Optimizing FIS Integration – Leveraging OEM and Modifier Strengths

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BIOGRAPHY

Jason Day is a 23-year veteran of Textron Aviation and has been the Project Engineer for four flight inspection airplane contracts. He is now a member of the Capture Engineering group of Special Missions, helping shape proposals to meet customer requirements. He advises the Special Missions team on airplane capabilities and helps shape future design programs. He specializes in Special Mission adaptations of the Cessna-brand airplanes and in interfacing with Garmin avionics. Prior to joining the Capture Engineering group, Jason was a Special Missions Project Engineer for 11 years. He also spent time in Airframe Design and Engineering Production Support. He was the manager of the Cessna India design engineering group for two years in Bangalore, India. Jason graduated Magna Cum Laude from Texas A&M University with a degree in Aerospace Engineering. He just celebrated his wife, Katharine, putting up with him for 30 years. Together they have 6 children and 2 grandchildren and live in Wichita, Kansas, the Airplane Capital of the World.

ABSTRACT

Purchasing a new flight inspection airplane is an expensive and complicated task. This paper presents the strengths and weaknesses of different methods of procuring a new airplane modified for flight inspection. It examines the different design and certification aspects and how those are addressed differently between an OEM (Original Equipment Manufacturer or airplane manufacturer) and a Modifier (a company that specializes in airplane modifications). It also compares different scenarios of which entity assumes the role of the Prime (organization responsible for the whole effort). Lastly, this paper discusses lessons learned from experience in delivering flight inspection airplanes.

INTRODUCTION

The flight inspection airplane is a most amazing tool. It should transport mission crew to and from the airport or navigation aid, accurately measure a variety of radio sources, hold and power all necessary equipment, and operate efficiently and reliably over many years. Moreover, the agencies responsible for purchasing such airplanes are under increasing pressure to control costs, and airplanes are not cheap to purchase or maintain. This creates a very challenging situation. This paper seeks to equip the reader with the information necessary to deal more effectively with new airplane acquisition, helping the particular agency to get the most for their money. How should an airplane purchase project proceed to balance and optimize technical requirements and costs? This paper draws on the author's experience from various flight inspection airplane programs and other Special Mission projects. It also relies on input from experts at various companies that perform airplane modifications or design and provide flight inspection equipment.

THE REQUIREMENTS SETTING PROCESS

Although there are many common aspects to the job of flight inspection, each program has slightly different requirements, both in navigation measurement and in airplane requirements. Some countries require an airplane to travel long distances to reach remote airports; some require a very low operating cost. Navigation procedures and facilities differ slightly country to country. This prevents a one-size-fits-all flight inspection airplane solution. While a standardized flight inspection airplane might benefit some agencies, this paper will assume the need for a customized flight inspection airplane. The first step in this process is the establishment of requirements.

The typical procedure for government airplane purchasing begins with the RFI (Request for Information). The government agency ("Agency" henceforth) requests from various companies a response to the Agency's best guess at its requirements. The Agency can then take these responses and create its final requirement to be published in the form of an RFP (Request for Proposal). The challenge here is the interdependency between Agency requirements and industry capabilities, between Agency budget and industry costs, and the interdependencies between (see Figure 1 below).

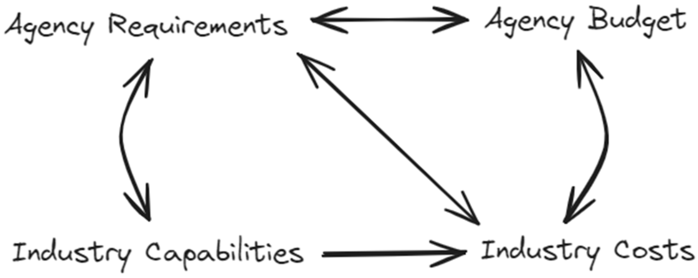

Figure 1 – Agency and Industry Interdependencies in the RFP Process

This paper offers three suggestions for improving the requirements setting process.

First, plan on an iterative RFI dialogue. Everyone wants more than they can afford. If the Agency and the potential providers can dialogue and pass ideas back and forth, the Agency can determine what capabilities are in budget and which may not be. Also, the Agency can learn what new technologies are available in the flight inspection equipment, the airplane, and the airplane-flight inspection equipment interface. A recent procurement program the author participated in involved three RFI cycles, each improving on earlier iterations, before issuing a final RFP. Obviously, this required a long procurement timeframe and much work from the Agency, but the Agency at the end felt very sure its requirements were both in budget and technically acceptable. This is not suggested as the optimal solution for all programs but represents a possibility.

