U.S. Department
of Transportation
**Federal Aviation
Administration**

Office of the Administrator

800 Independence Ave., SW.
Washington, DC 20591

March 31, 2020

The Honorable Richard Shelby
Chairman, Senate Committee on Appropriations
United States Senate
Washington, DC 20510

Dear Mr. Chairman:

As requested in House Report 115-237 for the Departments of Transportation, and Housing and Urban Development, and Related Agencies Appropriations Bill, 2018 (Pub. L. 116-6), the Federal Aviation Administration (FAA) is pleased to provide the enclosed report on Additive Manufacturing. The House Report asked the FAA to report on the use of additive manufactured parts within the civil aerospace industry, including any efforts to monitor what additive manufactured components are utilized on airframes and what measures are being taken to monitor and mitigate the use of counterfeit additive manufactured parts. The enclosed report addresses those efforts and measures.

We have sent identical letters to Vice Chairman Leahy, Chairwoman Lowey, and Ranking Member Granger.

Sincerely,

Steve Dickson
Administrator

Enclosure

U.S. Department
of Transportation
**Federal Aviation
Administration**

Office of the Administrator

800 Independence Ave., SW.
Washington, DC 20591

March 31, 2020

The Honorable Nita M. Lowey
Chairwoman, Committee on Appropriations
United States House of Representatives
Washington, DC 20515

Dear Chairwoman Lowey:

As requested in House Report 115-237 for the Departments of Transportation, and Housing and Urban Development, and Related Agencies Appropriations Bill, 2018 (Pub. L. 116-6), the Federal Aviation Administration (FAA) is pleased to provide the enclosed report on Additive Manufacturing. The House Report asked the FAA to report on the use of additive manufactured parts within the civil aerospace industry, including any efforts to monitor what additive manufactured components are utilized on airframes and what measures are being taken to monitor and mitigate the use of counterfeit additive manufactured parts. The enclosed report addresses those efforts and measures.

We have sent identical letters to Ranking Member Granger, Chairman Shelby, and Vice Chairman Leahy.

Sincerely,

Steve Dickson
Administrator

Enclosure

U.S. Department
of Transportation
**Federal Aviation
Administration**

Office of the Administrator

800 Independence Ave., SW.
Washington, DC 20591

March 31, 2020

The Honorable Patrick Leahy
Vice Chairman, Senate Appropriations Committee
United States Senate
Washington, DC 20510

Dear Vice Chairman Leahy:

As requested in House Report 115-237 for the Departments of Transportation, and Housing and Urban Development, and Related Agencies Appropriations Bill, 2018 (Pub. L. 116-6), the Federal Aviation Administration (FAA) is pleased to provide the enclosed report on Additive Manufacturing. The House Report asked the FAA to report on the use of additive manufactured parts within the civil aerospace industry, including any efforts to monitor what additive manufactured components are utilized on airframes and what measures are being taken to monitor and mitigate the use of counterfeit additive manufactured parts. The enclosed report addresses those efforts and measures.

We have sent identical letters to Chairman Shelby, Chairwoman Lowey, and Ranking Member Granger.

Sincerely,

Steve Dickson
Administrator

Enclosure

U.S. Department
of Transportation
**Federal Aviation
Administration**

Office of the Administrator

800 Independence Ave., SW.
Washington, DC 20591

March 31, 2020

The Honorable Kay Granger
Ranking Member, Committee on Appropriations
United States House of Representatives
Washington, DC 20515

Dear Congresswoman Granger:

As requested in House Report 115-237 for the Departments of Transportation, and Housing and Urban Development, and Related Agencies Appropriations Bill, 2018 (Pub. L. 116-6), the Federal Aviation Administration (FAA) is pleased to provide the enclosed report on Additive Manufacturing. The House Report asked the FAA to report on the use of additive manufactured parts within the civil aerospace industry, including any efforts to monitor what additive manufactured components are utilized on airframes and what measures are being taken to monitor and mitigate the use of counterfeit additive manufactured parts. The enclosed report addresses those efforts and measures.

We have sent identical letters to Chairwoman Lowey, Chairman Shelby, and Vice Chairman Leahy.

Sincerely,

Steve Dickson
Administrator

Enclosure

FEDERAL AVIATION ADMINISTRATION

FAA Report on Additive Manufacturing

In Response to House Report 115-237 to the Departments of Transportation, and Housing and Urban Development, and Related Agencies Appropriations Bill, 2018 (Pub. L. 116-6)

Table of Contents

1 Overview

In House Report 115-237 to the Departments of Transportation, and Housing and Urban Development, and Related Agencies Appropriations Bill, 2018 (Pub. L. 116-6), Congress requested the Federal Aviation Administration (FAA) to provide a report on the use of additive manufactured (AM) parts within the civil aerospace industry. The House Report asked the FAA to detail in the report any efforts to monitor what additive manufactured components are utilized on airframes, and what measures are being taken to monitor and mitigate the use of counterfeit additive manufactured parts.

