ACAST Aviation Certification and Business Case Project

Part II Final Report Certification Roadmap Report

To

NASA GRC

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Table of Contents

1.0 Introduction

The National Aeronautics and Space Administration (NASA) in cooperation with the Federal Aviation Administration (FAA) are investigating new technologies to increase the capacity and efficiency of the National Airspace System (NAS). The Advanced Communication, Navigation and Surveillance (CNS) Architectures and System Technologies (ACAST) Project led by the NASA Glenn Research in Cleveland, Ohio will be developing architectures and system technologies to initiate the transition of today's systems into a high-performance network-centric digital infrastructure to support the transformation of the National Airspace System.

The overall ACAST goal is to develop and design the transitional architecture and enabling system technologies to transform the NAS through a high-performance integrated Communications Navigation and Surveillance system. Other specific elements of the ACAST Project include the definition of a global air/ground network architecture, the development and identification of efficient aviation spectrum utilization, the implementation of efficient oceanic/remote operations through improved communications and surveillance, and increased air-ground data link performance and capacity for terminal, en-route and surface operations.

An essential element that is complementary to the advanced technology development will be the assessment of the policies, strategies and action plans related to operational concepts, business case development and transition strategies. The areas are not separate tasks, but an integration of activities that deliver valid, supportable concepts that the user community can embrace and understand well enough that they will actually support the technology and transition.

The timeliness of deployment of advanced technology is a critical path of success. FAA's avionics certification process is on this critical path and unless optimized may deny the timely deployment with associated benefits need effective transform the National Airspace System.

2.0 Overview

In order to insure that public investments made by NASA optimize their rates of return and create the greatest net present values for the development of air and ground aviation products, services and equipment, work performed in the development of avionics and its supporting infrastructure must provide a timely, clear and deliberate path to certification by the Federal Aviation Administration the leads to commercialization, deployment and use. Therefore, NASA must thoroughly understand and appreciate the Federal Aviation Administration's process and requirements for certification to insure NASA investments provide a solid base to build on future avionics systems. Further, due to the dynamics of the negotiated process, NASA must continue to work closely with the Federal Aviation Administration, manufacturers and users to insure issues identified, addressed and resolved with clarity and agreement in a timely manner. This may mean developing new and innovative approaches or applying new disciplines to the FAA certification process.

The objectives of the Certification Roadmap in support of a NASA multimode multifunction digital avionics (MMDA) initiative are to provide documentation, analyses and support coordination and facilitation processes between NASA, its designees, the Federal Aviation Administration, and others as approved or directed (including avionics and aircraft manufacturers and aircraft owners or operators or their representatives). These objectives are to be within the construct of the following requirements:

A Certification Roadmap must outline requirements for certification of MMDA and considers both a public aircraft certification for development and testing and a path for commercialization of the technology. Requirements that should be met by NASA and by NASA's vendors or technology transfer partners are included in the roadmap. A certification seminar developed for the ACAST staff is required.

Business case development support is to include a business approach, information needs to support the business case, concept development, and benefits definition. Data requirements for use in subsequent ACAST contracts are required to help generate information that supports business case development in later ACAST sub-projects. There is a requirement to support analysis and development of the certification process. This includes coordination of meetings between NASA and FAA regarding certification requirements as well as facilitating these meetings to result in an agreed-upon roadmap for MMDA. There is a requirement to support NASA in defining industry points of contact and facilitate meetings with user groups to support ACAST objectives

3.0 Product Identification and Development

The development of multimode and multifunction digital avionics systems is critical to the future of national air transportation system. Currently avionics systems constitute as much as 40% of the total cost of aircraft regardless of aircraft class, size or mission. Not only has this cost grown precipitously over the years, but the complexity of design and function as well as time from concept to certification has grown as well. This has resulted in avionics becoming the critical path to new aircraft development and deployment denying application of many new innovative technologies that contribute to increased safety and decreased costs. In recognition of the challenge to develop and transfer innovative technologies that create new levels of safety, performance and economic growth, NASA has undertaken the MMDA project.

The MMDA approach focuses on customer needs, wants and desires to create innovative concepts and designs that reduce avionics costs and increase functionality and performance as an enabling technology to transform the national and global air transportation systems.

First, the process itself relies on adoption and adaptation of a disciplined process known as Design for Six Sigma. This ensures a commercial best practices approach to optimize the development of an avionics product. The use of Design for Six Sigma provides a commonality of process and metrics with the Federal Aviation Administration early in the development process to insure public investments are productivity expended and all efforts contribute to an eventual certification and deployment of MMDA.

Secondly, the approach chosen for MMDA answers the need for improved performance at lower costs for virtually an unlimited suite of avionics functionality. In other words, NASA will contribute a fault tolerant open architecture avionics system hardware and software platform that can be granted a Technical Standard Order by FAA to serve as a repository for proprietary card driven functions and functionality from navigation, surveillance and communication to entertainment and emergency locating.

NASA's MMDA efforts will allow FAA to develop a critically needed Advisory Circulars to provide Design for Six Sigma guidance to avionics vendors to insure the maturity of the certification applicant avionics concept and design as well as prescribe acceptable documentation required by FAA to expedite the certification approval and deployment processes for all applicants.

These efforts will allow NASA and FAA to pioneer, validate and deploy new certification methodologies and new avionics functionalities that accelerate technological transfer and encourage new commercial enterprise to increase safety, capacity and efficiency of the national air transportation system while concurrently reducing costs.

4.0 Design for Six Sigma

As a discipline, Six Sigma began as a continuing outgrowth of post World War II methods to improve product quality and lower costs. Six Sigma began in earnest in the 1980s at Motorola and then expanded to other organizations such as GE, Allied Signal and Seagate with considerable success starting in the 1990s.

The essence of Six Sigma is to apply a disciplined methodology to define, measure, analyze, improve and control any process from manufacturing to services. Prior to adopting Six Sigma, most organizations operate in the neighborhood of three to four sigma quality levels. For manufacturers at three sigma this mean they are producing products with about 67,000 defects per million as opposed to a Six Sigma quality of 3.4 defects per million. The cost impact between operating at a Six Sigma level and a Three Sigma level can amount to as much as 25% of total revenues lost to inefficiencies. The central idea of Six Sigma is that if you can measure a process you have the means to control it.

The Design for Six Sigma developed in the 1990s as an extension of the Six Sigma method. Design for Six Sigma is an approach to designing product or services to meet and exceed customer requirements and expectations. Design for Six Sigma can be described as a disciplined, data-driven approach to process improvement aimed at the near-elimination of defects from every product, process or transaction. The purpose of Six Sigma is to gain breakthrough knowledge on how to improve processes to do things better, faster and at a lower cost. It can be used to improve every facet of business and government transactions. Unlike previous quality improvement programs, Six Sigma is designed to provide tangible measurable results.

Unfortunately without Six Sigma there is only a 60% chance a new product or process will succeed. The failures run the gamut from inadequate market analysis, product design failures or defects to higher than expected costs or technical and production shortfalls. To the contrary, Six Sigma provides a structure for managing development projects, adds value and improves customer satisfaction, minimizes design changes, reduces development cycle time and time to market, improves product quality, reliability and durability, and reduces costs. In other words Design for Six Sigma is targeted to meet NASA's MMDA objectives.

The Design for Six Sigma method is generally divided into five critical performance areas. These are generally characterized as phases of: (1) planning; (2) identification of customer and customer needs, wants and desires; (3) concepts and design of product and/or process; (4) optimization or iteration of concepts, designs and other factors critical to satisfaction; and (5) verification and validation of products and/or services to demonstrate they meet identified customer needs, wants and desires.

4.1 Plan

The purpose of a plan is to set up the team to succeed with the project mapping and all of the vital steps. It entails defining the project, providing resources to support the project, choosing a team, conducting orientation or training, establishing a charter and objectives, setting metrics and a goal, and establishing a timeline. In fact the Design for Six Sigma planning phase corresponds to the Federal Aviation Administration's roadmap for avionics certification described in this document with a few notable, but critically important exceptions. Those exceptions are establishing and measuring standard metrics of performance for all aspects of the certification process. This is almost a critical flaw in the current certification process that is driven by heuristics and not by management and decision making by data and fact. This is, therefore, the most important reason to introduce a Design for Six Sigma methodology into the FAA certification process.

The recommended planning approach is to encourage NASA to work with the FAA to develop Advisory Circular guidelines that are driven by disciplined Design for Six Sigma methods that provide a common understanding of the applicant's design and data quantity and quality needed to support a fact driven certification process.

4.1.1 Select the Project

While the choice of the certification project is that of the applicant, the FAA should ask for and be provided adequate project justification because of FAA expenditure of the public resources that must be allocated and expended. For a Design for Six Sigma method this means Voice of the Customer documentation represented by surveys, customer comments and/or internal or external justification. FAA has to also rely on other analyses of feasibility to insure producibility and reasonable marketability when allocating scarce government resources.

4.1.2 Initiate the Project

Every project should have a well-defined implementation plan with responsibilities, timetables, milestones and deliverables. FAA has provided considerable guidance to meet these objectives as outlined in Project Specific Certification Plans.

4.1.3 Establish Project Objectives

There are three essential parts in this step. First is to define the metrics to provide a measurable quantitative scale for assessing performance. Again this is the area where the FAA's certification processes need the greatest improvement. While this is usually accomplished within the certification process, it needs to be defined as definitely as possible prior to initiation of the certification process. FAA must tell an applicant up front what the metrics and data requirements are for certification.

Second, a baseline of data needs to be defined as a starting point based on previous information and experience as an adjunct to the initial metrics determined as a measure of certification performance and success.

Last, one or more goals must be established as an acceptable level of performance to know what is enough or in other words to know and measure when success has been reached enabling progress to the next step or phase.

4.1.4 Establish Timelines

The schedule is often a negotiated process that needs to begin early and be constantly reviewed and possibly renegotiated.

4.1.5 Develop a Strategic Plan

Again the FAA has done a very credible job in defining a variety of strategic or high level plans such as Partnership for Safety Plan, the Project Specific Certification Plan, the Plan for Software Aspects for Certification, and the Plan for Hardware Aspects of Certification that support the certification process. This step also includes a review of lessons learned for similar certifications and certification approaches.

4.1.6 Map the Process

This is an essential element of Design for Six Sigma that may be weak in a number of cases of FAA certification. The Design for Six Sigma focus is to list and categorize all of the key process variables to determine how they may affect the certification process. Before you can control or influence factors you must know what they are and how they can affect the project.

4.1.7 Communications

FAA has done well in emphasizing communications and teamwork in the certification process. This emphasis and its priorities are well outline in FAA planning documentation.

4.2 Identify

The identification phase is comprised of a number of steps including define the customer, prioritize customer requirements, establish ancillary requirements, identify Critical to Satisfaction (CTS) needs for quality, technical and performance as well as defining and establishing specification limits. It also includes the need to prioritize the CTSs and provide analyses to establish metrics, create specifications, establish metrics and create scorecards.

Part of the identification process moves on to select the most appropriate concept and design and to focus on the most critical metrics. This phase is the most critical to overall Design for Six Sigma success due to the need to provide access to an iterative process from all participants involved in the product or process. This is the essence of the concept of an Integrated Product Team.

Additional efforts strive to develop innovative alternatives to satisfy functional requirements as well as perform risk analysis and consider means of error proofing and finally perform engineering analysis.

4.2.1 Voice of the Customer

In order to determine the marketability of new avionic concepts, functions and features it is necessary to explore customer interests, requirements and motivations. This is done as an initial part of a Design For Six Sigma (DFSS) process known as voice of the customer or VOC. The VOC uses a number of approaches to insure a comprehensive initial understanding of the customers' perspective can be translated into appropriate functional, conceptual, design and process paradigms and subsequently validated. Since product / service design is only 5% of the total product to market cost but influences 70% of these costs, getting customer needs right the first time may likely mean the difference between success and failure.

There are a number of tools and methods for VOC. An analysis of previous customer feedback, such as field reports or complaints on record (1) provide an excellent starting point to classify areas on needed functional or performance improvements. Surveys (2) of potential customers are also a tried and true method of gathering customer information. However, surveys must be carefully crafted and properly distributed and tracked to insure unwarranted bias is not introduced. Focus groups (3) can also be beneficial in exploring customer needs at a more detailed and integrated level generally when initial functions, concepts an designs are explored. Interviews, especially with contextual inquiries (4), that discuss established product attributes during their use directly with the user can reveal customer dissatisfiers (expected must have), satisfiers (wants and expects) and delights (functions, features and capabilities the exceed needs or basic wants). Interviews can also support conjoint analysis (5) where customers establish the opportunity costs of functions or features. Literature surveys or searches which seek out customer specifications (6) all also a valid means of collecting customer data. Finally interactive prototyping (7) is an excellent method of further exploring and validating customer desires and expectations.