Secondly, the RFI and RFP should include threshold and objective requirements (or needs and wants, respectively). If the Agency can delineate between definite needs and desires, this will help the seller create a better solution. Even in a Lowest Cost Technically Acceptable (LCTA) competition, the seller has options that may not add any cost. Which path should they pursue? Moreover, a rating of desires is helpful. Does the Agency want leather seats just as much as they want storage space for 10 duffel bags? Again, discussions with the potential sellers will help the Agency understand what various options exist.

The host of this conference, the Japanese Civil Aviation Bureau (JCAB), has a history of creating very detailed RFI's and RFP's. They are recommended as a resource for other agencies needing to develop their own RFI or RFP. JCAB has offered to share a copy of their English translated RFP to any Agency that would benefit from seeing it. A thorough set of requirements set at the beginning of the program prevents disputes at the final delivery when unvoiced expectations are not met.

Lastly, the RFP should direct the structure of the team providing the flight inspection airplane. The typical team to respond to an RFP is an OEM (Original Equipment Maker, or airplane manufacturer) and a Modifier (a company able to modify the base airplane to install the specific flight inspection equipment). The arrangement of that team is a key decision that affects the cost, schedule, and complexity of an airplane procurement process. This paper deals with this decision in detail later.

THE AGENCY, OEM, AND MODIFIER RELATIONSHIP

There are three potential team arrangements with the Agency, OEM, and Modifier in a flight inspection airplane procurement:

- Agency Prime – The Agency contracts directly with the OEM and Modifier. The Agency builds requirements for each entity separately and manages the interplay between the OEM and Modifier.
- OEM Prime – The Agency contracts with the OEM. The OEM contracts with the Modifier and is responsible for the end product.
- Modifier Prime – The Agency contracts with the Modifier. The Modifier contracts with the OEM and is responsible for the end product.

There are strengths and weaknesses to each team arrangement, and each Agency should carefully consider which approach is best for its particular situation. First, it would be good to briefly review the potential design and certification aspects of a new flight inspection airplane.

CERTIFICATION ASPECTS RELATED TO FLIGHT INSPECTION MODIFICATIONS

The below list covers some of the more frequent certification areas involved with flight inspection modifications.

Icing – Antennas added for flight inspection must be shown to not cause harm through potential ice shedding. Also, the airplane must be able to handle added drag from ice shapes forming on antennas.

Acoustics – The final configuration of the flight inspection airplane must be shown to be within the particular limits of certifiable noise levels as heard from the ground. Ideally, the OEM or Modifier can run an analysis to show the added shapes result in a "no acoustic change" from the base airplane acoustic level. If this is not possible, the FAA requires a flight test to show compliance to 14 CFR Part 36; EASA (European Union Aviation Safety Agency) requires compliance to CS-36. Also reference the parallel requirements in ICAO Annex 16.

EMI/EMC – ElectroMagnetic Interference / ElectroMagnetic Compatibility - With all the added electrical equipment on a flight inspection airplane, there are many opportunities for electromagnetic interference between radios and antennas. A thorough check of all potential interferences must be performed and any issue resolved.

Structural Analysis - Any structural changes must be shown to be sufficiently strong for the certified loads of the airplane.[1] OEM's are reluctant to share that proprietary loads data. Therefore, either the OEM can perform structural changes or a Modifier can make changes. The Modifier must either obtain proprietary information from the OEM or perform "reverse engineering". "Reverse engineering" is examining the structure in the area of the modification, making assumptions on the loads in the area, and installing structure that is at least as strong as the original design. Also known as designing for "equivalent strength."

Fatigue Analysis – Any structural change to the airplane must be evaluated for impact on the fatigue-resistance of the airplane. There are several means of compliance to the regulations, depending on the date the airplane was certified. The latest airplanes use a DADT (Durability and Damage Tolerance) approach that assumes crack growth and ensures detection of a crack before failure. Compliance can be shown through either testing or analysis. Again, the OEM holds the proprietary information on the fatigue properties. A Modifier would be able to make limited airframe changes using standard assumptions about the fatigue properties of the particular airframe section. Larger changes or anything potentially affecting structural inspection intervals would need to be handled by the OEM.

