Official Report

of the

Special Committee

to review the

Federal Aviation Administration's

Aircraft Certification Process

Executive Summary

January 16, 2020

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Our Mandate

In April of 2019, U.S. Secretary of Transportation, Elaine L. Chao, created the Special Committee to Review the Federal Aviation Administration's Aircraft Certification Process (the Committee). This action was taken in response to the crashes of two Boeing 737 MAX 8 aircraft: one in Indonesia and one in Ethiopia, which claimed a total of 346 lives. The Committee was commissioned as an independent panel of aviation and safety experts to conduct an objective review of the Federal Aviation Administration's (FAA) procedures for product certification and the processes followed by the FAA and Boeing during the certification of the 737 MAX 8. The Committee was instructed to review the certification process, evaluate potential enhancements to the system, and make recommendations to bolster aviation safety. This report captures the findings and recommendations of the Committee.

Timeframe and Approach

Over a period of six months, the Committee worked to obtain firsthand information and insight from the FAA and stakeholders regarding the aircraft certification system. The Committee met with an array of aviation and safety management specialists. The Committee talked to subject matter experts and managers from the FAA, along with representatives from aviation trade associations, labor organizations, industry, and other U.S. government agencies. The Committee also spoke with those directly involved in the certification of the 737 MAX 8, including key staff from the FAA's Boeing Aviation Safety Oversight Office (BASOO) and a large panel of Boeing engineers, test pilots, and safety specialists.

A Collaborative Review

The Committee conducted its review of product certification as several other government entities were investigating aspects of the Boeing 737 MAX 8 or the related accidents. Amid these parallel examinations, it is important to note that the findings and recommendations of this Committee are not the product of an official investigation. Instead, the members of the Committee were commissioned to conduct a review of the FAA's current certification process. The Committee's approach was collaborative, not investigatory. Its mandate was to collect and analyze information, not find fault. Its focus was to make findings and recommendations to enhance the process moving forward. The mandate and focus of the Committee, therefore, is unique.

The Committee's fact-finding discussions and deliberations—focused on certification process improvements and conducted through a spirit of collaboration—fostered an atmosphere that was conducive to allowing the aviation and safety specialists interviewed to speak freely and truly focus on safety and opportunities to improve potential vulnerabilities. Also, while the Committee's interactions were collaborative in nature, members of the Committee challenged one another, worked through differing perspectives, and worked hard to reach consensus on this report and its recommendations.

Primacy of Safety amid Risk

In all its interviews and discussions, the Committee encountered a strong, unwavering commitment to the primacy of safety and a keen awareness of risk. The Committee engaged in compelling discussions with the National Aeronautics and Space Administration (NASA). One NASA official underscored a foundational fact that is revealed in reality every day: all complex safety systems built and maintained by humans will experience malfunctions and human error that put safety at risk. NASA encouraged the Committee to review safety systems with this in mind.

The Committee's work also confirmed what each member's professional experience had already told them: that safety is a complex global web of interrelated events and actions that come together to form a complex system with factors that, by themselves, are often manageable, but can combine to produce unintended consequences. The FAA and industry combat this phenomenon through a combination of certification, training, inspections, data analysis, system redundancies, and corrective measures designed to break the accident chain before a safety incident occurs.

The very mission of the regulatory system faces its own challenges. U.S. law (Title 49 USC, Chapter 447) directs the FAA "to provide service with the highest possible degree of safety in the public interest." Risk can never be completely eliminated from any complex system, but rather it must be managed proactively. Managing risk proactively requires that the regulator have access to data that will help highlight areas of vulnerability. Government-industry data sharing is fundamental to the proactive discovery and mitigation of emerging safety risks before they result in an incident or accident. However, a delicate balance exists between too much regulation, which stifles innovation, and too little regulation, which could result in safety lapses. Recognizing that the U.S. aviation system leads the world in attaining safety and efficiency, the Committee considered this delicate, critical balance and made recommendations for potential enhancements.

U.S. Aviation: Extremely Safe

While it is important to define the scope and approach of the Committee's work, it is also helpful to clarify the context in which this report was produced. Amid the review of the FAA's certification process and Boeing's role in that process, the Committee felt compelled to begin this report by putting the safety of U.S. aviation in its proper context. Despite the inherent risks of human flight, commercial aviation in the United States is a model of safety, efficiency, and innovation across the world.

