Official Report

of the

Special Committee

to review the

Federal Aviation Administration's

Aircraft Certification Process

January 16, 2020

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Letter from Committee Chairs

January 16, 2020

The Honorable Elaine L. Chao
Secretary of Transportation
U.S. Department of Transportation
1200 New Jersey Ave, SE
Washington, DC 20590

Dear Secretary Chao,

On behalf of the Special Committee to Review the Federal Aviation Administration's Aircraft Certification Process, we are pleased to present you with our report on the FAA's aircraft certification process, with particular focus on the Boeing 737 MAX 8 certification program.

Thank you for your confidence in selecting us to serve on this Committee. The independent panel you selected comprised a diverse group of leaders, managers, safety experts, human factors experts, and pilots, all with several decades of experience in the industry. Our combined proficiency allowed us to examine aviation safety and the aircraft certification system as a whole. While our interactions with each other and with stakeholders were collaborative in nature, we challenged each other, worked through differing viewpoints, and ultimately reached consensus on this report and its findings and recommendations.

The Committee's goal in this report was not to elaborate on the complexities of aircraft certification, but rather to evaluate the system and offer insights into mitigating risk and also to provide recommendations on how aviation can, and must, mature. Our aim is to enhance a rigorous certification system that has served us well for decades, but needs adjustments as technology advances and aviation continues growing on a global scale. As you read through our report, you will see that we found that the FAA's workforce comprises committed safety professionals.

We are confident that implementation of the report's recommendations will enhance the FAA's processes and advance aviation safety. We believe that our recommendations will bolster current transformation efforts and offer areas for improvement for both industry and government.

We would also like to acknowledge the valuable assistance and cooperation we received from a variety of aircraft certification stakeholders. We met with devoted professionals who are the linchpins of this safest era in aviation history and contribute to making it better.

Respectfully,

Donald Lee Moak

Captain Lee Moak
Co-Chair

Darren W. McDew

General Darren W. McDew, USAF (Ret.)
Co-Chair

Executive Summary

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 <u>all</u> 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

<u>Finding</u>

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.

<u>Recommendations</u>

- 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

<u>Finding</u>

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.

<u>Recommendations</u>

- 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.

1. Establishment of the Committee

In October 2018 and March 2019, 346 lives and two U.S. State of Design aircraft were lost in accidents in Indonesia and Ethiopia. In the wake of these accidents, U.S. Secretary of Transportation, Elaine L. Chao, established the Special Committee to Review the Federal Aviation Administration's Aircraft Certification Process, which became active on June 15, 2019. A group of five aviation safety experts was appointed to form this independent committee and provide objective insight into two main tasks:

1. To review the FAA's product certification process, the use of delegated authority, and the approval and oversight of designees;

2. To review the certification process applied to the Boeing 737 MAX 8, which occurred from 2012 to 2017.

This Committee was formed within the structure of the Safety Oversight and Certification Advisory Committee (SOCAC), which was also created by Section 202(g) of the 2018 Reauthorization Act.

Upon completion of its work, the Committee was asked to report its findings to the Secretary of Transportation and the FAA Administrator and make recommendations for improvement of the certification process. This document fulfills that requirement.

2. Methodology

The Committee was tasked to provide analysis of the FAA's aircraft certification system and provide recommendations for improvement. To this end, the Committee worked to conduct research and obtain firsthand information and insight from the FAA and stakeholders of the aircraft certification system, with a focus on the safety of aviation in the United States and abroad.

The members of the Committee possess a mix of expertise gained through decades of service in commercial aviation, military aviation, government operations, safety management, and human factors. In conducting a review of the FAA's certification system, the Committee members, with their unique backgrounds and experiences, were able to conduct an independent and objective review. They focused on studying the FAA's certification process and evaluating ways in which the system could be improved. The recommendations listed in this report reflect the application of this diverse expertise and insight gathered from a wide array of sources through a comprehensive process of research, interviews, briefings, site visits, and deliberation.

From June to November 2019, the Committee met with an array of aviation and safety management specialists, including subject matter experts and leadership from the FAA, representatives from aviation trade associations, labor organizations, U.S. industry, and U.S. government agencies. In August 2019, the Committee met with the FAA and Boeing in the Seattle area to discuss the details of the process used to certify the Boeing 737 MAX 8. With the goal of obtaining an understanding of the implementation of the FAA's certification process on a project level, the Committee met with several stakeholders of the process, including FAA and industry employees, representatives from their labor associations, and trade associations. As part of this effort, members of the Committee met with various Organization Designation Authorization (ODA) holders to gain their perspective on the use of delegation in their programs. In addition, conversations were held with the National Aeronautics and Space Administration (NASA) in order to gain an outside perspective on safety and learn some of their best practices, as well as their vision for the future of aviation. The Committee also met with representatives from Airbus in order to gain a global perspective, to use as a comparison.

It is important to note that the scope of this Committee's work was the FAA's process for certifying aircraft. It did not involve investigation of any particular accidents, incidents, or events, nor the technical evaluation of any aircraft, systems, components, or software. It also did not include any review of the aircraft production certification processes. Discussions therefore focused on regulations, policy, guidance material, and industry standards. Meetings with stakeholders and subject matter experts were collaborative in nature rather than investigatory, which created a productive environment for discussion and exchange, to reflect with candor on the current aircraft certification system and build ideas on how to further improve it.

Other committees, such as the Boeing 737 MAX Flight Control System Joint Authorities Technical Review (JATR), included certification experts from the U.S. and other civil aviation authorities. That panel of certification experts had a limited focus—the certification of the 737 MAX 8 flight control system. Their recommendations, therefore, are specific to the certification of flight control systems, whereas this Committee's review focused on the entire certification process.

The Committee’s goal in this report, therefore, is not to elaborate on the intricacies of the complex process of aircraft certification, but rather to evaluate the system as a whole and offer insight and recommendations on how aviation can mature to the next level of safety.

3. Aircraft Certification in the United States

The Committee began its work by conducting a review of the FAA's current aircraft certification system through independent research and in-depth discussions with a variety of stakeholders. This chapter is intended to provide a high-level assessment of the system, including applicable regulations, policies, and concepts.

3.1 Aircraft Certification Process

Although the public often thinks of certification as involving only airline or pilot certification, there are in fact many different types of regulatory approvals and certifications that need to occur at the product level throughout the life cycle of an aircraft. All civil aviation products (aircraft, engines, and propellers) and articles (materials, parts, components, processes, and appliances) must be approved by the FAA prior to being used in the National Airspace System (NAS). This process of certification involves approval of a product's or article's engineering design, approval of a manufacturer's production quality system, and ultimately certification that each individual aircraft conforms to the design and is in a condition for safe operation. Once a certified product enters into service, the focus shifts to continued operational safety (COS), to ensure the integrity of the product throughout its service life. COS includes mandatory requirements for modification, maintenance, and corrective actions. Together, these actions all form part of the aircraft certification process.

3.2 Approvals for Operation

Many separate FAA approvals are required to operate civil aircraft in the United States. These include, but are not limited to, the following:

1. Type certificates, which are unique to a product's design and signify compliance of the design to established FAA safety standards;
2. Production certificates, which are unique to a manufacturer and signify that the manufacturer has demonstrated that they have the quality and production systems necessary to produce the aircraft;
3. Airworthiness certificates, which are unique to an aircraft (by serial number) and signify the specific aircraft conforms to the approved design and is in a condition for safe operation;
4. Operator certificates, which are unique to an operator (air carrier);
5. Personnel (pilots, mechanics, dispatchers, etc.) licenses and approvals, which are unique to a person.

3.3 Aircraft Certification Activities

3.3.1 Organization

In the U.S. system, the FAA is responsible for certifying civil aviation products and articles. Within the FAA, the Aviation Safety (AVS) organization is responsible for the certification of aircraft, aircrew, operators, and facilities. AVS is composed of eight organizations with distinct, yet interrelated, responsibilities. Within AVS, the Aircraft Certification Service (AIR) is responsible for oversight of design, production, and airworthiness programs for all U.S. and foreign import civil aviation products and articles. AIR establishes the corresponding regulations, policy, and supporting guidance; determines compliance to such standards; and issues certificates and other approvals accordingly. After issuing certificates, AIR continues to monitor the airworthiness of products in service. While the FAA's aircraft certification process is primarily maintained and implemented by AIR, its execution involves input from, and collaboration with, other offices within AVS. The Flight Standards Service (AFX), in particular, plays a significant role in product certification, entry into service, and the maintenance process.

Certification has existed in one form or another for nearly a century. The FAA has refined the process since it was created in 1958. Over time, the FAA's regulations and policies have evolved, with the goal of adapting and keeping pace with a rapidly changing industry that now leverages global partnerships to develop new, more efficient, and safer aviation products and technologies. Across the agency, the FAA has adopted a risk-based approach to carrying out its work, focusing its resources on those areas that have been determined to have the highest risk to aviation safety.

3.3.2 Design, Production, and Airworthiness Certification

3.3.2.1 *Type Certification*

The FAA issues type certificates (TC) for new or derivative model aviation products. A TC is unique to a design and signifies the airworthiness of the design in accordance with applicable regulations. While commonly referred to simply as the type certificate, a TC actually consists of two separate documents: the TC itself and the Type Certificate Data Sheet (TCDS), which is a formal description of the product that includes general and technical information about the design.

The FAA's type design certification process is outlined in FAA Order 8110.4C: *Type Certification*, and includes the following major steps:

1. Familiarization Briefing
    - An applicant meets with the FAA to discuss a proposed design, with early emphasis on technical issues and unique or novel features.
2. Application
    - The applicant completes and submits an application, and the FAA assigns a management team to oversee the project.
3. Compliance to Regulations
    - The FAA establishes specific regulatory design requirements, known as the certification basis. The applicant must show compliance to this certification basis.
4. Certification Plans
    - The applicant submits a certification plan and schedule for showing compliance to the certification basis detailing design reviews, tests, and inspections.
5. Conformity Inspections
    - Inspectors verify and provide objective documentation that the test articles, parts, assemblies, installations, functions, and test setups that will be used to demonstrate compliance conform to the design data.
6. Compliance Findings
    - Determinations are made at the aircraft and component level to ensure the design complies with certification requirements.
7. FAA Flight Tests

    - The FAA conducts flight tests to verify the data reported by the applicant and to evaluate the aircraft's performance, flight characteristics, operational qualities, and equipment operation. The tests inform operational limitations, procedures, and pilot requirements.
8. Final Type Certification Board
    - Final meeting to validate that all elements of the certification plan are complete, and to issue a TC.

Certain aspects of the type certification process were of particular importance to the Committee in relation to its tasking and are therefore explained in more detail below.

Early Engagement

Today, the FAA encourages applicants intending to apply for a design approval to engage with the FAA in advance of presenting a formal application in order to both familiarize the applicant with the applicable certification requirements and to familiarize the FAA with the proposed design. Early engagement between applicants and the FAA helps shape a common understanding of the project, associated risks, and available methods of compliance, increasing the likelihood of project success. We often think of early engagement as being necessary for new products and novel technology: however, innovation applies to previously approved products as well, and early engagement is therefore critical to all projects. The concept of early coordination between the FAA and the applicant is therefore relevant throughout a product's life cycle, as products evolve and integrate new technology through various processes.

Applicable Regulations

Once an applicant and the FAA establish the certification basis for the proposed design, identifying the regulations applicable to the project, they develop and agree to a certification plan to identify how the certification basis will be met. In order to obtain a design approval, the applicant must show that the product complies with established standards and any special conditions applied by the FAA to account for novel or unusual design features. The applicant's showing of compliance is accomplished through detailed airplane-level analysis, lab tests, and flight tests, all of which are subject to FAA oversight. After all certification tasks are complete, the applicant provides the FAA with a final statement of compliance certifying that it has complied with the applicable requirements. Only when the FAA finds that a product complies with all applicable safety standards can it issue a design approval.

Changes to an Applicant's Existing Type Design

The FAA's certification process is based on compliance with regulatory requirements. An applicant must meet the rules that are in effect at the time of application for the design approval. Applicants who wish to amend their existing type design are still required to apply the latest requirements in effect on the date of application for the amendment. For an amendment to an existing TC the certification basis used for the original certification may be used for unchanged areas of the aircraft design. Amendments of existing design approvals and applications for new design approvals both use the same overall certification process. In fact, the addition of changes to an existing type design allows an increase in safety for derivative products that replace aging airplanes within an existing fleet.

Proposed design changes are evaluated to determine the applicable regulations that will form the certification basis. A new TC is required when there are extensive changes in design, power, thrust, or weight resulting in a substantially complete determination of compliance. Changes that do not retain general configuration or principles of construction, or invalidate assumptions used in certification, are automatically considered substantial and require a new TC. For other design changes not determined to be substantial, applicants can apply to amend their existing TCs.

Changes in type design that have no appreciable effect on critical airworthiness characteristics of the product are classified as minor and can be approved by the FAA under methods other than amending the type certificate. Generally speaking, all other changes are classified as major and therefore must be certified by the FAA.

When an applicant proposes a major change to one of its design approvals, they can apply for an amendment to their existing TC. In setting the certification basis for a changed product, the decision as to whether or not the applicant can use the regulations in effect on the date of application for the original certification is based on a determination of whether the change is found to be significant or not significant.

14 CFR 21.101, commonly referred to as the changed product rule, allows an applicant for a changed product to show compliance with an earlier amendment of a regulation in the following cases:

- The FAA finds that the change is not significant. In determining whether a specific change is significant, the FAA considers the change in context with all previous relevant design changes and all related revisions to the applicable regulations incorporated in the TC for the product. Changes that meet one of the following criteria are automatically considered significant:
    - The general configuration or the principles of construction are not retained.
    - The assumptions used for certification of the product to be changed are no longer valid.
- The FAA finds that an area, system, component, equipment, or appliance is not affected by the change.
- The FAA finds that an area, system, component, equipment, or appliance is affected by the change, but that compliance with the latest regulations would not contribute materially to the level of safety of the product, or would be impractical.