4.2.2 Voice of the Customer Methodology

Due to the compressed NASA schedule for this Certification and Business Case Project the methods chosen for VOC for multi-mode multi-function digital avionics are a customer survey (2) and literature search (6) that attempt to identify customer needs and wants.

An avionics survey is to be developed and coordinated through trade associations representing general aviation (AOPA), business aviation (NBAA), on demand air taxis (NATA), regional commercial carriers (RAA) and national commercial carriers (ATA). Additional survey instruments will be created for engineering and maintenance personnel through widely read industry publications (Avionics Magazine) and aviation maintenance organizations (PAMA). Survey VOC results will be complied by Aviation Management and analyzed to develop and validate concepts and functions prioritized by the customer using affinity diagramming or KJ method to identify needs similarities and redundancies as well as Kano model to classify basic, variable and latent requirements. This effort will support the initial stage of Quality Function Deployment (QFD) to transfer customer needs into an optimized product design.

The avionics survey needs to adequately identify and classify the respondent. Next the survey must determine the current sophistication and capabilities of the avionics the customer uses or is familiar with and the functions and features of those avionics that are dissatisfiers, satisfiers and delights. Next this survey needs to explore and prioritize current as well as new functions and features as well as explore costs trade-offs. A DFSS analysis through QFD should hopefully reveal product functional requirements and design concepts that consider a wide variety of Critical to Quality (CTQ) functions for design, manufacturer, distribution and support.

The literature search will survey avionics documentation of requirements, functions and features contained in a variety of government and government related publications including RTCA, FAA and NASA. In addition trade association and commercial publications will be reviewed to identify, classify and prioritize requirements, functions and features that are dissatisfiers, satisfiers and delights.

4.3 Design

The purpose of the design phase is to build a thorough base of knowledge about the product or service and its processes. The team translates the customers Critical to Satisfaction and Critical to Quality needs, wants and desires in functional requirements and alternative concepts or solutions. Through this process, the team evaluates and reduces the alternatives in seeking the best-fit concept.

4.3.1 Formulate Concept Design

In evaluating design alternatives, the team first uses a Pugh concept selection technique. The next mode of evaluation is based on Fault Mode and Effects Analysis. Here the teams evaluate a selected design concept for failure modes and effects to address these concerns early in the design effort.

4.3.1 Identify Part and Process Critical to Satisfaction and Critical to Quality Factors

For each technical requirement the team identifies critical-to-satisfaction and critical-to-quality design parameters and their influence on technical requirements using analyses, Design of Experiments, Simulation and Modeling.

4.3.2 Complete a Scorecard

The team maps the results of its analyses against critical-to-quality factors, specifications, process data, etc. to assess strengths and weaknesses of the design. This entire process is driven by transfer functions, or methods to translate initial needs into a viable design, process or product.

4.3.3 Establish Design Target Values and Tolerances

The team does this parameter and tolerance design to create a robust design, process or product. Tolerance analysis enables quantitative estimation of the effects of variation on requirements in early development. This is closely aligned to a major aviation certification priority for fault tolerant design. Methods to assess product and process performance are emphasized to do gap analysis and to identify, assess, address and manage risk.

4.3.4 Assess Design

Assess designs involves a wide variety of testing methods depending on the product or service. The results enable an update of the scorecard and results in iterating design, hardware, software, or process in the Optimize Phase.

4.4 Optimize

The purpose of the Optimize Phase is to achieve a balance of factors, including quality, cost and time. The team uses advanced statistical tools and modeling to predict quality level, reliability and performance. It uses process capability information and a statistical approach to tolerancing to develop detailed design elements to optimize design and performance.

4.4.1 Identify Potential Failures

The team performs Failure Mode and Effects Analysis or Anticipatory Failure Determination on both product and process. The team also uses reliability data to make predictions concerning field failure rates. This is a stage to finalize designs and take final corrective action.

4.4.2 Develop Robust Design

The focus of the design process is to develop a robust design that can perform acceptably despite variations in design, operating and process parameters. A variety of tools and methods are employed to optimize parameter values and reduce variation. This means screening out unimportant factors and continuing to optimize operating condition in a process. Again, the scorecards are update to reflect the results or this phase.

4.5 Verify/Validate

4.5.1 Validate Product, Service or Process

This may likely include prototype testing to demonstrate process capability, verify tolerances and evaluate reliability. The team then check again to determine to what extent variation within the measurement process contributes to overall process variability. This includes implementing statistical process controls.

4.5.2 Control Plan

Once the design has been proven to meet the specifications of the established requirements, the team takes action to stabilize the design. It establishes a control plan with processes so that process owners can monitor and control their processes.

5.0 Considerations for MMDA Needs, Wants and Desires

Integrating traditional avionics applications into composite functions which are interconnected across both hardware and software offers new capabilities for efficient use of communications, navigation and surveillance (CNS) functions, but it also calls for new approaches both to avionics design and to certification. Below are presented some ideas and guidelines for avionics boxes and code in hopes of reducing certification time and cost, with no negative impact on the utility, reliability or safety of the product. It is appropriate to state a vision for MMDA: “We seek safe passage -- separated from terrain, weather and traffic.”

In an effort to seek out a preliminary Voice of the Customer for needed MMDA functions and applications a compilation of ideas and concepts were developed during a literature search and a series of meetings with professionals in the field.

During January and February, 2005, materials from *Annotated Bibliography: NASA / AMA ACAST Multi-Mode Digital Avionics*, Draft 1, January 31, 2005, and from discussions with consultant Dr. James Farrell, Boeing engineer Tim Murphy, and Princeton University faculty member Dr. Robert Stengel were gathered to advance a discussion of MMDA needs, wants and desires that translated into important benefits for encouraging the development and transfer of new avionics functionality and technology.

Dr. Farrell works with integrated GPS/INS systems and is keenly aware of certification issues with such systems. Murphy has been involved with aging problems associated with multi-conductor cabling and connectors, GPS landing systems and sensor networks. Dr. Stengel was the Principal Investigator for Princeton’s involvement in the Joint University Program for Aviation Systems (With Ohio University and MIT), and has been involved in the NASA AGATE program, forecasting technology evolution and application to future general-aviation aircraft. All three men had definite ideas on architecture, integration and certification.

5.1 Evolution and Assumptions

Yesterday’s hardware interconnection of multiple avionics “boxes” or cards to achieve composite functions has given rise to a large support infrastructure. We have a library of interface specifications, and we build aircraft which are full of multi-conductor wire bundles, connectors and testing / marking / documentation /maintenance headaches.

We see today (Boeing) a move toward Ethernet networks of sensors feeding a “common core” which makes data available to the subsystems that need it. We see a variety of “integrated” products employing various loose or tight coupling methods among individual sensors and systems.

We assume that for the “next generation” of avionics, there will continue to be a movement toward repartitioning or integration of applications and functions, and that an increase in the ratio of software to hardware will develop. For the “generation after next”, we postulate a nearly complete separation of hardware and software, with the partition at or near the point where analog signals plus noise (S+N) are converted to digital samples.

We observe that software signal processing techniques, many of which are well established and in use in today’s avionics and elsewhere, can be re-used to carry out most applications.

We assume that processor capability will continue to increase rapidly, eventually permitting virtually all system functions except RF amplification to be carried out as digital processes after the initial analog-to-digital (A/D) conversion.

5.2 System Externals

It is easy to postulate that next- and after-next-generations of avionics hardware should consist of a single highly-capable computer at the heart of a network of sensors, with a user interface which is as independent of specific function as possible. Over-simplified or not, that is the vision. The details of processor and user-interface input/output (I/O) design remain hidden for now.

Software glues the sensors, the core processor and the user interface together. From the owner and installer point of view, the process can be much like installing a new interface card for a personal computer: Once the core system is installed and operating, the addition of a new application consists of first purchasing an application package which will often consist of an antenna, a hardware interface card and a compact-disk (CD). The disk carries application software, documentation, parts list, installation manual, test data, and other necessary support. After installation of the antenna and application card, the CD is used to load the application driver and the appropriate files to interface with the core system and the user I/O interface. (In Windows, these are often listed as Dynamic Link Libraries or .dll files.)

We assert that the point where hardware gives way to software in an application can affect its certification complexity – the more distinct this partition and the earlier it occurs, the easier is the certification process. The heaviest certification load is on the core system. This is the gatekeeper – the core processes must maintain overall system integrity as applications are installed or removed. The application must not be allowed to compromise the system, and the application’s data must be capable of being integritychecked at installation and at any other time during operation. The core must not accept bogus or non-approved application parts or packages.

In effect, one of the functions of the core processor must be to test and validate each application constantly during operation. The application designer must include end-to-end test capability in order to "play the game". If this sounds suspiciously like the Windows philosophy, it should. The differences for avionics lie mainly in the integrity area. We must develop not only the core itself, but also an application developer's toolbox that enforces avionics system interface specifications. Providing such a toolbox pushes validation and certification very close to the front of the development process, where it belongs.

An application could consist of a digital radio receiver (e.g. VOR, GPS), transceiver (e.g. DME, Communications, TCAS), a combination of such elements, or some entirely different sensor. As long as the interface to the core meets system interface specifications the application can "play". This subsystem-level partitioning allows great flexibility in application design and front-end integration, if desired. The design presented here is based on the assumption that each application card is as simple as possible, partitioning hardware to the card and software to the driver and .dll package in the core.

What is a "safe mode" for failure reversion – full service from a second system? The use of checkpoint/restart and "go-back" processes should be included in the core, to protect against contamination during an install, de-install or update operation. A "heartbeat" process including application and core end-to-end testing of hardware and software strings will facilitate monitoring, maintenance, fault detection and certification. Replication of processes within the core, or replication of the core system itself may be necessary to maintain flight-critical levels of integrity.

The overall goal is to develop applications with foolproof installation, update and maintenance tools and procedures that can potentially permit a high level of owner/operator participation, to minimize his cost. (The traditional FAA Radio-Repairman Card may need an overhaul.)

5.3 "Measurements, not Coordinates"

Each application card's driver(s) and .dll routines are expected to deliver raw data in the application system's domain to the core process. As examples, an ILS receiver would provide ddm; a GPS receiver would provide pseudorange plus carrier phase per satellite; Loran-C uses times-of-arrival or time-differences of arrival; an inertial measurement unit provides values of delta-v, delta-theta and temperature. Validity can be provided by the sensor or derived from the raw data in the application driver or the core processes.

The system design recognizes that the aircraft is only in one location at any moment. We propose a single core-system-resident process that computes the most probable position, using any available application data that can be validated for the purpose. Application package development and certification are facilitated by centralizing and simplifying coordinate conversion software, normalizing computations so that all systems operate in a common reference system, and perhaps most important, permitting entirely new models of integration to evolve. Basic position-determination software only needs to be certified once.

It is conceivable that integration at the raw-data level can strengthen the independent Communications, Navigation and Surveillance functions that are critical to NAS safety and utility. The ability to "outlink" raw data for processing by independent ground or other-aircraft agents can communicate state vectors which are equivalent to *combinations* of today's C, N and S elements. "Send measurements and/or corrections to measurements – not coordinates."

5.4 The Aircraft as Network Node

A computer-based MMDA immediately prompts ideas of data exchange at every stage. The avionics shop will need to be equipped with a system analyzer/tester unit which communicates with the onboard system, for example via Ethernet. Standard test signals can be applied to the application cards or antennas and the resulting data analyzed. Failure logs can be read out and analyzed to detect existing or incipient problems. Software updates can be applied and tested**.**

The aircraft will exchange data with other aircraft in flight, and with ground agents, for the existing variety of proposed uses, with more to be added.

The "open system" concept was discussed early on, for cost reduction. However, open to what? The critical nature of the aircraft node requires attention to minute details of data integrity maintenance, against intentional and unintentional threats. Fortunately, this same problem affects nearly every other network user at some level, so the MMDA designer is not alone – reusable code and techniques abound.

5.5 Conceptual Application Hardware Example

An example card is shown in Figure 1. This outline could be valid for a navigation receiver, or the receiver portion of a communications application. The intent is not to design a real card, but to discuss evolutionary elements.

As shown, the card can receive signal+noise (S+N), digitize it and hand the samples off to a core system. The sample time can be determined by an onboard (asynchronous) clock, or by the core system with the onboard clock unstrapped. The card contains comprehensive fixed identification data that can be accessed by the core during software installation and for continuing checks on the physical integrity of the system. Additionally, end-to-end test capability is provided.

The concept does not preclude gain at the antenna where needed, and hardware band pass filtering (BPF), although inclusion of hardware BPF reduces the card's flexibility.

In the next generation, the card will support on-card A/D, reducing load on the core system. For a generation-after-next installation, it is tempting to predict that core-system processing will be fast enough that the A/D function can be moved to core software and the Raw S+N out line can be the primary connection to the card driver in the core, with fewer connections than the parallel digital output case. Digital filtering can then be applied for alias reduction and signal extraction. The generation-after-next card becomes a broadband interface for a software-defined radio function that can serve a variety of Communication, Navigation and Surveillance (CNS) applications.