The statistics on passenger aviation are impressive. Every day—365 days per year—the FAA's Air Traffic Organization (ATO) provides service to approximately 44,000 flights. Each day, the FAA guides the travel of 2.7 million air passengers across more than 29 million square miles of airspace. Approximately 1 billion U.S. passengers fly annually. The FAA handles over 16.1 million flights annually. During peak operations, there are approximately 5,000 aircraft in the sky being directed by 518 air traffic control towers and scores of en route facilities.

The FAA aircraft certification workload numbers are equally demanding. Over the five-year period of 2013–2017, the Aircraft Certification Service (AIR) issued 1,127 Type Certification Data Sheets; 4,173 Supplemental Type Certificates; 10,340 New Parts Manufacturing Approvals;

2,128 Technical Standard Orders Authorizations; and 1,809 Airworthiness Directives. This while monitoring the continuing operational safety (COS) of all U.S. State of Design aircraft operating worldwide.

The collaborative efforts of manufacturers, regulators, safety specialists, flight crews, air traffic controllers, and maintenance crews have enabled the United States to lead the world in aviation safety, and the numbers speak for themselves. Since 1996, improvements in technology, training, procedures, and oversight combined to reduce the air carrier fatality rate from 80.9 per 100 million passengers boarded in FY 1996 to 0.6 per 100 million passengers boarded in FY 2019.

The Committee applauds the remarkable gains in safety achieved by U.S. aviation and recognizes the safety benefits provided to the worldwide aviation system. However, each member of the Committee fully acknowledges the two foundational premises that risk will always exist in aviation and that no fatality in commercial aviation is acceptable. This report reflects the Committee's work to make our extremely safe transport aviation system even safer.

The Federal Aviation Administration's Product Certification Process

Product certification refers to the process used by the FAA to approve aircraft, aircraft engines, or propellers. The type certification portion of the FAA's certification process requires that an applicant must show, and the FAA must find, that a given product complies with the relevant regulatory requirements. Such products may not be registered or operated until the certification process is complete.

The FAA's certification system is a process sanctioned by Congress, driven by regulation, directed by the FAA, and implemented by certified organizations and individuals. It is an iterative, comprehensive process grounded in the cumulative expertise of the FAA gained through over a half century of process management and oversight. The certification process must be conducted by the FAA either directly by FAA employees or through a combination of FAA staff and FAA-authorized designees. It typically takes the FAA five to eight years to work through the multiple stages of its certification process and issue a type certificate (TC) for an aircraft. It took the FAA five years to certify the Boeing 737 MAX 8.

Our Assessment—the Federal Aviation Administration's Certification Process

The Committee reviewed the FAA's certification process with a twofold focus on promoting safety and mitigating risk. The Committee found that while the FAA's certification process is rigorous, robust, and overseen by engineers, inspectors, test pilots, and managers committed to the primacy of safety, there are areas where improvement can be made. The Committee gained good insight into what it found to be an ever-evolving certification system shaped by the FAA's ongoing, safety-focused collaboration with industry, Congress, academia, and safety experts from around the world. As reflected by the safety statistics cited above, the Committee found that the FAA's certification system is effective and a significant contributor to the world's safest aviation system.

The Committee also found a genuine eagerness among the range of organizations we spoke with to continually improve the aviation system to meet the challenges of a rapidly changing and

expanding industry. This includes the FAA leaders, who want to learn from the various entities reviewing the FAA's certification process and embrace effective reforms. The agency is keenly aware of the challenges to safety amid a rapidly changing and expanding industry. While focusing on compliant designs, the FAA is also responsible for safely incorporating new technologies, such as carbon fiber airframes and unmanned aircraft system (UAS), into the National Airspace System. In recent years, the FAA has adopted its own reforms to keep pace and secure safety. For example, the FAA's Aviation Safety (AVS) organization, which oversees certification, conducted two significant reorganizations in 2017 to enable the agency to have a more coordinated approach to identifying and mitigating risk. Despite regulatory obstacles, FAA leadership also expressed its strong support for the adoption of safety management systems and principles that would provide a more holistic, top-to-bottom, safety-focused approach to certification.

