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TASAR Certification and Operational Approval Requirements — *Analyses and Results*

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May 2015

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Acknowledgments

This report represents one of two Summary Reports documenting the culmination of effort by Rockwell Collins and the University of Iowa Operator Performance Laboratory (OPL) on NASA Contract NNL12AA11C supporting NASA's development of the Traffic Aware Strategic Aircrew Requests (TASAR) Electronic Flight Bag (EFB) application. This report documents the analysis and assessment activities pertaining to Task 1 of this contract that determine certification and operational approval requirements for the TASAR EFB Application. The companion Task 2 Summary Report not contained herein provides approval artifacts derived from two Human-in-the-Loop (HITL) simulation experiments [0]. Rockwell Collins and the University of Iowa OPL are pleased to have been part of the extended TASAR research team. While many contributed to the overall effort, we would like to acknowledge the roles and contributions of the following individuals for their valuable contributions throughout this program:

- From NASA Langley Research Center: David Wing, the TASAR Program Principal Investigator and Technical Monitor of the research effort described in this report; Mark Ballin, strategic planner and visionary for advanced concepts such as TASAR; Dr. Kelly Burke for her leadership in the Human-in-the-Loop (HITL) simulation experiments and her Human Factors expertise; and Joey Ponthieux, for his support and collaboration with OPL on the development of the TASAR Computer Based Training Prototype.
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Contributions of those mentioned and others working behind the scenes resulted in an effective collaboration of the extended TASAR team led by NASA throughout this research program.

1. Introduction

This report documents the results of research and development work performed by Rockwell Collins in addressing the Task 1 objectives under NASA Contract NNL12AA11C. Under this contract Rockwell Collins provided analytical support to the NASA Langley Research Center (LaRC) in NASA's development of a Traffic Aware Strategic Aircrew Requests (TASAR) flight deck Electronic Flight Bag (EFB) application for technology transition into operational use.

The two primary objectives of this contract were for Rockwell Collins and the University of Iowa OPL to 1) perform an implementation assessment of TASAR toward early certification and operational approval of TASAR as an EFB application (Task 1 of this contract), and 2) design, develop and conduct two Human-in-the-Loop (HITL) simulation experiments that evaluate TASAR and the associated Traffic Aware Planner (TAP) software application to determine the situational awareness and workload impacts of TASAR in the flight deck, while also assessing the level of comprehension, usefulness, and usability of the features of TAP (Task 2 of this contract). This report represents the Task 1 summary report. The Task 2 summary report is provided in [0].

1.1 Background and Motivation for TASAR

The development of technologies such as TASAR support the objectives of the former NASA Airspace Systems Program (ASP) and its NextGen Concepts and Technology Development (CTD) Project, as well as the new NASA Airspace Operations and Safety Program (AOSP). The NextGen CTD Project developed innovative concepts and technologies to improve the efficiency, capacity, and safety of the National Airspace System. Research focus areas included traffic flow management, dynamic airspace configuration, separation assurance, super density operations, and airport surface operations. In the area of separation assurance, CTD research included the development of advanced concepts and technologies for aircraft to provide their own traffic separation services, i.e. airborne separation, using Automatic Dependent Surveillance Broadcast (ADS-B).

CTD research produced advanced algorithms for detecting and resolving traffic conflicts in the presence of weather and time constraints. Leveraging this far-term research, NASA envisions a near-term application of this advanced flight-deck technology to improve pilot-initiated requests for trajectory change(s) made to Air Traffic Control (ATC) in today's operations. In a concept called "Traffic Aware Strategic Aircrew Requests" (TASAR), pilots would use onboard automation tools to identify trajectory improvement opportunities that are deconflicted from traffic aircraft, i.e., traffic aware, and also aware of environmental constraints, e.g., weather, winds, airspace constraints, that may adversely affect their flight route, prior to making the trajectory-change request to Air Traffic Control (ATC).

The TASAR capability is anticipated to increase ATC approval frequency and therefore achieve benefits in areas such as flight efficiency, flight schedule compliance, passenger comfort, and pilot and controller workload. With TASAR, NASA intends to help accelerate the adoption of networked flight-deck automation systems and ADS-B equipage by the aircraft operator community.

1.2 Contract Objectives

The objectives of this contract were to 1) analyze and assess the implementation requirements for certification and operational approval of TASAR (Task 1 of this contract and addressed by this report) and 2) to assess human factors including pilot workload and situational awareness associated with the TASAR flight-deck technology (Task 2 of this contract, but addressed in a separate summary report [0]). By analyzing the implementation requirements and assessing pilot use of the TASAR capability in simulation, the path to implementation for operational use can possibly be shortened. NASA Contract NNL12AA11C was awarded to Rockwell Collins and its subcontractor, the University of Iowa Operator Performance Laboratory (OPL), for these tasks under the NASA Headquarters Aeronautics Research Mission Directorate (ARMD) NASA Research Announcement (NRA) entitled “Research Opportunities in Aeronautics” – 2010, Amendment 7, NextGen CTD Project, Subtopic 5.

1.3 Organization of this Report

Section 1 of this report presents an introduction and context for the research. Section 2 provides an overview and high-level description of the TASAR EFB application and summarizes the high-level results of this assessment. The research objectives for Task 1 of this contract and documented in this report are identified in Section 3 and the attendant research results are provided in Section 4. Due to the expansive nature of regulatory documents that apply to EFB applications, a number of appendices are provided that capture the TASAR-specific certification and operational approval requirements and provide some artifacts that were developed that may be used in gaining early operational approval for TASAR.

The certification and operational approval analyses included the development and analysis of a TASAR User Community Survey of end users, including pilots, dispatchers and flight operations personnel, to gain their perspectives and needs for the capabilities offered by TASAR. An operational hazard assessment of TASAR was made in order to determine the Failure Effects Classification (FEC) of TASAR, which plays a significant role in determining the extent of certification and operational approval requirements that must be addressed. EFB industry standards adherence requirements were identified for TASAR and a detailed review of FAA guidelines and regulatory requirements were made. A certification plan for TASAR was developed for future TASAR approval. Certification and operational approval requirements were identified and underwent review with in-house Designated Engineering Representatives (DERs) as part of an approval “Dry Run.” NASA and Rockwell Collins then met with key decision makers at FAA in a technical interchange which validated our analysis findings provided in Section 4.

2. TASAR Overview and High-Level Description

The TASAR EFB application is currently being developed by NASA in order to leverage emerging flight deck technologies for cost benefits to current flight operations. The TASAR operational

concept is described in [1] and [2] with the TASAR application description found in [3]. Reference [4] describes NASA's work in developing TASAR as a near-term, low-cost application. Reference [2] also provides a description of TASAR operational scenarios. A preliminary benefits assessment of TASAR is found in [5]. Screen shots of Version V2 of the TASAR Human Machine Interface (HMI) design are provided in [3]. An overview of the operational safety and certification assessment of TASAR is provided in [6] with a detailed operational hazards and safety requirements analysis of TASAR provided in [7].

Among the systems technologies that comprise or support TASAR are flight-optimizing software algorithms, a software hosting device such as a Portable Electronic Device (PED) EFB, ADS-B IN and other sources of traffic information, and additional airborne sensor data and ground-based information via data link, internet connectivity, etc. TASAR seeks to provide cost-beneficial optimization with respect to the current flight plan, taking traffic and other constraints into account. Using these information sources, the TASAR application has the ability to react in an agile manner to changes in the airspace environment (e.g., adverse weather, winds, airspace constraints, and / or improved timeliness and accuracy of information about factors that affect the aircraft's execution of its flight plan).

TASAR employs a flight deck-based application that seeks to identify and recommend trajectory improvement opportunities to the pilot that have a high probability of approval by ATC. Utilizing available information of own-ship flight status/plan and airspace environment (e.g., proximate traffic, weather, winds, ATC system status, etc.), the TASAR application seeks to identify and recommend candidate trajectories for consideration by the pilot that have higher probability of ATC approval. The pilot, at his or her discretion, can choose to issue a change request to ATC based on TASAR recommended trajectory change candidates.

Prior to recommending trajectory change candidates to the pilot, TASAR uses available on-board traffic data to account for potential conflicts. It uses weather and restricted airspace data to avoid these hazards. It may also account for known ATC rules to increase likelihood of approval. Thus, recommended trajectory change request candidates from TASAR to the pilot are expected to have the following characteristics that will encourage increased pursuit of flight plan improvements by the pilot from ATC via change requests:

- 1) Provide ongoing optimization of the flight plan in terms of time and / or fuel savings or other desired attributes such as passenger comfort.
- 2) Meet operational goals for the flight, as provided by pilot preference inputs
- 3) Have a high potential for approval by ATC by considering ATC constraints in the identification process

TASAR trajectory change request candidates are advisory-only to the pilot, and the pilot has full discretion on whether or not to select a TASAR-provided trajectory change for a subsequent change request to ATC. Pilot training ensures that the pilot's priorities (aviate, navigate, and communicate) and proper coordination with ATC, (e.g., change requests) are followed as in today's operations. The pilot has responsibility to evaluate TASAR-provided trajectory change candidates for operational acceptability before making a change request to ATC.

As in today's operations, ATC has separation responsibility and is authorized to deny change requests from the pilot that do not meet ATC constraints and requirements. TASAR makes no changes to the rules and procedures that govern the interactions between pilots and controllers.

Summary of TASAR Research Results from this Contract

As described below in the main body of this report, the TASAR EFB application was analyzed in detail against applicable FAA regulatory documents to determine certification and operational approval requirements that must be met to gain approval for use as an advisory decision support tool to the flight crew. Operational hazard analyses were conducted to determine the TASAR Failure Effects Classification (FEC) and associated safety requirements. The results of these analyses were presented to FAA certification (AIR) and operational approval (AFS) authorities by NASA and Rockwell Collins as part of an information meeting held at the FAA office. The FAA AIR and AFS authorities concurred with the findings of our certification and operational approval requirements analysis and confirmed that the TASAR EFB application would be considered for a Class 2 EFB and be representative of a Type B application. They also noted that the TASAR application would be approvable using a “Minor Effect” FEC due to potential workload considerations and would warrant a “No Effect” designation from a loss of function perspective.

For software and hardware-specific approval requirements, FAA concurred that there are no software airworthiness approval requirements for TASAR as a standalone application. TASAR, as a standalone application, does not require DO-178B compliance in its development even for a Design Assurance Level D. Some software-specific requirements will need to be addressed if TASAR is hosted on a platform that is also hosting other certified applications.

The majority of certification-related compliance requirements for the TASAR EFB system fall into the hardware domain. Airworthiness regulations apply to installed EFB components and do not apply to the portable EFB components, including internal components of the EFB. For TASAR this primarily involves the installed components related to mounting (size and weight), power (maximum electrical load, voltage, and current frequency), and data connectivity (input/output data specifications and security). Software and hardware-specific requirements are discussed in detail in the body of this report.

In addition to the analyses of certification and operational approval requirements leading to future approval of the TASAR application by FAA, this contract also developed and performed two HITL human factors experiments using the TASAR EFB application integrated in the University of Iowa OPL Boeing 777 simulator. The goal of these HITL studies was to determine via objective and subjective measures the impact of TASAR on the conduct of flight operations (including non-normal situations), as well as to evaluate the HMI at two stages in its design. The development, execution, and analyses of the two HITL simulation experiments represents Task 2 of this contract and are provided in a separate document [0].

3. Research Tasks and Activities

This section identifies the specific research tasks and associated activities that were performed in Task 1 of this contract. The objectives of Task 1 were to perform analyses and assessment of the TASAR EFB application to support its near-term implementation, i.e., to gain early certification and operational approval of TASAR by FAA approval authorities.

The implementation assessment tasks and activities described in this report are intended to generate guidance that ensures that all preparatory research and development by the TASAR team (NASA, Rockwell Collins and OPL, and other TASAR contractors) have maximum applicability

toward enabling the near term implementation of TASAR. The description and results of these activities are documented in Section 4.

The analyses and assessments performed and documented herein identify the requirements for equipment certification, operational approval, and user / FAA acceptability for entering TASAR into operational service. They serve to refine the TASAR concept in collaboration with NASA and other TASAR contractors by engaging the user community and the FAA, subsequently lead to strategies and requirements for implementation of the TASAR concept.