2 Executive Summary

The use of AM technologies in civil aviation and commercial space has continuously increased over the past few years. The FAA defines acceptable levels of safety risks within civil aerospace and applies that to each project involving AM components based on the components' criticality and specific application. The FAA approves the design and manufacture of civil aircraft, the maintenance programs, and the operational system in which they are used. In contrast, vehicles used in commercial space operations are primarily regulated from an operational aspect only to ensure risks to other aircraft in the National Airspace System (NAS) and the public are adequately mitigated.

The FAA has a long history of supporting the safe introduction of new materials into aviation through appropriate regulatory guidance. Through collaboration with industry, other government agencies and academia, the FAA is working to develop performance-based guidance and leverage voluntary industry consensus standards. The FAA requires that applicants using AM technology comply with all applicable safety standards and requirements. Furthermore, the FAA is examining whether limitations exist with current non-destructive inspection (NDI) and in-situ monitoring techniques when applied to AM processes. Finally, the FAA uses the Suspected Unapproved Parts (SUP) Program to monitor and eliminate any counterfeit parts regardless of the manufacturing method.

3 Technical Considerations

Additive Manufacturing is not the first complex manufacturing technology to pose challenges for the aerospace industry and the FAA certification process. For example, the introduction of composite materials many years ago posed similar challenges at that time but those challenges have since been resolved and composite materials are now widely used in aviation products. There are similarities with other traditional manufacturing processes such as casting, forging, welding and extruding where manufacturing processes can affect the strength and fatigue characteristics of the part.

AM technologies also require rigorous attention to manufacturing processes due to the high levels of process sensitivity and complexity, resulting in parts with unique material properties and characteristics. Achieving consistent mechanical performance of AM parts is dependent on the complexity of controlling the AM manufacturing process.

4 Civil Aviation

4.1 Development of Critical Standards and Assessment Methods for Certifying AM Components

The FAA is maximizing the use of performance-based policy, guidance documents and risk-based principles for AM technology used in civil aviation. Due to the rapid evolution of AM, the FAA is leveraging voluntary industry consensus standards, and industry working group recommendations in the evaluation of potentially acceptable means of compliance to regulatory requirements. The FAA has sponsored research and hosted annual AM workshops since 2015 to promote learning across the FAA and to facilitate discussion on the qualification and certification of AM parts between the government agencies, academia, industry, and foreign civil aviation authorities.

The FAA continues to coordinate with other government agencies, academia and industry organizations. To help facilitate industry standardization, the FAA is collaborating in the following ways:

- The FAA requested SAE International and Aerospace Industries Association (AIA) to form committees and an advisory working group to develop standards, specifications and best practice documents.
- The FAA participates with ASTM International (formerly American Society for Testing and Materials) Committee F42 on AM partnered with International Organization for Standardization (ISO) to produce unified voluntary consensus standards on AM.
- American Welding Society (AWS) chartered the D20 committee to address AM standardization. The FAA participates on this committee.
- The FAA is a member of the America Makes consortium (including co-sponsored research), the Kansas Aviation Research & Technology Growth Initiative (KART) focused on AM (industry members include Airbus, Spirit AeroSystems, Textron Aviation, and Bombardier),
- The FAA is a member of the Next Manufacturing Consortium headed by Carnegie Mellon University (members include General Electric, Alcoa, etc.).
- The FAA actively supports the AM Standardization Collaborative (AMSC) initiative, a joint effort between the America Makes members and ANSI (the American National Standards Institute), focused on developing the public standardization roadmap and working with government/industry consortiums for materials handbook development like the Metallic Materials Properties Development and Standardization (MMPDS) and the Composite Materials Handbook-17 (CMH-17).

The FAA intends to develop performance-based policy that will potentially allow an applicant to demonstrate compliance to FAA requirements using the consensus standards and best practices developed by the groups listed above.

4.2 Use of AM within the Civil Aerospace Industry

Multiple metallic and polymeric materials are processed into aviation parts using different manufacturing technologies, which include laser sintering, powder bed fusion, directed energy deposition, and material extrusion processes. Polymer AM parts are currently in use but are largely limited to low-criticality parts. At this time, metal parts produced through AM techniques are less prevalent than polymer parts but are used in higher criticality applications, including load-carrying structural components. The FAA expects the introduction of safety-critical metallic AM parts in the near future, both for airframe and engine applications.