Federal Aviation Administration's Certification of the Boeing 737 MAX 8

The Committee also conducted multiple briefings with the FAA, Boeing, and other aviation safety experts on the process used by the FAA to certify the Boeing 737 MAX 8. Before addressing the Committee's findings, some basic background information is helpful. The FAA issued the initial 737 type certificate to Boeing in 1967. Since its original issuance, that TC has been amended 13 times for each successive model of the 737. There have been three major categories for the derivatives of the 737. Boeing categorized the 737 derivatives as the Classic, the Next Gen (NG), and the MAX. Each of the three major derivatives introduced a new engine, lowered noise, improved range, and improved fuel efficiency.

Based on Boeing's conversations with the FAA and the paperwork submitted, the FAA determined that the 737 MAX 8 project qualified as an amended type certificate. The FAA's determination that the 737 MAX 8 met the criteria for an amended TC meant that the certification process would focus on changes and areas affected by the changes, but would not need to revisit the areas that were unchanged or unaffected from previous iterations of the 737.

The information and details provided by Boeing to the FAA early in the process played a key role in the FAA's determination of two important decision points in the FAA's certification process. Such information determined whether Boeing was eligible to submit an amended TC, and it directed the FAA's determinations about which elements of the certification plan required direct FAA oversight. The comprehensive nature of the FAA's certification system is reflected in the fact that the FAA and Boeing agreed to a certification plan for the 737 MAX 8 that included 93 individual certification plans. The FAA initially determined that 35 of the 93 elements of the Boeing 737 MAX 8 project were eligible to be managed by (i.e., delegated to) the Boeing Organization Designation Authorization (ODA) unit. The FAA also initially determined that 58 elements of the certification plan required direct oversight by the FAA and must be retained by the FAA. The ratio of retained and delegated items changed throughout the five-year process as the FAA's confidence in the aircraft design and the related risk analyses evolved, including Boeing's ability to manage such elements.

In nearly all its interviews, the Committee asked a wide range of stakeholders the same two questions: "If Boeing had applied for a new type certificate for the 737 MAX 8, would it have made a difference to the level of scrutiny of the aircraft during certification?" and "Would

seeking certification via a new TC have produced a safer aircraft?" The answer from the experts was consistent; each said a new TC would not have produced more rigorous scrutiny of the 737 MAX 8 and would not have produced a safer airplane. Seeking certification via a new TC would have required all of the 737 MAX 8 to be certified again—including those parts and systems now in use in the 737-800 that were previously certified and remained unchanged and unaffected by changes. However, the Committee concluded that additional consideration of the interface between the changed item and the rest of the system, as well and the impact of multiple changes over time, should be required. This includes assessment of their combined effect on the flight crew's ability to safely manage operational tasks.

An area of focus regarding the certification of the 737 MAX 8 is one of the functions of the flight control system—the Maneuvering Characteristics Augmentation System (MCAS). MCAS is an extension of Boeing's speed trim system, which has been used extensively and safely on the Boeing 737-800. Boeing added a new functionality to MCAS for the 737 MAX 8, reconfiguring a flight control system that had 200 million flight hours of operational safety.

It is important to note that the FAA retained design approval of the 737 MAX 8 flight control system, including MCAS, through the end of certification process. This means the task of certifying the flight control system was only delegated to the Boeing ODA after several years of design review and discussion. It is also noteworthy that MCAS was identified and tested in both Boeing's and the FAA's certification flight tests. The FAA's regulations and protocols did not require testing of MCAS for combinations of mechanical and human failures. Boeing and FAA inspectors determined that a malfunctioning MCAS system would present itself as runaway stabilizer trim, an occurrence with specific non-normal checklist procedures and for which pilots are trained to address.

Our Assessment—Certification of the Boeing 737 MAX 8

Based on its briefings and discussions, the Committee found that the FAA's aircraft certification process was followed by the FAA and Boeing in the certification of the 737 MAX 8. The Committee concluded that the FAA followed regulations and guidance materials in determining that the project qualified as an amended type certificate project.