Performance – The added antennas for flight inspection may decrease performance of the airplane below the published baseline. Analysis or flight testing must be accomplished to determine the impact of the added drag. If there is an appreciable change in performance, the responsible part of the team must create an AFMS (Aircraft Flight Manual Supplement) with either the effective change (deltas) or whole new performance tables for affected areas of flight. The delta change is much less work to create but assumes worst-case scenario and provides a slightly degraded performance versus new complete charts.

Propulsion – If there is a decrease in performance due to added antennas, this could affect the ability of the starter/generator to keep cool under maximum load. Typically, a flight test must be accomplished to show that the starter/generator remains within temperature limits while the maximum amount of power is pulled.

EWIS – Electrical Wiring Interconnection System – This relatively new Part 25 requirement (FAA 14 CFR Part 25 Subpart H amendment 25-123, EASA CS 25 Subpart H amendment 5) adds regulations around the installation of wiring and connectors. Any wiring added to an EWIS-certified airplane must comply with these standards.

DAP – Development Assurance Process – The FAA and EASA have begun to require new designs and avionics updates to include DAP for Part 25 aircraft. We expect both agencies to expand requirements to larger Part 23 airplanes in the near future. Any systems design change to a DAP-qualified airplane must follow DAP procedures.[2]

Avionics – Often with today's newer airplanes with integrated avionics systems, the flight inspection modification requires a change to the avionics software. This may be a minor configuration change (E.G. audio output level changes) or a major software addition, such as adding avionics displays in the aft cabin (see Figure 2 below). The interface between the flight inspection equipment and the primary airplane avionics is key. This complicated topic is broken down in the next section.

Figure 2 – Garmin GTC Controller Mounted in Aft Cabin

Aeronautical Security – This is another newer requirement. This deals with ensuring unauthorized personnel cannot tamper with the avionics suite. EASA already has this in CS 25.1319. The FAA is working toward publishing 14 CFR 25.1319. Both refer to DO-326A. The Cessna Citation Longitude incorporated Aeronautical Security for the FAA via Special Conditions. Both FAA and EASA seem to be pushing for Part 23 incorporation of Aeronautical Security.[3]

AEH – Airborne Electronic Hardware – Assuming the flight inspection computer that interfaces with the avionics has a Design Assurance Level (DAL) of D or lower, this does not need to be addressed. The mission computer should be set up so that it is not flight-critical, and could therefore be DAL D or E.[4]

Software – This is similar to AEH in that it doesn't have to be a concern for flight inspection aircraft. A well-designed interface with the avionics can allow the Modifier to avoid a complex certification effort. For example, if the mission computer is receiving ARINC 429 data from the avionics suite, it should use a non-critical communication bus. This minimizes safety concerns. See the below discussion on data reception from the avionics suite.[5]

AVIONICS

While the avionics suite may use several data links for internal data, such as RS-232, Arinc 429, and Ethernet, there is typically one or more busses available for ARINC 429 data for output to the flight inspection computer. The maker of the flight inspection computer should coordinate with the avionics manufacturer through the OEM to determine the ARINC 429 data available. That coordination should cover if any further data is needed that is not currently available and how the existing data is delivered (bus, ARINC 429 word and rates). The avionics manufacturer may be able to add more data points or labels. Further, the OEM may have FOQA (Flight Operations Quality Assurance) equipment installed such as the Cessna AReS maintenance recording system that can provide hundreds of data points in real time. These record many flight parameters from the avionics and other sources and are typically used for assisting maintenance actions. Also, the Modifier could install an aftermarket FOQA system that could provide flight data in real time. Regardless, on modern aircraft there is a wealth of real-time data available to the flight inspection equipment.

More challenging is sending information to the avionics suite. A frequent example of this is sending video to the cockpit screens. Some avionics allow video on any of the typical three-screen format (2 Primary Flight Displays (PFD) and 1 Multi-Function Display (MFD)), some only allow video on the MFD. One other factor to consider is the video format. Some avionics accept composite video, some accept HD (SMPTE) 292M HD Serial Digital Interface (HD-SDI) standard, some accept compressed (ethernet) video, some accept a combination of them.

Another set of data that is desirable to send to the cockpit is flight plans. There are a number of ways to accomplish this including ACARS (Aircraft Communications Addressing and Reporting System), wireless, and wired interfaces. Some avionics suites allow transfer of individual waypoints and two-way transfer of flight plans to and from a mission computer. The Agency should consider what of this is needed and what is desirable.

