Integration of Aircraft Connectivity Systems in Flight Inspection Environments

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BIOGRAPHY

Tracy Bohaboj is a Government Contracts Sales Representative with nearly 19 years of experience at Duncan Aviation in Lincoln, Nebraska. She brings a unique combination of engineering expertise and industry knowledge to her role, supporting complex aviation projects and customer needs. Prior to transitioning into sales, Tracy served as an Engineering Team Leader for Structural and Interior Engineering, as well as Certification Coordination. In this role, she led a multidisciplinary team responsible for the design, analysis, FAA certification, and international validation of a wide range of engineering projects. Her work included complex avionics installations, special mission modifications, and interior alterations on business jets. Tracy began her career at Duncan Aviation in 2007 as a Structural Engineer. Before joining Duncan, she worked as an Aerospace Engineer at Raven Aerostar in Sulphur Springs, Texas, a global leader in aerospace systems, surveillance technology, and navigation solutions. Earlier in her career, Tracy served as a Mechanical Engineer with New Mexico State University, stationed at NASA's Wallops Flight Facility in Virginia. There, she supported the NASA Balloon Program Office, focusing on thermal modeling and analysis of high-altitude balloons and payload instrumentation. She also contributed to the Deployment Experiments for Ballooning on Mars (DEBOM) team, conducting subscale prototype testing for planetary balloon technology development. Tracy holds a Bachelor of Science in Aerospace Engineering from Iowa State University and is also a certified private pilot, further reflecting her passion for aviation. She was born and raised in Nebraska.

ABSTRACT

As flight inspection operations evolve, aircraft connectivity is increasingly being considered to support multi-mission requirements, operational efficiency, and improved coordination with ground teams. This paper examines key technical and operational considerations associated with introducing or expanding onboard connectivity within flight inspection aircraft. Topics include the integration of satellite-based internet systems, including low Earth orbit solutions, and the resulting impacts on antenna placement, potential relocation of existing flight inspection antennas, and electromagnetic compatibility within antenna-dense aircraft environments. The paper also explores multipurpose applications of connectivity, such as real-time data sharing and video communication, and evaluates their influence on crew resource management and operational safety. In addition, current methods used by flight inspection crews to communicate with ground personnel are reviewed, with consideration given to how enhanced connectivity may augment existing processes without introducing distraction or operational risk. The objective of this paper is to provide a balanced assessment of connectivity benefits and challenges, offering practical considerations for operators planning connectivity integration while preserving the safety, reliability, and integrity of flight inspection missions.

INTRODUCTION

Flight inspection operations rely on highly specialized aircraft configurations, where mission-critical systems, antenna placement, and electromagnetic compatibility are carefully engineered to support precise navigation and communication measurements. Historically, these aircraft have operated with limited or no onboard internet connectivity. Concerns about cost, reliability, impact to the aircraft, and system interference have been the some of the focus.

Now, as real-time data sharing and video communication are a reality offered by the current connectivity systems many operators are evaluating the feasibility and potential impacts to their aircraft and operations.

TECHNICAL CONSIDERATIONS

Satellite Connectivity Solutions

As satellite-based communication technologies have matured, including the emergence of low Earth orbit (LEO) networks, aircraft connectivity is increasingly becoming a viable capability and resource for Flight Inspection aircraft who have traditionally operated in disconnected environments.

Within business aviation, similar discussions began to emerge as operators sought more reliable onboard connectivity to support conducting business activities while in transit.

In 2013, several Chief Executive Officers (CEOs) of Fortune 100 companies came together and shared that their in-flight connectivity experiences were falling short of what they expected. After identifying common issues, the National Business Aviation Association (NBAA) created a focus group in 2014 to explore ways to improve the reliability and performance of onboard internet.

Although every aircraft is configured differently, the NBAA group spent the next several years tracking operators and collecting a large amount of data on connectivity performance.

In 2017, Akshatha wrote in the International Journal of Science and Research, "The two main issues affecting the current state of Wi-Fi in air travel are rooted in quality and accessibility."[3] This point further reinforces the importance of the subcommittee's effort.