The following represent the research activities performed in support of Task 1 of this Contract:

1. User Community Survey (see Section 4.1 for details)
 - a. Design a User Community Survey on current aircraft-operator practices for improving trajectories while aircraft are en route (Section 4.1.1)
 - b. Review results of NASA’s preliminary data analysis; provide additional findings and recommendations for the TASAR concept and implementation strategies that would accelerate user adoption of TASAR (Section 4.1.2)
2. Certification and Operational Approval Requirements (see Section 4.2 for details)
 - a. Analyze TASAR for comprehensive operational hazards. Define and document safety requirements to mitigate the operational hazards (Section 4.2.1)
 - b. Determine TASAR requirements for adherence to industry standards for aircraft systems development and EFB devices; determine and document the specific design, development, test, validation, and approval requirements necessary for entering TASAR into operational service (Section 4.2.2)
 - c. Analyze TASAR with respect to FAA guidelines and regulatory requirements for certification and operational approval; determine the most appropriate and efficient methods and processes for pursuing certification and operational approval, and produce a corresponding detailed plan (Section 4.2.3)
 - d. Develop representative TASAR artifacts for certification and operational approval processes. “Dry run” these processes with in-house Designated Engineering Representatives (DER). Document the review process, the DER’s feedback, and the associated changes to the artifacts and processes (Section 4.2.4)
 - e. Determine the additional certification and operational approval requirements, if they exist, of the TAP HMI Version 4 as a “delta” analysis to the findings of the certification and operational approval requirements analyses (Section 4.2.5).
3. Engage the FAA community in coordination with NASA, including the directorates responsible for certification and operational approval, to research FAA guidance for entering TASAR into operational service (Section 4.3).

4. Research Program Description and Documentation of Results

This section provides a detailed description of the research activities conducted in Task 1 and the results of this research. Research results focus on the implementation assessment of TASAR and identify certification and operational approval requirements and artifacts that can be used toward gaining FAA approval.

4.1 User Community Survey

As part of its development of the TASAR application, NASA tasked Rockwell Collins to develop a user community survey of key stakeholders in order to gain insight into their operations to inform the development of the TASAR application. Rockwell Collins developed the initial draft survey and then worked jointly with NASA and a contractor subject matter expert to collaboratively refine and further develop the survey that was then used by NASA in engaging the operators. Three aircraft operators were surveyed representing 1) a major network carrier (i.e., global operator), 2) a domestic low-cost airline, and 3) a fractional operator of business aircraft. Surveyed within these operators were pilots, dispatchers, and flight operations personnel. The surveyed operators represent a relatively broad spectrum of potential users of TASAR.

4.1.1 TASAR User Survey Overview

The goal of the TASAR survey was to solicit information from potential end users of TASAR concerning their current flight operations, with specific focus on flight planning and re-planning in today’s airspace operations. The survey requested information on a notional flight in terms of “challenges” and their frequency of occurrence during flight operations and flight re-planning in the presence of changing conditions affecting the flight. The survey requested response on available support tools, information sources utilized, and their effectiveness (i.e., well-served or under-served) in achieving efficient flight operations. The survey also sought information on current and planned avionics equipment of operator fleets that are closely aligned with the type of capabilities associated with TASAR.

The survey included questions directed at various stakeholders within each operator organization, including pilots, dispatchers, and flight operations personnel. Tables 1, 2, 3, and 4 summarize survey questions in tabular format. NASA provided a consolidated data set of survey results that integrated the individual responses from each stakeholder survey. Approximately 12 pilots and 12 dispatchers responded from the three operators surveyed. It was this consolidated data set that was reviewed in order to provide the observations and recommendations that will be discussed in the next section (Section 4.1.2).

The TASAR User Community Survey consisted of four sections. The initial section, summarized in Table 1, represents survey topics that focused on the demographics of the operator. Table 2 represents survey topics requested from the pilot community of the operator. Table 3 summarizes the survey topics that pertained to dispatchers, and Table 4 lists survey topics addressed to the operator’s flight operations.

Table 1 Operator Survey Questions by Category – Operator Demographics

Survey Topic		
	Category	Detail
Operator Demographics	Type of Operator	E.g. major air carrier, domestic airline, fractional operator, etc.
	Aircraft fleet size	<10, 11-49, 50-99, 100-500,>500 aircraft
	Fleet mix	Type / make of aircraft
	Stage Length	Short haul (<2 hr. flight), medium haul (2 to 4 hr.), long haul (greater than 4 hrs.)
	Typical flight departure and arrival airports	Hub, non-hub airport
	Number of active pilots	
	Peak airborne number of flight	

	Number of dispatchers	
	Number of dispatchers on duty during peak operations	
	3 rd party in-flight optimization	Not for flight planning, but service support during flight

Table 2 Operator Survey Questions by Category – Pilots

Survey Topic		
	Category	Detail
<i>Pilot Survey Questions</i>	Years of experience	
	Flight categorization by level of challenge	Percentage of flights viewed as minimally, moderately, or extremely challenged – level of disrupted operations due to environmental factors, e.g., weather, adverse winds, airspace disruptions, traffic delays, security event
	Estimated impact in terms of fuel burned and flight time of “actual” flight when compared to “original” pre-departure flight plan	Under various challenge levels (minimally, moderately, extremely challenging flight conditions)
	Impact of ATC constraints on operational efficiency	
	In-flight re-planning capabilities available to pilots	E.g., Flight Management System (FMS), automation / manual cockpit tools, company provided, 3 rd party provided, other
	Effectiveness of in-flight re-planning capabilities	<ul style="list-style-type: none"> • Provided by dedicated company personnel – without tools; with tools • Provided by automated monitoring, advisory service–company resource; 3rd party • Achieved by pilot, with tools
	Typical number of change requests per flight	Function of stage length
	Types of change requests during en-route operations	E.g., change requests for altitude, heading, lateral route, speed, or combination
	Level of coordination of change requests with dispatcher	Percentage of change requests coordinated with dispatcher
	Type of coordination of change requests with dispatcher	Initiation and coordination of change request with/without dispatcher
	Type and Frequency of action by ATC in response of change request	E.g., immediately approved, cleared after standby, etc.
	Reasons for denial of change request	E.g., traffic, traffic congestion, weather routing, metering, controller workload, other

4.1.2 Survey Results, Findings, and Recommendations

This section provides an overview of the review and assessment of received TASAR survey responses and NASA’s preliminary consolidation and analysis of these responses. The objective of the analysis performed by Rockwell Collins was to determine findings and recommendations for the TASAR concept and implementation strategies that would accelerate user adoption of TASAR. Detailed results of the TASAR User Survey analysis are found in Appendix A.

Recommendations and observations derived from the analysis of TASAR user survey responses fall into two categories as follows:

- 1) Equipage for TASAR

2) TASAR cost benefits, usability, and synergy with dispatch and ATC processes.

Table 3 Operator Survey Questions by Category – Dispatcher

Survey Topic		
	<i>Category</i>	<i>Detail</i>
<i>Dispatcher Survey Questions</i>	Years of experience	
	Average number of flights managed per dispatcher	
	Peak number of flights managed per dispatcher	
	Organizational policies and procedures	With respect to level of empowerment for pilot to perform flight re-planning
	Automation tools for monitoring flight efficiencies	Available automation tools
	Adverse factors affecting original flight plan	Adverse weather, metering, etc.
	Constraint factors affecting flight re-planning	Connecting flight, fuel reserve, lack of sufficient information on flight or airspace status, lack of accurate and timely weather information, etc.
	Available flight planning capabilities	Company provided with/without tools, company automated monitoring, 3 rd party automated monitoring, etc.)
	Information sources for Dispatch support	Accurate convective weather forecasts, wind speed / direction / temperature, airspace status, airport facility status / weather / traffic information
	Priority ranking of information sources for Dispatch support	
	Effectiveness of information sources for Dispatch support	
	Comments on areas lacking and insufficient information for dispatch	
	Comments on areas of information source improvement	
	Time spent on flight optimization	
	Effectiveness of current flight optimization capabilities	Under various levels of challenged flights (minimally, moderately, extremely challenged)
	Level of flight planning constraint impacts in being able to achieve desired (unconstrained) flight	
	Reason for flight re-planning by dispatch	In-flight emergency, equipment failure, low fuel reserve, significant weather, etc.
	Time savings threshold for initiating an en-route re-plan	
	Fuel savings threshold for initiating an en-route re-plan	

4.1.2.1 Equipage for TASAR

Based on survey responses from the three operators surveyed, a favorable finding is that from an equipage perspective, the operators surveyed in many cases are beginning to equip with the type of avionics systems and associated EFB and data communication capabilities needed to enable

TASAR. ADS-B OUT (primarily 1090 MHz), EFB Class (1, 2 or 3), internet access (via terrestrial and/or satellite networks) and data communications (Aircraft Communications Addressing and Reporting System (ACARS), Controller Pilot Data Link Communications (CPDLC)) are already in their plans. ADS-B IN (1090 MHz and/or Universal Access Transceiver (UAT)) plans are considerably less certain.

Table 4 Operator Survey Questions by Category – Flight Operations

Survey Topic		
	Category	Detail
<i>Flight Operations Survey Questions</i>	Avionics equipage current and plans (today, in 2 years, by 2020)	<ul style="list-style-type: none"> • ADS-B Out • ADS-B IN • 1090 MHz, UAT • EFB Class (1, 2, and/or 3) • EFB Operating System (Windows, Linux, iOS) • Internet Access – terrestrial and / or satellite based • Data Communications via ACARS • Data Communications via CPDLC
	Priority rating of cost factors affecting flight path performance	Fuel, flight time, schedule integrity, ride quality, other
	Level of costliness of cost factors	
	Revenue impact sensitivity rating for operational factors	E.g., on-time performance, fuel efficiency, ride quality, other
	Rating of level of disruptiveness of flight factors	E.g., poor forecast of winds, airspace disruptions, etc.
	Assessment of actual versus original flight plan performance	With respect to flight time, fuel burned, on-time arrival
	Factors that adversely affect performance	Weather, metering, etc.
	Company constraints to be consider by pilots when initiating en route flight re-planning.	E.g., arrival sequence with other organization flights, gate availability, critical connections, requirement for fuel stop, etc.

In this regard, the Fractional Operator, with its fleet of business and regional aircraft, is already well equipped with data connectivity to ground systems. The two airline (air transport) operators, particularly the Global Network Carrier, are more reliant on ACARS and data communications and are currently not as connected to internet data networks, but this is improving. It is recommended that data connectivity be strongly encouraged for all operators to provide the most effective information access for TASAR. While TASAR’s traffic awareness is highly desirable, a prolonged period of mixed ADS-B equipage (both ADS-B OUT and ADS-B IN) is likely a reality for several more years, with the ADS-B OUT mandate in the United States not becoming a requirement until 2020. Cost benefits that can be gained from TASAR may help with this, but these must be fairly significant to create the pull for ADS-B IN equipage on their own. More likely, additional beneficial ADS-B applications for NextGen will need to assist with this pull.

The most significant and encouraging finding is that the operators surveyed, representing a significant cross-section of aircraft operators, are beginning to have avionics and associated EFB and data communications capabilities capable of supporting early introduction of TASAR.

4.1.2.2 *TASAR Cost Benefits, Usability, Synergy with Dispatch & ATC Processes*

In order to achieve a positive business case for TASAR, two key requirements must be achieved:

- 1) Access to relevant, quality (i.e., accurate, timely {sufficient update rates, sufficient latency}) information sources (both ground-based and flight-deck based)
- 2) Synergistic integration of TASAR with available flight (re)planning tools and processes used by dispatchers and pilots, while also being consistent with Air Traffic Control processes (i.e., change requests, traffic flow management including arrival flows).

Without sufficient quality and completeness of information, TASAR is unlikely to provide reliable cost benefits. Pilot acceptance of TASAR is likely dependent on TASAR providing consistent and believable trajectory change recommendations with the indicated savings in fuel and/or flight time being actually achieved. In the longer term, TASAR's utility should be integrated in a consistent manner with other flight planning and flight optimization processes utilized by Dispatch and should be consistent with ATC processes and procedures.