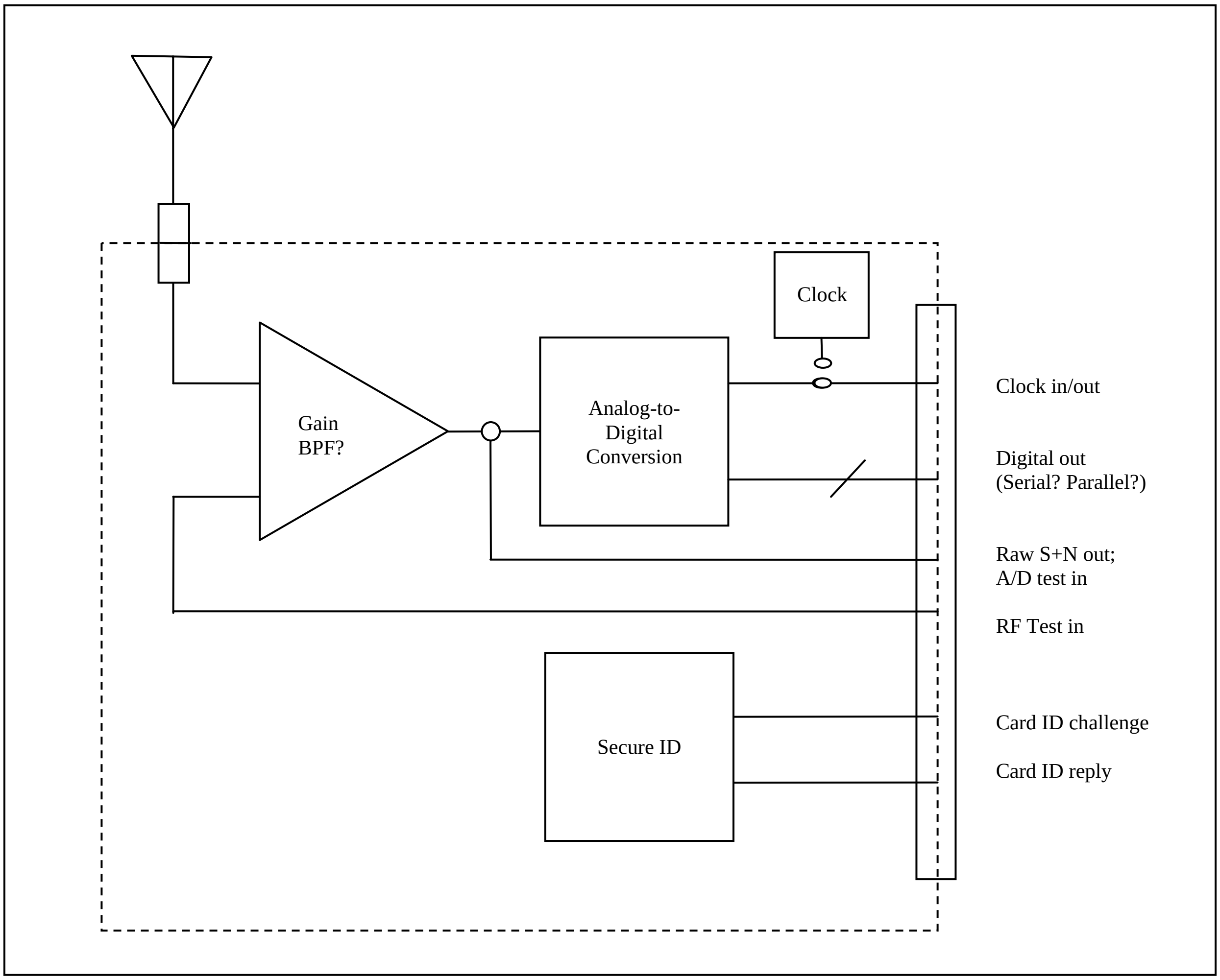

Figure 1: Conceptual Hardware Example – Receive-only application

From a certification standpoint, this partitioning of hardware and software allows some advantages.

The interface card can be produced separately from the supporting software for any particular application, and the card can be certified separately. Principal concerns are data integrity (stuck bits, broken edge connections) bogus-parts detection, etc.)

Data integrity is approached through end-to-end testing. When a core process detects suspicious data behavior, end-to-end testing of the card can be performed on the fly. Duplicate hardware can be selected in the case of failure, either through redundancy on the card or through multiple card installations.

The presence of a non-certified part can be detected through the secure card ID process. The core crypto-interrogates the card and expects to receive the correct encrypted reply, with card ID information. As long as the codes are secure, the cards should be secure. A failure at installation results in refusal to plug-and-play. A later failure (replacement of a good card with a bogus part) results in core refusal to use the card.

Given appropriate interface standards, there should be no necessity for hardware and software to be produced by the same manufacturer. This could reduce prices and allow for creative marketing of avionics.

5.6 Evolution of Deeply-Integrated Applications

Manufacturers, as reflected in a Honeywell presentation at ION-NTM-2005, are making specific system combinations more deeply integrated. INS is now helping GPS receiver tracking loops, for example. The combination gives better SV acquisition and improved interference rejection. Ohio University researchers have developed software that may simplify the tight-integration process by removing the need for iterative computations. This reduces processor loading and provides other advantages. The Apache helicopter avionics package now features a deeply integrated communications and navigation capability, likely based on the Joint Tactical Radio System.

5.7 RF Integration Lags at Present

An airframer representative observed that integrated CNS is not “there” yet. The computers are in place and capable, but generally they are used in stovepipe, special-purpose fashion. Additionally, there has been little integration on the radio-frequency end of the chain.

5.8 Standardization

Recognizing that we are at an early stage in the MMDA evolution now is a good time to provide some structure to the look-and-feel aspects of the user interface. The non-airline fleet today is anything but standardized; there is an opportunity to help, with consistent terminology and display shape and color. As MMDA concepts trickle down to the single-pilot GA community where rental aircraft are often unfamiliar, there will likely be a positive impact on enjoyment and safety both.

5.9 Off-Network Upgrades and Equipment Re-Use

One application which may become popular or required will be a user-operated data loader / unloader – usable for software updates, chart and approach data uploads, upload of flight plans and download of flight log data, or it may even pressed into service for in-cabin entertainment media. Such data uploads/downloads will certainly evolve toward data-link interchange between cockpit and data providers – government or commercial. Existing RTCA-defined data "wrapper" technology or similar protection will be required to insure integrity of the data streams in such applications where end-to-end testing is more difficult.

5.10 Marketable MMDA Applications

The term "killer application" is just not going to work in this context, but some combination of TAWS, "Stormscope" and some TCAS-like function are important elements of an MMDA demonstration. These two applications offer cockpit workload reduction and flexibility in a world moving toward cockpit-requested RNAV routine as the standard. If cost reductions can be affected for these applications, then the unit can be marketed as a way to chart ***real-time safe passage -- separated from terrain, weather and traffic***.

6.0 Disruptive Technology

One of NASA's major roles in Aeronautics has been in developing and transferring technology for commercial application. In the past NASA Aeronautics has worked from Technology Readiness Levels 1 (basic technology research) through 6 (technology demonstration) in attempting to find a transfer point for the technology where commercialization is feasible from a cost and revenue perspective. Essentially NASA has assumed an appropriate government role and responsibility of funding high risk, and sometimes high cost, for potentially high return research and development. This approach has paid handsomely in the past by creating technologically advanced and economically viable commercialization of products and related services for US companies. This has promoted and established national economic vitality as well as world leadership.

These Technology Readiness Levels (TRLs) are a systematic metric/measurement system that supports assessments of the maturity of a particular technology and the consistent comparison of maturity between different types of technology. The technology maturation process model for NASA space activities for which the TRL's were originally conceived; other process models may be used. However, to be most useful the general model must include: (a) 'basic' research in new technologies and concepts (targeting identified goals, but not necessary specific systems), (b) focused technology development addressing specific technologies for one or more potential identified applications, (c) technology development and demonstration for each specific application before the beginning of full system development of that application, (d) system development (through first unit fabrication), and (e) system 'launch' and operations.

Unfortunately NASA Aeronautics may be losing past research focus of high risk and high reward in an effort to provide highly developed ready for deployment capabilities for the FAA in support of the day-to-day operation of the National Air Transportation System. The NASA MMDA project holds hope to refocus some of NASA critical capabilities to develop new and innovative technologies that can contribute to economic growth through commercialization while addressing critical future National Air Transportation System safety, capacity and efficiency needs.

The development by NASA of an MMDA capability based on a core open architecture hardware and operating system platform can revitalize part of NASA's research agenda. Not only does the MMDA hold great promise as discussed, but the opportunities presented by virtue of a close NASA and FAA working relationship to develop an Advisory Circular for a Design for Six Sigma certification method holds significant promise to accelerate the certification process and lower its associated costs to both government and industry.

There is no question that the development of a Technical Standard Order for an open architecture MMDA functionally capable hardware and core software systems would allow the development of an incredible number of application cards that could be inserted in the MMDA platform. The design and functionality of the MMDA platform would allow an unencumbered design and certification process and potentially promote the development of a cottage industry developing and manufacturing a variety of cards providing a tremendous variety of new functionality at reasonably low cost to the aircraft.

Unfortunately, the disruptive nature of this approach occurs because a relatively small number of avionics vendors certify and sell comprehensive proprietary avionics systems at high costs. The introduction of new non-proprietary low cost avionics would be ant ethical to the business models of today's large successful avionics companies.

7.0 Certification Roadmap

7.1 Vision

FAA, NASA and the aviation industry continue to seek a vision and certification roadmap with a credible and concise product certification process. Key to this objective are results that are: (1) timely and efficient product type design and production approvals; (2) a process with clearly defines roles, responsibilities, and accountability of all stakeholders; (3) a timely identification and resolution of the certification basis, potential safety issues, and business practice requirements; and (4) an optimal delegation using safety management concepts with appropriate controls and oversight.

The building blocks to bring about the vision of the new certification process are plans that must be agreed to by both the FAA and the applicant prior to conducting a certification project. It is important to adhere to the guidance and intent of yet to be derived standards documents aligned to a Design for Six Sigma process and used to the greatest extent possible, focusing on safety and allowing flexibility in other areas where the FAA's and applicant's work processes and related customer bases may differ. Certification plan formats can be adapted and enhanced within the FAA's regulatory and policy requirements to meet the needs and work processes of the FAA and applicant.

7.2 Framework for Avionics Certification

The avionics Certification Process focuses on special issues typically faced by applicants and the FAA during the avionics approval process and provides information regarding the most efficient path for various types of avionics approvals. The approval process may include either Technical Standard Order (TSO) approval or installation approval via Type Certificate (TC) or Supplemental Type Certificate (STC), or both. The process varies depending on the applicability of Technical Standard Order standards and issues that arise regarding the installation of the equipment.

Principles of up-front planning, project management, and documenting the certification process and working relationship are applicable to all applicants. This extends from large Type and Production Certificate applicants to those applying for avionics approval through the Technical Standard Order approval process.

The below listed items are issues that should be addressed when developing a new avionics product. This will provide the FAA and the applicant a clear understanding of the best processes to use in the certification of these systems.

- Project Operational Concept (including background, operational purpose, justification, project maturity and user interest).
- Project benefits, e.g. safety enhancements and efficiency.
- Anticipated constraints of the project and equipment.
- Project specific operation procedures (including new phraseology, task analysis, contingency and emergency procedures).
- Human factors issues (including display requirements, crew training, additional workload demands, and crew resource management).
- Equipment compatibility issues.
- Technical requirements (including Minimum Operational Performance Standards (MOPS), bench and flight tests, and Instructions for Continued Airworthiness).
- Operational safety assessment (including a proposed target level of safety and failure mode analysis).

For avionics equipment that may be installed similarly on several different aircraft models, one certification approach to consider for certain applications is the generic Supplemental Type Certificate approval process. The goal of the generic Supplemental Type Certificate approval process is to develop installation instructions that can be used to install avionics equipment in several different aircraft models. This concept reduces the number of follow-on approvals that must be obtained by the avionics installers.

One way to do this is for the manufacturer to develop installation instructions that incorporate both generalized installation guidelines and specific instructions. The generalized installation guidelines could reference standard practices used in the installation, for example aircraft electrical wire selection as specified in Advisory Circular 43.13-1B. The specific installation instructions would address more critical elements of the installation, for example guidance about antenna placement. These instructions should include procedures for determining the placement, installation, and post installation checkout of the avionics equipment. For example, post installation checkout procedures could include the following: electrical load analysis, equipment mounting/wiring testing/verification, Electro-Magnetic Interference (EMI)/Radio Frequency Interference (RFI) test, compass interference test, etc. Assistance from an avionics repair station and the local FAA Flight Standards Inspection Office (FIFO) should be obtained in developing and reviewing these instructions.