The FAA and Boeing developed a comprehensive certification plan used to scrutinize all areas of the 737 MAX 8 that were changed or affected by other changes. The Committee found that the FAA acted appropriately in determining its level of involvement for each element of the certification plan.

The Committee concluded that there is opportunity for improvement in the following areas: assumptions related to pilot performance and training, clarification and implementation of human factors assessments, review of the cumulative effect of multiple changes to aircraft design, providing of a holistic system operational risk assessment, and internal communication and communication between Boeing and FAA.

Committee Conclusion

The Committee found the FAA's overall certification system to be effective. It also concluded that reforms must be adopted to help our extremely safe aviation system become even better at

identifying and mitigating risk. The Committee determined that potential vulnerabilities within our complex, global aviation system will be mitigated by better use of data and safety management systems, better integration of human factors, enhanced coordination and communication, and the harmonization of global standards. The Committee concluded that some of the decades-old industry assumptions used in the certification of aircraft are no longer valid when applied to today's rapidly evolving, global aviation environment.

As reflected by the findings and recommendations listed below, the Committee seeks to make our safe aviation system even safer—to mitigate risk and bolster safety worldwide. In this ongoing pursuit of safety, the Committee cautions against any actions that would systematically dismantle the FAA's current certification system and its use of delegated authority. Any radical changes to this system could undermine the collaboration and expertise that undergird the current certification system, jeopardizing the remarkable level of safety that has been attained in recent decades. The Committee emphasizes that the suggested safety benefits of these proposed reforms cannot be fully realized unless adopted and practiced globally. The Committee, therefore, encourages the United States to adopt these reforms and then take a leadership role in promoting these safety enhancements worldwide.

Committee Recommendations

A focus on safety exists within the U.S. aviation community. Regulators, manufacturers, engineers, inspectors, flight crews, maintenance crews, and air traffic controllers all share responsibility for ensuring a safe aviation system. The Committee worked hard to evaluate the FAA's aircraft certification process and to propose modifications and enhancements to help prevent future accidents. A summary of the Committee's findings and recommendations appears below; each is designed to help drive our extremely safe commercial aviation system to the next level of safety. See Chapter 5 for the Committee's complete findings and recommendations.

***Summary of Key Findings and Recommendations*:**

1. **Safety Management Systems**

   Finding

   Safety Management Systems (SMS) help to ensure a holistic, proactive assessment of whether the combination of design, procedures, and training will support effective safety performance. There is no requirement for SMS for design and manufacturing organizations.

   Recommendations

   - The FAA currently requires an SMS only for part 121 operators. The FAA must mandate implementation of SMS for design and manufacturing organizations, thereby ensuring connection and interrelationship with the existing SMSs of airlines, airports, and service providers.
   - The FAA should take the necessary steps to ensure a total system approach to safety, linking all safety requirements from type certification to pilot training, and operational performance of the product.

- The FAA should encourage the integration of Partnership for Safety Plan (PSP), SMS, and ODA activities to create an effective oversight process between manufacturers and FAA to better manage safety and certification issues.

2. System Safety

Finding

System Safety Assessments (SSA) are an essential component of safety risk management that can be expanded to better consider human–machine interaction.

Recommendations

- The FAA and industry should review requirements and guidance materials to promote more consistent use of systematic analysis of Human Performance and Error Assessments to complement SSAs in aircraft certification.
- The FAA should consider removing exclusions for skill-related errors associated with manual control of the airplane and ensure crew interaction with automated systems active in manual flight are systematically assessed.
- Current guidelines recommend that human factors be considered when the system is new or novel, complex and/or integrated. In the future, the FAA should enhance standards to ensure that systematic human factor analyses are conducted for all safety-critical functions and failure modes associated with a change under the changed product rule (14 CFR 21.101).
- Test and evaluation should include multiple failure mode scenarios and involve trained pilots who reflect the anticipated end-users of the product. Resulting data should be fed back into the overall safety assessment of the total system. Significant changes to safety assumptions or performance levels should be tracked.
- A summary document explaining SSA assumptions and conclusions relevant to safe operation should be communicated throughout the development process and to end-users of the product as reference data for an operator's SMS program. End users should be required to monitor leading indicators to validate the assumptions of the SSA once the product enters service.