Engineering Assumptions

During the design and certification of systems, decisions are made by designers, regulators, and operators to ensure that products are compliant and can be operated safely. Processes that help inform these decisions include design specifications, operational performance specifications, and system safety assessments, all of which rely on engineering assumptions.

In any engineering project, assumptions need to be made as part of the design process. Assumptions are statements that the design team initially accepts as facts. In today's aerospace industry, assumptions are generally based on longstanding industry standards and frequently relate to prior experience with the product or similar products. In an aircraft certification project, design assumptions play a critical role in the development of the certification plans and in identification of areas for review. It is therefore essential that the applicant communicate those assumptions to the FAA, including how they are tested, validated, communicated, and challenged. Regulations do not require communication of design assumptions to the FAA; however, in practice, critical assumptions are conveyed and addressed through the FAA's review of the applicant's proposed methods of compliance, which establish how compliance will be shown for a particular regulation.

The information and details provided by an applicant to the FAA early in the process play a crucial role in the FAA's determination of two critical decision points in the certification process. These are used to determine whether the applicant is eligible to submit an application for an amended TC or must submit an application for a new TC. Such information also determines what elements of the certification plan require direct FAA oversight because they represent significant changes, novel features, or elevated safety risk. In all cases, the FAA reviews and makes its own determination regarding preliminary characterizations of the type design by the applicant.

Level of Involvement Decisions

The FAA's discretionary authority allows the agency to determine the FAA's level of involvement for any particular project. FAA involvement can be either direct, when performed by FAA employees, or indirect, when performed by authorized designees. Regardless of whether it is FAA staff or FAA-authorized designees responsible for certain aspects of a certification program, the applicant is always required to <u>show</u> compliance, while the FAA is responsible to <u>find</u> compliance. With the exception of certain areas such as a noise, the FAA has discretion in deciding how it will find compliance, and makes that level of involvement determination based on risk. In certain cases, the FAA may choose to leverage applicant expertise to help identify the areas of highest risk. Information provided by the applicant at this stage is crucial for the FAA to conduct informed risk assessments.

Projects have various risks associated with them, but the level of involvement decision focuses mainly on the safety risk of a noncompliance. The level of oversight for a particular certification project is based on the FAA's confidence in an applicant's management of risk, including compliance assurance systems. When the FAA has higher levels of confidence in an organization's systems, the FAA can delegate more elements of the certification plan to be performed by authorized designees. The applicant's and the FAA's responsibilities for a given path to compliance are documented in the certification plan for accountability of both parties.

Just Culture and Accountability Framework

AIR's Accountability Framework is a concept that helps clarify FAA and industry roles that form the backbone of the airworthiness system. While the FAA and industry work together to ensure safety, and their roles are linked throughout the certification process, there is a clear delineation of roles and responsibilities. All stakeholders of the aircraft certification system share an obligation to ensure the development, production, and maintenance of safe products. However, final accountability for compliance to safety regulations always rests with the organizations that seek or hold certification approvals. AIR's role is to perform oversight of applicants and approval holders throughout the certification process. This framework is designed so that organizations will proactively demonstrate compliance with regulations, and be more committed to compliance, self-correction, and voluntary disclosure.

In accordance with 14 CFR 21.20, an applicant for a TC must show compliance with all applicable requirements, provide the means by which compliance has been shown, and provide a statement certifying that it has complied with the applicable requirements. This statement is a legal certification that the applicant meets all applicable regulations and that the ultimate responsibility for compliance rests with the applicant.

3.3.2.2 ***Production Certification***

An FAA production approval is separate from a design approval. The production approval allows the production of an aviation product or article in accordance with its approved type design and the manufacturer's approved quality system. For aircraft, the FAA issues its production approval in the form of a production certificate (PC), which represents approval to manufacture duplicate products under an FAA-approved type design. The PC holder is often the same as the TC holder, but they may be different.

The FAA's Production Certification process is outlined in FAA Order 8120.22A: *Production Approval Procedures*.

3.3.2.3 ***Airworthiness Certification***

The FAA issues an airworthiness certificate for individual aircraft to indicate that each final product conforms to its approved type design and is in a condition for safe operation. Standard airworthiness certificates indicate that all relevant certification processes (type certification, production approval, and airworthiness approval) have been certified by the FAA.

The FAA's airworthiness certification process is outlined in FAA Order 8130.2J: *Airworthiness Certification of Aircraft*.

3.3.3 Continued Operational Safety

After the FAA issues initial certification approvals and a product enters into service, focus shifts to the continued operational safety (COS) of the product. COS involves problem prevention, service monitoring, and corrective actions that feed back into a product's design and production. The FAA's COS program is used to assess and manage operational safety risk.

The FAA characterizes COS as a three-party shared responsibility between the TC holder, the operator, and the regulator, who are tasked to work together to ensure the integrity of a product throughout its service life. Regulations require the TC holder to track certain design and manufacturing malfunctions and defects and report them to the FAA, and to develop modifications to correct unsafe conditions. An aircraft owner or operator is required to maintain its aircraft in a condition for safe operation by compliance with instructions for continued airworthiness (approved manuals, etc.) and Airworthiness Directives. It must also report certain malfunctions, failures, and defects to the FAA. Finally, the FAA follows regulations and International Civil Aviation Organization (ICAO) guidance to monitor the safety of the worldwide fleet of U.S.-designed and manufactured products, and notify affected civil aviation authorities of mandatory corrective action.

3.3.4 Aircraft Certification Service and Flight Standards Service Coordination

Aircraft design, production, and airworthiness certification is managed by AIR, working in coordination with AFX via its Aircraft Evaluation Groups (AEGs). AEGs were established to meet FAA's operations and maintenance responsibilities during the type certification process. The AEGs comprise operations and airworthiness inspectors who work directly with AIR to provide an operational perspective to engineering activities. The AEGs advise manufacturers of applicable operational and maintenance requirements during the design and certification process and make recommendations about flight training, inspection programs, and flight crew qualifications. The genesis of the AEG's responsibilities is in FAA Order 8110.4C: *Type Certification*.

The AEG typically begins these responsibilities at TC application, alongside AIR, and is part of the certification team. Their participation in the certification process includes attending general and technical briefings by the applicant throughout the project to communicate both certification intent, approach, and operational impacts to the aircraft. From there, operational and certification personnel meet with the applicant's personnel responsible for the operational or engineering aspects to further refine the applicant's approach and the FAA's questions, needs, or concerns. Operational and engineering personnel are expected to interface and communicate as needed during the entire certification project to contribute an operational perspective to engineering activities. The AEG may participate in compliance and testing to evaluate the operational suitability of the aircraft and its systems as part of the AEG evaluation.

For large jet and large propeller aircraft, the FAA generally establishes a Flight Standardization Board (FSB), comprising AEG personnel, to determine the operational suitability of the aircraft and its systems. This assessment includes requirements for flight crew training aids, type rating requirements for pilots, and any unique or special training requirements. Industry and regulatory authorities generate the Maintenance Review Board Report (MRBR) as a coordinated effort to achieve timely compliance with the applicable certification regulatory requirements and the minimum scheduled maintenance requirements. The MRBR contains the minimum scheduled tasking/interval requirements for a particular aircraft and on-wing engine maintenance programs. The MRBR becomes part of the instructions for continued airworthiness (ICA). AEG airworthiness inspectors are intended to coordinate with design approval holders and AIR to ensure a complete set of ICAs that meet the applicable airworthiness regulations is acceptable and furnished to product owners and to any person required to comply with them.

These required aircraft certification tasks are executed through AFX policy and guidance found in FAA Order 8900.1: *Flight Standards Information Management System*, and AC 120-53B: *Guidance for Conducting and Use of Flight Standardization Board Evaluations*.

3.4 Regulatory Framework and Guidance Materials

Title 49, United States Code (49 USC) is reserved for transportation. The statutory provisions of 49 USC provide the FAA with the authority to issue rules and guidance. The FAA establishes regulatory standards to ensure safe operations in the National Airspace System (NAS). The aviation and aerospace communities have a statutory obligation to comply with established regulatory standards.

<u>Regulations</u>
FAA regulations are contained in Title 14, Code of Federal Regulations (CFR)—Aeronautics and Space. Parts 1 through 199 govern the design, production, sales, operation, and maintenance of civil aviation products and articles. The most relevant sections of 14 CFR for the certification of aviation products are listed below:

- *Operational Standards*
  Parts 91, 121, 125, 129, and 135 define operating requirements by type of operation.

- *Certification Procedures*
  Part 21 provides the comprehensive general framework for certifying aviation products.

- *Airworthiness Standards*
  Parts 23, 25, 26, 27, 29, 31, 33, 34, and 35 contain the specific airworthiness standards for design approvals by product type.

Airworthiness Directives (ADs), which are notifications issued to correct an unsafe condition in a product, are considered regulations since they are legally enforceable requirements issued by the FAA under its general rulemaking power and 14 CFR part 39. The FAA shares ADs with the international community for follow up by civil aviation authorities with affected aircraft on their registry.

When it finds that current airworthiness regulations do not contain adequate or appropriate safety standards because of a novel or unusual design feature, the FAA issues special conditions. A special condition is a regulation that applies to a particular aircraft design.

Historically, the FAA's airworthiness regulations have been prescriptive, outlining specific conditions that must be met in order to obtain a certain outcome. In August 2017, the FAA issued a new part 23 rule for small airplanes that was innovative in that it replaced prescriptive requirements with performance-based standards coupled with consensus-based compliance methods for specific designs and technologies. The 2018 FAA Reauthorization Act called for the FAA to "ensure that regulations, guidance, and policies … are issued in the form of performance-based standards, providing an equal or higher level of safety." Over time, other airworthiness standards, including those for transport category airplanes, are expected to follow suit. This regulatory approach recognizes there is more than one way to deliver on safety. It offers a way for industry and the FAA to collaborate on new technologies and to keep pace with evolving design and manufacturing processes, reducing the need for special conditions and exemptions, and providing flexibility for new methods of compliance.

<u>Orders</u>
An Order is a document issued by the FAA to FAA employees as guidance material for FAA personnel, used to outline procedures for performing FAA job functions.

<u>Advisory Circulars</u>
The FAA issues advisory circulars (ACs) as guidance to the public. They outline acceptable means, but not the only means, of showing compliance with regulations or requirements. ACs are neither binding nor regulatory. While the issue identified in an AC must be addressed, the actual way that an applicant shows compliance can deviate from the guidance in the AC, as long as it provides a similar outcome.

3.5 Delegation

3.5.1 Introduction

In the context of aircraft certification, delegation refers to a process consistently endorsed by Congress whereby the FAA authorizes a qualified person or organization to perform certain duties on behalf of the FAA.

The Federal Aviation Act of 1958 was the original statute enabling the FAA to delegate activities, as the agency deemed necessary, to approve private people across a variety of functions. Although self-employed or in some cases employed by the regulated entity, these designees serve as representatives of the FAA Administrator. They act as surrogates for the

FAA, and the FAA is responsible for overseeing their work. In aircraft certification, designees are experts in the engineering, systems, inspections, and avionics communities who are familiar with the regulations and certification requirements necessary to issue a certificate. The current delegation numbers reflect the FAA's reliance on the expertise of designees. There are approximately 7,500 private-sector, FAA-authorized designees, compared with a total staff in AIR of approximately 1,340.

The FAA has the option to conduct oversight of any aspect of a certification program, and review the details of the certification approach. FAA regulations, however, do not require FAA personnel to be involved in all compliance findings. Furthermore, the FAA acknowledges that it neither has the resources nor the ability to keep pace with rapidly changing technology. As a result, the FAA Reauthorization Act of 2018 required the FAA to make progress toward "achieving full utilization of…delegation." Using designees for routine certification tasks allows the FAA to focus its limited resources on safety-critical certification issues, as well as new and novel technologies, while leveraging the extensive technical expertise available in industry for other areas. Recognizing and making good use of the industry's capabilities allows the FAA to move towards performance-based oversight and away from simply compliance with prescriptive regulations.

There are two types of designees: individuals and organizations. Individual designees can be either a company employee or an individual consultant. Delegated organizations (ODA: Organization Designation Authorization) comprise two or more individuals who are designated to perform the authorized functions of the FAA. Whether an individual or an organization, both are considered designees and the FAA is responsible for their oversight and management.

3.5.2 The Role of Designees in Aircraft Certification

AIR may authorize designees, within limits and under the supervision of their FAA advisor, to perform examinations and inspections and witness tests in the manufacturing and engineering areas. Designees must be familiar with, and have ready access to, all appropriate FAA publications and documents. Designees are not authorized to approve departures from policy and guidance, new/unproven technologies, equivalent level of safety findings, special conditions, or exemptions. These are inherently governmental functions that cannot be delegated.

Designees can perform only their authorized functions, within the limits of designated authority. While acting pursuant to their appointment, designees serve as representatives of the Administrator for specified functions and are not considered employees of the FAA. Designees are authorized to use their titles only when performing those functions specifically delegated by their FAA managing office.

The ongoing authority to serve as a designee is dependent upon their ability to conduct work on behalf of the FAA independently and with the highest degree of objectivity. Upon appointment and renewal, designees must acknowledge that designation is a privilege, not a right, and understand that their designation may be terminated at any time for any reason.

As the FAA faces increasing demands regarding continued operational safety of in-service products and the development of those regulations and airworthiness standards necessary to increase the level of safety, direct involvement of the agency's resources in all areas of domestic approvals and foreign validations would exceed AIR's capabilities at this time. The current system would not be able to keep up with innovation and new designs and would suppress industry under a regulatory backlog. Leveraging designee expertise allows the FAA to focus resources on new applications of existing technology, on new and evolving technologies, and on innovation and growth in aviation.

