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AIRCRAFT CERTIFICATION

FAA Can Better Meet Challenges Posed by Advances in Aircraft Technologies

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Mr. Chairman and Members of the Subcommittee:

We appreciate the opportunity to testify on the Federal Aviation Administration's (FAA) aircraft certification program. Over the past 2 years, we have reported on FAA's domestic and international certification activities for large commercial airplanes at the request of this Subcommittee.[1] FAA's certification program has a key role to play in promoting aviation safety. Our testimony today will focus on long-standing problems that affect the certification program, FAA's ability to meet the challenges of new technology, and actions that FAA can take to make a generally safe system even safer.

In summary, we found that:

-- FAA has not provided its staff with the guidance, technical assistance, and training needed to improve their technical competence. As a result, the staff's ability to effectively oversee or add value to the certification process as well as understand new technologies has been questioned by internal FAA reviews as well as by some manufacturing officials. Our findings are similar to those of the National Academy of Sciences, which in 1980 warned that FAA's certification staff were falling far behind industry in technical competency.

-- The current certification process generally results in safe aircraft designs because of the efforts of the manufacturers and expertise of their FAA-designated employees, who perform tests and carry out other activities for FAA staff during the typical 5-year process.[2] However, the technical competence of FAA staff has been limited because FAA has not (1) established meaningful guidance to ensure that its staff are effectively involved in a process that delegates up to 95 percent of all activities to manufacturing designees, (2) fully staffed a program established in 1979 for in-house experts to assist staff, (3) ensured that these experts are involved early and at key junctures in the process, (4) provided staff adequate technical training, and (5) addressed the high level of turnover among staff. We have made recommendations to address these problems.

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[1]Aircraft Certification: New FAA Approach Needed to Meet Challenges of Advanced Technology (GAO/RCED-93-155, Sept. 16, 1993) and Aircraft Certification: Limited Progress on Developing International Design Standards (GAO/RCED-92-179, Aug. 20, 1992).

[2]The Federal Aviation Act of 1958 authorizes FAA to delegate certification activities, as necessary, to designated, FAA-approved employees of manufacturers.

Acknowledging that it needs to improve the competency of its certification staff, FAA has recently initiated efforts to improve its training and reduce the level of turnover among its staff. We support both of these efforts. However, current challenges posed by the certification of Boeing's 777 aircraft, which may be the most advanced commercial airplane ever produced, as well as future challenges posed by the certification of a potential high-speed civil transport, make it imperative that FAA address each of the problems facing its certification program, many of which were identified by the Academy 13 years ago.

We would now like to discuss FAA's certification process and our findings in more detail.

BACKGROUND

Before introducing a new aircraft into commercial service, a manufacturer must obtain from FAA a certificate signifying that the basic design and systems meet minimum safety standards. To obtain such a certificate, the manufacturer must, usually over a 5-year period, supply FAA with detailed plans, drawings, test reports, and analyses demonstrating the aircraft's compliance with FAA's design requirements and produce a prototype of the new aircraft for both ground and flight tests. FAA employs approximately 120 engineers and test pilots to certify new transport airplane designs. In carrying out their functions, these staff also rely on--and must oversee--approximately 1,300 manufacturer designees who act as surrogates of FAA in approving certification tests and analyses.

After a 1979 accident that resulted in 273 fatalities, the Secretary of Transportation established a "blue-ribbon" committee to assess the adequacy of FAA's certification program. Under the direction of the National Academy of Sciences, the committee reported in 1980 that FAA's system of delegation was sound but warned that the technical competence of FAA's staff was falling far behind that of manufacturers' designees, to the point that the agency's oversight was becoming superficial.[3] The committee recommended that FAA develop a more systematic approach to the certification process, hire 20 to 30 experts to assist staff in understanding the more complex technologies, and improve staff competency by hiring, retaining, and training highly competent engineers.

