Considerations for Ease of Flight Inspection System Integration, Installation, & Certification

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BIOGRAPHY

Tracy Bohaboj is an Engineering Team Leader for the Structural and Interior Engineers and Certification Coordinators at Duncan Aviation in Lincoln, Nebraska, USA where she leads a team in the design, analysis, and FAA certification and international validation efforts of a wide range of engineering projects. These projects include complex avionics installations, Special Mission installations, and interior alterations on business jets. Tracy joined Duncan Aviation in 2007 as a Structural Engineer. Before coming to Duncan Aviation Tracy was an Aerospace Engineer for Raven Aerostar, the world's leader in the design and manufacture of highly technical aerospace, surveillance technology, navigation aids and specially sewn products located in Sulphur Springs, TX. Prior to that, she served as a Mechanical Engineer for New Mexico State University stationed at the NASA Wallops Flight Facility in Virginia supporting the NASA Balloon Program Office. Thermal modeling and analysis of high altitude balloons and payload instrumentation for balloon flights was her primary focus. She was also a member of the Deployment Experiments for Ballooning on Mars (DEBOM) team where she conducted subscale prototype tests as role in planetary balloon technology development. Tracy received a Bachelor of Science degree in Aerospace Engineering from Iowa State University and was born and raised in Nebraska, USA.

ABSTRACT

This paper presents the basic considerations and process for developing a Supplemental Type Certificate (STC) for a Flight Inspection System (FIS). Many certification considerations must be taken into account, such as: state of registry and design of the aircraft, type certification and airworthiness standards, including the United States Federal Aviation Administration (FAA) Title 14 of the Code of Federal Regulations (CFR) Part 23 “Normal” or “Commuter” category or 14 CFR Part 25 “Transport” category. Aerodynamic impact to the aircraft, noise, icing, human factors and pilot work load, system safety, passenger egress, etc., must all be evaluated. Steps including developing a certification plan, design data, analysis, testing, and coordination with the FAA or other certifying entity will be discussed. Coordination with various Civil Aviation Authorities for special flight authorizations and validation of the STC may also be required.

This paper also describes the considerations in selecting materials, components, and Aircraft Flight Inspection equipment to aid in the ease of installation and overall certification. Material strength properties and design values must be evaluated and determined to meet the applicable regulations. Utilizing components manufactured under a Technical Standard Order (TSO) authorization or components modified by the original equipment manufacturer (OEM) and TSO authorization holder streamlines the certification process. Selecting TSO’d antennas, shown to be previously installed and certified on a similar aircraft, also reduce the efforts needed to certify the installation. Overhaul and repair capabilities on components may bring a unique advantage in proving quick turn support, experience, and parts ordering to FIS designers and end users. End users may also prefer the benefits of having Parts Manufacture Approval (PMA) replacement parts.

INTRODUCTION

The integration, installation, and certification process can seem daunting. Aircraft systems are complex and somewhat unique to each aircraft. Careful thought and consideration in material selection and components can aid in and simplify the

installation and certification efforts. Familiarization of the Supplemental Type Certification (STC) process, general timelines to be aware of, and basic design, analysis, and testing requirements can also be beneficial.

DEVELOPING A SUPPLEMENTAL TYPE CERTIFICATE

Design, Analysis, Test & Inspections are all used to document compliance to the regulatory requirements for an STC project.

Before any compliance and regulatory basis can be established and addressed, state of design and registry of the airplane must be reviewed. Typically, many Civil Aviation Authorities (CAA), including the Federal Aviation Administration (FAA), will not provide a design approval of any type unless the product is either manufactured in country or will be registered for use in that country, and there is a bilateral agreement in place. The FAA will not issue an STC to "Modify foreign-registered aircraft without the involvement of the CAA of the state of registry".[1] Verifying the state of design and state of registry of the airplane prior to aircraft selection may be an important consideration to avoid delays. Coordination between the modifier, FAA, and the CAA will be required if the airplane is registered outside the United States prior to STC application, modification, and flight testing. Special Flight Authorization (SFA) may also be required from the Flight Standards District Office (FSDO), to conduct flight tests, if the aircraft is not registered in country of modification. Although it is not required, utilizing an airplane that is registered in the United States streamlines the process for an FAA STC.