3.5.3 The Benefits of Delegation

Industry continues to grow and innovate, developing new technologies with potentially lifesaving safety enhancements. Certification experts at the FAA and within industry share a belief that an expanded certification system fully dependent on FAA staff would fall behind the cutting-edge expertise of industry. FAA employees regularly have industry experience, but over time they can lose touch with the latest innovations and technical advancements when working for the regulator and not industry. To counter that knowledge gap, the FAA leverages the expertise of external resources who, as active daily members of industry working on innovation and development, have a thorough familiarization with their products and the technology behind them. Designees add value to the certification process, while adhering to the strict standards of professional accountability demanded by their delegated authority from the FAA.

Civil aviation authorities such as Transport Canada Civil Aviation and the European Aviation Safety Agency include a form of delegation as part of their certification system. Since its inception, the FAA's delegation system has been reviewed and consistently approved by Congress, and the program has been gradually expanded and enhanced over time, in response to many congressional enquiries.

3.5.4 Oversight of Designees

FAA managing offices are responsible for supervising, monitoring, and tracking designees' activities to ensure designees perform their assigned authorized functions in accordance with the appropriate regulations, policies, and procedures. Periodic review of an organization's systems provides insights to inform and direct oversight activities and necessary stakeholder actions.

For individual designees, each Designated Engineering Representative (DER) is assigned a managing office and an advisor who conducts oversight during normal interactions with the DER. Oversight is conducted through both direct observation and paperwork review, and the DER is rated as "satisfactory," "needs improvement," or "unsatisfactory."

For organizational designees, an FAA Organization Management Team (OMT) oversees each ODA. The OMT comprises subject matter experts from each technical discipline for the projects the ODA will work. The OMT's role is to provide direct supervision of the ODA and to audit the work completed by the ODA to ensure it is completed in a manner that meets FAA regulations, standards, policy and guidance. The current oversight model includes a detailed audit every two years, annual supervision record/review by each OMT member in each area of specialty, and continual oversight through program notification letter reviews (to determine specific delegation). In addition to FAA oversight of an ODA, the ODA unit itself is also responsible for performing oversight of its individual unit members.

3.6 Recent Changes to the Certification Process and the Aircraft Certification Service & Flight Standards Service Organizations

The FAA's certification process is one of many factors that affect the time it takes for U.S. products to reach the market. It can also affect the predictability of product development schedules. These impacts affect the competitiveness of this important sector of the U.S.

economy. Consequently, the FAA must strike the proper balance between oversight and efficiency. The FAA must ensure safety without unduly hindering the ability of safety-enhancing innovations to be approved and implemented.

To respond to the globalization of aviation, industry growth in all sectors, the velocity of change, and heightened expectations for the FAA to perform its critical tasks faster and with greater accuracy, AVS has conducted two significant reorganizations in recent years of two of its major components: AIR and AFX.

In July 2017, AIR, which is responsible for issuing approvals for new and changed products and for the continued operational safety of the existing and rapidly expanding fleet of U.S. State of Design products, shifted from a product-based organization to a functionally based one. In parallel to AIR's organizational transformation, AFX underwent a similar organizational change to make itself also functionally based, taking it away from its prior geographic-based organization.

The FAA's aim in changing both organizations was to increase organizational efficiency and effectiveness and streamline processes by improving consistency and standardization while allowing the organization to operate under a systems approach that considers how decisions and information impact safety risks across the product life cycle. Generally, the feedback the Committee received from stakeholders was positive. They saw the reorganization of AIR and AFX as a step towards improving standardization and efficiency, and welcomed the shift to applying performance-based principles and using a systems approach to certification.

AIR's organizational transformation was focused on increasing safety while allowing for more reliance on industry compliance assurance systems and delegation. This was done by "book-ending" the certification process. Engaging earlier with applicants helps assure that the FAA and industry agree on compliance methods. At the same time, the organization began focusing more on system oversight. Through the AIR transformation, the FAA established a new division within AIR to focus on oversight, which did not exist previously.

As part of its reorganization, AIR has also established an "Innovation Center," designed to provide a single-entry point for emerging technologies, new production methods, and new business models for the purpose of enhancing safety and certification processes. It is also expected to provide a forum for FAA and stakeholders to engage in innovations and explore the need for new regulations and policy prior to an applicant seeking certification.

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

The previous chapter of this report provides a high-level outline of the FAA's certification process in general terms. This chapter continues the review of the certification process by providing an exemplar for drawing lessons learned from the implementation of the Boeing 737 MAX 8 program.

The content is based on multiple briefings with the FAA and Boeing, along with information and insight gained through site visits and research. The Committee met with both the FAA and Boeing to understand the processes involved in the FAA's certification of the Boeing 737 MAX 8 aircraft, which took place from 2012 to 2017.

It is important to note that the Secretary's instructions to the Committee were to review the certification process, and not to conduct a technical evaluation of the aircraft itself or of any of the assumptions used in the evaluations. Accordingly, the Committee met with both the FAA and Boeing to understand the processes involved in the FAA's certification of the Boeing 737 MAX 8 aircraft.

4.1 Background

The Boeing 737, designed and manufactured by Boeing Commercial Airplanes (Boeing), is a U.S. State of Design, U.S. State of Manufacture short- to medium-range transport category aircraft with over 50 years of history. The FAA issued the initial 737 TC to Boeing for the 737-100 in December 1967. Since its original 737-100 certificate issuance in 1967, that TC has been amended 13 times, for each new 737 model. Each of the 13 amendments to the TC required certification by the FAA, and applicable new regulations were incorporated into the certification basis with each new aircraft model. Each of the three major derivative families (Classic, Next Generation [NG], and MAX) has introduced a new engine, lowered noise, improved range, and increased fuel efficiency.

Original:
- Model 737-100 (TC issued December 15, 1967)
- Model 737-200 (TC issued December 21, 1967)
- Model 737-200C (TC issued October 29, 1968)

Classic:
- Model 737-300 (TC issued November 14, 1984)
- Model 737-400 (TC issued September 2, 1988)
- Model 737-500 (TC issued February 12, 1990)

Next Generation (NG):
- Model 737-600 (TC issued August 12, 1998)
- Model 737-700 (TC issued November 7, 1997)
- Model 737-800 (TC issued March 13, 1998)
- Model 737-700C (TC issued August 31, 2000)
- Model 737-900 (TC issued April 17, 2001)
- Model 737-900ER (TC issued April 20, 2007)

MAX:

- Model 737 MAX 8 (TC issued March 8, 2017)
- Model 737 MAX 9 (TC issued February 15, 2018)

The Boeing 737 MAX family includes the Boeing 737 MAX 7, 737 MAX 8, 737 MAX 9, 737 MAX 10, and 737 MAX 8200. The 737 MAX 7, 737 MAX 10, and 737 MAX 8200 have not yet been certified.

The fact that the 737 TC has been amended 13 times is not unusual. In fact, as a comparison, the TC for the Airbus 319/320/321 aircraft has been amended 43 times since its initial issuance on the Airbus A320 in 1995. (See Appendix 6.1.)

4.2 Project Timeline and Milestones

This timeline lists some of the significant steps taken during the five-year certification of the Boeing 737 MAX 8. While this list is ordered chronologically, some portions of the certification process occur in parallel.

- January 2012: Application for TC submitted by Boeing to the FAA
- March – May 2012: General and technical familiarization meetings
- June 2012 – April 2015: Certification basis evaluation
- November 2013: Master certification plan established
- February 2014: Certification basis established
- January 2016 – February 2017: Applicant flight testing
- November 2016: FAA acceptance of detailed certification plans
- February 2017: FAA certification flight tests complete
- February 2017: FSB type rating & training determination complete
- March 2017: Type certificate issued

4.3 Classification of the TC Application

Prior to the onset of any certification program, the applicant and the local FAA office meet regularly to discuss and plan the project. An important first step in this discussion is the decision to classify the application as a new TC project or as an amendment to an existing TC. That decision is made according to regulatory criteria and impacts the development of the certification basis.

14 CFR 21.17 requires an applicant for a TC to comply with all applicable requirements in effect on the date of application, plus any special conditions. For an amendment to a TC, 14 CFR 21.19 also applies. It states that an applicant for a change to one of its TCs may be able to apply for an amendment to the existing TC or may be required to apply for a new TC, depending on established criteria. For an amendment to a TC, 14 CFR 21.101 is used to determine the applicable regulations to be used as the certification basis. An applicant for an amended TC must still meet the requirements of 14 CFR 21.17; however, there is no requirement for the areas of the product that were previously certified by the FAA, and that remain unchanged, to be re-evaluated. The FAA has designed the certification process for an amended TC to allow the FAA to focus its expertise and resources on those areas of the aircraft that have changed. Regulations

also require an analysis of the impact of a potential change on other areas and the aircraft as a whole.

The FAA is responsible for determining whether an applicant's classification of a proposed change and its proposal for the certification basis are consistent with the applicable rules and FAA interpretation. FAA Advisory Circular 21-101B (*Establishing the Certification Basis of Changed Products*) provides guidance on establishing the certification basis for amended TC projects.

Based on the regulations and guidance materials, Boeing applied for certification of the 737 MAX 8 as an amendment to the 737-800 TC. In reviewing the application, the FAA evaluated the proposed design changes in consideration of the regulatory guidance. The FAA also reviewed determinations made on previous certification programs. After conducting its review of the aircraft's design changes and the regulatory requirements, the FAA concluded that the design changes for the 737 MAX 8 were not sufficiently extensive to require a new TC. The FAA approved Boeing's request to seek an amended TC, and in so doing, focused the 737 MAX 8 certification program on the aircraft's changes and areas affected by the changes.

4.4 General Description of the Aircraft

The Boeing 737-800, which was granted a TC by the FAA in March 1998, was used by Boeing as the baseline model for the Boeing 737 MAX 8.

The 12 changes identified by Boeing at the time of application as "significant" under the changed product rule, in accordance with 14 CFR 21.101 are:

1. The use of more powerful engines with better fuel efficiency;
2. A longer nose landing gear strut to provide greater engine ground clearance;
3. New strut and nacelle to account for heavier engines and new engine positioning;
4. Advanced technology winglets to maximize the overall efficiency of the wing and reduce fuel use;
5. A reshaped tailcone to reduce drag;
6. A digital engine bleed system for increased optimization of the cabin pressurization and ice protection systems, giving reduced fuel use;
7. A fly-by-wire spoiler system to improve production flow, reduce weight and improve stopping distances;
8. Strengthening the main landing gear to accommodate heavier engines;
9. A modified fuel system;
10. Strengthening of the local empennage and fuselage to accommodate heavier engines;
11. System revisions (note: changes to flight controls, including the introduction of MCAS, were covered by this listing);
12. Wing strengthening to accommodate heavier engines.

(See Appendix 6.2.)

4.5 Certification Basis

As is standard practice, Boeing proposed the certification basis for the Boeing 737 MAX 8 following guidance provided in Advisory Circular (AC) 21.101-1B and Order 8110.48A (*How to Establish the Certification Basis for Changed Aeronautical Products*).

As an amended TC project, the initial certification basis for the 737 MAX 8 was that of the baseline 737-800 plus the requirements effective on January 27, 2012 (the date of application) for the areas affected by the change, with certain exceptions in accordance with 14 CFR 21.101(b)(3), plus special conditions, exemptions, and equivalent safety findings. As part of the typical iterative project process, during the period 2012 – 2015, the FAA and Boeing collaborated on changes to Boeing's initial proposal for the certification basis. The changes involved removing, revising, and adding regulations, and issuing various exemptions, special conditions, and findings of equivalent safety. The final certification basis for the Boeing 737 MAX 8 is 14 CFR part 25 through amendment 137 (the latest amendment applicable on the date of application), applicable to the components and areas affected by the change, with certain exceptions in accordance with 14 CFR 21.101(b)(3), plus special conditions, exemptions, and equivalent safety findings. Amendments through 25–141 related to gust and maneuver load rules were later added to ensure commonality of certain areas across models.

4.6 Use of Delegation

4.6.1 History of Boeing's Organization Designation Authorization

Boeing has a long history of using delegation in seeking product certification. As the FAA's regulations and policy on delegation have evolved over time, Boeing has expanded its delegation programs accordingly. Individual designees (DERs) employed by Boeing were used in certain areas of the Boeing 707 certification program in the 1950s. AIR's Seattle area office and Boeing worked together in the 1990s and 2000s to strengthen project management skills and project norms, through a mutually developed document titled the Partnership for Safety Plan (PSP). This work also encompassed improved clarity on the role of designees through the project life cycle and specifically their role in compliance activities. A PSP is a document that outlines high-level agreements on project management norms and expectations for the management of projects, both large and small. The PSP between Boeing and the FAA helped provide a foundation upon which the Boeing ODA was built, but it is managed largely as a separate process from the ODA.

Over time, Congress and the FAA moved to expand the certification system to include organizational delegation, and industry stakeholders like Boeing followed suit. Previous forms of organizational delegation, such as Organizational Designated Airworthiness Representatives (ODARs) and Delegation Option Authorization (DOA), were used to certify the Boeing 777-300ER in the early 2000s. Boeing transitioned its ODAR and DOA to its current state—Organization Designation Authorization (ODA)—in 2009, and the ODA was used in the Boeing 787, 737 MAX, and 777X certification programs.

4.6.2 Boeing's Organization Designation Authorization Today

The responsibilities and high-level procedures to be followed by the ODA are prescribed in the FAA-approved Boeing Commercial Airplanes ODA Procedures Manual. Boeing, as the ODA holder, must follow strict FAA guidelines in evaluating and appointing ODA Unit Members based on their experience proposing prospective DERs and DOA authorized representatives. At the writing of this report, Boeing had 1,399 ODA Unit Members – 1,004 assigned to engineering and 395 assigned to manufacturing.