While initial studies indicate the benefits of TASAR [5], a thorough assessment of TASAR cost benefits is likely required. Current on-going and planned flight simulations (University of Iowa OPL pilot evaluations in the use of TASAR using a Boeing 777 simulator), flight trial (Advanced Aerospace Solutions, LLC flight evaluation of TASAR using their Piaggio Avanti P180 aircraft), and ongoing research by NASA can assist in development of the TASAR business case.

The following, in no particular order, represent the collection of general observations and comments identified regarding current flight planning and in-flight re-planning procedures, tools, information sources and their effectiveness (or lack thereof) as determined from survey responses from pilots, dispatchers, and flight operations personnel from the operators surveyed:

- 1) From a Dispatch perspective, significant weather as observed by Dispatch or per notification from the pilot or ATC is the primary reason for re-planning of the flight. Airspace disruption notification from ATC follows weather as the next key factor for re-planning.
- 2) Dispatchers rate the effectiveness of current flight optimization capabilities (and the available time to perform those duties) as moderately effective (4+ of 7, with 7 being most effective). These capabilities were slightly more effective for "minimally impacted" flights and slightly worse for "extremely impacted" flights due to adverse environmental factors.
- 3) Weather is a primary consideration for dispatchers, with ATC constraints, airspace disruptions and constraints being a somewhat secondary factor (still important but not at the level of weather). Conversely, for pilots, ATC constraints and airspace disruptions are a larger factor, with en route weather being a secondary, less constraining factor in in-flight re-planning.
- 4) Tools provide a range of strategic and tactical capabilities with respect to monitoring flight efficiencies. Tactical tool capabilities seem to focus on Dispatch gaining access to a specific aircraft's Flight Management Computer (FMC) for position reports and associated flight parameter data and do not appear to provide a tactically integrated view of flight operations. TASAR has the ability to provide a more integrated tactical view from the specific own ship's perspective, factoring in environmental constraints with respect to the current flight path.

- 5) Timeliness, accuracy, and breadth of information must continue to improve to enable effective flight re-planning. At the same time, information management is required to avoid dispatcher information overload of excessive information detail and rapidity of updates. This requires intelligent automation to support dispatchers to allow them to manage the planning and re-planning of flights while keeping workload at reasonable levels.
- 6) It is evident that both dispatchers and the pilot can benefit from improved information, particularly related to weather. Airspace information seems to be less of a factor. TASAR likely plays a tactical role in re-planning of the flight, while the role of Dispatch is more strategic.
- 7) From pilot survey inputs concerning use of tools it is noted that tools are generally employed. Without tools, any support is not viewed as effective:
 - a. Hands-on company support is used significantly (80+ %) and is moderately to very effective. Automated monitoring and advisory services are used less frequently but when used, are effective. Most pilots (80%) do not use 3rd-party automated monitoring and advisory service support. Effectiveness was rated best for the more impacted flights (extremely and moderately challenged) due to adverse environmental conditions.
 - b. Pilot in-flight re-planning with tools is heavily used (90%) and very to moderately effective (used a bit less when extremely challenged – perhaps due to pilot workload). Without tools, pilots still attempt to try to consider re-planning, but only with somewhat effectiveness at best.
 - c. Survey results and insight into the pilot tools used (except for the FMS, which is always used), are not very specific and would require further investigation and dialog with pilots.
- 8) Pilots have considerable latitude for making flight changes, particularly for altitude and speed changes, guided by the company Operations Control Manual. Request for route changes are more likely to require dispatcher approval. Sufficient pilot empowerment is in place at the surveyed operators to allow utilization of TASAR capabilities to seek improvements to the current flight plan.
- 9) From a Dispatch perspective pertaining to time spent on flight optimization, there is a trade-off on time spent versus savings achieved; if airlines are not focused or motivated to spend additional time to improve the efficiency of flights, then they either do not have the means to do better (i.e., in the way of tools and available quality information), or it is not a big cost issue to be considered. It is unlikely that they are just not focused on seeking cost improvements due to lack of focus and is likely related tool availability.
 - a. A follow-up question would be concerning which flights should Dispatch expend more effort on optimization – long haul and/or international flights? Also, once operators are able to operate in a more “free flight” airspace perhaps in NextGen, with fewer constraints imposed (versus the more rigid route structures of today’s operations), then more significant gains can be made, and greater focus on optimization by Dispatch may be warranted.

- 10) Dispatcher can inquire position reports from the FMC and derive additional real-time information on current flight parameters, which is viewed as a very effective re-dispatch and re-evaluation tool.
- a. From survey responses, Dispatch tends to play a relatively limited role for in-flight re-planning. This is particularly the case for the Global Network Carrier surveyed, which only provides support services while the aircraft is in-flight when prompted by pilot requests.
 - b. A potential area of research is to determine to what extent should Dispatch focus on in-flight re-planning, which is currently not their focus, or should this be delegated to flight-deck tools, e.g., TASAR. What is the proper balance of Dispatch versus aircraft-based in-flight re-planning to ensure synergy? In addition, to what extent can TASAR take on flight planning typically done by dispatch, particularly in future NextGen operations that support “free flight” capabilities?
- 11) TASAR, with good (i.e., pertinent, accurate, and timely) information on ATC metering and flow management and weather information (especially en route and at the destination airport), has the potential to provide significant tactical re-planning capabilities for operational efficiency. With TASAR, the key issue is its usability, i.e., providing benefits while at the same time being streamlined with operator dispatch, own ship flight procedures using the FMS, and with ATC’s overall air traffic control paradigm (change request clearances, traffic flow management, arrival management, etc.).
- 12) A number of improvement opportunities are identified as a result of survey responses. It would be beneficial to more closely evaluate the major aspects of flight planning and re-planning processes and how they translate into successful conduct of the flight. Further analysis on which information elements and how improvements in information quality will provide improved flight planning and in-flight re-planning is warranted.
- 13) Additionally, the roles of Dispatch in planning and in-flight re-planning, in conjunction with the role of the flight deck (applications and flight crew capabilities) in performing in-flight re-planning using tools such as TASAR should be clearly delineated and allocated synergistically for maximum benefit. In addition, re-planning in the presence of changing environmental factors needs to be accomplished in a consistent way with current and future ATC processes and procedures.

In summary from an aircraft equipage perspective, TASAR is poised to be readily achieved, with the possible exception of ADS-B IN. A positive cost benefit business case is a key requirement for operators to continue to equip and enhance their avionics, EFB and data communications level of equipage for their aircraft fleets. Perhaps the most significant challenge is the development of a more robust cost benefit assessment for TASAR that supports synergistic usability with Dispatch and ATC processes as part of the in-flight re-planning to achieve operational efficiencies in the presence of changing environmental conditions (e.g., weather and airspace disruptions).

Note: While survey results were carefully reviewed, survey questions and corresponding responses are at times qualitative and subjective in nature. In addition some responses represent only a small sample and thus cannot be used to make fundamental conclusions and extrapolations. However, the three operators represented in the survey and the comprehensive questions and responses from the various stakeholders involved in flight

planning and flight execution do allow reasonable conclusions to be drawn that were used to inform the TASAR research team in developing updates to the TASAR application.

4.2 Certification and Operational Approval Requirements

This section examines the certification and operational approval requirements for TASAR. The analysis begins with a comprehensive operational hazards analysis and defines and documents safety requirements that serve as mitigations to potential operational hazards (Section 4.2.1).

Section 4.2.2 determines TASAR requirements for adherence to industry standards for aircraft systems development and EFB devices. Specific design, development, test, validation, and approval requirements needed for entering TASAR into operational service are also documented in this section.

Section 4.2.3 provides an analysis of TASAR with respect to FAA guidelines and regulatory requirements for certification and operational approval and determines the most appropriate and efficient methods and processes for pursuing certification and operational approval. A corresponding detailed plan for approval is provided.

TASAR artifacts for certification and operational approval processes were identified and underwent a “dry run” review with DERs at Rockwell Collins for feedback to determine if any changes to the artifacts and the approval processes were deemed necessary. These are documented in Section 4.2.4.

The TAP HMI has undergone redesign by NASA to incorporate pilot feedback based on HITL simulation experiments and from actual flight trials. Section 4.2.5 documents the results of an analysis of NASA’s TAP HMI Version 4 to assess certification and operational approval requirements. Specific focus of this analysis is on the TAP HMI V4 graphical elements depicting aircraft navigation information (e.g., routes, heading), traffic information, weather and airspace information, and wind information. The analysis provides observations with respect to regulatory reference on specific HMI changes to reduce the threshold for certification and operational approval.

4.2.1 TASAR Operational Hazard and Safety Requirements Analysis

This section provides the results of safety analyses performed to identify Operational Hazards and Safety Requirements for TASAR as an application that can be hosted on a PED / Portable EFB. Two safety assessment methodologies were used that are compliant with the FAA’s Safety Management System (SMS):

Method 1 A traditional safety assessment identification of hazards for the intended function of the system being developed, determination of worst credible effect due to the hazard, and subsequent FEC using ARP 4761 [9], AC 23-1309 [10] and AC 25-1309 [11] for Part 23 and Part 25 aircraft operations

Method 2 RTCA DO-264 / EUROCAE ED 178A Operational Safety Analysis [12].

The full report of the Operational Hazard and Safety Requirements Analysis is found as a NASA Contractor Report [7].

4.2.1.1 Approach to Safety Assessment

Two safety assessment approaches were used to determine the FEC for TASAR. FECs are based on Operational Hazards and available mitigations that were identified using these two methods. As presented below, the two safety analyses conclude that the worst case FEC for TASAR will likely be of “No Effect” and no higher than “Minor Effect.” This determination is subject to evaluation and approval by cognizant FAA certification and operational approval organizations responsible for authorization of EFB applications. Supporting rationale for the “No Effect” designation is provided in the safety analyses in 4.2.1.4 and 4.2.1.5 below.

Note: NASA and Rockwell Collins met with FAA certification (AIR) and operational approval (AFS) authorities and presented the approval requirements described in this report to them. They indicated that TASAR would warrant a “Minor Effect” FEC due to workload considerations, but noted that from an operational failure perspective, the “No Effect” designation is justified. Section 4.3 discusses the results of the meeting with FAA.

4.2.1.2 Safety Assessment Methodology High-Level Description

4.2.1.2.1 Method 1 Safety Assessment Overview

Method 1 (i.e., based on the analyses indicated by ARP-4761, AC 25-1309, AC 23-1309) represents the traditional system safety process for airborne systems and equipment, e.g., TASAR. This method performs the following steps relative to the intended function of the new system capability:

- 1) Evaluate the intended function per phase of flight
- 2) Identify failure events, e.g., loss of function; undetected, erroneous trajectory change request(s), etc.
- 3) Examine the effect of these failures on aircraft, pilot (or flight crew), and ATC
- 4) Determine the Hazard Classification, e.g., Major, Minor, No Effect
- 5) Determine frequency of occurrence, e.g., per flight hour, per operation
- 6) Provide rationale for hazard assessment.

4.2.1.2.2 Method 2 Safety Assessment Overview

Method 2 (i.e., based on RTCA DO-164 / ED-78A) represents a system-of-systems analysis approach that is well-suited for allocating safety requirements across a multiple-system function. This allows a more balanced allocation of safety requirements across systems and sub-systems, which is particularly beneficial for higher criticality systems. While an excellent approach for systems analysis, it is not as well suited for lower criticality systems such as TASAR. This is particularly true in the realm of “Minor” criticality systems, where this approach puts excessive emphasis on formal analysis related to operational effects such as workload (pilots and air traffic controllers), which are often highly subjective and difficult to assess in a quantitative manner.

Method 2 follows the following evaluation steps:

- 1) Perform an Operational Hazard Assessment (OHA)
 - a. Identify Operational Hazards
 - b. Determine the worst credible outcome of the Operational Hazard, i.e., the Operational Effect, e.g., collision, loss of separation, workload, etc.