It is important that the applicant and the FAA Aircraft Certification Office (ACO) agree to the use of this process early in a project. Together they should review the installation instructions to verify their applicability for the aircraft models requested. The resulting Supplemental Type Certificate, with its associated approved model list, would greatly reduce the need for the installers to request a field approval. This will save valuable resources for both industry and the FAA.

7.2.1 NASA MMDA Approach

When a Technical Standard Order does not exist for a specific avionics system, the system may be certified in accordance with the airframe/engine regulations. The Project Specific Certificate Plan associated with this approval would identify certification requirements for both the avionics system and the installation of that system. The manufacturer or applicant may elect to develop the Project Specific Certificate Plan in such a way that would allow the format of the Project Specific Certificate Plan to be transferred to another applicant. This would allow the manufacturer or applicant to develop avionics systems for which a Technical Standard Order does not exist and without a specific installation in mind. The manufacturer would develop the product to meet requirements documented in the Project Specific Certificate Plan, which would include intended functions, software level, and environmental test requirements. The manufacturer would be responsible for showing that the avionics system performs its intended function and meets its specified software and environmental requirements. This Project Specific Certificate Plan would model the relevant portions of the Technical Standard Order Project Specific Certificate Plan. The manufacturer would have the option of continuing the Supplemental Type Certificate process or transferring the Project Specific Certificate Plan to the installation company and allowing them to finish the Supplemental Type Certificate process.

7.3 Partnership for Safety Plans and Project Specific Certification Plans

To come to an early and clear agreement on the certification process, the first plan the FAA and applicant develop is the Partnership for Safety Plan. It defines generic procedures to plan for product approval, establishes the general expectations or operating norms, and identifies deliverables. The Partnership for Safety Plan also defines the discipline and methodology to be used in planning and administering subsequent specific approval projects. Examples of content include generic processes and procedures for use of designees, conformity inspections, communication, issue resolution, and generic metrics for measuring project progress.

Depending on the specifics of a project, two Project Specific Certificate Plans may be recommended. The first Project Specific Certificate Plan is the one that covers the Technical Standard Order Authorization (TSOA) aspects of a project. A Project Specific Certificate Plan covers the design approval phase as well as the production phase of obtaining a Technical Standard Order Authorization. There may be cases when a Line Replaceable Unit (LRU) or some form of interface unit is required for an installation when there is not an applicable Technical Standard Order but still requires qualification testing. These types of Line Replaceable Units are often approved during the installation phase; therefore, in this case the certification aspects may be covered by the installation Project Specific Certificate Plan. In the case where an applicant is seeking qualification of a Line Replaceable Unit (Technical Standard Order not applicable) without an installation, the Technical Standard Order Authorization Project Specific Certificate Plan should be used and revised accordingly.

The primary reason for not combining the two Project Specific Certificate Plans is the approval requirements and stakeholders involved in obtaining a Technical Standard Order Authorization versus an installation approval are quite different.

Additionally, the two approvals often involve different applicants. Once a Project Specific Certificate Plan is developed for the installation of a specific avionics appliance, it may be used as a basis for an installation Project Specific Certificate Plan by another applicant with the same installation.

These Project Specific Certificate Plans are designed to be used as project management tools providing milestones, performance measures, and information unique to obtaining a Technical Standard Order Authorization or installation approval for a certification project. It takes the generic principles and a procedure outlined in the Partnership for Safety Plan and applies them to specific projects.

It should be recognized that an avionics approval (depending on the project specifics) might take the form of one of several processes. Technical Standard Order Authorization is a design and production approval based on meeting FAA criteria, which is published in a Technical Standard Order. It is granted after the Aircraft Certification Office and Manufacturing Inspection District Office (MIDO) reviews and concurs with an applicant’s statement of conformance to the requirements of the Technical Standard

Order. It does not include installation approval.

First-of-Type Supplemental Type Certificate and basis for Line Replaceable Unit Parts Manufacturer Approval if seeking Parts Manufacturer Approval (PMA): Supplemental Type Certificate is an aircraft modification and installation approval based on the applicant showing that the modification and installation meets the minimum airworthiness requirements. Parts Manufacturer Approval is a design and production approval that can be based on the prior approved design and installation data such as a Supplemental Type Certificate. The installation approval is documented by a Supplemental Type Certificate. Consequently, the Parts Manufacturer Approval provides eligibility for installation only for the aircraft specified on the Supplemental Type Certificate.

Follow-on Supplemental Type Certificate and basis for Line Replaceable Unit Parts Manufacturer Approval if seeking Parts Manufacturer Approval: Supplemental Type Certificate is an aircraft modification and installation approval based on the applicant showing that the modification and installation meets the minimum airworthiness requirements. Parts Manufacturer Approval is a design and production approval that can be based on the prior approved design and installation data such as a Supplemental Type Certificate. The installation approval is documented by a Supplemental Type Certificate. Consequently, the Parts Manufacturer Approval provides eligibility for installation only for the aircraft specified on the Supplemental Type Certificate.

“Follow-on” Field Approval via Form 337 does not require a Project Specific Certificate Plan. A “follow-on” Field Approval is an installation approval based on a previously approved Supplemental Type Certificate. The level of similarity between the candidate installation and the Supplemental Type Certificate upon which the data approval is based depends on the level of complexity of the installation. There can be cases where the interface complexity is such that the data approval may rise to the level of a Supplemental Type Certificate even though the product being installed is the same as the original installation. In these cases, a Supplemental Type Certificate application would be needed. For those less complex installations the data utilized may come from any number of sources in addition to the previously approved data. The inspector may elect to use the previously approved Supplemental Type Certificate and then field approve the remaining data necessary for the installation. The inspector could also utilize Designated Engineering Representative (DER) data plus the Supplemental Type Certificate data and field approve any remaining elements of the alteration not covered by these sources. However, when using Supplemental Type Certificate data as the basis for any approval, written permission must be obtained from the holder of the Supplemental Type Certificate.

The applicant will present the FAA Form 337 completed in accordance with Advisory Circular 43-9. The inspector will evaluate the data and if satisfactory will sign Block 3 of the form indicating data approval. The form will then be returned to the applicant and the alteration can be accomplished. The flight manual supplement is signed by the Aircraft

Certification Office unless a handbook bulletin or an Advisory Circular (AC) specifically authorizes the inspector to approve it.

Production approvals (Technical Standard Order Authorization and Parts Manufacturer Approval) always require an FAA approved production system. This means the Manufacturing Inspection District Office has evaluated the production quality system and found that it meets the requirements. This evaluation and finding of compliance is accomplished before the Technical Standard Order Authorization or Parts Manufacturer Approval is granted. Note that if both installation and operational approvals are desired for a Technical Standard Order product, both the Technical Standard Order Project Specific Certificate Plan and installation Project Specific Certificate Plan are needed.

7.4 Certification Phases

There are five Certification Phases that move from early project concept and initiation through post certification activities. Each Phase is built on early mutual awareness of key certification issues, commitment to planning and managing projects, early identification and resolution of issues and other elements to achieve the aforementioned vision. All phases contribute to improving safety and serve to mitigate cost and project risk.

The fives phases outline extensive up-front engagement of both the FAA and an applicant. The Certification Phases depicts the Key Players in the process, the tasks for each Phase, and the required information, deliverables, and criteria for success. Roles shown also include the responsibilities, and quality attributes or best practices for teaming, communication, and accountability.

Key Players and Approaches

All of the key players outlined below are involved in all of the product certification Phases:

7.4.1 FAA and Applicant's Management

The applicant and the FAA work to establish a Partnership for Safety Plan to reach a clear common understanding of their respective responsibilities for the design and production definition and the approval requirements. The respective managements provide leadership and resources to product approval teams through the Project Managers (PM) in order to resolve issues and accomplish the project. The management has ultimate responsibility through the product approval team for the quality of compliance finding work, standard application of regulatory compliance policy and procedures, and the timely, efficient completion of the product approval projects.

It is important to ensure that appropriate managers provide the commitment necessary to accomplish the approval goals. For projects such as advanced avionics, it is essential that FAA management in the Flight Standards Division support the process because of the important reliance on operational and installation issues. Within Aircraft Certification, the Aircraft Engineering Division will play an important role in the process.

7.4.2 FAA and Applicant's Project Managers

The FAA, designees, and applicant's Project Managers are the principal focal points for the project. They coordinate and direct the certification team's effort and ensure things are kept moving to achieve the product approval objectives. The Project Managers ensure the right people from the FAA and applicants are involved in the project. The Project Managers develop and maintain the Project Specific Certificate Plan. The Project Managers ensure that the Product Certification Project team is aware of design features, proposed means of compliance, new materials, new production processes, co-production or foreign supplier issues, and other critical issues for timely resolution. The Project Managers ensure effective communication flow and quality documentation among specialists, FAA offices, and the applicant. The Project Managers are also responsible for coordinating new design features with the responsible FAA offices, participating in the development of new project-specific policy safety issues, and coordinating technical decisions and regulatory issues with their respective team members.

7.4.3 FAA Standards Staff Project Officer

The directorate Standards Staff provides the certification team with clear and timely regulatory and policy guidance specific to the project. The Project Officer is the focal point within the accountable project directorate for that policy. The directorate ensures timely support of the project regulatory and policy development for installation of new systems. The directorate provides guidance on standardized application of rules and policy. The directorate ensures that last minute changes in policy are applied to the applicant's products only when critical new safety issues are identified, that is, the potential for an accident or service difficulty sufficient to warrant Airworthiness Directive action if the product were in service.

7.4.4 FAA Engineers and Designees

The Aircraft Engineering Division provides the certification team with clear and timely Technical Standard Order regulatory and policy guidance specific to the project. The Avionics Systems Branch within that Division approves all Technical Standard Order deviations. That branch also ensures timely response to requests for Technical Standard Order deviations. The Avionics Systems Branch also provides guidance on standardized application of rules and policy for avionics related issues. In addition FAA Engineers and Designees apply regulations and policy to find compliance including the determination of the adequacy of type design and substantiation data.

7.4.5 FAA Inspectors and Designees

The FAA Aviation Safety Inspectors provide consultation and advice on production processes proposed in the design. They conduct and oversee, through designees, a variety of conformity inspections and evaluations of aircraft airworthiness, and they issues airworthiness certificates or other approvals. They conduct evaluations of the manufacturer's quality and production systems for eventual production approval.

7.4.6 FAA Flight Test Pilots and Designees

Conduct FAA flight tests.

7.4.7 FAA Chief Scientific and Technical Advisor (CSTA)

The Chief Scientific and Technical Advisors (CSTAs) play a technical leadership role within the FAA and with industry in the design and development of aircraft and in the application of regulatory policies and practices for certification of state-of-the-art technology. Chief Scientific and Technical Advisors in disciplines pertinent to Avionics Approvals are: Flight Deck Human Factors; Aircraft Computer Software; Flight Management; Advanced Avionics/Electrical; Electromagnetic Interference; and Aeronautical Communications.

Chief Scientific and Technical Advisors provide professional technical guidance, advice, and assistance in their discipline to the certification team on issues that require precedent setting means of compliance relating to new or complex technology and technical specialties. Technical areas specific to avionics equipment approval that require early involvement by specialists include software and human factors.

7.4.8 FAA Aircraft Evaluation Group (AEG)

The FAA Aircraft Evaluation Group (AEG) provides a link to applicable Flight Standards Service technical services. The Aircraft Evaluation Group serves as the focal point for all Flight Standards interests in the approval process. They Flight Standard personnel assist engineers in determining that means of compliance meet operations and maintenance requirements. They work with the Flight Standards Flight Technologies and Procedures Division to ensure that requirements and policies affecting new avionics equipment are fully coordinated with the applicant.

7.4.9 FAA Flight Technologies and Procedures Division

The FAA Flight Technologies and Procedures Division (AFS-400) is the principal organization in the Flight Standards Service that develops FAA requirements and policies for the operational certification, implementation, and approval of advanced CNS technology. They participate in a “hands-on” manner with the aviation community in the testing, prototyping, research, engineering, and development of new flight technologies and procedures. AFS-400 interfaces daily with numerous other government and industry partners and stakeholders on national and international levels to achieve the introduction of new Communication, Navigation and Surveillance technology into global all weather operating environments.

7.5 Criteria for Success

Each Phase of certification has certain “Criteria for Success” that are unique to that Phase. The following is a list of Criteria for Success applicable to all Phases that must be embedded in both the FAA’s and applicant’s culture to assure a successful process:

- Establish mutual trust.
- Ensure confidentiality.
- Meet all commitments.
- Emphasize empowerment.
- Maintain open and timely communication.
- Provide proper levels of technical project and management leadership with frequent reviews to ensure all are aware of project status, significant issues, and commitments.
- Conduct early familiarization meeting(s) and document accordingly.
- Conduct meeting(s) using well-structured agendas/presentations, ensure Key Players attend, and document agreements, issues and actions accordingly.
- Agree to clear time frames, expectations, and action plans to accomplish all Phases.
- Produce timely, high quality documentation of decisions, agreements, schedules, milestones, action item assignments, compliance/conformance submittals, and approvals.