3. Globalization

Finding

Although U.S. products are operating worldwide, the FAA does not have a means to influence the maintenance and pilot training requirements for U.S. products operating under another civil aviation authority.

Recommendations

- The FAA should acknowledge the international profile of operators of U.S. State of Design aircraft and implement the necessary changes for its aircraft certification system to consider differences in operations, training, and oversight across States.
- Some members of the international community are using the Flight Standardization Board (FSB) reports intended for U.S. operators as the foundation for their operational programs, which was not their intended purpose. The FAA, therefore, should consider including operational requirements as part of the type certificate in order to better

communicate minimum standards and promote advanced training and qualification programs. This would allow transfer of operational and training requirements through the validation process.

- The FAA should expand its engagement, policies, technical assistance, and training efforts to foster higher international safety standards and practices for aircraft certification, operations, and maintenance.

4. Data

Finding

Aviation safety would be bolstered by better data gathering, targeted analysis of aviation data by experts, and the use of all available data for developing and implementing corrective actions to mitigate risk.

Recommendations

- Operational data needs to be made available in a single repository for analysis. To this end, the FAA and industry stakeholders of the certification system should continue to develop a means for expeditious gathering and analyzing, and acting on large quantities of operational data and reporting de-identified results to the aviation community, using Aviation Safety Information Analysis and Sharing (ASIAS) as an example.
- The FAA should propose to the International Civil Aviation Organization (ICAO) the sharing of operational data internationally, to enhance safety initiatives.
- The FAA should find a way to integrate de-identified and confidential data sources so that the aircraft certification workforce, Flight Standards inspectors and other safety organizations can focus on near-time risk factors as part of their continued operational safety activities.
- The FAA should continue working with NASA to develop an in-time aviation safety management system that can be used both by the regulator and industry.

5. Coordination between the FAA's Aircraft Certification Service and Flight Standards Service

Finding

The FAA's Aircraft Certification Service develops and manages the aircraft certification process, which involves personnel from the Flight Standards Service (AFX)—a separate organization with its own policies, guidance, leadership, and culture. The potential exists for a disconnect between design and operational requirements.

Recommendation

- The FAA should review and clarify the roles and responsibilities of the Aircraft Evaluation Group (AEG) in the product certification process to define objectives, precise engagement, and timing throughout the process. This process should include a review of the working relationship between AFX and AIR to ensure that AEG representatives are engaged early enough in the certification process to review operational safety requirements and oversee assessments of design features and assumptions affecting operations. The AEG should have sufficient engagement throughout the process to be aware of any design changes that occur after the first certification plan is executed.

Clarifications should be reflected in policy and guidance materials, which should also be evaluated to determine which organizations should be responsible for them.

6. Personnel

Finding

The FAA cannot accommodate the growth and complexity in certification workload without effectively understanding and managing its personnel requirements and influencing cultural changes in the workforce to adapt to the changing nature of the work. Priorities include proper skill identification, skill development, and attracting the right talent.

Recommendations

- The FAA should plan an aggressive recruitment campaign to encourage students to pursue careers at the FAA. The FAA should re-evaluate its current position descriptions and desired skill sets—especially as they relate to covering systems and process knowledge—to ensure that personnel with the right range of skills occupy safety-critical positions so that the agency can meet evolving industry needs.
- Workforce planning is not just about hiring new people; it is also about filling the gaps between what the FAA currently has and what it needs and making effective use of current staff. AVS should re-evaluate its workforce strategy to ensure it is sufficient to accomplish the AIR transformation and adapt with ever-changing global aviation industry.

7. Delegation

Finding

The FAA's delegation system is an appropriate and effective tool for conducting aircraft certification. It relies on effective standards, oversight, and communication between stakeholders.