- c. Determine the Severity Classes for each Operational Effect, e.g., Catastrophic, Major, Minor, etc., and identify the maximum allowable probability of occurrence of the Operational Effect
 - d. Determine the Effects Probabilities, which represent the probabilities of available mitigation(s) to the system to help reduce the probability of occurrence of the Operational Effect due to the Operational Hazard
 - e. Assign Safety Objectives, which represent the probability of occurrence of each Operational Hazard that is allowable for ensuring the safety of the application
 - f. Identify External Mitigation Means, i.e., barriers external to the application that reduce the adverse effects and impact to safety when Operational Hazards occur.
- 2) Allocate Safety Objectives and Safety Requirements
- a. Identify Abnormal Events and Basic Causes internal to the applications that could lead to the occurrence of each Operational Hazard
 - b. Identify Internal Mitigation Means, i.e., barriers internal to the application that reduce the probability of the Operational Hazard from occurring in order to achieve the required Safety Objective
 - c. Allocate Safety Requirements to the sub-functions comprising the application.

4.2.1.3 Trajectory Change Requests – Today’s Operations

This section briefly describes the trajectory change request process in today’s operations between the pilot and ATC for making change requests to the current flight plan. As conditions change during flight, it is common for the pilot to request an amendment to the ATC-cleared trajectory, e.g., to meet some need for safety, efficiency, or ride quality / comfort for passengers.

In today’s operations, pilot requests are often made with little or no awareness of the traffic situation or ATC sector considerations. Some of these change requests are denied by ATC for the following reasons:

- 1) Change request conflicts with other traffic
- 2) Change request conflicts with sector procedures in use by ATC
- 3) Change request is requested too close to the next sector handoff

The effects of denial of a change request by ATC to the pilot are:

- 1) Unnecessary workload burden on ATC
- 2) Discourages the pilot from making future requests to improve their flight
- 3) Flight improvement opportunities are often unrealized because pilot may not be aware of requests that would improve efficiency and be ATC approvable.

In general, the pilot seeking opportunities of improved safety, efficiency or ride quality has rather limited awareness of many of the factors that would adversely affect ATC acceptability of change requests to the current flight plan. This environment is not conducive for the pilot to seek operational efficiency improvements due to lack of situational awareness of the external environment that may constrain changes to the flight plan.

The next section explores a new TASAR capability that serves as an advisory-only tool to the pilot, providing informed trajectory change request candidates for pilot consideration as possible change requests to ATC for operational benefit.

4.2.1.4 TASAR “Intended Function” Description

TASAR is a flight deck-based decision aid consisting of software automation algorithms and a primarily textual display and is intended as an advisory-only service to the pilot to seek trajectory improvement opportunities over the current flight plan. TASAR is expected to be a hosted software application on an EFB. A Class 2 EFB installation is anticipated, with TASAR becoming a future Type B software application, pending successful certification and operational approvals by FAA. The TASAR EFB will interface to avionics as read-only (i.e., it will not transmit to avionics) as defined in the current concept of operations.

Note: A comprehensive assessment of FAA EFB regulations and guidance on PED / Portable EFB-based flight deck application was made under this contract and is presented in subsections of Section 4.2 below. Feedback from FAA approval authorities on the TASAR application is also provided below in Section 4.3 and in Appendix E of this report.

Based on inputs provided by 1) the pilot (in the form of flight objectives and optimization criteria), 2) on-board avionics systems, and 3) airborne internet data connectivity, the TASAR application computes available trajectory change request candidates that may improve the current flight plan. Trajectory change request candidates provided by TASAR are intended to have relatively high probability of ATC approval if requested by the pilot, as TASAR seeks to provide flight-optimizing, traffic-avoiding recommended trajectory candidates that anticipate ATC and airspace constraints.

The pilot has full discretion on the use of TASAR-provided trajectory change request information; they can choose to use TASAR-recommended trajectory change request candidates as part of a change request to ATC, or they can choose to ignore them. TASAR can be manually inhibited at any time, for any reason. Thus, in the event of observed spurious behavior of TASAR due to any system failure, inaccurate data obtained via network enabled information sources, or TASAR being a source of distraction to the flight crew, the pilot can simply inhibit or ignore TASAR. By following their training, the pilot can manage the use of TASAR in such away so that TASAR will not result in any workload increase in the flight deck.

TASAR is a supplemental system intended to provide operational benefits, without adversely impacting safe operations, and it does not replace any aircraft system or procedure needed for flight operations. The TASAR display is passive without explicit display of traffic and own ship position nor audible alerting. Loss of the TASAR EFB application for any reason does not affect the Minimum Equipment List (MEL) and does not affect normal flight operations.

TASAR information sources may include the following:

- 1) Own ship systems (aircraft state, auto-flight settings, flight plan and performance information from FMS, etc.)
- 2) Traffic data via ADS-B IN, Traffic Information Services Broadcast (TIS-B), or other sources via airborne internet
- 3) Airspace system status and forecast (sector use and configuration, Traffic Management Initiatives, Special Use Airspace (SUA), etc.)

- 4) Weather status / forecast
- 5) Wind status / forecast
- 6) Operator flight planning, preferences, and objectives.

4.2.1.5 Method 1 Safety Analysis – Conventional Method

This section addresses the safety assessment of TASAR using the traditional system safety process based on ARP 4761 [9], AC 23-1309 [10], and AC 25-1309 [11]. The key outcome of this safety assessment process is the determination of the FEC of the TASAR application. The FEC then drives the development and validation requirements and processes to be followed in integrating TASAR into the flight deck to gain certification and operational approval.

Using this safety assessment process (i.e., Method 1), applicants and certification and operational authorities (i.e., FAA aircraft certification and flight standards organizations) follow the process of assessing the new application and attendant procedures for potential failure modes and their impact on safety.

4.2.1.5.1 Key Factors that Influence the FEC of TASAR

The following list represents key factors that influence the determination of the FEC for TASAR:

- 1) TASAR is a supplemental system and thus is not relied on by critical functions supporting flight deck operations
- 2) TASAR use is optional, i.e., not a required system for flight operations. In the event of failures of the TASAR system, TASAR can be ignored or disabled without adversely affecting operations
- 3) TASAR has no MEL requirement
- 4) TASAR can be manually inhibited at any time, for any reason
 - a. Detected failure of the TASAR application
 - b. Detected failure of the host EFB
 - c. Spurious or inconsistent performance of recommended trajectory change requests
 - d. Distracting effects of TASAR to the pilot
- 5) Presence or loss of TASAR does not change responsibilities of the pilot for flight operations
- 6) TASAR is an “advisory-only” system (i.e., does not provide guidance information)
 - a. Pilot is not reliant on TASAR outputs to any extent to perform flight operations
 - b. Pilot can choose to either utilize or ignore trajectory change candidate recommendations from TASAR as part of change requests to ATC
- 7) Change request procedures are unchanged.
 - a. Pilot must direct all change requests to ATC using conventional means
 - b. ATC is responsible for reviewing request for acceptability, including separation from traffic
 - c. ATC either 1) approves request and issues clearance, 2) provides an amended clearance, 3) defers request to next controller, or 4) denied request
- 8) Undetected, misleading information associated with TASAR recommendations will have “No Effect” on the pilot, aircraft, and/or on ATC. Whether due to failure of one of the

TASAR sub-systems and associated automation processing, or being the result of inaccurate data obtained from ground-based or flight deck systems, spurious change requests are mitigated by flight crew inspection of the recommended trajectory change and by mitigation associated with the existing change request process.

4.2.1.5.2 Failure Effects Classification (FEC)

Figure 1 (from [11]) provides a mapping of the “Effects” due to failures and the allowable “Probability of Occurrence” that lead to the determination of the FEC of the planned application (i.e., TASAR). Based on the above noted factors alone, this safety analysis (Method 1) comes to the conclusion that TASAR can be safely developed and implemented with a “No Effect” designation. Potentially, in the worst case, TASAR could rise to a “Minor Effect” designation in event of inconsistent candidate trajectory change request recommendation(s), which could result in workload issues (for the pilot and / or ATC). However, workload issues are not anticipated to be an issue for the pilot’s use of TASAR, as the pilot can simply ignore TASAR for any reason. Through proper training in the use of TASAR, the pilot should not allow to be distracted or be adversely influenced in using TASAR while conducting flight operations. From an ATC perspective, controllers will continue to conduct the trajectory change request process as in today’s operation and are not expected to experience a workload issue due to TASAR.

Note: Based on our Technical Interchange Meeting with FAA approval authorities, FAA noted that TASAR would be viewed as a “Minor Effect” EFB application due to pilot workload considerations. Refer to Section 4.3 and Appendix E for results of our meeting with FAA approval authorities on the TASAR EFB application.

Probability (Quantitative) [Not to Exceed]	FAA AC	1	10 ⁻³	10 ⁻⁵	10 ⁻⁷	10 ⁻⁹	
Probability Descriptive	FAA	N/A	Probable	Improbable		Extremely Improbable	
	JAA	N/A	Frequent	Reasonably Probable	Remote	Extremely Remote	Extremely Improbable
Failure Condition Hazard Severity Classification	FAA	None	Minor	Major	Hazardous/ Severe Major		Catastrophic
	JAA	None	Minor	Major	Hazardous	Catastrophic	
Effects on Aircraft and Occupants	FAA	<ul style="list-style-type: none"> No Safety Effect 	<ul style="list-style-type: none"> Does not significantly reduce airplane safety (Slight increase in safety margins) Crew actions well within capabilities (Slight increase in crew workload) Some inconvenience to occupants 	<ul style="list-style-type: none"> Reduce capability of airplane or crew to cope with adverse operating conditions Significant reduction in safety margins Significant increase in crew workload <p>Severe Cases:</p> <ul style="list-style-type: none"> Large reduction in safety margins Higher workload or physical distress on crew – can’t be relied upon to perform tasks accurately Adverse effects on occupants 	<ul style="list-style-type: none"> Conditions which prevent continued safe flight and landing 		
	JAA	<ul style="list-style-type: none"> No Safety Effect 	<ul style="list-style-type: none"> Nuisance 	<ul style="list-style-type: none"> Operating limitations Emergency procedures 	<ul style="list-style-type: none"> Significant reduction in safety margins Difficult for crew to cope with adverse conditions Passenger injuries 	<ul style="list-style-type: none"> Large reduction in safety margins Crew extended because of workload or environmental conditions Serious or fatal injury to small number of occupants 	<ul style="list-style-type: none"> Multiple deaths, usually with loss of aircraft
System DAL	--	E	D	C	B	A	

Figure 1 Acceptable Risk versus Potential Effects (Defined for Civil Aviation)

4.2.1.5.3 TASAR Application Internal Mitigation Means

The TASAR application itself provides additional inherent capabilities that further reduce the possibility of unintended adverse effects and are expected to enhance the usability of the application. These further serve to strengthen and support the “No Effects” FEC for TASAR:

- 1) In order to prevent lengthy, complex trajectory change requests from the pilot to ATC, TASAR utilizes standard navigation databases and places limits on excessive waypoints included in the recommended change requests it provides
- 2) TASAR displays flight path change opportunities using standard phrasing to facilitate voice communications
- 3) TASAR may include capabilities to assess sector complexity and own ship’s proximity to the sector boundary in order to only recommend change requests that have a high likelihood of being approved by ATC.

4.2.1.5.4 Procedural Mitigations Available to the Pilot

- 1) An additional characteristic of TASAR is that there is no “recovery” time required for the flight crew associated with its use. In other words, in using TASAR, the pilot remains on an ATC-cleared trajectory at all times. In the event of a TASAR system fault, the pilot need only remain on the current clearance while disregarding the TASAR display. A simple reset of TASAR, or by simply choosing to ignore TASAR inputs (e.g., by not looking at the TASAR display) allows the pilot to continue to focus on primary tasks in conducting flight operations (whether during normal operations or in the event of abnormal or emergency situations)
- 2) The pilot has responsibility to evaluate TASAR-provided trajectory change candidates before making a change request to ATC, providing cross-check opportunities to detect spurious or false trajectory change candidates being offered by TASAR
- 3) Aircraft systems, e.g., FMS, weather radar, serve as available, higher integrity information allowing quick check on acceptability and performance impacts of TASAR recommended trajectory change requests

4.2.1.5.5 TASAR Phase of Flight Considerations

- 1) From a phase of flight perspective, TASAR is intended for use primarily during en-route operations
 - a. Trajectory change request candidates are offered by TASAR during the later portion of climb, while en-route, and to a lesser extent, into the early portion of descent operations
 - b. TASAR is thus used primarily during non-critical phases of flight, i.e., above 10,000 ft.