7.6 Phase I: Conceptual Design

This Phase is initiated when the applicant begins design concept for a product that may lead to a viable certification project. The intent is to ensure early, value added, joint involvement with an expectation to surface critical areas and the related regulatory issues, and begin formulating a preliminary Project Specific Certification Plan (Project Specific Certificate Plan). This is an opportunity to apply the Partnership for Safety Plan principles to develop a mutual understanding of potential new projects.

Because avionics designs often introduce new technology, information about new designs, materials, processes, and so forth, is required. Also, proposed certification basis and means of compliance are especially important for advanced designs and are part of the required information. Any new avionics approval must consider the product design and production approval as well as the operational and installation approvals. The applicant needs to discuss these issues with the appropriate FAA counterparts. This normally will involve staff within the Aircraft Certification Office, MIDO, and Flight Standards District Office (FSDO) as well as staff within the appropriate Certification Directorate, Division, or Flight Standards Division.

The FAA and the applicant should determine the approval process path using the decision tree. It should be clearly understood that the FAA's objective is to find compliance with the regulations and not to dictate design.

7.6.1 Tasks

- Early Familiarization Meetings on design concepts.

7.6.2 Required Information

- New designs, technology, materials, processes, etc.
- Proposed certification basis and means of compliance.
- Supplier relationships.
- Initial safety assessments.

7.6.3 Deliverables

- Meeting minutes and correspondence to document decisions, agreements, schedules, milestones, and action item assignments.
- Preliminary certification basis considering the intended means of compliance, initial safety assessments, and relevant policy material and initial formulation of a Project Specific Certification Plan.
- Definition and plan for resolution of critical issues, e.g. new designs, technology or processes, potential special conditions, exemptions or equivalent safety findings, co-production or foreign supplier arrangements requiring undue burden assessments; etc.
- Identify core team for commitment to developing the preliminary Partnership for Safety Plan elements to ensure continuity.
- Initial Safety Assessment.
- Establishment of the FAA and applicant project certification team.
- Draft critical issues list and mitigation plans.
- List of relevant software policy material and preliminary compliance plans (preliminary Plan for Software Aspects of Certification (PSAC)).
- List of relevant human factors policy material and preliminary compliance plans.
- Consensus regarding which Project Specific Certificate Plan(s) will be used.
- Determination of need for any Technical Standard Order deviations.
- Draft Project Specific Certificate Plan(s).
- Phase I Evaluation Checklist.

7.6.4 Criteria for Success
- Commitment to the signed Partnership for Safety Plan.

7.7 Phase II: Requirement Definition

Efforts in this Phase clarify the product definition and the associated risks, and conclude with a mutual commitment to move forward with product certification. Specific regulatory requirements and methods of compliance or critical issues are formulated. A more formal Project Specific Certificate Plan is developed.

Efforts in this phase clarify the product definition and the associated risks, and they conclude with a mutual commitment to move forward with product approval. Specific regulatory requirements (certification basis, if applicable), means of compliance, and critical issues are revised. The Project Specific Certificate Plan is refined.

At the conclusion of Phase II the refined Project Specific Certificate Plans should include project milestones and related events such as program status reviews. Definition of project issues such as means of compliance including special conditions, equivalent safety findings, deviations, exemptions, and so forth, should be complete. However, as a project progresses to later phases, other major issues may be identified. Unanticipated issues should be resolved as quickly as possible developing a plan to achieve resolution.

7.7.1 Tasks
- Meetings to refine product definition, requirements, and develop the Project Specific Certification Plan.
- Preliminary Certification Board Meeting.

7.7.2 Required Information
- Applicant's descriptive design & production data.
- Critical issues definition.
- Refined safety assessments.
- Proposed schedule.

7.7.3 Deliverables
- Deliverables are prerequisites for subsequent Phases and must be completed before entering the next Phase, unless otherwise mutually agreed by the FAA and the applicant.
- Submission of Application, FAA Form 8110-12 (FAA Order 8110.4).
- Acknowledgment of Application.
- Certification Project Notification (FAA Order 8110.4) and establishment of project.
- Establishment of FAA and applicant project certification team.
- Meeting minutes and correspondence to document decisions, agreements, schedules, milestones, and action item assignments.

- Preliminary Project Specific Certification Plan including project milestones and related events such as program status reviews.
- Agreement of Type Certificate Certification Basis Plan and definition of project issues such as means of compliance including special conditions, equivalent safety findings, exemptions, etc.
- Phase II Evaluation Checklist.
- Safety Assessment.
- Refined Project Specific Certificate Plan(s).
- Refined critical issues list and mitigation plans.
- Applicant notification of certification project initiation.
- FAA acknowledgment of project initiation.

7.7.4 Criteria for Success

- Apply the Partnership for Safety Plan and commit to the early development of the Project Specific Certification Plan.

7.8 Phase III: Compliance Planning

During this Phase a Project Specific Certificate Plan is completed. The plan is a tool to which the responsible parties commit and use to manage the product certification project.

7.8.1 Tasks

- Project planning and Project Specific Certificate Plan development meetings.

7.8.2 Required Information

- Initial Failure Modes and Effects Analysis/Safety Assessments.
- Stakeholder identification.
- Refined critical issues.
- Production processes.

7.8.3 Deliverables

(Deliverables are prerequisites for subsequent Phases and must be completed before entering the next Phase, unless otherwise mutually agreed by the FAA and the applicant.)

- Meeting minutes and correspondence to document decisions, agreements, schedules, milestones, and action item assignments.
- Signed Project Specific Certificate Plan.
- Project schedule with established FAA/applicant milestones for completion of analyses, test plan submission, Type Inspection Authorization, conformities, flight test, Aircraft Evaluation Group evaluations, critical issues resolution plan, and other items affecting the completion of the project.
- Agreed Type Certification Basis.
- Compliance Check List.
- Completion of Stage 1 on all issue papers.

- Identification of stakeholders, including suppliers, installers in the case of engines, propellers, or systems, etc.
- Delegations defined with oversight criteria.
- Resource requirements.
- Conformity procedures.
- Project evaluation measures.
- Phase III Evaluation Checklist.
- Updated critical issues list and resolution plan.
- Defined delegations and oversight criteria.
- Refined operational and installation issues.

7.8.4 Criteria for Success

- Apply the Partnership for Safety Plan and commit to agreement on the Project Specific Certificate Plan.

7.9 Phase IV: Implementation

During this Phase the applicant and FAA work closely in managing, refining, and achieving their agreed Project Specific Certificate Plan to ensure that all agreed upon product specific certification requirements are met.

7.9.1 Tasks

- Demonstration of compliance.
- Compliance and conformance requirements verification.
- Final Certification Board Meeting.

7.9.2 Required Information

- Design and production analysis.
- Witnessing.
- Inspection results.
- Safety analysis.

7.9.3 Deliverables

(Deliverables are prerequisites for subsequent Phases and must be completed before entering the next Phase, unless otherwise mutually agreed by the FAA and the applicant.)

- Meeting minutes and correspondence to document decisions, agreements, and action item assignments.
- Meet milestones for completion of analyses, test plans submission, Type Inspection Authorization, conformities, flight test, Aircraft Evaluation Group evaluations, critical issues resolution plan, and other items affecting the completion of the project.
- Completed test plans/reports, conformity requests, inspections, and compliance documentation.
- Issue Papers, Special Conditions, Exemptions, Equivalent Safety Findings

- Compliance and conformance findings.
- Type Design and Production approval issuance.
- Phase Evaluation IV Checklist.

7.9.4 Criteria for Success
- Apply Partnership for Safety Plan and manage to the Project Specific Certificate Plan.
- Conduct frequent project schedule and compliance checklist status reports, team and management reviews, and make revisions as needed to Project Specific Certificate Plan.

7.10 Phase V: Post Certification

During this Phase closeout activities provide the foundation for continued airworthiness activities and certificate management for the remainder of the product’s life cycle.

7.10.1 Tasks
- Project follow-up and closure.
- Certificate Management.

7.10.2 Required Information
- Airworthiness Limitations.
- Maintenance and Operations requirements.
- Project lessons learned.
- Relevant safety data.
- Type Certificate Data Sheet.
- Evaluation findings.
- Design change data.

7.10.3 Deliverables
- Meeting minutes and correspondence to document decisions, agreements, schedules, milestones, and action item assignments.
- Compliance Summary Document.
- Type Inspection Report.
- Instructions for Continued Airworthiness.
- Continued Airworthiness Management Plan.
- Phase V Evaluation Checklist.
- Completed test plans/reports, conformity requests, inspections, and compliance documentation.
- Compliance and conformance findings.
- Technical Standard Order/specific Joint Airworthiness Authorities (JAA) Technical Standard Orders required data submittal.
- Quality Control System Manual.
- Issue Papers, Exemptions, Equivalent Safety Findings.
- Technical Standard Order Authorization.

- Instructions for Continued Airworthiness.
- Issued Supplemental Type Certificate.

7.10.4 Criteria for Success

- Work together for continuous improvement.
- Apply Partnership for Safety Plan and manage to the Project Specific Certificate Plan with a focus on continued operational safety.
- Provide proper levels of technical project and management leadership with frequent reviews to ensure project closeout to schedule and resolution of significant post Type Certificate issues.

8.0 Avionics Partnership for Safety Plan

8.1 General

The purpose of a Partnership for Safety Plan (PSP) is to define a working relationship between the Aircraft Certification Service of the Federal Aviation Administration (FAA) and the applicant. It provides the foundation from which to build mutual trust, leadership, teamwork, and efficient business practices.

The scope of the Partnership for Safety Plan is intended to cover the working relationship between the FAA and an applicant seeking FAA approval for avionics equipment. The applicant may be either an avionics manufacturer or installer, or both or for purposes of the NASA MMDA project, a government agency. The types of FAA approval may include a Technical Standard Order (TSO) Authorization, Supplemental Type Certificate (STC), or Parts Manufacturer Approval (PMA). The avionics approval may involve one or more of these types of FAA approvals depending on the type of avionics equipment (whether a Technical Standard Order exists), and whether the applicant is seeking an installation approval. Avionics approvals typically include a component level design and manufacturing approval (Technical Standard Order or Parts Manufacturer Approval), and an installation approval (Supplemental Type Certificate or field approval). The needs of the applicant and the FAA may vary from project to project. If an applicant already has a Partnership for Safety Plan with the FAA, the content of this guide may be used to refine the existing Partnership for Safety Plan and to consider the alternate paths to approvals and certifications described herein. The Partnership for Safety Plan enables the FAA, the applicant, and their staffs to expedite approval projects by focusing on safety significant issues.

In the establishment of this Partnership for Safety Plan, it is understood that a cooperative working relationship is required for this process to be effective. To successfully achieve this Vision, it is understood that the applicant and the FAA team members will work in accordance with the guidelines contained in this Partnership for Safety Plan.

The Partnership for Safety Plan becomes effective upon approval by the FAA Directorate/Division Manager and the applicant’s executive empowered to commit for the applicant. It continues in effect until it is superseded, revised or terminated and may be amended by mutual consent of the parties. Any change in the services furnished or other provisions of this Partnership for Safety Plan is formalized by an appropriate written amendment signed by both parties, which outlines the nature of the change.

The Partnership for Safety Plan is a living document developed by the FAA and the applicant to the greatest extent possible in advance of any specific approval project. The Partnership for Safety Plan is an important prerequisite to a specific product approval project. It establishes the principles and procedures for early identification of critical issues and early planning so that, subsequent to this Partnership for Safety Plan, future projects can be completed in a timely and efficient fashion. The Partnership for Safety Plan is managed and maintained by the FAA's and the applicant's management focal points. The applicant and the FAA agree to work to the principles and operational norms outlined in this Partnership for Safety Plan and to future Project Specific Certification Plans that may be developed in conjunction with this agreement. The Partnership for Safety Plan should also define the process for determining when a Project Specific Certificate Plan is not required for a specific project. For, example, minor changes as defined in 14 CFR Part 21, 21.93, paragraph (a), and 21.611, paragraph (a), would not require the development of a Project Specific Certificate Plan. The Partnership for Safety Plan should also address the process used for the incorporation and approval of minor changes.

Since the Partnership for Safety Plan is used to define communication, coordination, and delegation between the applicant and the FAA, it needs to be accepted by the relevant organizations that will use it. If the applicant is likely to have approval projects with more than one FAA Aircraft Certification Office (ACO) or Manufacturing Inspection District Office (MIDO), the Partnership for Safety Plan should be developed with the secondary FAA offices involved as well.