4.6.3 Federal Aviation Administration's Oversight of Boeing's Organization Designation Authorization

The FAA's oversight of the Boeing ODA is managed by an Organization Management Team (OMT) primarily composed of staff from the FAA's Boeing Aviation Safety Oversight Office (BASOO). The BASOO is part of AIR's System Oversight Division (AIR-800) and is based in the Seattle area. The BASOO conducts routine audits and supervision, large-scale inspections, and post-project reviews; retains involvement in safety-critical, novel, or unusual areas; and participates in test witnessing, inspections, flight tests, and ground tests. Supporting personnel on the OMT include members from Flight Standards' AEG for operations, airworthiness, and maintenance issues; the Seattle and Los Angeles ACO Branches for fleet safety monitoring; the AIR Flight Test Branch for certification flight test; and the Certificate Management Office for oversight of Boeing's production system.

4.6.4 Federal Aviation Administration's Level of Involvement Decision for the Boeing 737 MAX 8

As with most certification projects, the FAA used its discretionary authority and applied risk-based decision making to determine which areas of the Boeing 737 MAX 8 certification to be involved in, either directly or through delegation. The FAA's risk management process started at the onset of the project through review of the certification plan. The risk assessment was both qualitative and quantitative. It involved factors such as regulation criticality, and lessons learned from continued operational safety and historical operational data on the baseline aircraft, as well as expectations and standard practices regarding maintenance and operational practices intended to maintain a compliant product. Much of the assessment was based on the documented performance of the applicant and related input from the technical specialists.

The FAA determined that certain elements of the Boeing 737 MAX 8 project were eligible to be managed by Boeing Commercial Airplanes' ODA. Of the original 93 detailed certification plans, the FAA initially retained 58 (62%). The FAA also initially retained 67 of 129 (52%) certification flight test plans. As is typical in a large certification project, more of the detailed certification plans were delegated as the project progressed, the FAA risk analysis evolved, and the FAA grew more comfortable with the design and direction of the testing program.

4.7 Flight Deck Automation Philosophy and Human Factors

With regard to the design of the 737 MAX 8, Boeing applied its Top-Level Flight Deck Philosophy, which is based on a set of human factors principles that drive decisions about how flight crews interact with aircraft systems and automation. The major tenets of the Boeing philosophy are as follows:

- The pilot is the final authority for the operation of the airplane
- Both crewmembers are ultimately responsible for the safe conduct of the flight
- Design for crew operations based on pilots' past training and operational experience
- Design systems to be error-tolerant
- The hierarchy of design alternatives is: simplicity, redundancy, and automation
- Apply automation as a tool to aid, not replace, the pilot
- Address fundamental human strengths, limitations, and individual differences—for normal and non-normal operations
- Use new technologies and functional capabilities only when:
    - They result in clear and distinct operational or efficiency advantages, and
    - There is no adverse effect to the human-machine interface

The FAA's Aircraft Certification Service has a staff of Human Factors Specialists who serve as subject matter experts on projects involving human factors issues with a new flight deck system, a new aircraft, or an alteration to an existing aircraft. Although they typically focus on flight deck systems, Human Factors Specialists may also address other aspects of an aircraft, such as maintenance or identifying human factors issues with flight controls and aircraft handling characteristics.

The following items were noted as changes in the 737 MAX 8 Flight Deck and Instrumentation:

Modify all instruments and electrical displays on the main instrument panel and the glare shield panel and associated circuit breaker panel (as needed) to support the following changes:

- Delete the following:
  - Six D-sized display units
  - Two clock installations (the clock function will be displayed on the new display system)
  - Flap indicator/leading edge/load relief annunciations functions will be displayed on new display system
  - Two Electronic Flight Information System (EFIS) control panels
  - Existing remote light sensors
  - Four coax splitters under the Multifunctional Control Display Units (MCDUs).
  - Coax cables and replace with fiber optic cables
  - Selective Call (SELCAL) and registration number placard will be incorporated into the display system as part of the auxiliary format.
- Add the following:
  - Four new 9 x 12 inch display units
  - Two EFIS control panels
  - Two new remote light sensors
  - Two chrono switches to glare shield and associated wiring
- Redesign the main instrument panel including indication and control repositioning and illumination lights.
- Delete the P2-2 panel and add the multi-function panel.
- Revise autoflight status annunciator to improve visibility of the annunciator.

The following systems are Not Affected Exceptions by the Product Level Change for Fuel Burn and Community Noise; however, these systems are affected, but not changed, by the addition of the display system upgrade. These systems were substantiated as part of the display change:

- Communications Management Unit System,
- Radio Navigation Systems,
- Cockpit Voice Recorder,
- Traffic Collision Avoidance System,
- Flight Deck Printer.

Upon review of the above, the FAA and Boeing agreed that the changed product rule application did not drive any significant change in flight deck design.

4.8 Risk Assessments

In accordance with 14 CFR 25.1309, AC 25.1309-1, and industry best practices (SAE ARP 4761), Boeing conducted system safety assessments (SSA) to evaluate aircraft functions and the

design of systems performing the functions to help identify the failure modes and determine whether the mitigations of those hazards were appropriately addressed.
Key components of the system safety analysis included:

- Functional Hazard Assessment (FHA):
  - Categorizes potential high-level outcomes identified and associated hazards;
- Failure Modes and Effects Analysis (FMEA):
  - Assesses failure of each component in a system,
  - Considers different failure modes,
  - Describes system-level or airplane-level effect and how the failure would be detected,
  - Identifies expected crew actions or response;
- Fault Tree Analysis (FTA):
  - Assesses system architecture and calculates probability of occurrence of undesirable outcome.

The SSA is a foundation for establishing compliance for the system design and bridges many regulatory requirements. This analysis is designed to promote a fail-safe concept and to provide assurance that all relevant failure conditions identified and significant combinations of failures are considered. While all 93 detailed certification plans were reviewed, not all anticipated failures resulted in complex and comprehensive assessments. The thoroughness of an SSA is a function of the severity of the anticipated failure based upon experienced engineering assumptions and operational judgment.

4.9 Federal Aviation Administration's Assessment of MCAS

Given historical events, no review of the 737 MAX 8 certification can be complete without a brief discussion of MCAS. The Maneuvering Characteristics Augmentation System (MCAS) is a new software functionality of the 737 MAX 8's Flight Control Computer. MCAS was designed to augment flaps-up maneuvering characteristics by providing enhanced control column force gradient. In simple terms, MCAS was designed to increase the airplane nose-down pitching moment and resulting aft column force when it detects the aircraft may be in danger of stalling. It was designed to operate only during manual flight and activate only during an abnormally high angle of attack.

The FAA reviewed the MCAS function as part of the review of the flight control system in the detailed certification plans. Intended system activation was limited to rare, non-normal, high-angle-of-attack flight conditions in manual flight mode. Boeing's analysis considered the effect of an erroneous MCAS activation throughout the flight envelope. The system hazard was assessed as less than that associated with a runaway horizontal stabilizer condition, which is a required training event. This analysis asked the question: is the human likely to be able to complete the procedure effectively? FAA and Boeing both conducted flight tests with the system fully functional and with the system inoperative. The FAA found that Boeing demonstrated compliance using accepted methods and accounted for stated assumptions, and therefore, with the information and experience before it at the time, the FAA concluded that additional training and procedures were not needed as a result of MCAS implementation.

4.10 Aircraft Evaluation Group Pilot Training Evaluation

To determine pilot training requirements for the Boeing 737 MAX 8 certification, a comparison was made between the 737-800 as the base aircraft and the 737 MAX 8 as the differences aircraft. AEG determined pilot type certification could be obtained by using handling and differences tests using aided instruction with an existing 737-800 type rating. The 737 MAX 8 pilot testing pools consisted of a mix of FAA pilots and industry pilots.

4.11 Issuance of Type Certificate

On March 8, 2017, after Boeing demonstrated compliance with all the applicable requirements outlined, the FAA found the design to be compliant and issued the amended TC for the Boeing 737 MAX 8 to Boeing.

4.12 Committee Assessment of the Boeing 737 MAX 8 Certification

Earlier in this report (Chapter 3.3.2.1) the Committee identified six critical aspects of the complex certification process that it believed are important in the overall success of any certification program. These elements include: early engagement between applicant and regulator, a comprehensive review of applicable regulations, an evaluation of changes to an applicant's type design in accordance with established guidance materials, well-understood engineering assumptions, and an appropriate level of involvement in decision making and application of Just Culture and Accountability Framework. The Committee found positive evidence of all six elements in the 737 MAX 8 certification program. In summary, we found good faith compliance efforts with the regulatory requirements by both Boeing and the FAA but also noted several areas where there is opportunity for improvement in meeting the challenges of our technologically advancing global aviation system.

In any design and development program, the use of baseline engineering and operational assumptions is required. Without these assumptions and judgments, no design would ever get airborne. The 737 MAX 8 is no exception. The benefit of hindsight suggests that several of these assumptions related to pilot performance and training may no longer be accurate in today's global aviation system.

The requirements to systematically consider human performance (and the potential for error) in conjunction with the system safety analysis and operational safety evaluations are not well defined and systematically applied to all safety-critical functions. For example, the requirement to assess automated systems active in manual flight should be further reviewed. The committee believes that this provides a lost opportunity to catch safety issues before they are evidenced in the operation.

Extensive technical expert engagement and involvement between Boeing and FAA throughout the certification process were noted. The 737 MAX 8 certification was a complex five-year program with 93 required certification plans and 129 flight test plans that are built off a baseline certification basis that, in some instances, dates back to 1967. The benefits of the ability to amend a type certificate are well understood and appreciated but this creates an interesting challenge related to the interface of older and newer design philosophies and technologies. This includes the cumulative effect of multiple changes over time and then assessments of their combined effect on a flight crew's ability to safely manage operational tasks. Understanding these relationships should be explored further.
Many detailed safety assessments were completed and jointly accepted. This complexity meant that, in some cases, communications were fragmented. No holistic assessment of total system operational safety risk was required, or presented, that might have provided a broader review of safety risk to various management levels in the Boeing and FAA organizations. This holistic

assessment would also serve to enhance communication of assumptions and feedback of data across the global aviation system.

Each of these opportunities is addressed in the Findings and Recommendations of this report.

5. Findings and Recommendations

Definitions:

Finding
A finding is a conclusion drawn by the Committee based on review of briefings, analyses, reports, and other factual evidence.

Recommendation
A recommendation is a proposed action for the FAA to consider. Recommendations are based on the Committee's findings.

5.1 Safety Management Systems

Findings

The FAA requires Safety Management Systems (SMS) for part 121 air carriers; however, there is no requirement for SMS for design and manufacturing organizations. Expanding SMS regulations to include design and manufacturing organizations would create better connections and management of functional and operational safety risk.

The FAA has many robust processes to oversee each phase in a product's life cycle; however, the various oversight mechanisms are unique and independent, and not adequately linked to each other to ensure a complete, system wide approach to aviation safety from design to operation.

Partnership for Safety Plan (PSP), Safety Management Systems (SMS), and delegation are critical structures that are related to one another, but not sufficiently integrated.

Discussion

The international aviation community defines an SMS as a standardized approach to managing safety that incorporates organizational structures, accountabilities, policies, and procedures. An SMS establishes a formalized, safety risk-based approach to the management of an organization, whereby every process, decision, activity, acquisition, procedural change, or program modification is examined from a holistic safety risk perspective in order to ensure that all of the potential associated hazards are uncovered, examined, and mitigated. A mature and effective SMS is designed to improve cross-communication and information sharing within specialized functions of manufacturers, airline operators, maintenance providers, and regulators.

The FAA Aviation Safety Organization adopted a final rule in 2015 requiring operators (i.e., air carriers) authorized to conduct operations under 14 CFR part 121 to develop and implement a Safety Management System. The rule provides a general framework for an SMS that a part 121 air carrier may adapt to fit the needs of its operation. While air carriers must implement an SMS, the FAA has no such requirement for design and manufacturing organizations. The U.S. aviation system therefore has no mandatory SMS that extends from design to operation, which allows for potential gaps in understanding of safety risk. The Committee discussed the merit of requiring organizations holding design and production certifications to adopt a comprehensive SMS. In discussions with the FAA's new AVS ODA Oversight Office, FAA managers recommended the adoption of a mechanism to require adoption of scalable SMS for design approval applicants. The International Civil Aviation Organization (ICAO) adopted ICAO Annex 19, Safety

Management, in 2013, and expanded ICAO's safety management standards to organizations responsible for the type design and manufacture of aircraft to be effective in 2019.

The Special Committee spent considerable time discussing the potential benefits of incorporating an SMS within the FAA's certification system. Stakeholders ranging from FAA officials to trade associations to unions all expressed the benefits of an SMS over a certification system based solely on compliance. AIR told the Committee that the greatest resource to help it do its job more effectively would be the adoption of SMS. Many original equipment manufacturers (OEM) have implemented a voluntary SMS. However, without FAA regulatory standards for an SMS, there is a lack of standardization among the voluntary programs and considerable inconsistency among OEMs in their SMS implementation. The FAA and industry produced some guidance supporting implementation of SMSs in the design and manufacturing organizations; however, the FAA must establish a regulatory framework to standardize the development, implementation, and efficacy of SMSs. The FAA's SMS regulations for design and manufacturing organizations should be scalable to fit the needs of both small and large businesses.

The incorporation of an SMS supports effective, safety–focused decision making and oversight at all levels of an organization, from the Board of Directors to the original drafting of a product's design. This comprehensive focus on safety creates a culture, mindset, and policy framework for engineers, inspectors, managers, and corporate leaders designed specifically to identify and mitigate potential hazards and risks. Unlike the current certification system's focus on compliance, SMSs foster a holistic assessment of whether the combinations of actions such as design, procedures, and training work together to counter potential hazards.