4.2.1.5.6 TASAR Information Source Quality

- 1) Due to the “No Effect / Minor Effect” FEC anticipated for TASAR, TASAR information source quality and integrity must be commensurate to support this FEC.
 - a. TASAR input information quality and integrity requirements are driven not by safety considerations but by operational use considerations.

- b. Low quality and/or misleading information can result in poor recommendations to the pilot for candidate trajectory change requests. The net effect is that TASAR will not be as effective in achieving envisioned operational benefits (e.g., time or fuel served).

4.2.1.5.7 TASAR Undetected Failure – Worst Case Effect

- 1) From a TASAR Undetected Failure perspective, inefficient routing is the only adverse outcome. Existing mitigation of any safety hazards is provided by ATC, as already is done for trajectory change requests today.

Note: The Safety Analysis using Method 2 (based on the Operational Safety Assessment {OSA} of DO-264 / ED-78A) described in the next section takes a closer look at specific failure modes of TASAR.

4.2.1.6 Method 2 Safety Analysis – Operational Safety Assessment Process

This section provides the safety analysis of TASAR using the Operational Safety Assessment (OSA) process from RTCA DO-264 / EUROCAE ED-78A [12], referred to as Method 2 in this report. Figure 2 illustrates the process at a high-level using the ‘bow-tie’ model.

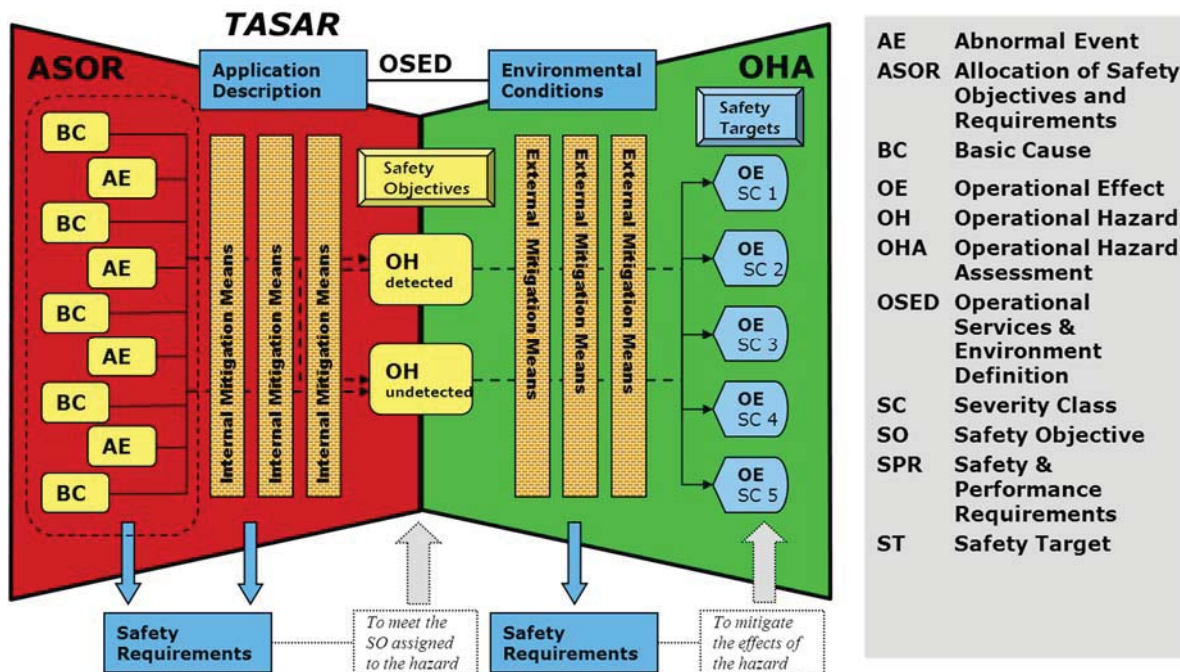


Figure 2 Operational Safety Assessment Process – Method 2.

In Figure 2, the system of interest, in this case the TASAR application, is represented in the left-hand side of the “bow-tie”. The external environment in which the application operates, including environmental conditions (e.g., airspace influences, weather, traffic) and the external systems that are part of the overall operational concept (e.g., aircraft systems and ATC systems), are represented by the right-hand side of the “bow-tie.”

The OSA process consists of the following major sub-processes: 1) the Operational Hazard Assessment (OHA), and 2) Allocation of Safety Objectives and {Safety} Requirements (ASOR).

In performing the OHA, the first step is to use operational experts from all stakeholder communities to identify potential Operational Hazards that may result from the application (e.g., TASAR). For each identified Operational Hazard, the next step is to determine the worst “credible” outcome, also referred to as the Operational Effect (OE). Examples are collision, loss of separation (major loss versus minor loss), workload, etc.

For each Operational Hazard and associated Operational Effect, the Severity Class is determined. Severity Classes include catastrophic, severe major, major, minor, and no effect. For each Operational Effect and associated Severity Class, a “Probability of Occurrence” not to be exceeded to assure safety of operations are established, ranging from 10^{-9} , 10^{-7} , 10^{-5} , 10^{-3} , etc. for occurrence of the Operational Effect. The Operational Effects and Severity Classes are noted in Figure 2 on the right side of the bow-tie.

Figure 3 provides a mapping of hazards to “the associated effects on operations due to each hazard class. The likely regions of applicability for the TASAR OSA process described in this section are highlighted in Figure 3. The highlighted regions represent “Minor” and “No Effects” FECs.

Hazard Class	1 (most severe)	2	3	4	5 (least severe)
Effect on Operations	Normally with hull loss. Total loss of flight control, mid-air collision, flight into terrain or high speed surface movement collision.	Large reduction in safety margins or aircraft functional capabilities.	Significant reduction in safety margins or aircraft functional capabilities.	Slight reduction in safety margins or aircraft functional capabilities.	No effect on operational capabilities or safety
Effect on Occupants	Multiple fatalities.	Serious or fatal injury to a small number of passengers or cabin crew.	Physical distress, possibly including injuries.	Physical discomfort.	Inconvenience.
Effect on Air crew	Fatalities or incapacitation.	Physical distress or excessive workload impairs ability to perform tasks.	Physical discomfort, possibly including injuries or significant increase in workload.	TASAR OSA Focus Areas	
Effect on Air Traffic Service	Total loss of separation.	Large reduction in separation or a total loss of air traffic control for a significant period of time.	Significant reduction in separation or significant reduction in air traffic control capability.	Slight increase in workload. Slight reduction in separation or in ATC capability. Significant increase in air traffic controller workload.	No effect on flight crew. Slight increase in air traffic controller workload.
Example of ASAS operational consequences	<ul style="list-style-type: none"> Mid-air collision Controlled flight into terrain Total loss of flight control High speed surface movement collision (i.e. collision in runway) Leaving a prepared surface at high speed. 	<ul style="list-style-type: none"> Large reduction in separation or safety margins Loss of separation resulting in wake vortex encounter at low altitude. Large reduction in safety margins like abrupt manoeuvre is required to avoid mid-air collision or CFIT (e.g. one or more aircraft deviating from their intended clearance) Large reduction in aircraft functional capabilities Total loss of air traffic control for a significant period of time 	<ul style="list-style-type: none"> Significant reduction in separation or safety margins Loss of separation resulting in wake vortex encounter at high altitude. Low speed surface movement collision (i.e. collision in taxiway) Leaving a prepared surface at low speed Significant reduction in aircraft functional capabilities Significant reduction in air traffic control capability 	<ul style="list-style-type: none"> Slight reduction in separation or safety margins Significant increase in air traffic controller workload Slight increase in flight crew workload 	<ul style="list-style-type: none"> No effect on operations /traffic Slight increase in air traffic controller workload No effect on flight crew

Figure 3 ED78A/D0264 Based Hazard Classification Matrix

From the OHA sub-process, each Operational Hazard is assigned a Safety Objective that it must meet in order to assure safe operations. It is the task of the ASOR to ensure that the Safety Objective is met. It is noted that for each Operational Hazard, there could be multiple Operational Effects, thus resulting in multiple Safety Objectives being assigned to each Operational Hazard. The ASOR must assure that all Safety Objectives are met for each Operational Hazard.

In order to mitigate the effects of the Abnormal Events and Basic Causes identified as root causes of failures, it will be necessary to identify relevant mitigations internal to the application, denoted as Internal Mitigation Means. These mitigate the effects of Abnormal Events and Basic Causes to

achieve the Safety Objectives for each Operational Hazard. This then also allows specifying Safety Requirements that are associated with sub-system elements internal to the application. The combination of Abnormal Events, Basic Causes, Internal Mitigation Means, Safety Objectives and Safety Requirements are illustrated by the left-side of the bow-tie.

The OSA process in [12] is beginning to be widely used by EUROCONTROL and FAA in the development of Safety, Performance, and Interoperability Requirements for ADS-B IN applications. This process is well suited for higher criticality system-of-systems and allows a more formal analysis process using fault trees and event trees. Fault Trees are typically used to capture the left-hand side “bow-tie” process of the ASOR, while Event Trees are typically used to represent the OHA process characterizing the external environmental factors represented by the right-hand side of the bow-tie.

Note: While the strength of the OSA process is that it is able to analyze complex, high-criticality system-of-systems and allows for a relatively balanced approach for allocating integrity requirements across all systems, the process may not be as well suited for lower-criticality systems, e.g., TASAR, as the fault tree and event tree methodologies and associated calculations begin to become onerous in terms of their ability to analyze the more qualitative and subjective aspects of these types of applications. It is also often quite difficult to quantitatively prove probabilities associated with workload factors and performance of the human to perform various functions. This often times becomes a significant and time consuming (and costly) issue in gaining approval for the safety requirements that result from using the methodology.

Note: Considerable consideration has been given in this report to the identification of Operational Hazards potentially associated with TASAR. However, the report intentionally stops short of performing a quantitative analysis of the Safety Objectives and the probabilities of the barriers provided by the mitigations identified, since TASAR was determined to have a “No Effect” or in worst case a “Minor” FEC. The OSA presented is thus an abbreviated OSA relative to [12].

4.2.1.6.1 Operational Hazards Identification

Before commencing with the identification of Operational Hazards using the Method 2 OSA approach in this section, it is noted that the same high-level factors and mitigation already described in 4.2.1.4 (Method 1) also apply here. The next step takes a closer look at Operational Hazards that could occur using the TASAR application.

As noted earlier, Operational Hazards result from Abnormal Events and Basic Causes, which represent errors and failures in actions associated with the human operator (e.g., the pilot), or systems functions (e.g., TASAR automation). Abnormal Events include both errors by the pilot in relation to TASAR use and in interactions with ATC as part of the change request procedure.

To more closely examine potential sources of errors associated with actions by humans and TASAR automation processing, Figure 4 illustrates potential information flows within the NASA TASAR application, TAP.