AM parts provide savings in cost, weight, schedule, and part consolidation. For example, one manufacturer anticipates reducing 855 separate metallic parts down to just 12 using AM processes. Another area for AM applications will be for spare and replacement parts used in maintenance (i.e., repairs and alterations) of aircraft and aircraft engines. The FAA continues to ensure the level of rigor applied to approving AM parts is the same as for traditional manufacturing techniques, whether the parts support new production or maintenance activities.

4.2.1 Certification

Certification of additively manufactured parts fits into the existing FAA regulatory system and is managed in a similar fashion to other process intensive material systems. Like other new and novel technologies, the FAA uses a risk-based approach when certifying AM parts. For higher risk AM applications, the Aircraft Certification Service (AIR) standards branches for each different product type (i.e., transport airplanes, small airplanes, rotorcraft, engine and propeller) monitor projects using AM parts. In an effort to ensure a standardized approach, proposals to use new AM processes are shared among the FAA's AM specialists in engineering, manufacturing, and maintenance. The FAA's approach to communication and standardization of AM used across product types is facilitated by AIR's transformation to a functionally aligned organization. As the FAA publishes policy, guidance and participates in the development of voluntary industry consensus standards, the level of involvement by the FAA in these projects will decrease.

4.2.2 Maintenance

Multiple maintenance organizations have approached the FAA to inquire about making spare parts through AM. Such applications are addressed on a case-by-case basis. The FAA issued guidance material for FAA inspectors of manufacturing facilities and maintenance facilities to ensure any planned use of AM in industry is evaluated and coordinated as needed with FAA engineering personnel.

4.3 The Development of Advanced Non-Destructive Evaluation Methodologies for Risk Identification and Assessment and In-Situ Manufacturing Process Controls

The FAA is focused on the development of advanced non-destructive evaluation methodologies for risk identification and assessment of in-situ manufacturing process controls. The FAA has already defined Research and Development (R&D) tasks to address these areas for metal AM as follows:

4.3.1 Non-Destructive Inspection (NDI) Technology for Metal AM

While the metal AM process of creating a part has unique process controls, the FAA's certification process is designed to accommodate and address these issues. The inspection techniques for metal AM parts must account for highly complex geometries (including hidden internal features), textured material microstructures, anisotropic properties, and rough surface finishes, which may impact the ability to inspect a part using existing NDI methods. AM can also create manufacturing defects and materials anomalies that are unique to AM processes, for which conventional NDI methods may not be effective. The FAA is working with industry, academia, government agencies, and standards development organizations to review NDI methodologies for suitability at detecting key defects/anomalies/flaws relevant to metal AM parts, just as similar concerns with structural alloys and composites were addressed in the past.

4.3.2 In-situ Manufacturing Process Controls

AM equipment manufacturers have implemented equipment and sensors for the purpose of real-time process monitoring of additive builds. This data is primarily used to supplement existing NDI by focusing inspections on specific locations in parts. In addition, some AM machines use in-situ monitoring data to actively control specific aspects of the build. The effectiveness of in-situ monitoring to identify anomalies in parts and actively control the build will continue to be evaluated.

4.4 Monitoring and Mitigating the Use of Counterfeit AM Parts

The FAA considers the counterfeiting of aviation parts a serious violation and risk to the safety of our NAS. Counterfeit parts are identified and mitigated through the FAA's long-standing Suspected Unapproved Parts (SUP) program. The SUP program applies to all parts whether produced using traditional methods or using newer technologies like AM. The FAA supports one system for handling SUP, and the FAA SUP program is able to adequately mitigate the risk of counterfeit AM parts.

5 Commercial Space

The FAA's Office of Commercial Space Transportation (AST) is responsible for licensing commercial launch and reentry operations to ensure the safety of the public from risks associated with commercial space launches and reentries. AST established a regime to license launch and reentry operations instead of certifying launch and reentry vehicles. Vehicle manufacturers use AM to build launch and reentry vehicle components faster and with less expense. AM is used to build rocket engine components that include propellant valves, pumps, injectors, and combustion chambers. Licensed launches have involved launch vehicles that use AM for primary engine components; the use of AM for other launch vehicle parts and components will continue to increase. AST's commercial space transportation regulations do not specifically address AM. However, for safety critical components that could affect public safety, AST's licensing process addresses manufacturing consistency and quality of safety critical components through requirements associated with qualification and acceptance testing, inspection, and through the system safety process to demonstrate compliance with acceptable risk criteria.

6 Summary

The FAA is committed to ensuring that this new technology continues to be addressed using a risk-based approach that will leverage industry collaboration and consensus standards. Through collaboration with industry, other government agencies, and academia, the FAA is working to develop performance based guidance and leverage industry standards. The FAA will continue supporting the safe integration of AM technology into the NAS.