A Partnership for Safety Plan (PSP) is a voluntary written agreement between the FAA and a manufacturer indicating how the FAA and that manufacturer will implement and maintain processes that support effective and efficient compliance with applicable FAA regulations policy material and with industry consensus standards. A PSP is a component of the FAA's delegation system.

Several original equipment manufacturers (OEMs) successfully use PSPs as a foundation for building and jointly overseeing SMS and Organization Delegation Authority (ODA) programs. This use of PSPs to create or oversee ODAs is not a universal approach. The Committee found that some OEMs have fully integrated their PSP with the ODA, while some manufacturers have significant separation between the PSP and the ODA. The FAA shared its view that a PSP and an ODA are separate systems, but systems that should work together. The FAA also stated that whether an OEM has a PSP or an ODA, the primary concern of the FAA is that the OEM should properly implement the policies of a safety management system. SMSs are designed to examine safety as an integrated system, across business functions, and work most efficiently with coordinated systems.

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 PSP, SMS, and ODA activities to create an effective oversight process between manufacturers and FAA to better manage safety and certification issues.

5.2 System Safety

Finding

The fundamental building blocks of system safety include the human, the equipment, and the environment. As part of design, evaluation, oversight, and day-to-day operations, it is necessary to understand what needs to go right (performance and design specifications), what could go wrong (human and equipment failure modes), what can prevent things from going wrong (controls and barriers), and the combination of events and scenarios in which the human–equipment system must function.

System Safety Assessments (SSAs) are an essential component of safety risk management that can be expanded to better consider human factors in order to provide additional safety value to the FAA's aircraft certification process.

Discussion

Today's transport category commercial aircraft are technologically advanced, and flight decks are improved by increasingly sophisticated automation. These advances accomplish important objectives such as reducing flight crew workload, adding additional capability, increasing fuel economy, and above all, improving safety. In fact, the current generation of highly automated transport airplanes has demonstrated a significantly improved safety record relative to previous generations of airplanes.

During the design and certification of systems, critical decisions are made by designers, regulators, operators, and other stakeholders to ensure the system is safe and operated safely. Processes that help inform these decisions include those described below.

<u>Design Specifications</u>

- What are the characteristics of the design?
- Safety rules have been developed over the years to verify that the system has the right attributes to be safe.

<u>Operational Performance Specifications</u>

- What does the equipment or the human–machine system need to be able to do and how well does it need to do this?
- Performance criteria help validate that people can use the system safely. Critical assumptions are made about the scenarios in which this performance needs to be achieved and the capabilities of the humans who need to work with the machine to achieve the performance outcomes.

<u>System Safety Assessment</u>

- SSA is the umbrella term for the analyses that occur at all stages of a product life cycle and help identify the failure modes and determine whether the mitigations are sufficient to keep the system safe. It is important that existing equipment analyses are complemented by systematic assessments of human errors, including human errors in responding to equipment failures. This should recognize that human errors are generally inevitable, and consider the consequences of an equipment failure compounded with a foreseeable human failure.
- Effective communication of the overall total SSA can aid oversight of the assumptions and evidence that potential safety hazards are mitigated by the combined design, training, procedures, etc., as well as the combination of two.

<u>Design of Equipment, Training, and Procedures</u>

- Ideally, the design, procedures, and training should be developed at the same time, iteratively improving to meet the design and performance specifications, taking into account the findings from the SSA.

<u>Test and Evaluation</u>

- A flight test by pilots should be included to determine whether the equipment and human–machine system are safe. It should include both verification of compliance and validation that operational safety performance can be achieved and the effects of system failures can be managed.

<u>Production</u>

- Producing the agreed design, to the specified quality criteria.

<u>Certification</u>

- The assumption is that the certification process includes oversight of all aspects of the safety process. The regulator takes all of the evidence to determine whether the system is safe to go into operation and to continue to operate.

<u>In-service Monitoring</u>

- This should be used both to validate that the assumptions made in the SSA are true in operational service and to identify new risks.

It is important that the outputs and assumptions made across these processes are captured in a way that enables effective communication and review amongst multiple stakeholders. This helps to give a system-level assessment of the key threats, the design, training, procedures and environmental conditions necessary to ensure safe performance of the total human-machine system.

While the FAA's current certification process requires consideration of human factors for novel, complex, or integrated systems, it does not mandate a systematic human error analysis for all safety-critical functions associated with a change (including errors in human response to equipment failures). FAA AC 25.1302-1, *Installed Systems and Equipment for Use by the Flightcrew*, shows the decisions flow in Figure 1: Methodical Approach to Planning Certification for Design-Related Human Performance Issues (see Appendix 6.6). This could be enhanced in future by balancing consideration of both the novelty, complexity, and integration and also the level of safety criticality of human performance for function (including the criticality of human performance in responding to equipment failures).

In addition, there are some areas in the current requirements that could be further enhanced. For example, skill-related errors associated with manual control of the airplane are specifically excluded from the required assessments. It is also important to consider flight crew interaction with automated systems active in manual flight. Systematic analysis must be conducted to determine the potential for safety-critical outcomes from a combination of an equipment failure compounded by a subsequent human failure, or the failure of the flight crew to respond to the equipment failure as expected. Traditional methods of assessing safety may be insufficient to pinpoint vulnerabilities that could lead to an accident, including conflicting actions taken by the flight crew and an airplane's automation systems.

There have been significant advances in human factors in recent years and methods for considering the safety impact of human error and ensuring the combined system supports effective human performance can be more practically applied. Consideration should now be given to developing standards for integrated assessment of human performance, and systematic assessments of human error as part of design assurance and validation.

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 compliment System Safety Assessments 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 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 a representation of 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.

5.3 Globalization

Findings

The U.S. system for aircraft certification is robust and proven, and the FAA is a leader in augmenting aviation safety worldwide. This system also allows the United States to lead the world in the development and implementation of innovative products in order to enhance safety.

Industry growth and globalization are among several factors challenging the FAA's current product certification system, resulting in new technology and innovative U.S. State of Design products being delivered to operators in States whose aviation authorities function at varying levels of maturity.

Globalization drives the need to harmonize requirements, regulations, and standards in commercial aviation. Although U.S. products are operating worldwide, the FAA has no mechanism in place to ensure the maintenance and pilot training requirements for U.S. products operating under another civil aviation authority.

Discussion

Proliferation of Aviation Globally

The aerospace industry has rapidly evolved into a global community, with complex international arrangements, global supply chains, and increasing participation by stakeholders in emerging authorities. Customer bases continue to grow and shift. In fact, the majority of U.S. State of Design aircraft are registered outside of the United States and operate under the jurisdiction of an aviation authority other than the FAA, each with its own standards and regulations. A more global industry can result in more variance among States' approach to regulation, training, and operation of aircraft. Industry develops increasingly capable and complex technical systems that U.S. and international flight crews need to be able to operate in both normal operating conditions and degraded modes.

Manufacturers make assumptions during the design engineering process, including assumptions regarding pilot training standards and pilot execution of actions consistent with that training. Design decisions are often made according to the assumption that an "average pilot" will perform the correct action at the right time. The concept of the "average pilot" has evolved, and the "average pilot" in one State (or jurisdiction) may not have the same skills as the "average pilot" in another. It is therefore important for manufacturers to have insight into their expected customer base and to design aircraft that take into consideration the expected end–users and variances in approach to pilot training worldwide.

International Validation of Design Approvals

Aerospace is a global industry, and one that continues to grow and evolve as industry continues to enter into more complex international partnerships. When the FAA issues a design approval for a U.S. product, that certification is made with regard to U.S. regulations and in accordance with FAA policy. Regulations and policy generally differ from State to State, and a product's certification to U.S. standards may not be sufficient for import into another authority's system.

The FAA and its partner authorities leverage the bilateral agreements to validate each other's approvals while avoiding unnecessary duplication of effort. Validation is an authority-to-authority process whereby the Validating Authority (VA) relies on its confidence in the Certifying Authority's (CA) regulatory system, and as a result of that level of confidence, the VA is able to leverage the CA's system and its existing design approval, in order to issue an equivalent approval in its own system. Validation ensures a foreign approval meets the requirements of an importing authority. While certain international aviation authorities actively validate the FAA's approvals, others, particularly those with less developed certification capability, accept them without further showing.

The FAA and the European Aviation Safety Agency (EASA) have some nuances in their approaches to issuing design approvals, which can result in a difference in the type of information transferred to the validating authority during the validation process. For the FAA, the certification basis includes the requirements for the approval of the aircraft but does not include approval of operational requirements, whereas EASA requires operational requirements in their certification basis. This means that in the FAA system, operational requirements can be met after the TC is issued, and prior to entry into service. In the EASA system, the EASA certification basis includes the operational requirements, and compliance with these standards must be complete at the time of issuance of the type certificate.

The Use of FSB Reports Internationally
The FAA's product certification system relies in part on the work of a Flight Standardization Board (FSB). The FSB's primary responsibilities include developing training objectives for normal and emergency procedures and maneuvers used in flight crewmember qualifications; publishing recommendations for FAA inspectors to use in approving an operator's training program; determining the application of standards for conducting practical tests used by the FAA to certify crewmembers; and ensuring initial flight crew member competency.

The FSB has direct input into operator training when such standards are established during the certification process. During the TC process, the applicant must submit a minimum training program to obtain initial qualification and issuance of the associated pilot type rating. The FSB evaluates and validates the applicant's training proposal using a standard process that includes multiple "test subjects" not previously aware of, or trained on, the subject aircraft. The FSB's findings are then documented in the FSB Report, and FAA Inspectors use the information as guidance in approving operators' crew training, checking, and currency programs. While the FSB makes training recommendations to the applicant, minimum training requirements do not become part of the TC.

The FSB report—while intended as a document to support the development of required operating manuals for U.S.-registered aircraft—is being used by some foreign civil aviation authorities as a basis for training their pilots and establishing minimum operating requirements. The FSB report is part of a complex system dependent on the full U.S. Federal Aviation Regulations, and therefore the current process does not support a sufficiently detailed FSB report that could be used as a stand-alone baseline document for international training requirements.

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 take into account differences in operations, training, and oversight across States.
- Some members of the international community are using the 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.

5.4 Data

Finding

Better data gathering, targeted analysis by experts, and the use of all available data to develop and implement corrective actions to mitigate risk would bolster aviation safety.

A vast array of operational safety data is generated by various stakeholders in the global aviation system that can provide valuable input to inform design, production, and continued airworthiness initiatives. Regulators, manufacturers, and operators all collect important data, yet the amount of aviation data available is expansive, and the systems for analyzing data are incomplete. Many of these systems, even those within the FAA itself, are independent of each other and lack the ability to communicate with each other. While usable data exists, it is often disparate in nature and accessibility of the data to the appropriate decision makers at the right time remains challenging. Timely access to relevant data in a meaningful form is lacking. Fully implementing safety management systems (SMS) is not possible without this integration of data sources.

In the future, once data sources are consolidated and integrated, big data analytics can make use of artificial intelligence to identify trends and precursors to allow the safety community to address them before an accident materializes. In any safety system, unforeseen issues are likely to materialize as a normal part of the process. Early, proactive identification of issues and an agile process of recovery are critical to avoiding future events.

Discussion

Disparate Data Repositories

Current sources of safety data include air traffic management data related to traffic, weather, and procedures, de-identified data from air traffic controllers and aircraft operators including digital flight data and safety reports submitted by flight crews and maintenance personnel, Service Difficulty Reports, etc. Some data is numerical in nature, while other data, such as narrative reports from the operational community, is more subjective. Certain data is received through mandatory reporting, while other data may come from voluntary systems. Once generated, the data is sent through various channels to different systems that are analyzed by different people, and sometimes in different organizations within the FAA (i.e., AIR, AFX, Air Traffic Organization, Airports, Accident Investigation and Prevention). Such data is extremely valuable to the entire FAA, yet the aircraft certification system and the agency do not currently reap the full benefits of all the available data.

Most modern aircraft and aircraft engines have the capability of relaying performance data to the operator and—depending on customer agreements—also the manufacturer. However, this capability is not always activated, and when it is, there is often a delay in transmission of the data, which is likely downloaded and transmitted only at regular intervals (daily, weekly, monthly), as opposed to providing real-time data streaming. Operational data is the property of the operator, and therefore access to it depends on specific airline operator and labor agreements. Critical international sources of data are even more difficult to obtain and are only possible through airline and manufacturers' agreements.

Proactive Data Analysis

The Aviation Safety Information Analysis and Sharing (ASIAS) program is leading the way in safety data analysis. ASIAS is a public-private initiative that leverages internal FAA datasets, de-identified airline proprietary safety data, publicly available data, manufacturers' data and other data to proactively identify safety trends and assess the impact of changes in the aviation operating environment. ASIAS does an excellent job of integrating confidential industry data and public data sources to address potential safety issues, but the data itself is not readily available to the aircraft certification workforce; rather, safety outcomes are shared after months of data analysis. In addition, current analytical capabilities are limited to queries that are fed into the system. In other words, while the system is highly capable of analyzing data on request by an analyst, it lacks the ability to proactively monitor itself and provide automated insight into emerging issues.

<u>In-Time Safety Management</u>
The National Aeronautics and Space Administration (NASA) is currently working to develop and adopt a real-time, system-wide safety assurance program. The system would require integration of a wide range of systems and practices, including building an in-time aviation safety management system that could support proactive decisions to mitigate high-priority safety issues as they emerge, before they become hazards. The system could continuously monitor the national airspace system, provide information to help assess the data that it has collected, and then recommend or initiate safety assurance actions as necessary. NASA's in-time aviation safety management system provides an excellent vision of how to adopt a real-time, system-wide safety assurance program, evaluate big data, and use it to take risk-mitigating action.