From Figure 4, the following information exchanges associated with human and automation processing actions represent potential sources for errors and misleading information that may result in Operational Hazards:

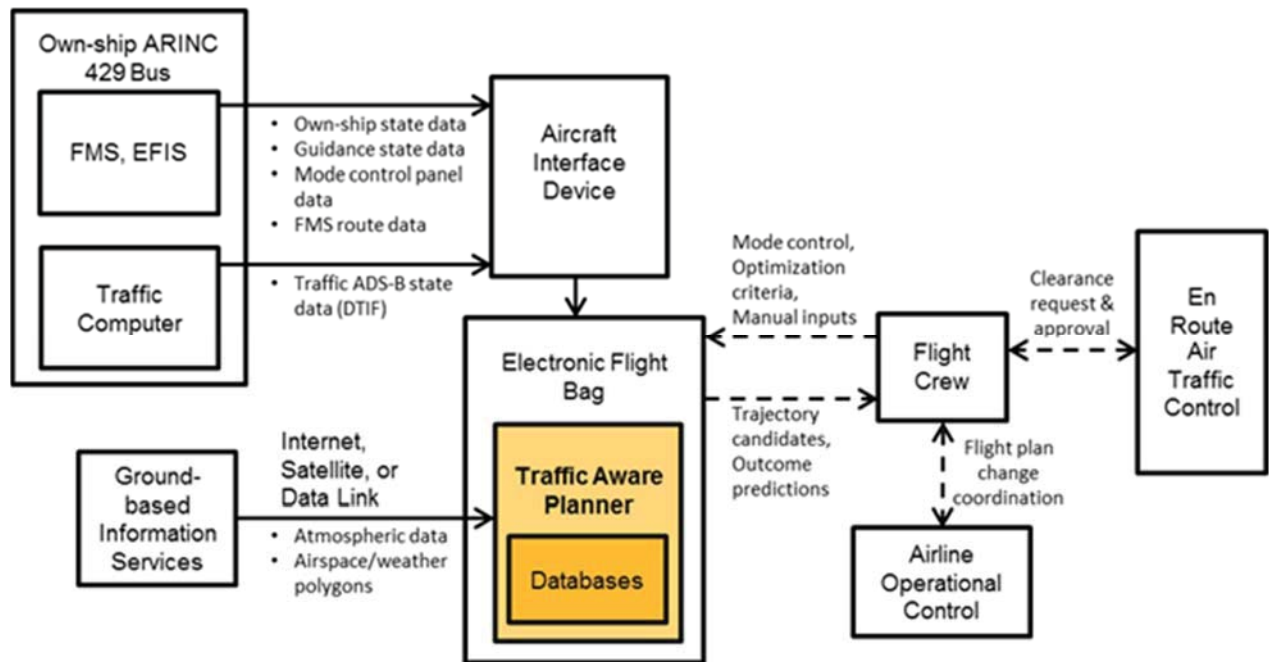


Figure 4 TASAR Functional Diagram*

*Note: The information elements identified in Figure 4 are notional at this point and are being refined as part of the detailed design of TASAR.

4.2.1.6.2 Human Actions Potentially Leading to Abnormal Events

The following list identifies human actions that provide the opportunity for occurrence of Abnormal Events (i.e., when human actions are performed in error):

1. Pilot, flight crew
 - a. Enters TASAR configuration, objectives, and optimization criteria via the TASAR HMI
 - b. Receives and interprets TASAR data via the TASAR HMI
 - i. e.g., recommended trajectories, conflict status, fuel reserve status, etc.
 - c. Communicates change requests to ATC
2. Air Traffic Controller (en-route)
 - a. Provides separation assurance services
 - b. Communicates change request clearances to pilots

Note: As the detailed design for TASAR is being developed, there is a concern that some route and constraint data may not be readily accessible from onboard systems and that it may be necessary that some of this data be manually entered by the pilot. This raises the potential of increased pilot workload that may become a concern for usability of the TASAR applications and could factor into the OSA as a workload issue; it may also increase the possibility of false data entry by the pilot.

4.2.1.6.3 TASAR Automation Processing Actions Potentially Leading to Basic Causes

The following actions performed by TASAR (i.e., decision support algorithms) provide opportunity for occurrence of Basic Causes (i.e., when actions by automation are erroneous):

- TASAR-related processing that could result in undetected misleading information.

Any misleading information provided by information sources to TASAR, or errors and failures in TASAR automation processing, could potentially result in misleading trajectory change request candidates being recommended to the pilot for consideration. Such misleading information may detract from the usability of TASAR to achieve operational benefits. However, since the flight crew has no authority to deviate from their ATC clearance, regardless of the information provided by TASAR, any occurrence of misleading information from TASAR will be non-hazardous in nature and is completely mitigated by the ATC clearance procedure.

Detailed assessment of Abnormal Events and Basic Causes associated with TASAR are discussed in [7].

Detailed List of Potential TASAR Operational Hazards

Table 5 provides a list of the Operational Hazards identified using the OSA process described in this section. Associated mitigations, internal or external to TASAR, are also identified.

Table 5 TASAR Operational Hazards and Mitigations

Operational Hazard	Description	Mitigation
OH – 1: TASAR could provide one or more change request candidates that are not conflict free	This Operational Hazard is the result of poor information quality and/or mixed ADS-B Out equipage environment, where not all traffic is known	ATC provides separation assurance independent of TASAR
OH – 2: Pilot could misinterpret TASAR candidate change request and could unknowingly request a trajectory clearance that is not conflict free or could lead toward hazardous airspace	TASAR could “inadvertently” mislead or confuse the pilot who could then misrepresent the TASAR change request to ATC	ATC provides separation assurance independent of TASAR Aircraft safety systems (e.g., Traffic Alert and Collision Avoidance System, weather radar, Terrain Awareness and Warning System) provide hazard detection and alerting
OH – 3: Pilot could follow the wrong trajectory clearance following receipt of amended clearance from ATC	Pilot could request a change recommended by the TASAR system, and although ATC amends the request, TASAR-induced confusion could lead the pilot to follow the request instead of the clearance	ATC monitors execution and intercedes (same as today) Pilot training Pilot crosschecks clearance with FMS
OH – 4: ATC, somehow being aware of TASAR capability for the aircraft / pilot requesting a change request to the flight plan, could be less vigilant to provide separation assurance	The concern is whether ATC could become complacent over time, when receiving TASAR requests (note that TASAR equipage is not specified on filed flight plans or included in pilot-request verbiage)	Existing ATC procedure to check all requests for separation Note: This is not a credible Operational Hazard because separation assurance is ATC’s primary responsibility
OH – 5: TASAR could provide numerous spurious and/or inconsistent series of change request candidates leading to multiple requests	If change request recommendations are not reinforced from one request to the next, multiple counteracting requests could be issued These requests could become a nuisance issue and potentially could lead to a workload issue for ATC	ATC denies user requests if workload is too high
OH – 6: TASAR could recommends a trajectory candidate with miscalculation of fuel burn	Pilot reliance on TASAR fuel burn estimates (presented to help pilots choose between multiple request options) could lead to greater fuel burn than expected	Pilot crosscheck of FMS prediction of fuel burn

Operational Hazard	Description	Mitigation
OH – 7: Unexpected weather could develop on TASAR recommended route after ATC approval	Unexpected weather could require additional change requests and therefore more fuel to be used	Normal procedures for responding to unexpected weather

Reviewing the above Operational Hazards, it is noted that due to the very strong and significant mitigations already provided by ATC separation assurance and pilot procedures in today’s very safe operations, the worst case safety effect could potentially be workload for pilot and/or controllers. Since TASAR is an advisory-only system and can be manually inhibited by the pilot at any time, for any reason, the most likely FEC for TASAR would be “No Effect”. With the “No Effect” or perhaps “Minor Effect” FEC, TASAR is amenable for integration as an EFB application.

Note: Based on our Technical Interchange Meeting with FAA approval authorities, FAA noted that TASAR would be viewed as a “Minor Effect” EFB application due to pilot workload considerations. Refer to Section 4.3 and Appendix E for results of our meeting with FAA approval authorities on the TASAR EFB application.

The safety analysis in this section strongly indicates that the TASAR EFB application at most warrants a “Minor Effect” FEC. The following subsections of Section 4.2 address EFB standards adherence requirements (Section 4.2.2), analyze TASAR with respect to FAA guidelines and regulatory requirements for certification and operational approval (Section 4.2.3), and develop representative TASAR artifacts for certification and operational approval processes (Section 4.2.4).

4.2.2 TASAR Requirements for Adherence to Industry Standards

This section documents the results of an analysis conducted to identify EFB standards adherence requirements for TASAR. While not yet directly providing the certification and operational approval artifacts for TASAR certification (discussed in Section 4.2.3), this section identifies the steps toward such approvals and makes observations as they apply to the TASAR application. This section focuses primarily on EFB hardware and software requirements, including installation considerations.

Note: The TASAR Operational Hazard and Safety Requirements Analysis in Section 4.2.1 above has already determined that TASAR will at most have a “Minor Effect” FEC which was confirmed in our meeting with FAA approval authorities (Section 4.3).

4.2.2.1 Applicable FAA Regulatory and Guidance Documents

This section summarizes key documents that are applicable as FAA regulatory or guidance documents for certification and operational approval of EFBs and their attendant applications. The following is among the list of documents reviewed or considered in assessing EFB standards adherence requirements for TASAR described herein:

1. AC 120-76C, *Guidelines for the Certification, Airworthiness, and Operational Approval of Electronic Flight Bag Computing Devices* [13].

This document is intended for all operators conducting flight operations under Title 14 of the Code of Federal Regulations (14 CFR) part 121, 125, 135, or 91 subpart F (part 91F) and part 91 subpart K (part 91K). It is a key guidance document for EFB use with applicability to TASAR.

2. Flight Standards Information System (FSIMS) – 8900.1 Change 47, Vol. 4, Chapter 15 – EFB Operational Authorization Process [14].

This document provides the FAA approval perspective, providing the Principal Operations Inspector (POI) checklists followed for EFB and associated applications approval, including approval considerations for TASAR. This is a key document that identifies the EFB authorization process and provides detailed guidance on the checklists that must be addressed with the POI.
3. AC 91.21-1, *Use of Portable Electronic Devices Aboard Aircraft* [15].

This document addresses the use of PEDs, including their potential to hazardously affect aircraft communication and navigation equipment. It allows the use of non-transmitting PEDs during non-critical phases of flight (e.g., >10,000 ft., which is currently the intended use for TASAR). It is noted that it may be desirable to use TASAR in the later stages of climb, and early stages of descent, perhaps below 10,000 ft.; this should be allowable due to the low FEC expected for TASAR, pending FAA approval as TASAR undergoes certification and operational approval. Wireless connectivity for TASAR could be considered as a Transmit PED (T-PED) and may require the ability to demonstrate isolation of the T-PED from interfering with avionics (e.g., communications and navigation systems).
4. AC 20-173, *Installation of Electronic Flight Bag Components* [16].
5. AC 21-16, *RTCA Document DO-160 “Environmental Conditions and Test Procedures for Airborne Equipment”* [17]. This document pertains to Electro-Magnetic Interference (EMI) requirements for read-only data interfaces to avionics and High Intensity Radiative Fields (HIRF) requirements for transmit data interfaces to avionics. TASAR requires only read-only access to avionics and thus will need to meet EMI requirements (or delegate this requirement to an Aircraft Interface Device through which the TASAR EFB may interface to the avionics systems. In addition TASAR wireless connectivity likely requires additional isolation testing (i.e., TASAR as a T-PED) to ensure non-interference to avionics systems.
6. TSO-C195 (i.e., RTCA DO-317 – ASAS MOPS), *Avionics Supporting Automatic Dependent Surveillance – Broadcast (ADS-B) Aircraft Surveillance Applications (ASA)* [18]. This document pertains to TASAR for ADS-B IN/OUT performance requirements, but not for traffic display purposes, which is not applicable for the TASAR HMI.
7. SAE ARP 4761, *Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment* [9]. Applicable for TASAR Safety Assessment of Operational Hazards.
8. AC 23.1309-1, *System Safety Analysis and Assessment for Part 23 Airplanes* [10]. Applicable for TASAR Safety Assessment of Operational Hazards.
9. AC 25.1309-1, *System Design and Analysis* [11]. Applicable to TASAR system design.
10. SAE ARP 4754A, *Guidelines for Development of Civil Aircraft and Systems* [19]. Applicable to TASAR system design.
11. AC 20-115, *RTCA, Inc., Document RTCA/DO-178B* [20]. This is not applicable to TASAR, as TASAR is expected to be at most a “Minor” failure effect classification. This document is primarily for Type C applications, e.g., applications that require depiction of own ship position and/or are of “Major” or higher FEC.

12. AC 20-152, *RTCA, Inc., Document RTCA/DO-254, Design Assurance Guidance for Airborne Electronic Hardware* [21]. This is not required for “Minor” FECs, as a Class 2 EFB FEC suffices; not applicable to TASAR.
13. AC 20-159, *Obtaining Design and Production Approval for Airport Moving Map* [22]. This document pertains to the display of own ship position, e.g., display and airport surface situational awareness applications hosted in EFBs. This is not applicable to TASAR per current concept of operations and HMI design.
14. AC 25-11A, *Electronic Flight Deck Displays* [23]. Applies to Class 3 EFBs, i.e., installed as part of flight deck and is not applicable for TASAR.
15. AC 91-78, *Use of Class 1 or Class 2 Electronic Flight Bag (EFB)* [24]. This is not applicable to TASAR, as it relates to Type A applications that apply to replacement of paper and other documentation.
16. TSO-C165, *Electronic Map Display Equipment for Graphical Depiction of Aircraft Position* [25]. Not applicable (NA) to TASAR as it related to display of own ship position; not part of TASAR concept of operations and HMI design.
17. RTCA/DO-257A, *Minimum Operation Performance Standards for the Depiction of Navigational Information on Electronic Maps* [26]. Not applicable to TASAR; not part of TASAR concept of operations and HMI design.

