum," which further explains why neither Dan Applegate nor Convair took action in response to this remarkable document. Whether they were ethically obligated to take this matter further is one of the central questions in the DC-10 case.

When there is a safety problem with an airplane, the FAA typically issues an airworthiness directive (AD), which requires corrective action to be taken on the aircraft within a specific time. Airworthiness directives have the force of law; they must be carried out in order to continue legal operation of the plane. They are also public documents, and issuance of a major AD after Windsor would have been an embarrassment to McDonnell Douglas, who was actively seeking buyers for its new DC-10. John Shaffer, head of the FAA, and Jackson McGowen, President of the Douglas Division of McDonnell Douglas, reached a "gentleman's agreement" that the plane would be fixed by service bulletins to the airlines issued by McDonnell Douglas. "Fat, Dumb, and Happy: The Failure of the FAA" traces the events that led to this solution and its consequences. Shaffer has been criticized for failing to issue an AD at this time. But it can be argued that Shaffer was conscientiously carrying out the objectives of the FAA charter, which requires that the FAA both promote the aviation industry and provide for its safety. This is an obvious source of conflict, and many believe that it is ethically unac-

ceptable to have an institution with these two roles.

The use of service bulletins to fix the cargo door did not generate rapid compliance throughout the airline industry. "Compliance with service Bulletin SB 52-37" shows that many aircraft were not modified until the following year, and one had still not received any changes when the 1974 Paris crash occurred. Congressional investigators were also critical of the gentleman's agreement, as "Conclusions of the U.S. Senate Oversight Hearings and Investigation of the DC-10 Aircraft" reveals.

THE 1974 PARIS CRASH

The modifications required in the service bulletins issued after the Windsor incident were not all carried out on Ship 29, which was still in McDonnell Douglas's possession. Forged or mistaken records exist to show that the required modifications were made, but in fact only one was completed, the addition a small viewing port to allow visual inspection of a lock pin. Ship 29 was later sold to Turkish Airlines, Turk Hava Yollari (THY), with only a partially modified rear cargo door. In March, 1974, it crashed outside of Paris, killing all 346 people on board. Investigators found six bodies and the rear cargo door several miles from the crash site. It was a virtual repeat of the Windsor incident, only this time with a fully loaded aircraft. "The French Report on the 1974 Paris Crash" provides chilling details of Ship 29's last flight.

Following the crash, the FAA issued an airworthiness directive to inspect the DC-10 fleet and make sure that modifications to the cargo door set out in earlier service bulletins had been carried out. A year later another AD required that the floors of all jumbo jets be able to withstand a sudden opening in the hull of 20 square feet (the rear cargo door is 14.5 square feet). Manufacturers met this requirement through a combination of stronger floors and the addition of pressure relief vents in the floors, which would allow excess air pressure to flow through the floor without causing it to collapse.

The Paris crash raises a host of ethical and professional issues. Applegate, Hurt, and Curtis all knew of the door problem and could have contacted McDonnell Douglas about it. Should these three individuals bear any of the ethical responsibility for the subsequent crash near Paris and the loss of 346 lives? Does Applegate have a special responsibility for the crash because, as an engineer, he was in the best position to understand the technical problems involved?

Since Hurt and Curtis were acting as agents of Convair, does the company bear any responsibility for the Paris crash?

Did Dan Applegate live up to his professional and ethical responsibilities in connection with the DC-10? In his chapter, "Engineers Who Kill: Professional Ethics and the Paramountcy of Public Safety," Kenneth Kipnis argues that professionalism involves more than simply expertise; it involves a public commitment to some significant set of social values. He believes that engineers should not participate in projects that degrade existing ambient levels of public safety unless information concerning those degradations is made generally available. Kipnis discusses the DC-10 case and Applegate's role in it and concludes that Applegate should have been aware that the use of the DC-10 aircraft represented a substantial degradation of the existing ambient level of safety for airline passengers. Applegate should also have realized that adequate information about the problem with the DC-10 was not being provided to the FAA. According to Kipnis, Dan Applegate knew that he was involved in a project that degraded ambient levels of public safety without adequate information about that degradation being generally available. Thus, he must share the blame for the crash of the Turkish Airlines DC-10.