The NBAA Connectivity Subcommittee, made up of pilots, IT specialists, flight attendants, service providers, equipment and aircraft manufacturers, and maintenance experts, including Duncan Aviation's Sr. Avionics Salesperson Justin Vena, continue advancing the effort and still meet regularly today. Because of their work, many resources and articles exist in guiding those looking for a system that might work well for them. Even though the committee is focused on business aviation, the information applies to special mission and flight inspection aircraft as well and is a highly recommended resource [1].

The basic categories when it comes to utilizing a method for your aircraft to connect to the internet are:

1. Air-to-Ground (ATG)
2. Air-to-Satellite
    - Low Earth Orbit (LEO)
    - Medium Earth Orbit (MEO)
    - Geostationary Earth Orbit (GEO)

This paper does not explore the range of ATG or cellular connectivity options available worldwide; however, these solutions should still be considered when operations are confined to regions within their coverage areas.

It also does not cover the GEO (i.e. Inmarsat, Viasat, etc) or MEO (used primarily for GPS) options. These are commonly a little slower upload and download speeds (Mbps) and have higher latency. These too should still be considered depending on the intended use.

Today, there are also several LEO networks, such as Kuiper, Telesat, Rivada, Iridium, etc, however most commonly requested systems of late are the ones that utilized SpaceX Starlink and Eutelsat OneWeb, which is utilized by the Gogo Galileo System. These systems have some of the highest download speeds ever seen in aviation (~ 200 Mbps).

Antenna Placement and Impact on Existing Flight Inspection Systems

The Starlink (see Figure 1) and Gogo Galileo HDX and FDX (see Figure 2) antennas are inherently large (~50 -75 cm in length) because of the very advanced electronically steered phased-array system.

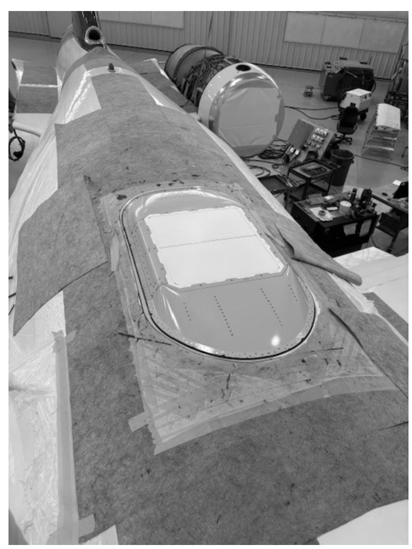

Figure 1. Starlink Antenna During Installation

Figure 2. Gogo Galileo FDX Antenna

They are required to be installed on the top of the airplane where space is limited due to the high numbers of antennas already installed for the flight inspection systems and aircraft dedicated antennas. Utilizing an existing Supplemental Type Certificate (STC) is often a common approach to reduce certification development time and cost; however, it constrains antenna installation to predetermined locations. These fixed installation positions may necessitate the relocation of existing mission-critical antennas, potentially introducing integration complexity and operational risk in antenna-dense aircraft environments. Developing and certifying a new connectivity antenna location can be costly. It can introduce the need to do bird strike testing on antenna installed on a spare fuselage section.

Relocating existing flight inspection dedicated antennas may require system recalibration, repeat antenna mapping, and potentially innovative solutions such as dual-element antenna configurations to accommodate installation constraints, all of which can introduce additional cost and potential schedule delays as well.

Electromagnetic Compatibility (EMC)

Like any high-power radio frequency (RF) system installed on an airplane, these systems are tested and evaluated. They are typically designed with tight RF containment in the antenna aperture, highly directional beams, and have extensive shielding and filtering. The aircraft specific STC process they go through assures here is not interference.

The wireless local network inside the cabin, based on standard Wi-Fi protocols use 2.4 GHz and 5 GHz band, which are very different from most aviation systems. Again, intentional testing provides the confidence these are not impacted.