4.2.2.2 Summary of EFB Standards Adherence Requirements

In establishing EFB standards adherence requirements, the EFB application’s intended function and associated FEC directly impact certification and approval requirements. The TASAR intended function was examined earlier in Section 4.2.1.3; TASAR is an optional, advisory-only decision support tool to recommend trajectory change improvement opportunities to the pilot / flight crew. As such, TASAR is supplemental equipment, does not replace any required avionics functions, and is not needed as part of the MEL for flight operations. Use of TASAR is at the discretion of the pilot, i.e., the pilot may choose to ignore TASAR or can manually inhibit its operation at any time for any reason.

Analysis of TASAR operational hazards and safety requirements suggests that TASAR at most warrants a “Minor Effect” FEC, and may in fact be of “No Effect” in terms of safety impact. This makes TASAR amenable as an EFB application (refer to Section 4.2.1 and [7]).

Note: Section 4.3 confirms the “Minor Effect” FEC designation based on feedback from FAA approval authorities (Section 4.3).

While TASAR, as a new EFB application, does not map directly into already defined Type A or Type B applications, it has many of the characteristics of a Type B application. Thus TASAR is well aligned with Type B applications; yet it is somewhat less stringent than typical Type B applications in terms of FEC per its intended function. TASAR is viewed to be of Type B.

Note: FAA approval authorities indicated that although not explicitly identified as a Type B application in AC 120-76, they consider TASAR to be of Type B (refer to Section 4.3).

In addition, TASAR is expected to be implemented as a Class 2 PED / Portable EFB. The Class 2 EFB requirement is due to the read-only interface needed by TASAR to on-board avionics systems and data link connectivity via installed antennas for accessible information sources, e.g., weather information.

As a Class 2 EFB, a mounting device is required for TASAR with the following attendant requirements (for the installed mounting device):

- 1) must have operational suitability in all ground and flight operations and conditions
- 2) must not interfere with flight crew duties
- 3) must be easily stowed when not in use
- 4) must not obstruct primary or secondary fields of view, and
- 5) must not obstruct egress.

As the TASAR EFB is portable (i.e., not installed permanently as part of the flight deck), it must be easily removable, without tools, by the pilot / flight crew member. The EFB must be accessible to the pilot / flight crew. A cockpit mount is recommended / selected for TASAR as compared to a yoke mount to facilitate operational approval and for a more cost effective installation.

Because TASAR is primarily utilized during en-route operations, generally above 10,000 ft., it is primarily used during non-critical phases of flight. However, due to its relatively low FEC, i.e., low-criticality of the TASAR application, it is expected to also be useable during the later portion of climb and early portion of descent operations and is not expected to adversely affect these more critical flight phases.

The EFB standards adherence requirements examined are expansive and detailed in nature. Appendix B documents these results; specifically the roles and responsibilities of the operator, manufacturer, installer, avionics vender, and also of FAA certification and operational approvers of newly developed EFB applications, such as TASAR.

4.2.2.3 FAA Principal Operations Inspector (POI) Checklists

The following represent the checklists that are used by the POI as part of the EFB approval process and are found in [14]. They are addressed later in more detail in Appendix D but are provided here for initial reference:

- Figure 4-79 represents Checklist 1, "Tabletop Electronic Flight Bag Evaluation
- Figure 4-80 represents Checklist 2, "Electronic Flight Bag Operational Evaluation"
- Figure 4-81 represents the "Evaluation Report Information Template"
- Figure 4-82 represents Checklist 4, "Electronic Flight Bag Line Evaluation Job Aid".

4.2.3 FAA Guidelines and Regulatory Requirements for TASAR Approval

This section examines FAA guidelines and regulatory requirements needed for the certification and operational approval of the TASAR EFB flight-deck application. It provides a conceptual plan that identifies anticipated steps to be followed that are expected to lead to successful certification and operational approval of TASAR. This section and Appendix C lay out this path to achieving approval without going through the actual certification and operational approval process. This information is provided to support a future certification effort for TASAR. Specifically it offers a Certification Plan for TASAR.

Note: In our meeting with FAA approval authorities (see Section 4.3), FAA did not see the need for a Project Specific Certification Plan (PSCP) for the TASAR software, just for the installation. If the applicant already has an existing EFB installation, then the operational approval process is for a user to go directly to their POI.

The results documented in this section also served as the basis for providing 1) representative artifacts for a DER review dry run, and 2) an analysis of DER feedback from this dry run, which are documented in Section 4.2.4 below.

4.2.3.1 FAA Certification and Operational Approval Process – High-level View

The FAA certification and operational approval of aircraft functions involves many disciplines in a highly interactive and coordinated manner in order to achieve product approvals that ensure their safe use in flight operations. This section provides a brief overview.

Addition of new avionics functions or updates to existing functions typically involves issuance of one of the following: Type Certificate (TC), Amended Type Certificate (ATC), Supplemental Type Certificate (STC), Amended Supplemental Type Certificate (ASTC), Production Certification (PC) or other means.

Key FAA organizations involved in this process of supporting and assessing the applicant's data submittals for approval are the Aircraft Certification Office (ACO), Flight Standards Services (AFS), and the Aircraft Evaluation Groups (AEG).

In order to achieve product approval requires multiple disciplines to be vetted and assured: 1) safety to demonstrate airworthiness, 2) manufacturing, 3) maintenance, 4) operations, etc. FAA ACO is responsible for assuring safety of new and updated avionics products and issues design approval via the approval process and guidelines for TC, STC, ATC, ASTC, PC, and other means.

In addition to the safety assurance processes of proving the integrity of the product design, another key aspect of the approval process involves the manufacturing of the avionics product itself. Manufacturing regulations and guidelines involve additional processes, including assuring that parts are manufactured according to Technical Standard Order (TSO), Parts Manufacturer Approval (PMA), or using Conformity inspections. FAA Manufacturing Inspection District Offices (MIDOs) are responsible for assuring the correctness and quality assurance of the manufacturing of avionics parts.

Initial engagement with FAA on a new or revised product approval may include dialog regarding orientation of the approval process, gaining some initial guidance before launching the actual certification project with FAA, and receiving a familiarization briefing about the process. This is then followed by launching the Certification Plan.

4.2.3.2 Purpose of Certification and Operations Approval Plan

The goal of the Certification and Operations Approval Plan {from here on referred to as the Project Specific Certification Plan (PSCP)} is to establish a framework plan and schedule between the applicant and FAA on how the applicant intends to demonstrate compliance of the new or revised system capability to the Federal Aviation Regulations (FARs).

A proper certification plan assures the FAA that the applicant has reviewed the FARs and is aware of the applicable requirements that need to be addressed as part of the approval process. The applicant receives FAA concurrence (or receives feedback on what updates will be needed to the PSCP in case not all elements are properly addressed) that the PSCP describes an acceptable means of demonstrating compliance with the FARs.

Note: There are multiple references made in FAA guidance documents concerning the Certification Plan, e.g., in FAA Order 8110.4C [27].

- 1) CP (Certification Plan) – previously not required by FAA in earlier versions, but now required by FAA in this latest order
- 2) CPP (Certification Project Plan) – represents FAA’s ACO’s high-level project plan
- 3) PSCP (Project Specific Certification Plan) – represents the composite of both the applicants and FAA’s project plan information. The PSCP contains elements of the CP and CPP and includes relevant details of the Certification Process Improvement (CPI) initiative [28] between FAA and industry.

The key element of the PSCP is the ***Compliance Check List***, which indicates that the applicant understands all appropriate regulatory requirements to be satisfied for achieving certification and operational approval. The Compliance Check List provides a summary of the regulatory requirements via reference and points to the type of associated data submittals (i.e., artifacts) that need to be provided to approving authorities.

The PSCP is important as part of the engagement process with FAA for product certification and approval. The PSCP ensures that the individual elements of the plan take place in proper order and at designated timeframes. This allows for planning of personnel and resources by both the applicant and FAA and provides a roadmap for coordination, information exchanges, and milestone completion dates. Without a well-coordinated PSCP and associated schedule information, the certification project stands little chance for timely completion.

Typically, preparation of the PSCP should begin as soon as the basic design has been determined in order to realize the benefits from up-front considerations of the FARs and engagement with FAA approvers. The PSCP should be submitted to the FAA as soon as possible after the design concept is firm. The PSCP needs to be submitted in advance of any requests to FAA for conformity inspections, test plans review, or compliance data reviews.

The remainder of this document describes the generalized content of the PSCP and provides TASAR-specific context where appropriate. A high-level Compliance Check List is provided as an input to the as-yet-to-be-determined certification and operational approval project of the TASAR EFB flight-deck application.

4.2.3.3 Project Specific Certification Plan (PSCP)

FAA allows a general form of the PSCP to be followed, and numerous similar outlines to this plan are documented in various FAA guidance documents. FAA does not impose an exact format to this plan and allows latitude to applicants for tailoring the process to their respective needs.

4.2.3.3.1 Certification Phases

“The FAA and Industry Guide to Product Certification (CPI Guide)” [28], provides a good overview of the certification process that is described herein.

There are five Certification Phases that move from early project concept and initiation through post certification activities. The content of the PSCP outlines the FAA and applicant agreement and operating practices for a Product Certification project. 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 five phases of certification are:

- 1) Conceptual design phase
- 2) Requirements definition phase
- 3) Compliance planning phase
- 4) Implementation phase
- 5) Post-certification phase.

To the extent warranted by the new or revised product (e.g., due its size and complexity) considerable up-front engagement of both the FAA and the applicant is a key part of the process represented by these certification phases. The certification process described here is applicable for all aircraft system certifications, from new aircraft developments to EFB applications. However, the process, level of involvement by FAA and the applicant personnel, and complexity of the PSCP can vary widely and typically is tailored to meet the objectives to ensure that the new or revised product is implemented in a manner to assure the safety of flight operations.

The key FAA participants in this process are as follows:

- **FAA and applicant's Management**
 - Make commitments to the certification project and provide leadership and resources
- **FAA and applicant's Project Managers**
 - Jointly orchestrate the PSCP
- **FAA Standards Staff Project Officer**
 - Provides timely standardized policy and guidance
- **FAA Engineers and Designees**
 - Apply regulations and policy to find compliance including the determination of the adequacy of type design and substantiation data
- **FAA Inspectors and Designees**
 - Determine conformity and airworthiness
- **FAA Flight Test Pilots and Designees**
 - Conduct FAA flight tests
- **FAA Chief Scientific and Technical Advisor**
 - Provides expert advice and technical assistance
- **FAA Aircraft Evaluation Group (AEG)**
 - Evaluates conformance to operations and maintenance requirements.

A more detailed description of the roles of the key players is found in the CPI Guide [28].

The following is a description of each of the five certification phases, providing a definition of each phase, identifying expected tasks, required information, deliverables, and defining criteria for success. Deliverables of each phase are prerequisites before entering the next phase.

The following list represents the criteria that should be applied to all phases of certification to ensure success:

- Mutual trust; confidentiality; meet all commitments; emphasize empowerment
- Open and timely communication
- Proper level of technical project and management leadership with frequent reviews to maintain awareness of status, significant issues, and commitments
- Early familiarization meeting(s); meetings with well-structured agendas and presentations attended by proper participants
- Document agreements, issues, actions; agree to clear time frames, expectations, action plans
- Timely, high-quality documentation of decisions, agreements, schedules, milestones, action item assignments, compliance/conformance submittals and approvals.

4.2.3.4 *TASAR EFB Applications Assumptions*

The following assumptions will influence the certification requirements for TASAR:

- 1) TASAR (as currently defined by the TASAR operational concept [1][2], and TAP application description [3]) is anticipated to be designated as a “No Safety Effect” FEC. This is based on the Operational Hazards and Safety Requirements Analysis in [7], which identifies a number of significant hazard mitigations resulting in this designation.

This failure effects designation is subject to approval by FAA certification and operational approval authorities. The highest failure effects designation for TASAR should be limited to no greater than “Minor” in the unexpected event that workload issues are deemed an issue with TASAR by approval authorities.