The chapter by Douglas Birsch, "Whistleblowing, Ethical Obligation, and the DC-10 Case," examines the question of whether Dan Applegate should have blown the whistle on Convair and McDonnell Douglas. Birsch presents two approaches to whistleblowing and two conclusions about Applegate. The first approach, developed by Richard DeGeorge, presents criteria which can be used to determine when whistleblowing is morally permissible and morally obligatory. Based on DeGeorge's conditions, Birsch concludes that it would have been permissible but not obligatory for Applegate to blow the whistle. Birsch criticizes DeGeorge's conditions by arguing that they have two main faults: they are too vague to make them practical and they allow people to escape from being involuntarily obligated to blow the whistle. This lack of involuntary obligation distorts the usual notion of ethical obligation. Birsch contrasts DeGeorge's position on whistleblowing with his own view which suggests that Applegate was ethically obligated to blow the whistle on Convair. He argues that his position is superior to DeGeorge's because it is more consistent with our usual view of ethical obligation and because it would be more likely to prevent tragedies like the Paris crash of 1974.

An interesting feature of the literature on the DC-10 case is that it tends to focus on Dan Applegate, as in the chapter by Kipnis. It should be remembered that there are other engineers at Convair

and at McDonnell Douglas who are just as accountable as Dan Applegate, but there is no public knowledge of their actions.

McDonnell Douglas's response to the door problem raises as many questions as Convair's involvement. Douglas engineers were aware of the door problem at least as early as the 1970 test failure on Ship 1. While Convair was forbidden from contacting the FAA about the problem, there were no such legal limitations on Douglas. McDonnell Douglas continually rejected the suggestions of the Convair engineers, such as latches driven by a hydraulic system and blow-out panels in the cabin floor, that would have resulted in a safer plane. In addition, Douglas handled the door repair, required by the gentleman's agreement after the Windsor incident, by issuing maintenance bulletins. This allowed dangerous planes to keep flying since they were not legally required to be fixed, nor were carriers adequately notified of the seriousness of the problem. Should the engineers and executives at Douglas bear any responsibility for the Paris crash?

Perhaps the most tragic of McDonnell Douglas's shortcomings was that their maintenance procedure allowed Ship 29, the aircraft that crashed near Paris, to enter into service with certification stamps stating that it had the required changes when those repairs had never been done. Should McDonnell Douglas bear the primary responsibility for the crash of Ship 29 since they controlled the DC-10 project and were responsible for failing to upgrade the door on Ship 29? Does the fact that Convair was Douglas's subcontractor and worked under its direction shift the burden of blame from Convair and Applegate to Douglas?

Peter French's chapter "What is Hamlet to McDonnell Douglas or McDonnell Douglas to Hamlet?: DC-10" moves the discussion from Convair and Dan Applegate to McDonnell Douglas by examining the issue of whether McDonnell Douglas is morally responsible for the crash near Paris and the death of 346 people. He argues that engineers and managers in the corporation designed an airplane which they should have known did not meet the engineering standards of the industry with respect to certain vital systems. While they did not intend for the plane to crash near Paris, they knew that they were manufacturing a plane with a higher risk of crashing than their competitors. Not only did they know of the shortcomings of their design, they were willing to manufacture and market this aircraft. French concludes that McDonnell Douglas can be held morally accountable for the Paris crash. In his commentary, Homer Sewell disagrees with some of French's criticisms of McDonnell Dou-

glas and with his call for a drastic overhaul of their quality control system. The "Statement of John C. Brizendine, President, Douglas Aircraft Company, McDonnell Douglas Corporation" presents a brief defense of his company, presented in a congressional hearing following the crash.