CURRENT COMMUNICATION METHODS

Radios onboard the aircraft, cell phones, and face-to-face communication are currently used for coordination. Each method presents its own challenges. Most operations are conducted at low altitudes where cell phone coverage is generally available; however, signal availability is not always reliable. Face-to-face communication requires additional landings, which increases both operational time and complexity.

SAFETY & OPERATIONAL CONSIDERATIONS

There are a number of safety and operational considerations, perhaps even challenges, that must be taken into account. This paper presents a high-level perspective one should take into consideration; however the list is certainly not all inclusive.

1. Distractions and workload management - Connectivity tools can unintentionally distract from critical flight inspection tasks.
2. Increased tasks of the flight crew - Adds another communication and coordination layer for flight crew to manage
3. Security of data
4. Service reliability limitations - Connectivity may be intermittent or temporarily unavailable during flight. Short outages can disrupt workflows and user expectations. Coverage may be limited at lower altitudes where many flight inspection maneuvers occur.
5. Cost and operational trade-offs - Installation and ongoing service costs can be significant.
6. Reduced face-to-face interaction - Less direct post-flight communication with ground technicians. Some operational context and relationship-building may be reduced without in-person debriefs.

CONNECTIVIY BENEFITS

Just as the CEOs of Fortune 100 companies benefit from being “connected,” there are numerous compelling reasons for flight inspection aircraft to be connected as well. When a group of experts from the flight inspection community were consulted, they identified the following benefits:

1. Real-time data transfer and operational efficiency

- Flight inspection reports can be sent directly to ground technicians in real time

- Images, graphics, and measurement data can be shared instantly for analysis
- Enables faster troubleshooting with maintenance teams and flight inspection support
- Supports potential use of AI tools for diagnostics and issue resolution
- Reduces delay between data collection and decision-making

2. Enhanced collaboration and remote expertise

- Less experienced inspectors can connect with experienced colleagues on the ground during missions
- Graphics and live data can be shared to support problem-solving in real time
- Ground technicians can provide immediate guidance during flight inspection issues
- Improves overall team capability and reduces operational risk

3. More efficient NAVAID calibration and support

- Ground teams can receive live aircraft data to support NAVAID adjustments
- Enables faster and more accurate calibration decisions without waiting for landing
- Reduces need for aircraft to return to base for minor corrections
- Calibration profiles can be sent digitally to improve coordination

4. Improved communication and coordination

- Enables real-time messaging with dispatch and ground personnel
- WhatsApp or similar tools help overcome language and accent barriers with clear technical messaging
- Useful in remote operations where English is not the primary language
- Helps ground personnel respond quickly

5. Better situational awareness and weather access

- Provides higher-resolution weather information than ADS-B alone
- Useful for smaller airports where weather is only available via phone or internet

6. Increased cockpit flexibility and connectivity tools

- Wi-Fi calling and messaging using existing mobile contacts
- Enables in-flight flight plan filing to reduce ground delays during unexpected stops
- Supports continued operations with minimal disruption

7. Data continuity and cloud integration

- Flight data can automatically sync to company cloud systems
- Ground teams can access recordings immediately for analysis
- Improves post-flight review and accelerates engineering feedback loops
- Especially useful during troubleshooting scenarios

CONCLUSIONS AND RECOMMENDATIONS

There are many items to take under consideration prior to putting a fight inspection aircraft down for a modification to add a connectivity system. Impact to the aircraft and existing systems, costs, and operational impacts are not inconsequential should be given great attention.

The following are highly recommended:

- Critical evaluation on how the system will be used and where geographically.
- Understanding certified antenna locations and impact to the airplane.
- Coordinating with a reputable installer, who is an approved dealer/vendor for the connectivity system.
- Getting other user feedback. The “customer experience” is often referenced when it comes to connectivity.

However, when appropriate steps are taken, the benefits of having a connectivity system onboard will likely outweigh the challenges.

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While I may be missing someone inadvertently, I deeply appreciate the time, guidance, and constructive dialogue provided by everyone who participated in discussions or offered feedback.

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