Recommendations

- The aviation community, including the FAA, industry, stakeholders, and Congress, should recognize that the delegation system allows U.S. industry and innovation to thrive, while allocating FAA resources to derive the greatest safety benefit.
- The FAA should continue to make use of the current delegation system, which is solidly established, well controlled, and promotes safety through effective oversight.
- The FAA and industry should work together to address concerns about potential undue pressure on an ODA Unit in order to maintain the independent decision-making structure of the ODA and ensure that the ODA fulfills its requirement to serve as a representative of the FAA Administrator.
- The FAA should ensure that its personnel involved in overseeing designees evolve in step with the delegation system. Oversight of a delegated organization is not the same as oversight of a delegated individual, and requires a specific skill set related to systems thinking. A continued focus on change management is needed to empower FAA staff and enable them to adapt to a changing work landscape.

- The FAA should provide clarification and guidance on how and when FAA technical specialists and ODA unit members communicate directly regarding technical concerns.

8. Amended Type Certificates

Finding

The FAA evaluates an application for an amended type certificate using the same structured process as for a new type certificate, and both processes result in certification of a safe product. In fact, the ability to change a TC is important and promotes an increase in safety for derivative models that replace aging airplanes.

Recommendations

- The FAA should work to ensure FAA policy and guidance are updated to include cross-system (equipment, human, and environment) evaluation of changes.
- The FAA should update existing guidance to highlight the vulnerabilities that can develop around multiple adaptations of existing systems, where transfer of historical assumptions may not be appropriate or may require specific validation. This can be relevant to new TC programs, but is more likely relevant to amended TC programs where system integration can have unique challenges.
- The FAA should clarify roles and responsibilities of the applicant and FAA in assessing cross-functional interface assumptions in determining what constitutes a significant change.

9. Innovation

Finding

The FAA's Aircraft Certification Service focuses its innovation work on guidance materials, standards, and regulations to support new entrants into the aviation market.

Recommendations

- Since the Innovation Center is a recently adopted concept, AIR should provide guidance expeditiously to both its employees and the industry on how the center will operate and expectations for success.
- The Innovation Center must include and encourage review of innovative methods of compliance to previously certified systems.
- The Innovation Center R&D portfolio should include and prioritize changes to the certification process and regulatory framework so that the FAA's certifying system can keep up with concepts and technologies in the products it certifies.
- FAA should continue implementation of performance-based regulations for the adoption of new technologies that do not stifle future innovations.

10. Existing Recommendations

Finding

Several prior certification and delegation reports exist with open recommendations for potential enhancements relevant to this Committee's work.

Recommendations

- The Committee recommends that the Secretary of Transportation and FAA Administrator conduct a thorough inventory of the more recent recommended actions from industry-government advisory committees and government oversight agencies and prioritize those actions that will enhance the safety and efficiency of the certification process. The Committee specifically endorses and encourages the FAA to expeditiously implement the following recommendations:
    - That the FAA undertake a review of FAA workforce certification program management processes. It should review, update, and strengthen the methods, tools, and training for performance-based system safety oversight through the use of effective risk-based resource targeting for project involvement and system safety oversight of delegation programs (Ref SOC-ARC, 21SMS-ARC, DOT-IG reports AV-2016-001 and AV-2011-136).
    - That the FAA undertake a review to update 14 CFR part 21 certification procedures to reflect a system safety approach to product certification processes and oversight of industry design organizations. This review should include consideration of minimum qualification and organizational requirements for design approval applicants and holders, including responsibilities and privileges such as implementation of compliance assurance and safety management systems consistent with the Certified Design Organization (CDO) concept (Ref ACPRR, 21SMS-ARC, SOC-ARC).
    - That the FAA establish an integrated aircraft program management framework with roles and responsibilities for type certification and operational evaluation to improve coordination between AIR and AFX for project planning and performance of issuance of design approvals and entry into service (Ref SOC-ARC).
    - That the FAA should develop comprehensive implementation plans for certification process improvement initiatives that address: people (knowledge, skills, and abilities [KSA], roles/responsibilities, and culture change), process, tools, training, and implementation (change management). These plans must include a means to track and monitor these initiatives to ensure effectiveness of implementation, including metrics for measuring expected benefits. (Ref ACPRR, SOC-ARC)
- The FAA must develop better procedures to quickly amend and adopt FAA orders, policies, and advisory circulars that provide agency personnel guidance on how to implement in the field the changes emanating from these various oversight and advisory committees and to assess effectiveness of implementation.