THE 1979 CHICAGO CRASH

While there have been no more accidents caused by cargo doors, other accidents have also cast doubt on the safety of the DC-10's control system. In 1979 an American Airlines flight out of Chicago crashed on takeoff when its left engine broke loose and accelerated upward, severing control cables and hydraulic lines in the leading edge of the wing. This caused an uncommanded retraction of the slats, movable extensions of the wing on its leading edge which are deployed to provide additional lift at takeoff and landing. When its slats retracted, the wing lost lift while the other did not. Because of the relatively low speed of the aircraft, the damaged wing stalled, i.e. lost its ability to provide lift. It dipped as the other wing rose, until the wings were perpendicular to the ground and the plane crashed. There were 273 deaths in this accident.

The immediate reason for the loss of the engine was an improper maintenance procedure by the airline, which had caused cracks in the huge pylon holding the engine to the wing. "The National Transportation Safety Board Report on the 1979 Chicago Crash" explains the FAA maintenance policies and raises questions about the vulnerability of the slat control system and the lack of warning to the pilot. (Had the pilot known what was happening, he could have prevented the accident.) Additional questions arose when it was learned that McDonnell Douglas knew about the improper maintenance techniques that led to the pylon cracks. Besides questions about the ethical adequacy of the FAA's maintenance policies, should McDonnell Douglas have informed the FAA that airlines were using a nonstandard method for removing the engine and pylon assembly?

In response to growing public concern about the DC-10, McDonnell Douglas issued "The DC-10: A Special Report" in 1980 to explain its side of the story. It poses a number of questions that have been raised about the pylon that failed, the safety of the DC-10's slat control system, and hydraulic lines. It clarifies many technical issues and ends with comparative data concerning the safety of the DC-10 and other wide-body jets.

The section on the Chicago crash ends with the chapter by Martin Curd and Larry May, "Two Models of Professional Responsibility." Curd and May set out two models of professional responsibility and apply these models to the Paris crash and the Chicago crash. Based on the first model, the malpractice model of responsibility, Curd and May believe that both Convair and McDonnell Douglas management and the engineers who worked on the DC-10, including Applegate, bear responsibility for the Paris crash of 1974. They apply the second model, the reasonable care model of professional responsibility, to the 1979 Chicago crash. They find that design engineers, McDonnell Douglas management, and American Airlines were responsible for that crash. In general, Curd and May believe that professional engineers must do more than write memos when corporations put profits ahead of safety. The engineer is the one most likely to know the dangers of highly technical products, like aircraft, and should accept responsibility for ensuring that the design is adequately safe.

THE 1989 SIOUX CITY CRASH

Debate continues today over the DC-10's safety because of the 1989 crash of United Airlines Flight 232 in Sioux City, Iowa, in which 111 people died. Questions have again been raised about the adequacy of protection for the control systems in the DC-10. The "National Transportation Safety Board Report on the 1989 Sioux City Crash" found that the cause of the accident was a metallurgical flaw in the fan assembly of the rear engine. A crack in the 370-pound fan disk started from the flaw and eventually caused it to disintegrate. Debris from the explosion severed all hydraulic lines, depriving the pilot of control over the flying surfaces on the tail and wings. The National Transportation Safety Board (NTSB) report also describes the weaknesses of the inspection system that is supposed to find flaws before they can cause damage, and it questions the certification of an aircraft with little protection of its hydraulic lines from uncontained engine failure debris.

John Fielder's "The 1989 Sioux City Crash" discusses the ethical issues of a tail engine design and compares the DC-10 with other aircraft. As in the other accidents, loss of the engine should not have resulted in loss of the aircraft but, as in the other accidents, subsequent damage to the DC-10's control system led to the crash. The DC-10 has three separate hydraulic systems, but all three converge

close together near the tail. As a result, shrapnel from an exploding engine can disable all three at once, leaving the plane without hydraulic control. An AD has been issued that requires the installation of devices to one hydraulic system which will prevent complete loss of hydraulic fluid in the rest of the system if it is damaged in the tail. An important ethical issue in this accident is the lack of initial protection for the hydraulic lines in the original design. Another is the familiar tradeoff between safety and economy that is played out in the role of testing and inspection in the aviation regulatory system.