The type certification and category found in the Type Certification Data Sheet for the airplane (i.e. United States Federal Aviation Administration (FAA) Title 14 of the Code of Federal Regulations (CFR) Part 23 "Normal" or "Commuter" category or 14 CFR Part 25 "Transport" category) is the primary driver for establishing the certification basis.

Certification Considerations

There are many considerations that must be taken into account when modifying an airplane. Aerodynamic impact to the aircraft, noise, icing, human factors and pilot work load, system safety, passenger egress, etc., must all be evaluated and tend to be areas that can cause delays or greatest impact to the certification efforts.

Any modifications to the exterior of the airplane can impact the aerodynamic performance, acoustic changes or increased noise, and additional ice accumulation on the airplane structure.

- Aerodynamic Impact - The effective impact on the aerodynamic performance of the airplane needs to be evaluated. The ability to compare to previously approved installation of antennas of similar size, shape, and location all simplify this process.

- Acoustic Changes/Noise – An analysis must be performed to substantiate that the modifications to the airplane do not result in an increase in noise certification levels and can constitute a "No Acoustic Change" in accordance with 14 CFR Subpart D Paragraph 21.93(b).[3] This must demonstrate the increased drag does not result in a noise increase, the engine noise sources and propagation paths are not changed, and the airframe source noise does not increase certification levels.

- Icing - An icing analysis must be completed to evaluate the threat with respect to ice accumulation and shedding hazards for the any external modification, most commonly the new external antenna installations and any relocated existing antennas. The Icing Analysis will show that the design change is compliant with 14 CFR 25.1093(b)(1)(i) and 25.1419(a).[2]

As noted above, careful consideration to placement and relocation of antennas based on size, shape, and previously approved locations by the OEM significantly aid in the ease of certification.

Even though FIS pilots are highly trained and experienced operators, modifications to the cockpit and pilot tasks can impact the human factors and pilot workload aspects. Careful planning should be taken for annunciator and switch location, colors selection/requirements, wording, and new components in the cockpit.

Added electrical equipment and changes to the system and the installation including circuit protective devices, and interface to other systems must be appropriate to their intended function. Equipment being used in a unique and novel method may require additional evaluation, analysis, and testing.

Any changes to the floorplan can impact passenger and crew egress. There are aisle width and head impact criteria that must be evaluated. Large FIS consoles, additional or relocated seats, can create a need to reevaluate and even demonstrate emergency evacuation compliance.

Process and Timeline

Familiarization of the STC process, general timelines to be aware of, and basic design, analysis, and testing requirements can be beneficial. The following major milestones are typical in an STC process:

- Coordination with the FAA or other certifying entity.
- Development of a certification plan.
- Application to the FAA
- Design Development
- Analysis
- Creation of the Instructions for Continued Airworthiness (ICA)
- Creation of the Airplane Flight Manual Supplement (AFMS)
- Issuance of the Type Inspection Authorization (TIA) prior to FAA testing
- Compliance Ground and Interior tests
- Coordination with CAA for Special Flight Authorizations (SFA)
- Compliance Flight Tests
- Issuance of the STC
- Validation of the STC

It should be noted that often FIS operators and maintenance technicians prefer to review the ICA and AFMS, timing should be accounted for in the timeline above.

The application, design, design substantiation, inspection/test, and show compliance phases of the application process are described in detail in the IFIS 2012 Proceedings by Russ Kromberg.[3] Utilizing a facility with an Organization Designation Authorization (ODA), an appointment by the FAA authorizing the organization to perform approved functions on behalf of the FAA, can significantly streamline many parts of the process and timeline noted above. The ODA's partnership with the FAA and certification experience will also often provide confidence and reassurance to the CAA validating the STC.