Flight inspection requires flying ILS (Instrument Landing System) offsets. There are several means of assisting the pilots to fly the edges of the ILS localizer or glideslope. Some avionics allow the pilot to select an edge of the ILS and the avionics then adjusts the ILS “needle” (the horizontal and vertical guidance) to line up on the selected edge. The particular example of this the author is aware of is becoming obsolete. Textron Aviation and Garmin are collaborating on a means of a mission computer sending ILS-type input to the avionics. In this scenario, the mission computer would send ARINC 429 labels to the Garmin system. The Garmin avionics would accept the input and display vertical and horizontal guidance for the pilot to follow either manually or with the autopilot. The mission computer would receive the ILS signal then add the desired offset before sending it to the cockpit.

Where the above approaches to ILS offset are not available, a video display from the mission computer can be used. The mission computer creates the offset and sends it to the cockpit display as an HSI (Horizontal Situation Indicator). The pilot can then manually fly the plane using the HSI as guidance.

Some avionics systems allow for a two-way interface between the cockpit and the mission computer. Textron Aviation is working with Garmin to provide a mission computer-avionics interface. In the G1000 avionic suite, the pilot will be able to put the soft keys on the MFD into a “mission mode”. This will allow the mission computer to populate the soft key labels, creating a custom mission menu. Pressing the soft keys will send signals to the mission computer, allowing the pilot to command the mission computer in any fashion programmable. This could change mission video being displayed, signal an event, or any other command. In the G3000 and G5000 avionics suites, the pilot will be able to command the GTC touch controller to enter a similar “mission mode”. The touch screen menu will be driven by the mission computer. Buttons and slides can be made available to the pilot to control anything the mission computer can do.

AUDIO SYSTEMS

Audio systems in a flight inspection airplane can vary from simple to highly complex depending on the number of radios and the audio requirements of various crew members. Several companies offer audio systems that can handle a large number of radios. That is the easy part. The more challenging design obstacle is how the mission audio interfaces with the avionics suite. The avionics suite of the airplane already handles the intercom and primary airplane radios. The challenge is how these audio systems interact with the mission audio. There are three ways to handle this interface.

1) Replace primary audio with mission audio
2) Splice in mission audio to primary audio
3) Expand primary audio to handle mission audio

The first scenario is straight-forward but may not be achievable depending on the complexity of the avionics suite. Textron Aviation has replaced the primary audio controllers in both the King Air and Caravan airplanes. This allows the relatively simple primary audio to be replaced with a more capable mission audio system. The mission audio then handles primary radios and intercom and mission radios.

The second scenario is more common. A transmit / receive port in the primary audio controller becomes the pathway for the mission audio input. The pilot will likely then have two audio control heads: one for primary audio and one for mission audio. It requires a bit more button pushes to create the desired audio setup, but the overall system is very capable.

The final scenario of the primary audio system handling all mission radios is the most challenging. The author is unaware of any primary audio system being able to handle multiple mission radios. However, the JCAB Longitude on display at this conference comes close. The Garmin system was expanded to allow control at three mission stations outside the cockpit and was able to integrate two mission radios. The author hopes that avionics companies will consider expanding their audio systems to handle significantly more radios and audio control heads. The seamless integration with the primary audio system is the easiest and most capable possible system.

As a side note, the intercom system on the JCAB Longitude is handled by icons on the touch screen controllers and is very intuitive. It is also capable of creating many different user settings, allowing the mission operator to have exactly the intercom setup desired (which stations are connected, and which are not to their particular intercom loop). One mission radio was integrated into the Garmin suite so that the radio could be selected and tuned through the touch control screens.

COMPARISON OF PRIME SELECTION

Now that the reader is armed with the above overview of what may be involved with the modification of a flight inspection airplane, this paper will explore the three different team arrangements for contracting a new flight inspection airplane.

RACI CHART

One helpful way to examine the different teaming arrangements is to consider who is responsible for each portion of the work. The below chart uses the RACI division of labor.

R = Responsible (Charged with doing the work)

A = Accountable (Final approver of work)

C = Consulted (Opinion sought on the work)

I = Informed (Told about the work)

Table 1 – RACI Chart for Modification Responsibilities for Different Teaming Arrangements