THE AVIATION SAFETY SYSTEM

The final part of the book deals with concerns about the institutional system set up to provide for aviation safety. The gentleman's agreement between McDonnell Douglas and the FAA, and the failure of the FAA to provide sufficient oversight of maintenance procedures to prevent the Chicago crash raise questions about the responsibilities of the FAA and whether it is doing an adequate job of fulfilling them. Ralph Nader's testimony before a subcommittee of the House of Representatives explores whether the FAA is adequately protecting the public in the wake of the Chicago crash of 1979. Nader claims that the FAA has failed to set adequate safety standards, and that there have been failures in the inspection process. He also makes several suggestions for reforms.

Partial confirmation of his criticisms may be found in "Management Improvement Needed in FAA's Airworthiness Directive Program," a Government Accounting Office (GAO) report on weaknesses in the FAA inspection program. It concludes that the FAA's airworthiness directive (AD) program is inadequate since the agency cannot effectively determine whether airlines are complying with airworthiness directives. The report finishes with specific recommendations for improvement.

The excerpt from Charles Perrow's book *Normal Accidents* is the last of the chapters on the FAA. Perrow suggests that the aircraft manufacturers, the airlines, and the FAA support safety modifications and additions only when these lead to increased economic efficiency. This hypothesis is explored and supported in the chapter "FAA, the Carriers, and Safety."

An interesting sidelight on the Chicago crash is that the Airline Passengers Association (now the Airline Passenger Association of

North America) went to court to force the FAA to take action. As a result of their efforts, the DC-10 fleet was grounded—the first such event since 1946—until the problem could be analyzed and solved. This organization and its partner, the International Airline Passengers Association, are strongly critical of the DC-10, and their position is set out in “International Airline Passengers Association Critique of the DC-10,” a letter sent to the Transportation, Aviation, and Materials Subcommittee of the U.S. House of Representatives.

In “Moral Responsibility for Engineers,” Kenneth Alpern investigates the issue of the moral responsibility of engineers in a more general manner than was done in earlier chapters. He argues that ordinary moral principles impose on engineers the burden of making personal sacrifices for the benefit of society. Practicing engineers, because they exert considerable control over technological developments, can greatly affect public welfare. Since they are in a position to contribute to great harm, it can be expected that they ought to make greater sacrifices than others for the sake of public welfare. The high standard to which we hold engineers is the result of the ordinary requirements of care and proportionate care as they apply to the circumstances of engineers. Alpern does not discuss the DC-10 case in his chapter but it provides another vantage point from which to draw conclusions about the case. It supports our contention that the engineers who design and build planes are a crucial part of the aviation safety system. Andrew Oldenquist argues for a less demanding view of moral responsibility for engineers, one that requires reasonable concessions of self-interest shared nearly equally by all. Samuel Florman holds that Alpern’s emphasis is misplaced, and points out that engineers do not and should not decide public policy questions concerning safety.

Is the DC-10 an aircraft with an inadequately protected control system, or is it a safe airplane that has had more than its share of bad luck and worse publicity? This is the central ethical issue in the DC-10 case, and how it is judged will strongly influence the ethical evaluation we make of the individuals, organizations, policies, and government agencies that responded to problems with the DC-10. Did these respondents meet their ethical responsibilities at crucial points of the case? Ethical judgments about the participants in the DC-10 case will depend upon whether one views the crucial design decisions, organizational actions, policies, and institutional arrangements as ethically acceptable responses, given the web of engineering, financial, time, organizational, and political constraints that were in place. Ethical decisions and ethical evaluations are strongly

context dependent; only by locating a decision or policy within the framework in which it is made can we have an adequate sense of the real options open to the players in the drama.

The chapters in this book will provide the information needed to make ethical judgments about the DC-10 case, but making an ethical evaluation also requires a reflective awareness of the ethical concepts we use in making them. They are the tools we employ to articulate the ethical issues, analyze them and reach ethical decisions. The following section, "Ethical Analysis of Case Studies," provides a introductory discussion of our basic ethical concepts and their application to a case study.