CONSIDERATIONS

Considerations should be taken when selecting materials and components to aid in the ease of installation and overall certification.

Selecting Materials

Material strength properties and design values must be evaluated and determined to meet the applicable regulations. The FAA states "Material strength properties must be based on enough tests of material meeting approved specifications to establish design values on a statistical basis."[2] Selecting materials with previously FAA established strength properties will help streamline the project and reduce the likelihood of full scale testing.

Meeting the flammability requirements depends greatly on material composition, thickness and adherence to other materials in a "build up". Tests will be performed to demonstrate the buildup is self-extinguishing per FAA guidelines.[2] Metals with more than 10% magnesium have the potential of burning hotter and faster than some plastic and needs to be tested. While

there are multiple factors that can affect the flammability of the materials, the materials that are already aircraft grade typically do well under flammability testing. Untreated to poorly treated fabrics, single ply veneers and exposed adhesives tend to more flammable. Polypropylene, a fiber found in stain resistant carpeting and other materials, is highly flammable. Natural fibers such as wool, are typically fire resistant.

Often chairs, card tables and even cabinets are removed from the airplane to make way for some of the larger consoles, however not all installations require the removal of these interior furnishings. Being mindful of the impacts to the weight and balance of the airplane, excessive floor loading, and equipment/radio rack limitations can be helpful.

The goal in designing a safe cabin is to create a cabin that protects the occupants whether they are seated or moving about the cabin in flight where they could potentially lose their balance during turbulence. One way to do this is to eliminate potential hazardous features such as sharp edges (< 0.125 inch). In some cases, a safety pad may be required in addition to the radiused edge. When possible a more generous radius is recommended. Installations will need to be evaluated on a case by case basis. The location of the design feature must also be taken into consideration.

Components

When it comes to components, there are a couple factors that aid in and often streamline the integration and certification process:

1. Components manufactured under a Technical Standard Order (TSO) authorization.

2. Components modified by the original equipment manufacturer (OEM) and TSO authorization holder.

If a component does not have a TSO, looking for DO-160 testing results and military standards (i.e. MIL-STD-XXX) can be helpful. Selecting TSO'd antennas, shown to be previously installed and certified on the selected airplane or at a minimum on a similar aircraft, also reduce the efforts needed to certify the installation. If there is no "pedigree" the component may fall under the Commercial Off the Shelf (COTS) classification and approval will be accomplished per the guidance provided by AC 20-168.[4]

Integrators with overhaul and repair capabilities on components may bring a unique advantage in proving quick turn support, experience, and parts ordering to FIS designers and end users.

Aircraft Flight Inspection Equipment

End users may also prefer the benefits of having Parts Manufacture Approval (PMA) replacement parts. Parts that are not purchased "as-is" or are new to the airplane may be excellent candidates to be PMA'd. Customers prefer parts that can be easily ordered, manufactured, and commonly exported. It may provide a way to reduce costs, increase reliability, and cut downtimes in years to come. Being able to offer PMA replacement parts is one viable solution to all three.

RECOMMENDATIONS

Often, the timeline for the modification and certification is critical to the end user. In order to streamline the process as much as possible it is highly recommended to do the following

- Consider the state of design and state of registration of the airplane to be modified.
- Coordinate with the certification entity before selecting final materials used in the airplane.
- Coordinate with the certification entity before finalizing the modification plans.
- Consider the previous testing and certification of the components to be installed in the console and the airplane.

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REFERENCES

[1] Type Certification, 8110.4C, Change 6

[2] Title 14 CFR, https://drs.faa.gov

[3] Kromberg, Russ, Aircraft Flight Inspection Systems Installations and Certifications, IFIS 2012 Proceedings

[4] AC NO: 20-168, Certification Guidance for Installation of Non-Essential, Non-Required Aircraft Cabin Systems & Equipment (CS&E) Advisory Circular