Since the Academy's review, the two domestic producers of large commercial airplanes--the Boeing Company and Douglas Aircraft Company--and their subcontractors have developed increasingly complex designs and systems. Dramatic advances have occurred, for example, in the use of software-based systems to monitor and

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[3]Improving Aircraft Safety: FAA Certification of Commercial Passenger Aircraft, National Academy of Sciences (June 1980).

control aircraft functions traditionally performed by cockpit crews and in the use of composite structural materials to increase aircraft performance. In many cases, software-based systems have virtually replaced the hydraulic and mechanical control systems used on earlier generations of transport airplanes. For example, pilots of Douglas's MD-11 aircraft--certified in 1990--depend on complex software systems to continuously monitor and adjust the hydraulic, electrical, and fuel systems without action by the crew, thereby reducing the number of cockpit personnel needed from three to two. Unlike its predecessor--the DC-10, certified in 1971, which has almost no software--the MD-11 uses complex software to control many critical functions previously handled by a flight engineer.

PROCESS HAS GENERALLY RESULTED IN SAFE AIRCRAFT, BUT FAA STAFF'S COMPETENCE IS LIMITED BY SEVERAL FACTORS

The certification process has generally resulted in safe transport airplane designs, largely because of the efforts and expertise of the aircraft manufacturers. The extent to which FAA staff materially add to this level of safety is unclear, however, because FAA has not addressed several key problems, some of which were identified by the Academy in 1980. These problems are (1) the lack of adequate guidance to ensure a minimum effective staff role in the certification process, (2) an insufficient number of in-house experts to assist staff, (3) the lack of adequate guidance to ensure that the experts are involved early and at key junctures in the process, (4) inadequate technical training for FAA staff, and (5) high staff turnover. Combined with a diminishing role in the certification process for FAA staff, these problems have limited the staff's ability to understand the advanced systems they are asked to certify. Acknowledging that the technical competency of its staff needs to be improved, FAA has recently initiated efforts to improve its training and reduce the level of turnover.

Manufacturers Have Kept the Number of Design-Related Problems Relatively Low

Because of the manufacturers' expertise and high commitment to safety, design problems have accounted for relatively few commercial transport airplane accidents over the last decade. Between 1983 and 1992, 173 "hull loss" accidents occurred; for 122 of these, causes have been officially identified.[4] Of these 122 accidents, 16, or 13.1 percent, were caused by a failure of the aircraft's design, systems, or structure. By comparison, 84 hull loss accidents, or 68.9 percent, were caused by errors made by the flight crew. Several of the "new generation" transport airplanes designed and manufactured domestically in the 1980s--the Boeing 757, Boeing 747-400, and Douglas MD-11--have not had a hull loss accident.

By Not Changing Its Approach, FAA Has Limited Its Staff's Technical Competence

In 1980, the Academy also noted the positive safety record achieved by aircraft manufacturers but warned that FAA was falling far behind industry in technical competence, in part because of its ad hoc approach to certification. Despite the Academy's warnings, FAA has not fundamentally changed its approach to certification. Instead, FAA has responded to the increasing complexity and the consequent increase in workload by delegating even more certification activities to manufacturing designees. Much of this increased use of designees has occurred because today's certification projects involve many more detailed analyses and tests of more complex systems than past projects.

Boeing officials estimated that the overall workload involved in certifying a new aircraft design has increased by as much as fivefold since the beginning of the jet aviation age in the late 1950s. Similarly, they projected that the number of test reports and analyses submitted to FAA for the current certification of the Boeing 777 aircraft will be double the number for the certification of the 747-400 aircraft in 1989.[5] In addition, FAA certification staff must increasingly rely on designees to conduct certification work because the staff's workload has increased in their two other areas of responsibility, which FAA defines as having higher

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[4]"Hull loss" accidents, commonly cited in discussions about aviation safety, are those in which the aircraft is damaged beyond economic repair. See Boeing Commercial Airplane Group, Statistical Summary of Commercial Jet Aircraft Accidents, Worldwide Operations, 1959-1992 (Apr. 1993).

[5]FAA expects to certify Boeing's 777 aircraft, which will use highly complex software systems to control such critical components as the aircraft's rudders and wings, in May 1995.

priority. These staff, besides certifying airplane designs, must continuously monitor already certified aircraft and issue airworthiness directives to ensure continued safety and assist in developing new regulations and policies. Increased demands in these areas have limited the amount of time staff can spend on lower-priority work involving certification.