Following the recent events in Indonesia and Ethiopia, U.S. flight data was analyzed to understand whether indicators may have existed that could have been addressed, and potentially preempted the accidents. The data showed zero incidents of runaway trim on Boeing 737 MAX 8 aircraft in the U.S. system. Better use of big data will improve the timeliness and effectiveness of in-time proactive actions to improve safety.

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 ASIAS as an example.
- The FAA should propose to 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 by both the regulator and industry.

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

Finding

While the product certification process is developed, managed, and implemented by the Aircraft Certification Service (AIR), personnel from Flight Standards (AFX) participate in the process and have a well-defined role through the five regional Aircraft Evaluation Groups (AEG). While both under the Aviation Safety (AVS) organization, AIR and AFX are separate organizations, each with its own policies, guidance materials, leadership, and culture. Much of the guidance material for AEG personnel resides within AIR, and precise guidance to direct the continuing interface between the two organizations is lacking, which could lead to a disconnect between product design and operational requirements.

Discussion

The FAA's type certification process is managed by AIR, yet involves personnel from other organizations—particularly AFX, through its five AEGs. The AEG was established to enable FAA to provide operations and maintenance direction during the type certification process. The AEG comprises operations and airworthiness inspectors who work directly with AIR personnel to provide an operational perspective to design engineering activities. The AEG also advises manufacturers of applicable operational and maintenance requirements during the design and certification process. Through the evaluation processes conducted by the AEG, manufacturers are made aware of operating rules that might influence design so they can deliver a service-ready product.

AEG FSB responsibilities are outlined in FAA Order 8110.4C: *Type Certification*, which is an AIR document. Recommended procedures for executing those responsibilities are outlined in AC 120-53B: *Guidance for Conducting and Use of FSB Evaluations*, which is an AFX document. The current state remains unchanged following the recent AIR and AFX organizational transformations: policy and standards originate within one organization, while operational guidance emanates from another.

The AEG process is key to understanding operational safety needs and assessing whether the combination of design, procedures, and training will achieve effective safety performance by the human–machine system in the intended environment, including when equipment and human failures occur.

The AEG is not consistently and adequately integrated into the certification process, and its involvement may vary from region to region and by project. The interaction between AEG and AIR is not guided by sufficiently delineated policies to be assured of knowing the design decisions and assumptions—and changes that occur during the certification process—necessary to make fully informed decisions regarding operational requirements.

Recommendation

- The FAA should review and clarify the AEG's roles and responsibilities 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 sufficiently early 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.

5.6 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. Current funding levels may be insufficient to support effective resource management. Priorities include proper skill identification, skill development, and attracting talent.

Discussion

Today's aviation system is highly innovative and incorporates new technologies at an ever-increasing rate. Current products demand new methods of compliance. Increased use of ODAs has changed the role of some FAA personnel from engineers and inspectors in specific technical disciplines to system managers. These changes are a result of a rapidly changing industry, and challenge the current system and require the FAA to adjust to the dynamic environment.

The FAA is working to transform the Aircraft Certification system to foster a forward-looking culture and certification system based on a holistic view of aircraft certification. This level of transformation requires more than updating and creating new policies, regulations, and guidance. The overhaul must include significant workforce development.

Ensuring the FAA has the right people with the right skill sets engaged at the right time throughout the certification process involves more than establishing early engagement with an applicant, which is an important effort in itself. Early engagement involves ensuring that all stakeholders in the process are involved at the right time, including timely and appropriate coordination between AIR and the AEG.

Effective use of resources also means making sure the certification workforce has the right balance of engineers versed in specialized disciplines to verify technical compliance and those with a high-level focus on the interaction of systems and overall human–machine system performance. The workforce should receive training to account for evolving roles to systems managers, helping to ensure a focus on key safety risk areas. Evaluating the extent to which the combined system can achieve effective safety performance in expected operational conditions should be a critical element of certification and oversight. In addition, staffing levels need to be commensurate with the expected workload.

As AIR continues its transformation, it is likely the FAA will require personnel with different skill sets. Backgrounds in data analytics, systems engineering, operations research, and program management are critical additions to technical disciplines when seeking to follow a harmonized multidisciplinary approach. To keep pace with the ever-expanding scope and volume of the NAS, growth and complexity in certification projects, and use of delegation, the FAA must adapt personnel requirements accordingly.

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.

5.7 Delegation

Finding

The FAA's use of delegation to exercise its discretionary authority is an appropriate and effective means for conducting product certification. It relies on effective standards, oversight, and communication between stakeholders.

The structured, safety-focused delegation system bolsters aviation safety and encourages innovation, efficiency, and industry growth. Delegation processes, including ODA, provide space for innovation and technical expertise while enabling the FAA to maintain its oversight processes and maintain established safety standards. By making use of delegation, the FAA is able to use a risk-based approach to focus its attention on the most critical certification areas.

The use of delegation in certification has been consistently endorsed by the agency, industry, and Congress as a means of ensuring safety and efficiency in the certification process while leveraging industry expertise. The delegation system is based upon a solid regulatory framework, with formal guidance and expectations for both designees and FAA employees conducting oversight of them. Controls are in place to require independent decision making within an ODA Unit, which ensures that the ODA functions as designed and guards against undue pressure on the ODA Unit from the business interests of the company.

Discussion

<u>History of Delegation</u>

The current delegation system precedes the FAA, and dates back to 1927, when the first designees were appointed as Aviation Medical Examiners under the Aeronautics Branch of the Department of Commerce. In 1938, Congress passed legislation specifically considering integration of the private sector into the certification process. As a result, the first Designated Engineering Representatives (DER), Designated Manufacturing Inspection Representatives (DMIR), and Designated Pilot Examiners (DPE) were appointed. Congress clarified the language for appointment of designees in 1950. One reason given by Congress for this clarification was that the "FAA was clearly in need of private sector expertise to keep pace with the growing aviation industry." The concept of delegation used in the Boeing 737 MAX 8 program has existed since 1956, when the first delegated organization for aircraft manufacture—at the time called Delegation Option Authorization (DOA)—was appointed by the FAA. The DOA concept has evolved over time to become what is known today as the Organization Designation Authorization (ODA). The FAA Act of 1958 provided legislative authority to appoint a wide variety of designees to issue certificates. The regulation was issued in 1962 under 14 CFR 183: Representatives of the Administrator.

Congress revisited its original push for delegation in 1973, when it questioned the ability of industry to work on behalf of the FAA. The delegation system was reviewed, the rationale was explained, and the system remained unchanged. Congressman Jack Brooks argued, "… it appears the regulated are regulating themselves. Such a procedure is most unique and requires exceptionally critical oversight." The FAA Administrator suggested the Act "recognized the practical necessity of utilizing the technical capabilities of the private sector in administering the many complex certification programs required by law." The Chairman of the National

Transportation Safety Board (NTSB) noted, "… the safety problems involving delegation which have come to our attention have involved such isolated circumstances that, with one exception, it is difficult to apply any generalities to our findings. It is clear, however, that these problems have generally been related to the implementation [of delegation] rather than the concept of the program."

At the direction of Congress, the ODA rule as we know it today was issued in 2005, as an amendment to 14 CFR 183. Organizational delegation continues to evolve to meet today's FAA demands.

Congress has promoted the concept of delegation for decades, and continues to expand the limits of delegation in the present day. The 2012 and 2018 FAA Reauthorization Acts both included language specifically instructing the FAA to expand its use of delegation in certification.

<u>Regulatory Foundation</u>

Each time the designee program has been expanded over time, regulatory notification provided justification for the expansion with the understanding that service provided to the public by designees would be more efficient, and overall government costs would be reduced. 14 CFR part 183 suggests that "… safety will be enhanced because FAA personnel relieved from tasks accomplished by Designated Airworthiness Representatives will be able to redirect their efforts to other areas affecting safety."

Public law enables the FAA to leverage its limited resources through delegation. 49 USC 44702(d) stipulates that the FAA may delegate to a qualified private person a matter related to issuing certificates, or related to the examination, testing, and inspection necessary to issue a certificate on behalf of the FAA Administrator as authorized by statute to issue under 49 USC 44702(a).

49 USC §44702(d) stipulates that the Administrator may delegate to a qualified private person, or an employee supervised by that person, a matter related to the examination, testing, and inspection necessary to issue a certificate and the issuance of the certificate. The term "private person" means an individual or organization other than a governmental authority.

<u>External Forces Challenging the Traditional Certification Model</u>

AIR is responsible not only for issuing approvals for new and changed products and articles, but also for the continued operational safety of the existing and rapidly expanding fleet of U.S. State of Design products in the United States and across the global fleet. Numerous external forces continue to increase the regulatory workload on the organization and on the agency as a whole. Delegation allows the FAA to address these challenges, respond to industry demands, and facilitate the entry into market of innovative, safety-enhancing technology. As the agency continues to focus attention on continued operational safety of in-service products and developing regulations and airworthiness standards necessary to increase the level of safety, direct involvement of the agency's resources in all areas of domestic approvals and foreign validations would simply be impossible for the number of engineers in AIR. Without delegation or a significant increase in technical resources, the FAA would not be able to keep up with innovation and new designs, and would suppress industry under a regulatory backlog. The designee system allows the FAA to focus resources on new applications of existing technology, on new and evolving technologies, and on innovation and growth in aviation.

Expansion of the Delegation System

Over the past two decades, numerous recommendations have been made to improve the FAA's certification process, several of which involve enhancing delegation and promoting system oversight. The FAA has generally acted upon these recommendations, resulting in the system we have today. See Appendix 6.4 for prior recommendations.

Increasing Use of Organizational Delegation

Throughout the history of the delegation program at the FAA, more and more companies are choosing to make use of organizational delegation. As the system evolves, processes are adapted to encourage standardization, and oversight models shift from overseeing specific technical processes to overseeing a system and ensuring it functions as intended.

In an effort to drive increased standardization between the FAA and designees, the FAA has reorganized the certification division from a regional structure to an organization structured by functional divisions. Responding to a directive by Congress, the FAA is in the process of establishing a new AVS ODA Oversight Office to create a centralized program office to oversee the effectiveness of the overall ODA program and identify areas of improvement for both the FAA and industry that will establish and enforce more standardized delegation policies and practices.

Level of FAA Involvement is Structured and Evolves throughout a Project Life Cycle

In large certification projects it is typical for the FAA's level of project involvement to shift as the project progresses. As the FAA becomes more familiar with the product and is certain that the delegated authority has the experience and expertise to manage the item, it is common for the FAA to delegate additional certification items that it had originally retained. These decisions are based on a determination of where FAA attention will derive the most safety benefit. FAA Order 8110.4C states that the value of FAA involvement "decreases when appropriate trust and designee capability exists to make the finding. However, when confidence in the designee is lacking or the designee is inexperienced, the value of direct FAA involvement increases."

Some key issues that will always require direct FAA involvement include special conditions, equivalent level of safety determinations, development of issue papers, and compliance methodologies for new or novel technology. Additional critical safety findings are identified according to the safety impact or the complexity of the requirement or the method of compliance. Additional factors to consider in determining the areas of direct FAA involvement include the FAA's confidence in the applicant, the applicant's experience, the applicant's internal processes, and confidence in the designees.

FAA Order 8110.4C states that "focusing FAA resources on the most critical areas maximizes the use of the delegation system while allowing for oversight and best use of [AIR's] limited resources. FAA confidence in designees allows for full delegation for other than inherently governmental areas or new standards that are developing an experience base. Furthermore, confidence that the important safety areas are covered promotes greater delegation."

The decisions surrounding delegation often involve a complex set of discussions around application of regulations related to the certification basis and determinations of what constitutes "substantial" and "non-substantial" changes, as per the FAA's Change Product Rule. When necessary, the FAA uses Issue Papers to clarify and document any unresolved issues in the certification process.

Delegation is not Self-Certification

Public concerns about the FAA's delegation system have been voiced over time and have resurfaced in the last year. Critics often refer to delegation as "self-certification" and argue that there is an inherent conflict of interest when employees of the company whose products are being certified are the ones performing some of the certification activities, thereby creating a regulatory blind spot. This interpretation is inaccurate. In fact, with strict FAA oversight, delegation extends the rigor of the FAA certification process to other recognized professionals, thereby multiplying the technical expertise focused on assuring an aircraft meets FAA standards.

The ODA Administrator is required to ensure that the ODA performs all authorized functions in accordance with the regulations and applicable FAA policy, and ensures that the ODA always complies with its own procedures manual. They serve in a position that provides authority to act in the FAA's interest, and must preserve that authority. Minimum requirements for an ODA Administrator include at least five years' working experience with the FAA on projects similar to those authorized under the ODA, various levels of technical airworthiness responsibilities and experience, and management experience in one or more technical disciplines (e.g., compliance engineer, quality assurance inspector, manufacturing inspector, or airworthiness inspector). They must have comprehensive knowledge of FAA regulations, policies, and procedures applicable to the ODA functions and demonstrate sound judgment and integrity. In addition, the ODA Administrator must be a full-time employee of the company seeking ODA.

The FAA maintains oversight of the appointment process for ODA Unit Members, but is not directly involved in their selection. Requirements for Unit Members include knowledge and understanding of regulatory requirements and general and specialized understanding of engineering principles, including 8 years of progressively responsible engineering experience. In addition, ODA Unit Members must have the ability to communicate and work with the FAA (sound judgment, integrity, and cooperative attitude), knowledge of the AIR designee program, and the responsibilities of a designee, as well as specific knowledge and experience in the technical area in which authority is sought.

When performing a delegated function, designees are legally distinct from, and act independently of, the organizations that employ them. To become a designee one must complete initial and recurrent training on regulations and the designee system operation. One must also demonstrate strong professional responsibility. Designees view this delegation as an honor and a privilege and strictly protect this grant of authority. Regulations require the ODA Unit Members be given sufficient authority to perform their authorized functions. Furthermore, the ODA holder (i.e., the company) is required to ensure that no conflicting non-ODA Unit duties or other interference affects the performance of authorized functions by ODA Unit Members.