	Agency Prime			**OEM Prime**			**Modifier Prime**		
	Agency	OEM	Modifier	Agency	OEM	Modifier	Agency	OEM	Modifier
Requirements Definition	A R	C	C	A R			A R		
Requirements Validation	A		R	A	R		A		R
FIS Performance	A		R		A	R			A R
DESIGN OF MODIFICATIONS									
Mission Console Design	A		R	A		R	A		R
Antenna Layout Design	A		R	A	R	R	A		R
Structural Mod Design	A		R	A	R		A		R
Avionics Mod Design	A		R	A	R	R	A		R
Interior Layout Design	A		R	A	R	R	A		R
Mission Power Design	A		R	A	R	R	A		R
ANALYSIS/CERTIFICATION OF MODIFICATIONS									
Icing	A		R	I	A R	C	I		A R
Acoustics	A		R	I	A R	C	I		A R
EMI/EMC	A		R	I	A R	C	I		A R
Structural Analysis	A		R	I	A R	C	I		A R
Fatigue Analysis	A		R	I	A R	C	I		A R
Performance	A		R	I	A R	C	I		A R
EWIS	A		R	I	A R	C	I		A R
DAP	A		R	I	A R	C	I		A R
Software	A		R	I	A R	C	I		A R
Local Certification	A	R	R	I	A R	C	I	C	A R
Foreign Certification	A	R	R	I	A R	C	I	C	A R

OBSERVATIONS FROM THE RACI CHART

There are an infinite number of adjustments that could be made. For example, in an OEM prime team, the Modifier could be empowered to certify extra antennas. (Modifier becomes Responsible while OEM remains Accountable for the end product. So, the "R" moves from the OEM column to the Modifier column.) The above chart is intended as a starting point of discussion for the Agency to consider who should be responsible for what.

Cost follows Accountability. If the OEM is prime, they carry much of the Accountability. As they hire and manage the Modifier, the OEM will incur cost to do that. Moreover, the Accountable party assumes risk management. If something varies from the initial plan, the Accountable party will need to absorb the cost impact. Therefore, a wise Accountable party (OEM or Modifier or Agency) should include a risk factor in their total cost assessment. An Agency can assume all Accountability (and therefore risk) and reduce the cost expected from the OEM and the Modifier.

Responsibility should go hand in hand with authority. If a team member is Responsible for a particular activity, it is crucial that the team member have all the tools and data and power to execute that activity. In the Agency Prime and Modifier Prime arrangements shown, the Modifier is charged with certifying modifications where they do not hold the base certification data. Responsibility is therefore potentially separated from authority; Modifier scope and capability should be clearly outlined.

STRENGTHS AND CHALLENGES OF THE DIFFERENT TEAM APPROACHES

Based on the above comparison and on the author's experience of the different teaming approaches, the strengths and challenges of each arrangement are presented below.

Agency Prime

- Lowest upfront cost – No markup from either OEM or Modifier to cover managing another team member.
- Agency owns all risk and must manage the Modifier who doesn't necessarily have all OEM data.
- Agency must manage both OEM and Modifier (indirect cost).
- No opportunity of work-sharing or risk-sharing between OEM and Modifier. E.G. if the OEM is running late, work cannot be easily shifted to the Modifier.

As an aside, the author has been the Project Engineer on multiple programs where work responsibility needed to shift from the OEM to the Modifier or vice-versa due to schedule challenges or complications. A flight inspection airplane with significant modifications or with new features not certified before runs a significant risk of changes in work scope as the project moves along.

OEM Prime

- Leverages OEM expertise and TC (Type Certificate) data.
- OEM responsible for Modifier and meeting all requirements.
- The OEM can accomplish future avionics upgrades and other Service Bulletins.

To elaborate on that last point, if the OEM supports the Modifier STC (Supplemental Type Certificate), the OEM is familiar with the modification and can adapt any new Service Bulletin to accommodate the STC. An OEM is challenged to modify any airplane that has outside STC's. This touches back on the discussion about Avionics. If the base airplane software is modified for the flight inspection mission, future software updates must be carefully handled to prevent issues with the modification. This may be an argument for stand-alone flight inspection modifications that do not interface with the base airplane avionics. However, the audio system requirements alone require at least some avionics interface. If there is any interface, it is the author's opinion that the Agency should maximize that interface for mission needs.

Modifier Prime

- Modifier is directly responsible for FIS performance including antenna layout.

- Modifier must manage OEM requirements.
- The modification cannot necessarily support future OEM Service Bulletins. See above discussion.

STRENGTHS OF AN OEM AND MODIFIER

The ideal airplane procurement program leverages the strengths of both the OEM and the Modifier.

OEM Strengths

- Full knowledge of the airplane and all means of compliance.
- Full knowledge structural capabilities and margins.
- Able to complete full performance charts.
- Can easily leverage full certification of Icing and Performance to create a cost-efficient solution.
- Better leverage with some suppliers (radios, avionics, etc).
- Able to do large-scale DADT analysis.