For example, an internal FAA study found that the agency delegated 95 percent of the certification activities for the Boeing 747-400 aircraft--certified in 1989. By comparison, FAA staff estimated that they delegated between 70 and 75 percent of certification activities in the early 1980s. Likewise, the number of designees involved in certifying new transport aircraft designs rose from 299 to 1,287 (330 percent) between 1980 and 1992. At the same time, the number of FAA engineers and test pilots responsible for certifying new transport airplane designs rose from 89 to 117 (31 percent).[6] (App. I shows a comparison of the number of FAA staff and designees.)

Despite the increasing demands on its staff and their declining role in the certification process, FAA has not taken steps to ensure that they remain effectively involved in the process. As a result, FAA staff have sometimes not understood the new technologies that they have been asked to certify. For example, an internal study by FAA's Transport Airplane Directorate found that during the certification of the Boeing 747-400 aircraft in the late 1980s, FAA engineers did not understand the complex flight management system, which operates the navigational system and monitors the performance of other systems; hence, they delegated to Boeing designees the approval of the entire system. The study noted that FAA staff "were not sufficiently familiar with the system to provide meaningful inputs to the testing requirements or to verify compliance with the regulatory standards." Similarly, the study found that because FAA engineers had minimal knowledge of 10 other systems, including the aircraft's braking system, the agency delegated to designees key analyses of those systems--analyses that on previous certification projects FAA had reserved for its own staff.

Likewise, FAA and manufacturing officials told us that FAA needs to improve its understanding of new technologies to adequately verify regulatory compliance. Moreover, a 1989 internal FAA review concluded that the amount of work delegated to designees had reached the maximum for properly managing the certification process and that further delegation would reduce FAA's ability to

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[6]FAA engineers and test pilots responsible for certifying transport category airplane designs are located in FAA's Seattle and Los Angeles Aircraft Certification Offices. These two offices are overseen by FAA's Transport Airplane Directorate in Renton, Washington.

effectively understand and monitor the highly complex technical work being done by designees. The review identified a need for better defining FAA's role in the process and recommended that FAA establish uniform "monitoring requirements" for overseeing designees. We found, however, that the amount of delegation has increased since 1989 and that FAA has not taken any action to address the review's concerns. The number of designees involved in certifying transport aircraft, for example, increased over the last 3-1/2 years by an average of 90 per year; meanwhile, the number of FAA certification staff increased by an average of 3 per year.

FAA's Program to Meet Deficiencies in Technical Competence Is Only Partially Staffed and Is Limited in Effectiveness

Recognizing in 1979 that it needed to improve its staff's competence, FAA established the National Resource Specialist (NRS) Program, through which in-house experts in such subjects as crash dynamics, composite materials, and advanced avionics would assist certification staff. The Academy in 1980 noted that FAA's hiring of in-house experts was a good idea and said that FAA needed approximately 20 to 30 experts. However, the program is much smaller than originally envisioned: Only 11 positions are authorized, even though FAA identified a need for 23, and only 8 of the 11 positions are actually filled. FAA cites an inability to attract qualified experts as the reason for its not fully staffing the program or filling the three vacant positions. According to certification staff and experts in the NRS Program, FAA's not fully staffing the program has caused staff to fall further behind in some areas of expertise. In addition, some experts are stretched increasingly thin, in part because they must (1) perform duties originally intended for another NRS position that was never authorized and (2) develop expertise to cover additional areas because of technological advancements.

A lack of direction from management has also limited the program's potential. FAA's guidance is silent on when and to what extent experts should be involved in the certification process. The experts are not required to involve themselves in the process, and certification staff are not required to use them, even though the experts are full-time FAA employees. As a result, the experts are sometimes not sought for advice or are often involved in the process too late for them to make the most effective use of their expertise. For example, one expert told us that he intervened in the process when he learned from an industry source that Boeing's proposed design for the 777 excluded "crack stoppers"--devices installed on the fuselage skin to prevent cracks from growing to unsafe sizes. As a result of his actions, he said, Boeing is reviewing its testing procedures in this area. According to the certification engineer, she did not request expert involvement because she believed no problems existed and no guidance defines when experts should be consulted.