ODA Holders are required to establish and maintain internal programs to shield the ODA Unit from commercial pressure to maintain project schedules and budget, as well as to manage issues when they arise. Such programs include an online tool for ODA Unit Members to anonymously report an issue, a network for reporting concerns before the need for resolution, and lessons-learned processes for determining actionable root causes and developing corrective actions. While these types of administrative structures exist for most companies, it is still possible for commercial priorities to intersect with, and conflict with, safety priorities of an ODA. Procedures exist, and constant vigilance is required, to maintain the independence of ODA units across industry.

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.

5.8 Amended Type Certificates

Finding

The FAA evaluates a product submitted for certification through an amended type certificate (TC) using the same structured process outlined in the regulations and Orders as for a new TC. The underlying issue related to new and amended TCs should not be whether a product is produced under a new type certificate or a changed one. Rather, the issue is whether the level of safety of the product, embodied in the airworthiness standards it complies with, is as high as practicable.

Discussion

The type certification process outlined in Chapter 3 describes whether an applicant applies for a new TC or an amended TC. The difference is how much of the product is evaluated under the process. A new TC project is a new design that has not yet been evaluated, determined airworthy, or issued a TC by the regulating authority and requires review of every aspect of the design to determine compliance with the applicable regulations in effect at the date of application. An amended TC project is based on a previously issued TC and is a request by the applicant to make a change to that design. The amended TC certification process is used when the proposed change does not constitute a new design and numerous evaluations and determinations must be made regarding the change before selecting this path. Except for certain minor exceptions, the proposed change and areas affected by the change must comply with regulations in effect at the date of the application for the change.

This does not imply that new TC products are safer. Amended TC products do, in practice, have features that address the intent of the current airworthiness standards and rely on the proven record of accomplishment of the certificated product to which the new technology is added. The underlying issue raised by recent discussions should not be whether a product is produced under a new type certificate or a changed one. Rather, the issue is whether the level of safety of the product, embodied in the airworthiness standards it complies with, is as high as practicable. Changes to a TC are important and promote an increase in safety regarding the latest regulations for derivatives that replace aging airplanes within an existing fleet. The amended TC process thereby promotes innovative safety improvements through incremental changes to proven type designs—safety enhancements that may otherwise not be made until a new TC is required.

Chapter 3 outlines the rigorous process by which all changes, and the areas affected by changes, are evaluated under an amended TC. During the development of the certification basis of a significant design change, there is evaluation of how the changed product rule is applied and how the applicant intends to meet the requirements of the rule. The scope and depth of the FAA's review depends, in part, on the applicant's thorough disclosure and accurate categorization of changes. The rule sufficiently addressed evaluation of the rule and areas affected by the rule, but the rule and associated guidance lacks specificity regarding how changes are evaluated for cross-system integration and for human–machine integration. Consideration should also be given to the impact of multiple changes in the equipment, users, or environment over time. Additional guidance and clarity would help amended TC applicants ensure their evaluation of changes is thorough and supports holistic assessments of safe operations, as well as providing accurate classification that lays the groundwork for defining the roles and responsibilities of the applicant and the FAA.

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.

5.9 Innovation

Finding

AIR Policy and Innovation Division Research & Development (R&D) focuses on guidance, standards, and regulations to support new products, and should also prioritize safety and certification process innovations.

Discussion

As part of the FAA's 2017 AIR Transformation, the FAA launched the Center for Emerging Concepts and Innovation (CECI). Known as the "Innovation Center," this new initiative is designed to provide a single-entry point within the FAA for emerging technologies, production methods, and business models into the Aircraft Certification Safety System. It will also provide a forum for FAA and stakeholders to engage in innovation and explore the need for new regulations and policy. The FAA will use this center as an additional means of working with stakeholders to develop consensus standards and foster a collective understanding of the implications of new policy.

The Innovation Center has been designed to facilitate the safe introduction into the National Airspace System (NAS) of new, innovative products such as electric and hybrid-electric powered vertical takeoff and landing (eVTOL), super/hypersonics, automation, unmanned aircraft system (UAS), hybrid/electric aircraft propulsion, fuel cells, and additive manufacturing. The creation of the CECI has also helped facilitate the FAA's push for early engagement with applicants to develop certification requirements and agreement on both the methods and means of compliance. These improvements benefit both the FAA and the applicant. Other key roles of the Innovation Center are R&D portfolio development and management, collaborative identification of future policy needs, outreach/education, and taking a creative look at the world of technological developments (technology scan).

Innovations in safety and certification should keep pace with technological innovations. In order to safely and efficiently certify novel aircraft concepts, the FAA must continually investigate new procedures for applicants to demonstrate compliance in design, production, and operational use. Through the Innovation Center, the FAA should be in lockstep with companies working to introduce new and emerging technologies well before certification has commenced. The current certification framework may not be sufficient for the design and production of future technologies and it should receive an equivalent level of focus as the technology itself. It is critical for the FAA to understand in advance of a TC application that new concepts are introduced that may extend beyond existing FAA technical expertise or existing regulations. The Innovation Center is housed within the FAA's Policy and Innovation Division, whose mission is to support aerospace innovation by creating novel means of compliance, which should shift to a high priority.

Within the context of innovation and safety, the Committee heard from a variety of sources that the FAA's technical capabilities and certification standards could be bolstered by a greater reliance on performance-based regulations. A performance-based approach to regulation provides a "hook" that encourages innovation by industry and provides an opportunity to prevent the ongoing cycle of regulatory language falling behind technology. The current prescriptive approach to regulation establishes specific technical requirements that must be met by applicants and approval holders. By comparison, a performance-based approach establishes outcomes that must be achieved and allows some flexibility in how the applicant or approval holder achieves those outcomes (i.e., the use of alternative means of compliance). Performance-based regulations offer greater agility in accommodating innovation and new technologies, offer an improved understanding of risks, and could create a stronger safety culture within the FAA and industry. While defining requirements and what compliance looks like in using performance-based regulations can be more difficult, the use of performance-based regulations must be considered as the FAA works to stimulate innovation and ensure that safety standards incorporate the best and most up-to-date technology.

The shift towards performance-based regulations, which are less prescriptive but maintain the level of safety, would enable the FAA to respond with agility to changes in aviation and to novel designs that are submitted for certification. The use of performance-based rules will promote innovative means of compliance not bound by unnecessary prescriptive technical requirements in the regulations. The transformed system will minimize barriers to the safe and timely adoption of innovative products, technologies, and practices.

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.
- The FAA should continue implementation of performance-based regulations for the adoption of new technologies that do not stifle future innovations.

5.10 Existing Recommendations

Finding

Several prior certification and delegation reports exist with open recommendations for action relevant to this Committee's work. See Appendix 6.4 for a summary of such recommendations.

Discussion

The aircraft certification process has been the subject of numerous congressional, Industry Advisory Committee, Government Oversight, and FAA internal review over the last ten years. These reports and their associated recommendations provide useful continuous improvement and change management to the certification process. Yet, many have not been implemented because of either bureaucratic inertia or regulatory impediments.

The Aircraft Certification Process Review and Reform (ACPRR) Congressional report, written in response to section 312 of the Federal Aviation Administration Modernization and Reform Act, and the Part 21 Safety Management System (SMS) Aviation Rulemaking Committee (ARC), provide guidance and blueprints for strengthening the aircraft certification process. Some of these recommendations have been implemented through the Certification Process Improvement (CPI) Guide, which provides guidance and best practices to industry and FAA personnel for improving the effectiveness and efficiency of the product certification planning and program management. Other recommendations for taking a system safety approach to product certification processes and oversight of design organizations—including adoption of SMS for Design, Manufacturing and Maintenance Organizations— remain unaddressed.

The Committee further notes that many of its observations and findings regarding the Flight Standardization Board (FSB) process and the inadequate coordination between the AEG-AIR organizations are or have been addressed by several other bodies. Specifically, the Committee notes that the proposals from the Safety Oversight Committee (SOC) ARC and the Flight Standards Board working group under the auspices of the Air Carrier Training ARC are germane to its findings. The Committee heard from both industry and FAA presenters that this process must be improved and strengthened.

Additional recommendations by these groups and others remain unaddressed by the FAA or are currently under review by the FAA. Delays or lack of adoption are often the result of internal bureaucratic processes, which lengthen the time to implementation. The Committee believes that if these recommendations were adopted, the certification process would improve and provide additional safeguards.

Recommendations

- The Committee recommends that the DOT Secretary 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 how to assess effectiveness of implementation.

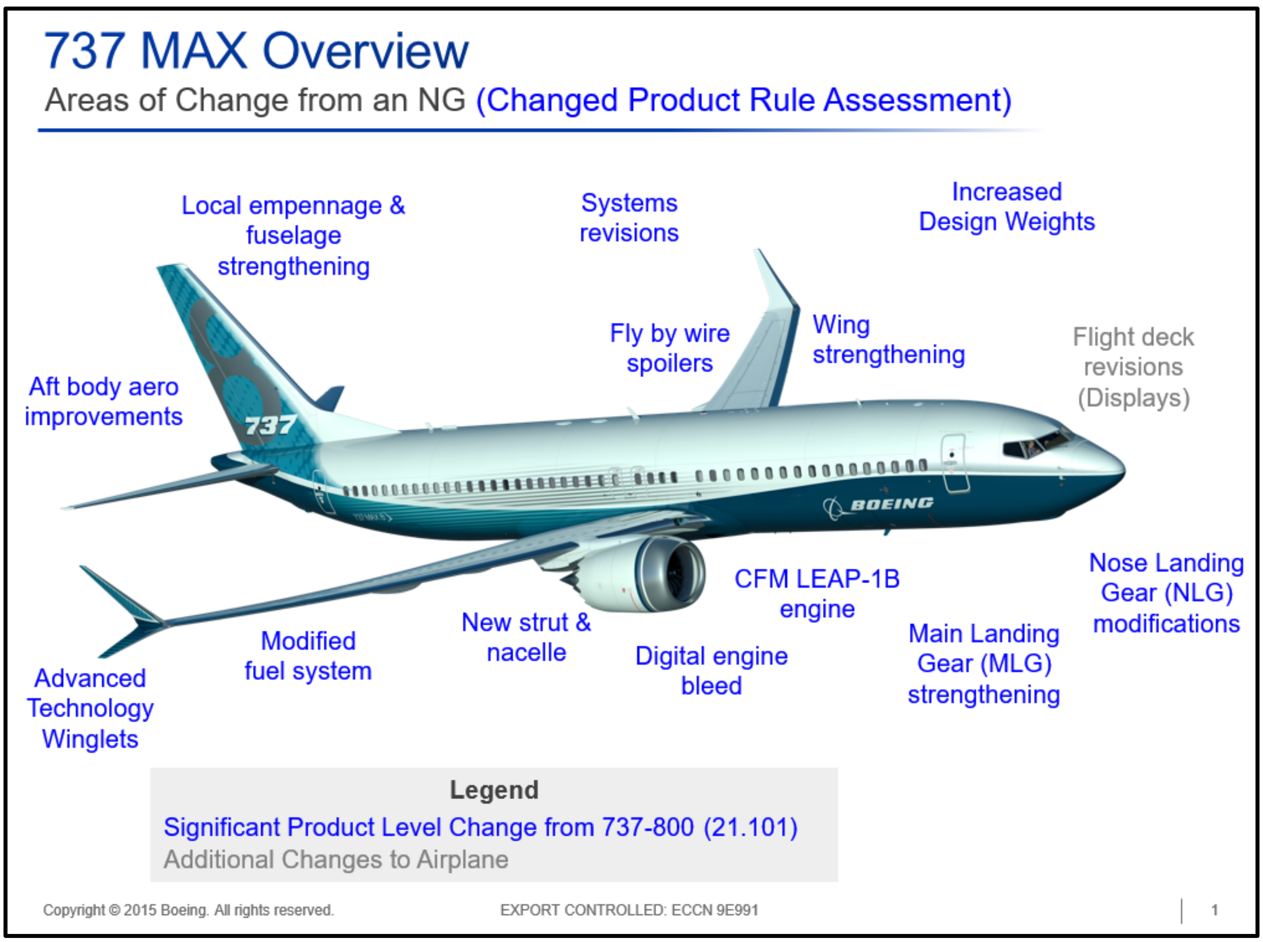
6. Appendices

6.1 Changes to Airbus 319/320/321 Type Certificate

A/C Model	Date of certification	Engine	Certification specification—Referenced Amdt / Cert Basis
A320-111 A320-211 A320-231	February 26, 1988 November 08, 1988 April 20, 1989	CFM 56-5A1 V2500-A1	JAR25 Change 10 Elect-to-comply with Change 11 except 25.207
A320-212 derived from A320-211	November 20, 1990	CFM 56-5A3	-
A320-232 derived from A320-231	September 28, 1993	V2527-A5	Certification basis amended by OP 91/1 (elect-to-comply) from A320-232
A320-214 derived from A320-212	March 10, 1995	CFM 56-5B4 CFM 56-5B4/2	-
A320-233 derived from A320-232	October 26, 1995	V2527E-A5	-
A320-215 derived from A320-214	June 22, 2006	CFM 56-5B5/P	-
A320-216 derived from A320-214	June 14, 2006	CFM 56-5B6/P	-
Sharklet applicable on A320 A320-214, -215, -216 A320-232, -233	 November 30, 2012 December 21, 2012		Significant Change, no new aircraft model EASA CS25 Amdt 8 / CRI A-0001-001 Issue 2
A320-271N derived from A320-211 fitted with Sharklet A320-251N A320-252N A320-272N A320-273N A320-253N	November 24, 2015 May 31, 2016 December 18, 2017 October 17, 2018 January 30, 2019 February 5, 2019	PW1127G-JM Geared Turbo Fan LEAP-1A26 LEAP-1A24 PW1124G1-JM Geared Turbo Fan PW1129G-JM Geared Turbo Fan LEAP-1A29	Significant Change, EASA CS25 Amdt 11 / CRI A-0001-002 Issue 3
A321 derived from A320 A321-111 A321-112 A321-131	 May 27, 1994 February 15, 1994 December 17, 1993	 CFM 56-5B1 or CFM 56-5B1/2 CFM 56-5B2 V2530-A5	Application of JAA Leaflet 18 (bottom-up approach): JAR25 Change11 amended for some paragraphs at Change13 CRI G-3001
A321-211 derived from A321-111	March 20, 1997	CFM 56-5B3/P or CFM 56-5B3/2P	-
A321-212/-213 derived from A321-211	August 31, 2001	CFM 56-5B1 or CFM 56-5B1/2	-
A321-231 A321-232 A321-212 A321-213	March 20, 1997 August 31, 2001 August 31, 2001 August 31, 2001	V2533-A5 V2530-A5 CFM 56-5B1 or CFM 56-5B1/2 CFM 56-5B2	-
Sharklet applicable on A321 A321-211 A321-231 A321-212 A321-213	 July,17 2013 July 30, 2013 June 16, 2014 June 16, 2014		Significant Change, no new aircraft model EASA CS25 Amdt 8 Application of Part 21.A.101—top-down approach