If an applicant's organizational structure is such that lines of business work independently with their respective FAA offices, then separate Partnership for Safety Plans may be appropriate. Alternately, a Partnership for Safety Plan agreement with the primary FAA office may be used as the basis for a Partnership for Safety Plan with other offices. When an applicant requires involvement with additional FAA offices, the applicant should share with those offices any existing agreements with the FAA, such as Partnership for Safety Plans or Project Specific Certificate Plans. This is especially important when an applicant and an Aircraft Certification Office agree to a process for an avionics installation and then the applicant seeks approval for a similar process with another Aircraft Certification Office.

8.2 Planning

The applicant and the FAA jointly conduct periodic management program reviews using an agreed process to provide early insight into future potential projects. These reviews also provide a forum to begin early planning for those projects. The reviews would, to the extent possible, touch broadly on areas that should require special attention, for example, special conditions, exemptions, equivalent safety findings, unique designs, new materials or processes, production or operational aspects, foreign validation, co-production or use of foreign suppliers, and continued airworthiness.

The FAA and the applicant will participate in early identification of product concepts, applicable standards, and in the product definition and risk management phases. This will be accomplished as potential approval projects arise to ensure agreement and commitment on dealing with critical issues in a value-added way. This is an iterative process requiring ongoing mutual evaluation and continuous improvement of the Partnership for Safety Plan and related processes. The Partnership for Safety Plan gives the FAA a means to keep the applicant informed of new proposed regulations or policy that could affect future product approval projects.

The Partnership for Safety Plan should document the agreement between the FAA and the applicant regarding the use of a Project Specific Certificate Plan. As noted above, some Technical Standard Order projects and Supplemental Type Certificate changes may not require a Project Specific Certificate Plan. Although the preference would be to always use a Project Specific Certificate Plan, a cost/benefit analysis may show a low return on investment for less complex or recurring Technical Standard Order Authorization projects. With this in mind, the applicant and the FAA should work together to ensure developing and using the Project Specific Certificate Plan is efficient and commensurate with the project. The point is that a Project Specific Certificate Plan should add value to the process by improving project efficiency for both the applicant and the FAA.

Project tracking and documentation provide for early identification and resolution of potential conflicts. Early communication between the applicant and the FAA in the conceptual/prototype stages of product development is critical to ensure availability of resources, adequate planning, and flexibility for both the FAA and the applicant. Effective project management oversight, planning, communication, and documentation are needed. This process is management and discipline dependent.

Avionics equipment may require one or more Project Specific Certificate Plans, depending on the type of project. For clarity and agreement between the applicant and the FAA, the Partnership for Safety Plan should include content to help all stakeholders decide which Project Specific Certificate Plans to use.

The Technical Standard Order Project Specific Certificate Plan is specifically for products where a Technical Standard Order exists and a Technical Standard Order Authorization is to be issued for design and manufacturing approval. The Installation Project Specific Certificate Plan should be used where the project will result in First-of-Type Supplemental Type Certificate and basis for Line Replaceable Unit Parts Manufacturer Approval if seeking Parts Manufacturer Approval, or follow-on Supplemental Type Certificate and basis for Line Replaceable Unit Parts Manufacturer

Approval if seeking Parts Manufacturer Approval.

Typical projects that may not require a Project Specific Certificate Plan include, but are not limited to: minor changes to existing Technical Standard Orders or Supplemental Type Certificates and Technical Standard Order projects that have been previously approved by the applicant at the same Aircraft Certification Office. Projects that may not benefit by having a Project Specific Certificate Plan are those low in complexity with little risk regarding the approval process or interpretation of the requirements for airworthiness.

8.3 Communication and Coordination

In the Partnership for Safety Plan, communication and coordination paths should be clearly defined between the FAA and the applicant. Focal points should be identified to avoid conflict and to keep both parties informed of all critical communications that affect the needs and responsibilities of their respective roles. This does not preclude any team members from communicating with any other members, but they need to ensure the focal points are informed. Thus, critical links should be defined to ensure roles and responsibilities are clear and to facilitate conflict resolution. The focal points will be responsible for the maintenance of the Partnership for Safety Plan.

The Partnership for Safety Plan should identify each organization that is responsible for elements in the approval process and the responsibility those organizations share in the approval of the product. The roles and responsibilities of each organization should be clearly stated in the Partnership for Safety Plan. In the approval process of avionics, several FAA organizations are responsible for different aspects of the approval. For example, the office responsible for developing the Technical Standard Order and approving deviations related to any Technical Standard Order is the Aircraft Engineering Division within the Aircraft Certification Service. This division is also responsible for developing policy as it relates to the avionics appliance.

The regulations and policy for installation of avionics into an aircraft falls under the responsibility of the directorates within Aircraft Certification. The type of aircraft in which the avionics are installed determines the accountable directorate:

- Small airplanes – Small Airplane Directorate.
- Transport airplanes – Transport Airplane Directorate.
- Rotorcraft – Rotorcraft Directorate.
- Installations specific to engines or propellers – Engine and Propeller Directorate.

Each directorate is also responsible for supporting certain Aircraft Certification Offices and Manufacturing Inspection District Offices to provide the FAA resources to support the applicants' projects. The Aircraft Certification Office is responsible for determining that the avionics and installation complies with the required regulations and policies. Operational issues during the approval process are the responsibility of the Flight

Standards Aircraft Evaluation Group. The approval for avionics production is the responsibility of the Manufacturing Inspection District Office. The Project Specific Certification Plan should identify what is expected from each of these organizations.

8.4 Delegation

The FAA depends on using both individual and organizational delegations in the approval process. Delegation will be used to the maximum extent practicable with appropriate oversight safeguards as defined in the FAA’s delegation management process policies.

A Designated Alteration Station (DAS) is an organization that is delegated to issue Supplemental Type Certificates in accordance with an FAA approved procedures manual. The FAA approved Designated Alteration Station procedures manual is, in effect, a partnership between the DAS and the FAA. An existing approved procedures manual, for a Designated Alteration Station or any other FAA organizational delegation, may be incorporated by reference in the applicant’s Partnership for Safety Plan but is not a substitute for the Partnership for Safety Plan. This concept would also apply to other delegated organizations.

The FAA Designated Engineering Representative and Aviation Safety Inspectors’ designees, designee oversight controls, related documentation, and so forth, should be identified and agreed upon early, preferably prior to a specific project. This should also include, by reference, reliance on existing agreements or working procedures generated between the FAA and the applicant, where appropriate. The Partnership for Safety Plan should be specific as to what aspects of the FAA project responsibilities are delegated, and should address the delegation and oversight process as well as designees’ disciplines and limitations. The FAA and the applicant agree to manage all designee activity within the regulations and policy regarding designee appointment, procedures, and oversight.

The expanded use of designees in the approval process is an important part of streamlining the avionics certification process. The FAA continues to explore ways to expand the use of Designated Engineering Representatives to help reduce the review time necessary for granting Technical Standard Order Authorization. When an applicant requests a Technical Standard Order Authorization they should work closely with the FAA to determine the scope of delegation the FAA will authorize. The FAA will explain the latest policies regarding use of Designated Engineering Representatives in this process, what authorizations are needed, and how best to utilize Designated Engineering Representatives in a project approval process.

It is essential that the FAA and the public have confidence in the integrity of the designee system and that it function properly. Both the FAA and the applicant agree to foster an environment where open communication between the designees and the applicant’s management, and between the designees and their FAA counterparts, is standard practice. That environment should encourage the designees, within the scope of their delegation, to openly communicate approval items with the FAA, which is necessary to maintain confidence in the designee system. The applicant agrees to create a working environment where designees can make compliance and conformity findings free from undue pressure and with the support and knowledge of the FAA. It should be clearly understood that the FAA's objective is to find compliance with the regulations and not to dictate design.

Because of the close integration of the design, production, and continued airworthiness processes, it is necessary to have all stakeholders in the delegation process agree on the extent of delegation, the procedures, and the degree of delegation oversight to be used in each project. The applicant and FAA engineers, Aviation Safety Inspectors, flight test pilots, and FAA designees will agree upon and document a plan. This plan will describe how the designees in different disciplines will work together directly to the greatest extent possible to ensure compliance with Title 14 of the Code of Federal Regulations while providing more timely project management.

The Partnership for Safety Plan should also describe the respective FAA and applicant roles in the conformity inspection process. As noted in applicable FAA Orders and Policy, the goal of the FAA and the applicant is to develop a system that ensures conforming products, and one that the FAA can rely upon, to the greatest extent possible, using the designees with appropriate oversight to expedite the work. This should include, in coordination with the delegation section of the Partnership for Safety Plan, criteria for determining which conformities will be conducted, which are delegated to both FAA Designated Engineering Representative and Aviation Safety Inspectors.

The system should include, but is not limited to:

- Maintaining the custody chain of conformed articles destined for an official FAA test.
- Notifying the FAA Manufacturing Aviation Safety Inspector of any changes to ground/flight test articles after conformity inspection has been completed.
- Ensuring requests are not duplicated and the timely and efficient conduct of conformities and dispositioning of deviations.
- Identifying who issues the requests, conducts the inspections, and dispositions the deviations.
- Providing for the completion of inspection, documentation, and dispositioning of deviations or changes before tests are conducted.

8.5 Production Quality System Evaluation

The Partnership for Safety Plan should describe the FAA and the applicant's roles in the production approval process. The goal of the FAA production approval is to verify that the applicant has established a system which ensures that only products and parts conforming to the FAA approved design are released to service. Evaluations to determine adequacy of this system should be conducted by the FAA as early as feasible during the project, where practicable. The FAA Aviation Safety Inspectors' designees, with appropriate oversight, could be used to facilitate the work.

8.6 Transition Plan

FAA recommends that the Aircraft Certification Office assign all of an applicant's projects to the same team of engineers. However, it is recognized that the Aircraft Certification Office and the applicant's personnel may be reassigned or leave the organization. To minimize disruption of a project and maintain continuity throughout the approval process, a transition plan should be implemented when Aircraft Certification Office/ applicant project personnel are replaced. The following is a recommended plan:

- The Aircraft Certification Office/ applicant will be notified of any changes to the project personnel within a prescribed time frame prior to the change, when possible. (For example, 2 weeks.).
- During the prescribed period, new personnel will be trained on the contents of this Partnership for Safety Plan.
- During this period, new personnel will be briefed on the status of all the applicant's projects (including the applicant's drawing, data, and document system).
- Incoming personnel shall accept previous formally communicated and agreed to positions.
- A meeting between the Aircraft Certification Office and the applicant with new and remaining personnel will be conducted to review all ongoing projects and to review this Partnership for Safety Plan so that all personnel involved will have a common understanding of the Partnership for Safety Plan.
- Individuals assigned to perform a backup role will have the background and authority to make decisions during personnel absences.

8.7 Issues Resolution Process

The objective of this process is to identify and resolve issues and disagreements as early as possible at the team working level facilitated by the applicant's and the FAA's Project Managers. The applicant and the FAA Project Managers will jointly maintain a project issues tracking list. They will continually manage those issues to ensure adequate progress is being made on the resolution of issues to ensure compliance with the regulations while not adversely affecting project schedules. The Project Managers will periodically keep their management and other certification team members apprised of the progress on resolving issues. If there is agreement on the progress of issues resolution, the applicant and the FAA Project Managers will document the actions, decisions, and outcomes in the project records. Any necessary changes to the project schedule or the issues will be coordinated and agreed upon by all affected team members. Should any problems arise with open issues where their resolution is not proceeding according to the agreed Project Specific Certificate Plan, the Project Managers will utilize the following issues resolution process:

- If there is disagreement, the applicant and the FAA Project Managers, their respective managers, and other appropriate team members in the affected

disciplines will review the issue and recommend a solution. If they agree, the resolution will be documented and all team members will be informed.
- If the managers and appropriate team members are unable to agree, the office raising the concerns will prepare a white paper detailing the issue, respective parties' positions, and options for resolution. Timelines will be established for resolution of each issue to permit tracking via the project issues list and ensure timely resolution. Where appropriate, the FAA Issue Paper process should be used, but it should not be applied just for the sake of tracking, which can be done through the project issues tracking list maintained by the FAA and the applicant Project Managers.
- The issue will then be submitted to the applicable directorate manager(s), the FAA, and the applicant Project Manager's management, and, where appropriate, the FAA regional counsel and other appropriate FAA division(s) for review and disposition.
- The applicant and the FAA Project Managers will document in the project records conclusions, recommendations, and outcome of the issue resolution.

8.8 Performance Measures

Project tracking and documentation provide for early identification and resolution of potential conflicts. Early communication between the applicant and the FAA in the conceptual/prototype stages of product development is critical to ensure availability of resources, adequate planning, and flexibility for both the FAA and the applicant. This process requires effective project management oversight, planning, communication, and documentation. Priority must be placed on early identification and resolution of issues critical to the success of the project.