Modifier Strengths

- Able to focus on key certification aspects only.
- More flexible in methods than OEM for design and certification.
- Better leverage with some suppliers (radios, avionics, etc).
- Potentially more agile manufacturing abilities

EXAMPLES OF MODIFICATIONS

To help illustrate the strengths of the OEM versus a Modifier, two examples are presented below.

Bubble Windows on a Cessna Caravan

The Cessna Caravan has been in service since 1985 and has numerous STC's for various modifications. One popular modification for Special Missions is an aft cabin bubble window. Great Lakes Aero Products of Flint, Michigan, USA holds an STC for bubble windows of various depths. These are available for less than $650 per window. (https://glapinc.com/Cessna/208/208b.htm#Cabin)

Recently, the author participated in an exercise to price bubble windows for a similar unpressurized airplane. Many engineering groups were involved: Icing, Acoustics, Performance, Propulsion, and Structural Analysis. An initial rough cost of per window was estimated and was significantly higher than the $650 target. The high cost was due to the engineering hours and flight test needed to certify the bubble window for all the above aspects.

The author cannot say with any certainty what efforts Great Lakes Aero Products did to certify their Caravan Bubble Window, but it was sufficient for FAA approval. As an OEM, Textron Aviation has a very high standard for certification and has found ways of meeting that standard while maximizing engineering efficiency. But even so, it is clear that a Modifier such as Great Lakes Aero Products has a different certification path.

Mission Antennas on a Cessna Longitude

Taking as an example the JCAB Longitude, Textron Aviation worked with the Modifier, Norwegian Special Missions (NSM), to determine mission antenna layout. Antenna interference potential was calculated for both mission and standard antennas. The resulting layout was agreed to by JCAB, Textron Aviation, and NSM. Textron Aviation installed and certified the mission antennas and left the wiring to NSM. Textron Aviation was able to leverage the initial TC data and eliminate any flight testing for the new antennas for Acoustics, Icing, or Performance. Moreover, Textron Aviation was able to use the TC loads data to create simple, lightweight doublers for antenna mounting.

This then is an example when an OEM can leverage its knowledge of the base airplane to accomplish a modification efficiently, even applying its typical high standard for certification.

CONCLUSIONS ON TEAM ARRANGEMENT

This paper has described the various new flight inspection airplane team arrangements, each with its benefits and challenges. While there is no single solution for every procurement program, the strengths and weaknesses of each arrangement presented above should guide the Agency in which is best for their particular situation. Modifications to an airplane like the Beechcraft King Air that has been around for decades with many existing STC's may lead to one arrangement, perhaps Modifier Prime. Modifications to a newer airplane such as the Cessna Longitude may lead to another, such as OEM Prime. Regardless, the Agency should decide the following key aspects of the team:

1) Who will handle the risk of the program scope and schedule? In other words, who will pay the bill when scope or schedule changes?
2) How will the Modifier certify changes to the airplane? Is OEM data needed? If so, how will the Modifier obtain that data?
3) How can the OEM and Modifier work together to best leverage the strength of each organization?

If the Agency has these three aspects fully answered, they should feel confident in their choice of team arrangement.

SUMMARY

The author has frequently watched in wonder as an airplane flies overhead. There is a wonder in a machine made of metal floating through the sky, a harmony of so many systems working together seamlessly to move people and equipment across invisible roads. The flight inspection function is key to the safe operation of those roads, especially the landing points. The flight inspection airplane is then both a wonder and a most necessary tool.

Hopefully the reader is now a little more equipped to work the process of procuring a flight inspection airplane. The resulting flight inspection airplane must meet Agency requirements for function, and it must demonstrate compliance with the relevant certification authority. The roles of the team members (Agency, OEM, and Modifier) should be clearly defined from the outset, each understanding who is responsible for each design and certification aspect. The well-prepared Agency has a plan of team member responsibility and authority. The Agency should also have an idea of the certification aspects involved including newer ones. Lastly, the Agency should leverage the strengths of the OEM and Modifier so that the final result delivers the maximum value.

It is the author's wish that at the end of the next procurement of a flight inspection airplane, the Agency can look with pride as their new airplane takes flight. They can look back over the design and building of the airplane and be proud of the efforts of the whole team. They can know that their efforts have resulted in a tool that will perform well for many years. Hopefully, there is also a sense of wonder watching the newest flight inspection airplane help keep the roads of the air safe.

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