A321-232	June 16, 2014		CRI A-0001-001 Issue 2
A321-251N derived from A321 fitted with Sharklet A321-271N A321-252N	March 01, 2017 December 15, 2016 December 18, 2017	LEAP-1A32 PW1133G-JM Geared Turbo Fan LEAP-1A30	Significant Change, EASA CS25 Amdt 11 Application of Part 21.A.101 CRI A-0001-002 Issue 3
A321-253N derived from A321-251N	March 03, 2017	LEAP-1A33	-
A321-272N derived from A321-271N	May 23, 2017	PW1130G-JM	-
A321- 251NX A321-252NX A321-253NX A321-271NX A321-272NX	March 22, 2018	LEAP-1A32 LEAP-1A30 LEAP-1A33 PW1133G-JM Geared Turbo Fan PW1130G-JM	Significant Change, EASA CS25 Amdt 15 CRI A-0001-003 Issue 2

6.2 Boeing 737 MAX 8 High-Level Changed Product Rule Assessment



6.3 Stakeholder Presentations to Committee

Aviation Trade Associations

Airlines for America (A4A)

National Air Carrier Association (NACA)

General Aviation Manufacturers Association (GAMA)

Aerospace Industries Association (AIA)

National Business Aircraft Association (NBAA)

Unions/Employee Associations

Association of Flight Attendants (AFA)

Airline Pilots Association (ALPA)

Southwest Airline Pilot Association (SWAPA)

National Air Traffic Controllers Association (NATCA)

American Federation of State, County, and Municipal Employees (AFSCME)

Professional Aviation Safety Specialists (PASS)

Government Agencies

FAA

NASA

NTSB

Joint Authorities Technical Review (JATR)

Industry

Airbus Commercial Aircraft

Boeing Commercial Airplanes

General Electric Aircraft Engines

Piper

Gulfstream

Delta Air Lines

Individuals

Co-Chair Flight Standardization Board Working Group, Air Carrier Training ARC

6.4 Recommendations Regarding Aircraft Certification

Over the past two decades, many recommendations have been made to improve the FAA's certification process, several of which involve enhancing delegation and promoting system oversight. The reports and recommendations referenced and summarized below should be considered in any effort to enhance the current system.

Aircraft Certification Process Review and Reform (ACPRR) Aviation Rulemaking Committee (ARC) Report to the Federal Aviation Administration – Recommendations on the Assessment of the Certification and Approval Process (May 2012)

The ACPRR ARC conducted an assessment of the certification and approval process to make recommendations to streamline and reengineer the aircraft certification process. The report noted that while the number of applications for product certifications and approvals did not specifically reflect a significant increase, the actual AIR workload for the FAA was expected to continue increasing. It found that the FAA had limited capacity and must handle competing priorities because it supports the entire product life cycle including COS, rulemaking, and certification, and must address certification of new technologies such as unmanned aircraft systems. The ARC observed many existing improvement initiatives for certification process efficiencies are already implemented or in progress. It found, however, that the FAA had not fully integrated these initiatives, overseen their implementation, measured their benefits, or clearly linked them to a future state. The ARC recommended developing comprehensive implementation plans and a tracking and monitoring process to ensure effectiveness, and maximizing delegation to the greatest extent in current delegation systems, preparing for the future of a systems approach to certification and safety oversight.

Part 21 / Safety Management Systems (SMS) Aviation Rulemaking Committee (ARC) Report to the Federal Aviation Administration – Recommendations on Certification Procedures for Products and Parts (October 2014)

The report provided recommendations to improve the overall effectiveness and efficiency of the certification procedures in 14 CFR part 21, Certification Procedures for Products and Parts, by updating regulations and policies to reflect a systems safety approach to product certification and FAA oversight. The ARC's goal was to determine the best way the FAA and industry could effectively fulfill their respective compliance and safety responsibilities while improving the efficiency and robustness of the certification process. The ARC provided recommendations including: phased implementation of a systems approach to certification, application of SMS requirements to design and production approval holders, and evolution of FAA oversight towards performance based systems safety (SMS) approaches.

Department of Transportation (DOT) Office of Inspector General (OIG) Audit Report AV-2016-001: FAA Lacks an Effective Staffing Model and Risk-Based Oversight Process for Organization Designation Authorization (October 2015)

The DOT OIG found that the FAA lacks a comprehensive process for determining staffing levels needed to provide ODA oversight. It noted that while the Agency used a staffing model to aid in identifying overall staffing needs, the model did not include detailed ODA data on important workload drivers, such as a company's size and location, type of work performed, and project complexity. In addition, it found that the FAA's oversight of ODA program controls is not fully systems- and risk-based, as recommended by an aviation rulemaking committee. This is largely because FAA inspectors and engineers lack adequate guidance and risk-based tools and do not conduct robust analyses of ODA data. The OIG made several recommendations aimed at improving FAA's staffing and oversight of the ODA program.

Safety Oversight and Certification Aviation Rulemaking Committee (SOC-ARC) Recommendation Report to the Federal Aviation Administration (December 2018)

The SOC-ARC was established by the FAA Administrator in January 2018 to evaluate the aircraft certification and safety oversight system and industry's current processes and provide recommendations for implementation of the Comprehensive Strategic Plan for AIR Transformation to meet future demands on FAA safety oversight and aircraft certification. The SOC-ARC provided recommendations to the FAA on developing a safer, more effective and efficient certification system. The recommendation report focused on areas of compliance assurance, flight standards integration, and performance measures and feedback loops.

6.5 Acronyms

Acronym	Description
AC	Advisory Circular
ACO	Aircraft Certification Office
ACPRR	Aircraft Certification Process Review and Reform
AD	Airworthiness Directive
AEG	Aircraft Evaluation Group
AFX	Flight Standards Service
AIR	Aircraft Certification Service
AIR-800	System Oversight Division
ARC	Aviation Rulemaking Committee
ASIAS	Aviation Safety Information Analysis and Sharing
ATO	Air Traffic Organization
AVS	Aviation Safety Organization
BASOO	Boeing Aviation Safety Oversight Office
CA	Certifying Authority
CDO	Certified Design Organization
CECI	Center for Emerging Concepts and Innovation (the Innovation Center)
COS	Continued Operational Safety
CPI	Certification Process Improvement
DER	Designated Engineering Representative
DMIR	Designated Manufacturing Inspection Representative
DOA	Delegation Option Authorization (can also be Design Organization Approval)
DPE	Designated Pilot Examiner
EASA	European Aviation Safety Agency
EFIS	Electronic Flight Information System
eVTOL	Electric and hybrid-electric powered vertical takeoff and landing
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FHA	Functional Hazard Assessment
FMEA	Failure Modes and Effects Analysis
FSB	Flight Standardization Board
FTA	Fault Tree Analysis
ICA	Instructions for Continued Airworthiness
ICAO	International Civil Aviation Organization
JATR	Joint Authorities Technical Review
KSA	Knowledge, Skills and Abilities
MCAS	Maneuvering Characteristics Augmentation System
MCDU	Multifunctional Control Display Unit
MRB	Maintenance Review Board
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NG	Boeing 737 Next Generation (Next Gen)
NTSB	National Transportation Safety Board
ODA	Organization Designation Authorization
ODAR	Organizational Designated Airworthiness Representatives
OEM	Original Equipment Manufacturer

OMT	Organization Management Team
PC	Production Certificate
PSP	Partnership for Safety Plan
R&D	Research & Development
SAE ARP	SAE International Aerospace Recommended Practice
SELCAL	Selective Call
SMS	Safety Management System
SOCAC	Safety Oversight and Certification Advisory Committee
SOC-ARC	Safety Oversight and Certification Aviation Rulemaking Committee
SSA	System Safety Assessment
TC	Type Certificate
TCDS	Type Certificate Data Sheet
UAS	Unmanned Aircraft System
USC	United States Code
VA	Validating Authority

6.6 Figure 1 of FAA Advisory Circular 25.1302-1

FAA Advisory Circular 25.1302-1, *Installed Systems and Equipment for Use by the Flightcrew*

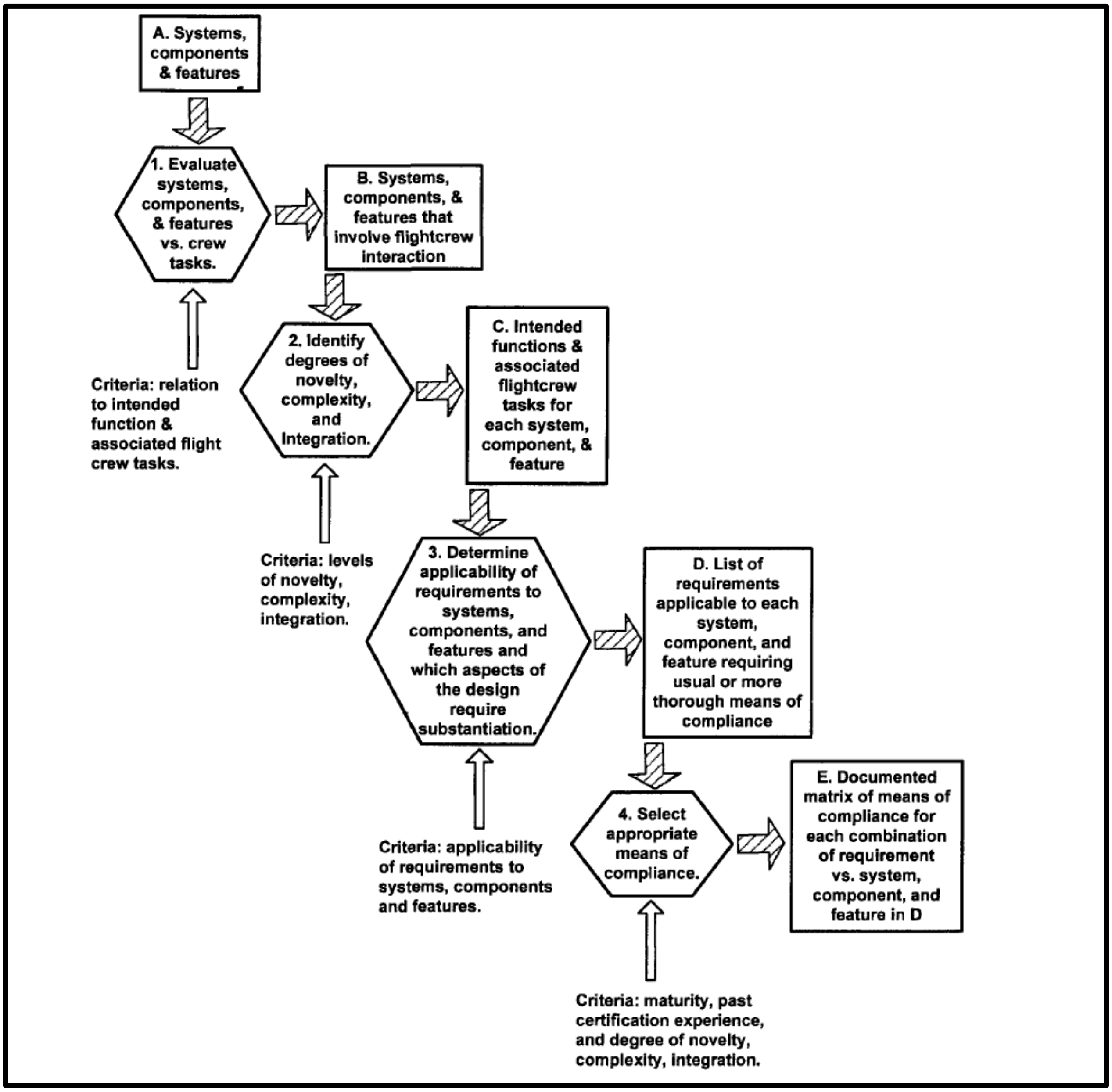


Figure 1 of AC 25.1302-1

Methodical Approach to Planning Certification for Design-Related Human Performance Issues

6.7 Approvals

We, the members of Special Committee to review the Federal Aviation Administration's Aircraft Certification Process, have produced the attached report and confirm it as our findings and recommendations.

Captain Lee Moak Co-Chair, Special Committee	1/16/20 Date
General Darren W. McDew, USAF (Ret.) Co-Chair, Special Committee	1/16/20 Date
Gretchen Haskins Member, Special Committee	1/16/20 Date
Kenneth Hylander Member, Special Committee	1/16/20 Date
David Grizzle Member, Special Committee	1/16/20 Date