Performance measures should focus on producing quality deliverables that show an efficient and credible approval process. These and other project deliverables can be associated with the phases in the approval process as delineated in this guide. Good planning will define the significant tasks, associated required information, and expectations necessary to meet the project completion objectives. The operating norms agreed upon between the FAA and the applicant will establish the basis for operating under this Partnership for Safety Plan and subsequent Project Specific Certificate Plans and provide a means of measuring progress.

The FAA will establish with the applicant agreed, documented, operating norms. These norms will guide the timeliness and quality of deliverables and services provided by both the FAA and the applicant during the project. Operating norms should be defined to meet the needs of the applicant and the FAA consistent with agreed Project Specific Certificate Plans.

Many factors affect the planning and management of approval projects, such as project size and complexity, and degree of delegation. The FAA and the applicants recognize, for example, that certification of an advanced avionics design concept, then initial installation, may have significantly different resource needs and timing than a modification to a design or an installation. The Partnership for Safety Plan and each Project Specific Certificate Plan should identify appropriate agreed operating norms since there could be different team members on different Project Specific Certificate Plans. An agreed Partnership for Safety Plan and early pre-project communication and planning in accordance with that Partnership for Safety Plan are essential prerequisites to preparing for successful approval projects. The objective of any successful project is to meet or beat the plan. Unless compelling reasons are presented to deviate from this guide, the operating norms for certain key deliverables should be set as low as possible as outlined in the schedule below.

8.9 Schedule

8.9.1 Within 2 weeks after submittal of 8110-12 application:

- Acknowledgment of application issued.
- Aircraft Certification Office Project Manager determines project significance per Order 8110.4.
- Aircraft Certification Office issues Certification Project Notification (CPN) and sends to appropriate directorate.
- Aircraft Certification Office receives concurrence or non-concurrence regarding project significance from appropriate directorate (per Order 8110.4).
- Appropriate directorate assigns Program Officer.

8.9.2 Within 1 month after application:

- Project team identified (FAA and applicant).
- Project Specific Certificate Plan drafted.
- Project familiarization and up-front planning meeting at Aircraft Certification Office.

8.9.3 Within 1 month after up-front planning meeting:

- Certification basis identified, if applicable.
- Technical and certification issues are defined.
- Project Specific Certificate Plan should be revised as appropriate to include comments and issues generated from the up-front planning meeting.

8.9.4 Within 2 to 3 months after up-front planning meeting:

- Certification basis established, if applicable.
- Resolution of technical and certification issues. (Where resolution is not possible at this early date in the project, the issues will be carried forward in the program on the critical issues list.).
- Issue papers written, as appropriate.
- Update the project schedule, if needed.
- Project Specific Certificate Plan agreed and signed, including the mutually agreed project schedule.

8.9.5 3 months prior to scheduled issuance of Type Certificate/Supplemental Type Certificate/Technical Standard Order Authorization:

- Resolution of all remaining technical and certification issues.
- All issue papers closed.
- Update to the project schedule, if needed.

8.9.6 One month prior to scheduled issuance of Type Certificate/Supplemental Type Certificate/Technical Standard Order Authorization:

- All required certification inspections and tests have been completed.
- Compliance data and documentation is submitted. (If the data is not FAA designee approved or recommended for approval, more time may be required. The use of designees should be taken into account early in the project planning and documented in the Project Specific Certificate Plan.).

8.9.7 Additional Norms:

- Request for a meeting should be accommodated within one month of the request.
- Meeting minutes should be completed, agreed upon, and signed within one month of the respective meeting.
- Request for a document review should be accommodated within six weeks of the request.
- Issue papers should be completed and released within one month of identifying the issue.
- Schedule slips and significant design changes will be communicated within one month of their identification.
- Deviation requests should be granted or denied within 6 weeks of the manufacturer's written request to the Aircraft Certification Office.
- FAA letters of Validation for non-US certifications should be provided within 3 weeks of the request.

Additional norms may be necessary or appropriate depending upon the specific project needs. When developing a Project Specific Certificate Plan, the need to define norms should be assessed for all issues identified. Any major issues, design changes, or compliance requirements should result in agreed revisions to the Project Specific Certificate Plan with appropriate milestones for closure. As the project progresses, other major issues may be identified. Where appropriate, issue papers and a revised Project Specific Certificate Plan will be prepared within one month after identification of the issue along with a plan to achieve its resolution. In such cases, the FAA will work within boundaries of their policies and public rulemaking procedures. The Partnership for Safety Plan compels the partners to work together to understand the product architecture early enough to preclude last-minute guidance (verbal or written), new interpretations, or rule escalation that would adversely affect the mutually agreed upon program goals.

8.10 Phase Evaluation Checklists

A Phase Evaluation Checklist is a tool that can be used for project management as the project moves through the five phases. The FAA and the applicant Project Managers should jointly prepare a Phase Evaluation Checklist at the beginning of a project. The applicant/FAA team should continuously evaluate the project for immediate process improvement. For long duration projects, the Project Managers should complete the “Deliverables” portion of the form at the end of each phase. For projects with a short completion time, the form should be completed at the end. The Project Managers are encouraged to include the review and update of the Phase Evaluation Checklist as milestones when preparing their Project Specific Certificate Plan schedule.

To facilitate continuous improvement the team should implement any necessary corrective actions. The Phase Evaluation Checklist should be maintained in the FAA and applicant’s official project file for future national or local program evaluation. When the evaluation identifies the need for corrective actions or improvements, it should be included as a part of the Compliance Summary Document for future reference.

9.0 Project Specific Certificate Plan

9.1 General

The purpose of a Project Specific Certificate Plan is to define and document a product approval plan between the Aircraft Certification Service of the FAA and the applicant. The plan should expedite the issuance of Technical Standard Order Authorization (TSOA) for the applicant’s Line Replaceable Unit (LRU) or system under standardized procedures.

If an installation is being worked as a parallel project, it should be stated as a parallel certification project, the installation approval would be covered by a stand-alone Project Specific Certificate Plan. This Project Specific Certificate Plan will provide the foundation from which to build mutual trust, teamwork, and efficient business practices between the FAA and the applicant during approval of the product. It is the mutual goal of all team members to meet or exceed the expectations of this agreement.

It is understood that this Project Specific Certificate Plan will be executed in accordance with the Partnership for Safety Plan. However, there are certain situations where a Partnership for Safety Plan is not warranted. In these situations, those applicable sections for a Partnership for Safety Plan must be incorporated into this Project Specific Certificate Plan. In the establishment of this Project Specific Certificate Plan, it is understood that a cooperative working relationship is beneficial for these procedures to be effective. To implement the Project Specific Certificate Plan procedures successfully, it is understood that both the applicant and the FAA team members will work in accordance with established guidelines. The FAA team members will recognize and utilize the knowledge of the FAA designees to the greatest extent possible and keep the applicant’s team members abreast of approval issues that may arise. The Project Specific Certificate Plan schedule will be within specified ranges agreed to in the norms of the

Partnership for Safety Plan. Additional milestones will be considered by the FAA and the applicant as firm commitments unless they agree to a change. It is intended that all team members facilitate review and approval of the necessary design and production data and related compliance documents in a timely manner with the objective of bettering the Project Specific Certificate Plan schedule wherever possible.

The Project Specific Certificate Plan is a living document. This means that if both the FAA and the applicant agree that modification of the Plan is needed, an amended Plan is drafted. The Plan will be developed to the greatest extent possible as soon as the FAA and the applicant agree that the approval project is a viable one for which resources can be planned and committed for its completion. As the project progresses, the Project Specific Certificate Plan will be managed and maintained jointly by the FAA and the applicant's Project Managers.

This Project Specific Certificate Plan shall become effective upon approval by the Managers of the Aircraft Certification Office, the appropriate Standards Office (Directorate or Aircraft Engineering Division), the Manufacturing Inspection District Office, the Aircraft Evaluation Group, and the applicant's Certification or Airworthiness Manager. The Project Specific Certificate Plan may be amended by mutual agreement or terminated by either the applicant or the FAA. This Project Specific Certificate Plan will continue in effect throughout all phases of the product approval unless it is superseded, revised, or terminated with written notice by either the applicant or the FAA. Any change in the services furnished or other provisions of this Project Specific Certificate Plan will be formalized by an appropriate written amendment signed by affected parties, which will outline the nature of the change.

9.2 Project Description

This section should contain a description of the project. It should include a listing of the Technical Standard Orders being applied for. The Plan should include a detailed description of the product. The description should consider the annunciation, control, and display requirements specified in the Technical Standard Order standard and its intended installation environment. The level of software assurance used should support those requirements and be clearly identified in the Technical Standard Order software documentation and installation instructions. The description should also include a detailed list of all systems functionality with an indication of any functionality that is not covered under Technical Standard Order. The intended uses of each function should be documented, as well as the operational assumptions. This detailed function or features list is critical as it will help focus the FAA evaluations on the extra functionality early in the program, leaving the applicant with the traditional role in the Technical Standard Order process focusing on ensuring compliance with the Technical Standard Order requirements.

9.3 Project Schedule

A detailed project schedule should be provided as an appendix to the Project Specific Certificate Plan. It should identify all major milestones, including appropriate project management reviews and any required scheduled deliverables such as those listed below. If required, these milestones need to be established in accordance with the operating norms identified in the Partnership for Safety Plan. Every effort must be made to establish realistic schedules considering both the FAA and the applicant's total workloads and other resource commitments. Design, production, operational, and maintenance aspects, as well as foreign authority validation requirements, should be planned for and considered. All issue papers, if applicable, should also be included with a resolution plan and prioritization of the issues to be resolved. This would include identifying in the schedule all appropriate deliverables for the project such as, but not limited to, those shown below:

9.3.1 Deliverables:

- Familiarization, up-front planning, and technical meeting(s) minutes.
- Roles and responsibilities of FAA and applicant project teams.
- Product approval team and management status reviews.
- Delegation plan.
- Draft and Final Project Specific Certificate Plan.
- Applicant's Technical Standard Order Statement of Conformance.
- Listing of specific Technical Standard Orders being applied for.
- A listing of deviations, as applicable, to the Technical Standard Order performance standards.
- Letter accepting Technical Standard Order deviations.
- Compliance Summary Document.
- Quality Control Procedures.
- Production approvals.
- Data submittals (to support compliance and conformance (e.g., test plans/reports, analyses, installation instructions, operating manual, etc.)
- Human Factors Approval Plan, if applicable.
- Other data required by applicable Technical Standard Order.
- Technical Standard Order Authorization letter.
- Foreign approvals anticipated that would involve the Aircraft Certification Office.
- List of specific Joint Airworthiness Authorities (JAA) Technical Standard Orders (JTSO) being applied for including a listing of deviations, if any, to the specific Joint Airworthiness Authorities (JAA) Technical Standard Orders performance standards.
- Foreign approval compliance documentation list.
- Letters of conformance and application for the foreign approvals.
- FAA letters of validation for the foreign approvals.
- Phase Evaluation Checklist.

9.4 Technical Standard Order and specific Joint Airworthiness Authorities (JAA) Technical Standard Orders Application and Means of Compliance

9.4.1 Technical Standard Order Application

In this section the applicant should identify the Technical Standard Order authorization requested. The applicant should also identify if a specific Joint Airworthiness Authorities (JAA) Technical Standard Orders authorization is to be requested. The certification basis should also be identified, along with any requested deviations. The Certification Basis of obtaining a Technical Standard Order is 14 CFR Part 21, Subpart O, the applicable Technical Standard Orders. When making application for a Technical Standard Order the applicant submits:

- A statement of conformance certifying that the applicant has met the requirements of Part 21, Subpart O, and
- A statement certifying that the article concerned meets the applicable Technical Standard Order that is effective on the date of application for that article. The application, if applicable, includes the listing of deviations to the Technical Standard Order and equivalent safety findings, if any. An issues list should be included to highlight for resolution those special requirements and other areas that may be significant, even though they may not warrant a special condition, exemption, or equivalent safety finding.

The Certification Basis of obtaining a specific Joint Airworthiness Authorities (JAA) Technical Standard Orders is JAR Part 21, Subparts N-O, and the applicable specific Joint Airworthiness Authorities (JAA) Technical Standard Orders s. Application is made by letter to the Aircraft Certification Office and includes:

- A copy of the statement of conformance that certifies the applicant has met the requirements of JAR 21, Subpart N-O, that the article concerned meets the applicable specific Joint Airworthiness Authorities (JAA) Technical Standard Orders, and lists any deviations from the specific Joint Airworthiness Authorities (JAA) Technical Standard Orders requirements.
- A copy of the list that shows the compliance data provided to the National Airworthiness Authority (NAA) by the FAA or the applicant.
- The Aircraft Certification Office issues a letter of validation to the NAA responsible for specific Joint Airworthiness Authorities (JAA) Technical Standard Orders approval.
- Other non-U.S. approvals require a process similar to the specific Joint Airworthiness Authorities (JAA) Technical Standard Orders process. These applications are made to the Aircraft Certification Office and result in an approval on an individual country basis (national approval). These approvals do not confer a Technical Standard Order or specific Joint Airworthiness Authorities (JAA) Technical Standard Orders authorization. The FAA maintains advisory documents that explain procedures required for different countries.