FAA's Certification Training Has Been Inadequate

FAA has provided its staff with little training in new technologies since 1980. In 1987, FAA released a study called "Project Smart," which examined the entire certification program, including training. Like the Academy's 1980 study, FAA found that the certification workforce was 3 to 5 years behind the developments in industry. The study recommended that FAA develop and implement a more formal, structured program with specific annual training requirements. This program was to include a system for identifying, developing, and evaluating training opportunities both inside and outside FAA. Agency officials stated that budget constraints kept them from responding to these recommendations.

In the face of little progress in improving training, FAA hired a contractor in 1990 to survey the certification workforce and document training needs. In February 1991, the contractor reported that all levels of the certification organization were dissatisfied with the state of technical training.[7] The contractor noted that certification staff had no comprehensive, up-to-date program that (1) described the training courses needed, (2) related these courses to job performance, (3) established the sequence in which the courses should be taken, and (4) ensured that the courses were available. It also identified a need for training in over 100 different areas, including such technical subjects as composite materials and software.

We found that the amount of technical training available is not adequate to ensure the staff's competence. For example, FAA continues to provide little training in the sophisticated computer systems being deployed on current aircraft. We found that between fiscal years 1990 and 1992, only 1 of the 12 engineers responsible for approving and certifying aircraft software in the Los Angeles and Seattle Aircraft Certification Offices had attended a software-related training course. Acknowledging that the agency's technical training needs to be improved, FAA officials have initiated a major effort to improve certification training and expect to have a strategic plan for this effort by the end of the year.

High Turnover Has Complicated FAA's Efforts to Ensure Staff Competence

FAA has also had difficulty keeping up with advanced technologies because of the increasing inexperience of its staff. For example, in 1987, 58 percent of the Seattle Aircraft Certification Office's systems and equipment branch engineers--responsible for certifying electrical, mechanical, and software-

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[7]Human Technology, Inc., Description of the Current Training System Within the Aircraft Certification Service (Feb. 1991).

related systems--had at least 6 years of FAA certification experience. However, as of April 30, 1993, the percentage of staff with 6 years or more of experience had decreased to about 17 percent. Likewise, over half of the engineers with primary responsibility for certifying the 777 have never participated in a major certification project.

FAA officials attributed this declining experience level to a high turnover among staff, which is caused largely by the lack of a technical career path within the certification unit. Certification staff seeking promotion must either move to positions outside the unit or leave FAA. As a result, nearly one-half of the nonsupervisory engineers at the Seattle and Los Angeles Aircraft Certification Offices joined these offices within the last 4 years. Boeing officials told us that as a result of this high turnover, each certification project brings with it a new set of FAA staff that need to be "educated" in advanced technologies. To help reduce the level of turnover within the certification offices, FAA has initiated efforts to retain competent engineers by attempting to create a technical career path within these offices. A GS-14 "senior engineering series" would be created between the GS-13 engineer and GS-15 NRS positions. FAA expects to have such a career path in place by October 1994.

ISOLATED SAFETY PROBLEMS, FUTURE CHALLENGES HIGHLIGHT NEED FOR MORE VALUE ADDED BY FAA STAFF

Although relatively few design-related accidents have occurred over the last decade, one tragedy and future technological advances highlight the need for FAA staff to keep up to date on new technologies so that they can provide an effective check on the manufacturer's activities. In May 1991, a Boeing 767, whose design was certified in 1982, crashed in Thailand after an engine thrust reverser accidently activated in flight; 223 people were killed. Thai investigators--assisted by the National Transportation Safety Board (NTSB)--concluded that "the consideration given to high-speed in-flight thrust reverser deployment during design and certification was not verified by flight and wind tunnel testing and appears to be inadequate." NTSB's representative in the Thai government's investigation of the accident told us that he believed that FAA had added little value to the process in this instance.