- Technical Standard Order Table and Minimum Operational Performance Standards (MOPS).
- A table that lists the applicable Technical Standard Order requirements should be used. This table should identify the requirements and the means used to show compliance to the requirement.

9.5 Communication and Responsibilities

9.5.1 Communication

This section describes the communication responsibilities of the FAA and the applicant's certification teams. The FAA and the applicant establish the appropriate communication and coordination paths by identifying the respective team members. The FAA and the applicant's Project Managers must be kept informed of all critical communications. Critical links should be defined to ensure that roles and responsibilities are clear to define accountable team members responsible for deliverables and to facilitate conflict resolution. This does not preclude any team member from communicating with any other member, but they need to ensure the Project Managers are informed. Team members typically will communicate with the Project Managers via email and telephone.

9.5.2 Roles and Responsibilities

This section describes the roles and responsibilities of the applicant and the FAA team members. Please note that different programs may require team members with different roles and responsibilities than those listed. In some cases, additional members should be included. For instance, the project may require FAA or applicant legal representatives on a consultation basis. If international certification is involved, other authorities should be included. This is especially important if assistance with test witnessing, conformity inspections, or type certification validations in anticipated.

9.5.3 Delegation

A Technical Standard Order program is a self-certified process where the applicant makes conformance statements to the FAA indicating compliance with those items listed in 14 CFR Part 21 21.605 and to the applicable Technical Standard Order. However, the process may be difficult if the Technical Standard Order applicant is new to this process or has limited knowledge of the Technical Standard Order certification process. In this case, it may be helpful for the applicant to become familiar with the certification process or use a designee who is familiar with the process to review the data that is to be submitted to support the project.

The expanded use of designees in the approval process is an important part of streamlining the avionics certification process. The FAA continues to explore ways to expand the use of Designated Engineering Representatives to help reduce the review time necessary for granting Technical Standard Order authorization. When an applicant requests a Technical Standard Order Authorization, they should work closely with the FAA to determine the scope of delegation the FAA will authorize. The FAA will explain the latest policies regarding use of Designated Engineering Representatives in this process, what authorizations are needed, and how best to utilize Designated Engineering Representatives in a project approval process.

9.6 Testing Plan

9.6.1 General

This section should outline the applicant's approach to developing test-based compliance documentation. Plans for Hardware and Software Aspects of Certification (PHAC and PSAC respectively) are typical means used to identify Verification and Validation (V&V) methodologies. This portion of the Project Specific Certificate Plan should also consider the requirements of the specific Technical Standard Order and associated Minimum Operational Performance Standards where performance under normal and severe environmental conditions is concerned. A strategy for the planning, preparation, and conduct of the required environmental and qualification testing would be appropriate content. The plan should identify the proposed methods for evaluating the flight crew interface aspects of the product. The plan should address the occasions when and how FAA human factors evaluations are to occur, and recognize that the findings from such evaluations need to be documented and validated to ensure appropriate "credit" will be evaluated if needed for subsequent installation approvals.

9.6.2 Flight Test

In some cases – such as for Traffic Alert and Collision Avoidance System (TCAS) products – flight tests are necessary to provide compliance data. While FAA participation in these flight tests is not required, the responsible Aircraft Certification Office may have an interest in observing use of the product in its actual operating environment. This section of the Project Specific Certificate Plan should specify how to accommodate such requests. Where a concurrent aircraft level project (Supplemental Type Certificate) has been initiated, use of language in the project's Type Inspection Authorization may be used to enable FAA participation. This will also facilitate the applicant's ability to take credit for these tests as part of the Supplemental Type Certificate project. Since a Type Inspection Authorization is not necessary to authorize the applicant's conduct of flight tests associated with gathering Technical Standard Order compliance data, special approval may be needed for Aircraft Certification Office personnel to participate in flight tests that are solely in support of a Technical Standard Order project. This issue should be negotiated with the responsible Aircraft Certification Office manager early on in the Technical Standard Order project.

The need for evaluation of the product's human factors attributes should also be addressed in this section. Many new and revised Technical Standard Orders contain requirements for human centered design considerations. In addition, some FAA Aircraft Certification Offices are including this type of evaluation as a part of the Technical Standard Order project where the product has a major man-machine interface element (such as display systems). This item should be discussed with the Aircraft Certification Office early in the project's life cycle. For some products, use of a bench simulator or demonstrator may be adequate. Others may require a combination of bench and flight test evaluations. Where flight test human factor assessments are warranted, a plan for FAA participation similar to that described immediately above may be needed.

9.6.3 Configuration Control

Articles used for compliance testing must be subject to a control process to ensure an accurate accounting of their configuration. This section of the Project Specific Certificate Plan should indicate the process/procedure to be used. Where an FAA-approved company quality control system exists, an inspection conducted in accordance with that system and resulting in a Certificate of Conformity is typically adequate. In general, all drawings, specifications, and other documentation defining the hardware and software design of the article should be released into the applicant's configuration control system prior to conducting any conformity inspection.

An inspection process involving Manufacturing Inspection District Office personnel, or resulting in an 8100-1 Conformity Report or 8130-3 conformity finding, is not required. However, one of these alternate means of configuration control may be necessary when the Technical Standard Order test article is installed on an aircraft for obtaining certification data in support of a Supplemental Type Certificate/Type Certificate project. The applicant's plan for these requirements should be included in this section.

The applicant should also describe a process to maintain configuration control of the test article throughout compliance testing. Test articles may require repair or design changes as a result of qualification testing. The applicant should establish a process to maintain configuration control for all changes or repairs incorporated into the test article. This process should be sufficient to ascertain where credit may be taken for tests already completed and where re-testing is required.

9.6.4 Compliance Documentation

This section should describe the procedures for submittal and processing of compliance documentation. The Project Specific Certificate Plan should identify what data will be submitted and by whom. It should account for all data (not just drawings) pertinent to defining the type design, including manufacturing specifications, and pertinent to conducting the showings of compliance required for FAA approval. The following list of items should be considered:

- PSAC (Plan for Software Aspects of Certification).
- Environmental test reports.
- Technical Standard Order Minimum Operational Performance Standards compliance test reports.
- Software Accomplishment Summary (SAS).
- Software Configuration Summary.
- Functional Hazard Assessment (FHA)/System Safety Assessment (SSA) at Line Replaceable Unit level.
- Bill of Material.
- Line Replaceable Unit identification tag(s).
- Operating manual.

Designated Engineering Representatives should be utilized to submit data as defined in the Partnership for Safety Plan. Designated Engineering Representatives submit FAA Form 8110-3 with data that has been Designated Engineering Representative approved or recommended for approval. Data submitted without an FAA Form 8110-3 will require FAA engineering review and approval, which may add to the processing time. This should be taken into account when developing the project schedule.

The FAA and the applicant will agree and document the amount of time needed for review, disposition, and approval or acceptance of the data, as appropriate. Typically, this may be up to four (4) weeks for designee recommended approval data. Some submittals, due to size or complexity, may require more time. Some examples include: Instructions for Continued Airworthiness and safety analyses. The timing and process for such submittals should be agreed upon between the FAA and the applicant and documented in the Project Specific Certificate Plan. Data submittals that are designee approved are reviewed only for designee oversight purposes, whereas data that is recommended for approval must be reviewed for those aspects that the designee could not or did not evaluate. Hence, communication and pre-planning for data submittal and consideration of the level of delegation between designees and the FAA is essential and encouraged to ensure timely efficient data approval.

9.7 Production Approval

This section of the Project Specific Certificate Plan should outline production quality project issues and tell how they will be managed to permit early approval of the production system. The goal is to have concurrent design and production approval issuance. The primary focal points for the production approval process are the FAA Principal Aviation Safety Inspector and the applicant's Project Quality Manager. Production approval is granted after the applicant has demonstrated, and the FAA has verified, that the applicant has developed and is capable of maintaining a quality assurance system. This system will ensure that only products and parts conforming to the design data are released for commercial service use. For existing Production Approval Holders (PAH) who will be adding a new product to an existing approved production system, issues to be considered should include the following:

- Approval of new materials, new processes, new suppliers, co-production agreements, new technologies or new applications of existing technology, etc.
- FAA undue burden assessment of either non-US suppliers or co-producers, or both.
- Instructions for assembly and test of the final product to ensure conformance.
- Coordination with engineering on production Material Review Board requirements and integrating engineering and production Certificate Management activities.
- Controls to be placed on production as a result of design Airworthiness Limitations or the criticality of parts and components.
- Configuration control requirements.
- Any other reviews necessary to ensure that a conforming product will be produced under the FAA approved quality inspection system.

Applicants who do not hold an existing production approval for the type of product that is being approved under this Project Specific Certificate Plan must also demonstrate, to the satisfaction of the FAA, the existence of and compliance with a quality system that satisfies all of the requirements of the applicable subparts of 14 CFR Part 21.

9.8 Post Approval Requirements Compliance Summary Document

The applicant and FAA Project Managers will prepare a summary at the end of each approval project to capture and retain the corporate knowledge learned during the project. The summary should capture only unique data, precedent issues (for example, regulatory, policy, or technical), and both the applicant and the FAA perspectives, feedback, and lessons learned. This document is not to be a complete history of the project but should only document those areas out of the ordinary that require process improvements, affect rule/policy making, and so forth, in order to provide continuous improvement of the FAA and the applicant's working relationship. This summary, plus the phase evaluation checklists, should be evaluated by the team and appropriate changes to the Partnership for Safety Plan or future Project Specific Certificate Plans should be made.

9.9 Project Issue Planning

The applicant and FAA Project Managers will jointly maintain a project issues tracking list. This list, at a minimum, should include issues identified as potential "show-stoppers." The list will identify the issue, the plan and milestones for their resolution, as well as the primary responsible team member for ensuring the closure of each issue within the operating norms of the project schedule. The Project Managers will continually manage those issues to ensure adequate progress is being made on their resolution to not adversely affect the project schedule. The Project Managers will identify to their management and other appropriate team members, concerns and problems with open issues and seek early resolution of any items not proceeding according to the agreed Project Specific Certificate Plan. The process, as defined in a Partnership for Safety Plan, may be incorporated by reference in the Project Specific Certificate Plan, or a specific process could be included here to meet any unique needs of the particular project.

9.10 Continuous Improvement

9.10.1 General

In this section a statement should be made that the continuous improvement processes detailed in the Partnership for Safety Plan will be followed.

9.10.2 Phase Evaluation Checklist

The Phase Evaluation Checklist is a tool that can be used for project management as the project moves through the five phases. The FAA and the applicant Project Managers should jointly prepare a Phase Evaluation Checklist at the beginning of a project. The applicant/FAA team should continuously evaluate the project for immediate process improvement. For long duration projects, the Project Managers should complete the “Deliverables” portion of the form at the end of each phase. For projects with a short completion time, the form should be completed at the end. The Project Managers are encouraged to include the completion of the Phase Evaluation Checklists as milestones when preparing their Project Specific Certificate Plan schedule.

To facilitate continuous improvement, any necessary corrective actions should be implemented by the team and the Phase Evaluation Checklist should be maintained in the FAA and applicant’s official project file for future national or local program evaluation. When the evaluation identifies the need for corrective actions or improvements, it should be included as a part of the Compliance Summary Document for future reference.

10.0 Implementation

This report lays a foundation for an approach to enable NASA to identify critical elements of consumer need for the development and deployment of Multi-mode Digital Avionics. Further, this report identifies and recommends issues and methods to assist NASA in determining the nature of public investment for the development of MMDA as well as guidelines for work closely and partnering with the FAA to advance innovative methods to improve the FAA’s certification process.

Aviation Management is fully prepared to assist NASA in next step efforts needed to deploy the myriad benefits of MMDA that helps drive a transformation of the National Air Transportation System. These are as follows:

- Apply a Design for Six Sigma regime to the development of MMDA concept and design suitable for prototyping.
- Work with NASA and selected vendors to coordinate closely with FAA certification offices and officials to optimize efforts to build prototype designs that are consistent with FAA certification processes.
- Work with NASA and selected vendors to coordinate closely with FAA certification offices and officials to develop new methods and approaches to improve the FAA's certification process.

The benefits of NASA investments are achieved when MMDA deployment is realized and it proves its worth in the commercial marketplace. This report has provided a first step to realize this goal. The next step towards development and implementation of MMDA technology is up to NASA.