In addition to the challenges of today, further dramatic technological changes will be incorporated in the next generation of large commercial airplanes. Douglas officials estimate, for example, that the next aircraft the company may develop--the MD-12--will use twice as much software as the MD-11. By 2005, according to National Aeronautics and Space Administration officials, pilots of a high-speed civil transport aircraft will likely navigate using sensors and satellite systems, while traveling at three times the speed of current aircraft. Instead of looking out the cockpit

window, pilots will view a video screen that will display an enhanced image of the outside generated by these systems.

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In summary, the aviation industry has witnessed rapid changes in aircraft technology since the 1980s. The future will bring more changes, such as the further development of electronic systems for sensing the environment and controlling the aircraft and more advanced uses of composite materials in aircraft structures. Such advances will present significant challenges to FAA in terms of certifying these technologies and ensuring safety. FAA engineers and test pilots must be up to date to carry out their certification and regulatory tasks.

In 1980, the National Academy of Sciences found that the competency of FAA's certification staff was falling far behind that of the engineers in the industry they regulated. Since 1980, FAA has not provided its staff with the guidance, expert assistance, and training needed to improve the staff's competence. Combined with the staff's decreasing role in the certification process and increasing inexperience, these problems have led several FAA internal reviews, as well as some manufacturing officials, to question the extent to which FAA staff understand new technologies or add value to the certification process.

We recognize that the demands on FAA's resources and the complexity and size of certification projects make it unreasonable to expect FAA engineers to review all certification data. Likewise, we recognize that FAA is taking some actions to improve its training program and reduce the high level of turnover among its staff. However, we believe that FAA needs to go further than the current initiatives. By (1) better defining its role in the process, (2) improving its use of in-house experts, (3) establishing specific training requirements, and (4) keeping its training as current as possible, FAA can more effectively meet the challenges posed by advanced technologies and add more value to the certification process.

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This concludes our testimony. We would be happy to respond to any questions you may have.

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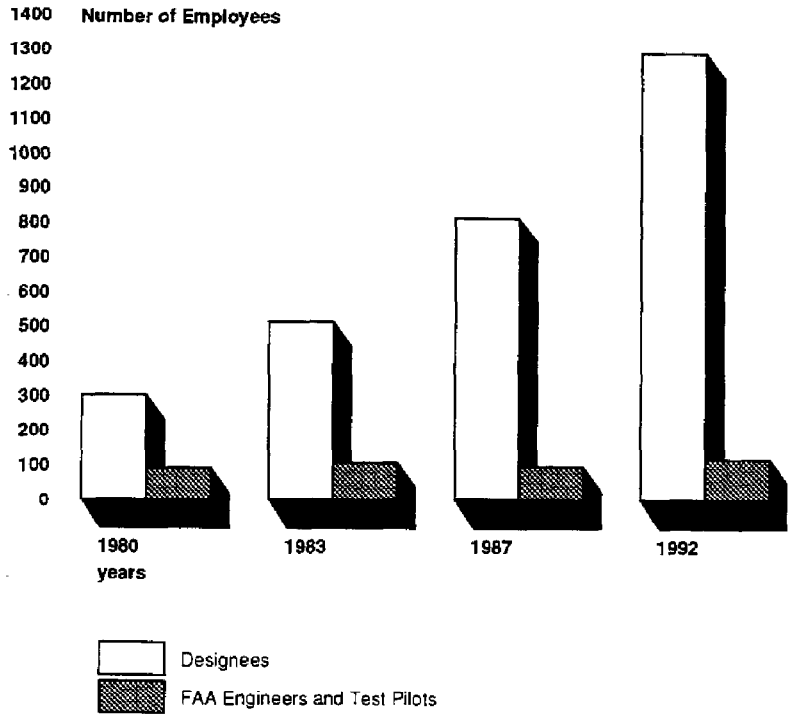
COMPARISON OF THE NUMBER OF DESIGNEES WITH THE NUMBER OF FAA ENGINEERS AND TEST PILOTS RESPONSIBLE FOR CERTIFYING NEW TRANSPORT AIRPLANE DESIGNS, 1980-92



Note: Figures for 1980 are from March 1980. All other data are as of the end of the fiscal year.

Source: GAO's analysis of data from FAA and the National Academy of Sciences.

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