Note: After meeting with FAA, TASAR will be designated as “Minor Effect” due to potential pilot workload associated with TASAR due to misleading / bad data (Section 4.3).

- 2) TASAR is expected to be implemented and hosted on a Class 2 Portable Electronic Device (PED).

TASAR requires a read-only interface to on-board avionics systems, but will not be transmitting information to avionics systems.

TASAR is expected to utilize antennas for accessible information sources via commercially available communication data links and associated networks. These antennas may either be permanently installed or may be self-mounted.

- 3) For this certification and operational approval plan (i.e., the PSCP), the TASAR Class 2 EFB is expected to be installed as a “cockpit mount” in the flight deck. A cockpit mount allows for easy insertion and removal of the EFB by the flight crew. A cockpit mount is desired compared to a yoke mount, which is a more critical installation. The cockpit mount is not to be confused with a fully installed EFB per Class 3 devices, which is not planned for TASAR.

Note: It is at the discretion of the implementer and end user on whether or not the portable TASAR EFB will remain un-mounted or be mounted in the cockpit while in use.

Note: Per FAA feedback, the only certification requirements would be for mounting / installation of the EFB, getting one-way, read-only access to certified systems data (e.g., via ARINC 429 busses), and partitioning and protections for non-interference with certified systems. The Aircraft Interface Device (AID) is intended to accomplish much of this. FAA did not see the need for a PSCP for the TASAR software, just for the installation. If they already have an existing installation, then the operational approval process is for a user to go directly to their POI (Section 4.3).

- 4) TASAR is expected to utilize an AID to serve as an intermediary interface to avionics systems.

The use of an AID device is not an explicit requirement. However, since the TASAR Class 2 PED/EFB is expected to utilize a Commercial-Off-The-Shelf (COTS) computing device, an AID is needed to serve as the interface between the PED and the avionics systems that provide information to the TASAR application. Without an AID, the COTS PED would require modification to the commercial product to provide the avionics interface and associated interference and security protections on its own. This of course significantly reduces the cost benefits of using COTS products to enable EFB applications in the flight deck.

- 5) The TASAR software application is closely aligned to Type B EFB applications per AC 120-76C [13]. While not mapping exactly to the Type A or Type B software applications as defined in [13], TASAR is well aligned to Type B applications. TASAR is viewed to be Type B “Lite”.

Note: After meeting with FAA, TASAR is viewed to be a Type B application. The additional designation as a Type B “Lite” should not be used. Type B designation is sufficient (Section 4.3).

Similar to Type B applications, TASAR utilizes processing algorithms to achieve its intended function (i.e., it is not just used for storage and lookup of static database information as is the case for Type A applications).

As additional mitigations for TASAR when compared to Type B applications, Type B applications may be used in all phases of flight including flight critical phases. TASAR is primarily used in en route operations and during the latter portion of climb and early stages of descent operations. More importantly, unlike typical Type B applications, which are relied upon to support flight operations, (e.g., providing weight and balance; and aircraft performance calculation) the TASAR application’s sole purpose is to seek and provide flight path improvement opportunities to the pilot. Thus while similar to Type B applications already approved by FAA, TASAR is expected to have a lower threshold to meet the safety and operational requirements compared to Type B applications.

4.2.3.5 *General Use Considerations*

- 1) Components of the Class 2 EFB include all hardware and software needed to support EFB intended functions

- a. A Class 2 EFB may consist of modular components (e.g., computer processing unit, display, controls)
 - i. Any EFB hardware not accessible to the flight crew on the flight deck (e.g., AID, antenna for aircraft wireless) and/or not portable must be installed in accordance with the applicable airworthiness regulations (AC 20-173 [16])
- 2) Class 2 EFBs are typically mounted to the aircraft via a mounting device and may be connected to a data source, a hard-wired power source, and an installed antenna (e.g., TASAR)
- 3) To be considered portable, the EFB must be removable from flight deck without use of tools by flight crew

4.2.3.6 *Software-Specific Approval Considerations*

- 1) Class 2 EFB hardware, internal components, and software do not require FAA airworthiness approval
- 2) For Portable EFBs, DO-178B does not apply even for minor failure effects

Note: FAA confirmed that Type B applications running on non-certified hardware (e.g., Class 2 EFB) do not require DO-178B compliance (Section 4.3).
- 3) Type A and Type B applications are typically considered as “hosted” because they have no requirement to be installed as part of aircraft type design or as an alteration
 - a. Such equipment would usually identify the hardware installed as miscellaneous, non-required equipment
- 4) Portable EFBs are limited to Type A and Type B software applications – the Airport Moving Map Display (AMMD) for ground operations is a Type C application and is the only current non-Type A or B exception being allowed on portable EFBs
- 5) Single or Dual EFB Configurations
 - a. Allows for partitioned Operating Systems (OS) and software applications
 - i. Separate DO-178B Linux and non-certified Windows OS
 - ii. DO-178B approved software applications and non-DO-178B hosted software applications allocated to their respective EFB and partitioned OS
 - b. “Hosted” and “Approved” software applications
 - i. Need to demonstrate that hosted applications (e.g., TASAR) when integrated with approved applications do not interfere with them
- 6) Downloads of newly revised software applications into the EFB must provide assurance (i.e., have a means to verify) that other approved applications are not adversely affected
- 7) Type A and Type B software development process does not require DO-178B

Note: FAA confirmed that Type B applications running on non-certified hardware (e.g., Class 2 EFB) do not require DO-178B compliance (Section 4.3).

The following steps are required for software development in this case (i.e., non-DO-178B):

- a. Develop and review high-level requirements
- b. Develop architecture on low-level requirements; these do not have to be reviewed
- c. System requirements (all derived)
- d. Prove code meets high level requirements; no structural coverage needed to be demonstrated
- e. Ensure that high-level requirements
 - i. Comply with system requirements
 - ii. Are accurate and consistent
 - iii. Are traceable

4.2.3.7 Hardware-Specific Approval Considerations

- 1) Airworthiness regulations apply to installed EFB components
 - a. Do not apply to portable EFB components
 - b. Must only address specifications associated with the installed components
 - i. Mounting (size and weight)
 - ii. Power (maximum electrical load, voltage, and current frequency)
 - iii. Data connectivity (input/output data specifications and security)
- 2) Class 2 EFB hardware, internal components, and software do not require FAA airworthiness approval
- 3) EFB components are “installed” when they are incorporated into aircraft type design under 14 CFR part 21 or as a proper alteration under 14 CFR 43.3
 - a. All other EFB components are considered “portable,” regardless of how often they are removed from the aircraft
- 4) Type A and Type B applications are typically considered as “hosted” because they have no requirement to be installed as part of aircraft type design or as an alteration
 - a. Such equipment would usually identify the hardware installed as miscellaneous, non-required equipment
- 5) An alternate view on certification consideration for “Non-Flight” Systems:

A number of systems may be installed in an aircraft that do not affect the basic flight capability of the aircraft. Systems such as 1) passenger entertainment systems, 2) information systems, 3) data storage devices, and 4) potentially TASAR may fall into this category.

Certification approval of such systems depends on their function, and the kinds of hazards that the system can present to the aircraft.

Non-flight systems could be for use only on the ground or may be used on both ground and while airborne (e.g., TASAR).

A primary concern in gaining approval for such systems is that the hardware needs to be compatible with the rest of the aircraft and its systems. Testing must ensure that operation or failure of the non-flight system does not affect the safe flight of the aircraft:

- a. in general, units must stay in place during a crash and must not fail in such manner to cause a hazard (such as fire or smoke) to the aircraft they are installed in
- b. the function of potentially affected systems determines what level of integrity and environment testing that must be completed to meet the certification and customer requirements
- c. if failure of the unit has no safety consequence (i.e., effect) then from a certification perspective, the unit only has to be shown to be airworthy.

The certification of non-flight systems as described above is closely aligned with Class 1 and Class 2 EFB hardware that support Type A and Type B applications and is expected to support TASAR (as a Type-B application).

4.2.3.8 Project Specific Certification Plan (PSCP) Overview

The following is a representative outline of a PSCP that is amenable for use with TASAR:

1) Purpose or Introduction

Identify the intent of the Certification Plan.

2) Description

A brief description of the system, product and associated application should be included or submitted as a separate document if the design description is not yet available in detail or is too complex.

3) FARs

Applicable regulations need to be listed by sections and subsections, including the amendment level if it differs from the certification basis established for the product. Any plans for exemptions, equivalent levels of safety, or special conditions should be included, if known.

4) Compliance

Tell how compliance will be shown. Provide analysis results of failures and safety performance. Indicate tests, e.g., vendor qualification tests, applicant ground tests on test rig, ground test on flight test article, and flight test. Demonstrate software compliance, show similarity, demonstrate the design, and provide inspection results. If compliance is to be through the use of unique methodology, it should be so noted in the certification plans and should then be covered by separate submittals and discussions. Compliance data should be made a part of the certification plan.

5) Conformity

Indicate what parts of the installation conformity will be required. Ensures that parts are built to specifications.

6) Data

List the data to be submitted to show compliance. It is acceptable to give “to be determined” (TBD) report and drawing numbers.

7) Airplane Flight Manual (AFM)

Indicate if this document is affected and how it will be revised (or revised as an AFM supplement).

8) Type Certificate Data Sheet

Indicate if this document is affected and how it will be revised.

9) Proposed DER(s)

The project ACO must determine the appropriateness of assigning designees to represent the FAA, e.g., the Designated Engineering Representative (DER), Designated Manufacturing Inspection Representative (DMIR), Designated Airworthiness Representative (DAR), and others as appropriate for each project. The ACO may not delegate the authority to approve certain aspects of a project even though a DER may have previously been granted authority in that general area.

10) Master Minimum Equipment List (MMEL)

Indicate if the MMEL is affected and describe the intended minimum Dispatch configuration.

11) System Criticality

For applicable systems, the results of the preliminary function hazard analysis need to be made known, e.g., system criticality, software criticality, functional failure conditions summary.

12) Schedule

Provide a schedule which shows the following:

- a. Significant milestones
- b. If applicable, identify when a preliminary hazard analysis will be submitted and when all detail data submittals will be made:
 - i. Descriptive data submittals (drawings)
 - ii. Substantiating data submittal (compliance reports)
 - iii. Test schedule (when and where), including Type Inspection Authorization (TIA), e.g., conformity and airworthiness inspections
 - iv. Conformity inspection requests and schedule (parts, systems, and installation)
 - v. Compliance inspection schedule
 - vi. Final approval

After the FAA has indicated concurrence with the PSCP, it is not necessary to reflect the approval by revising the report. The letter of concurrence is considered as sufficient evidence. FAA letters of concurrence can be used as updates to conditional approvals or to subsequent revisions of the PSCP without the need to revise the report, resubmit it and then wait for another FAA letter of concurrence.

4.2.3.9 *Additional PSCP Activities and Artifacts for TASAR*

The following additional activities and associated artifacts are candidates for further preparatory tasks by NASA:

- *Hold an Informational Meeting / Pre-Certification Meeting with appropriate FAA personnel prior to launching an actual Certification Project. This would allow comments from FAA to be factored into the actual certification.*

Note: This meeting was in fact accomplished since initially recommended (Section 4.3). FAA seems open to further engagements with the NASA TASAR team, even without a formal applicant. However a formal applicant would be beneficial when in engaging with FAA. FAA also suggested engaging with the POI as appropriate.

- *Artifact development pre-Certification Project kickoff:*
 - 1) *Some artifacts have already been developed as part of NASA and TASAR team member development and analysis effort:*
 - *Understanding of EFB airworthiness requirements (per this document)*
 - *TASAR Concept of Operation [1][2], TAP Application Description [3] and associated intended function and HMI design*
 - *Safety Assessment; Analysis of Operational Hazards; Safety Requirements [7]*
 - *University of Iowa OPL human factors assessment of TASAR in a Boeing 777 simulation environment*
 - *Advanced Aerospace Solutions' TASAR flight evaluation using a Piaggio Avanti P180 aircraft in November 2013 [8].*
 - 2) *Remaining, yet to be developed artifacts:*
 - *A second flight trial of TASAR is expected to be conducted in May 2015*
 - *Analysis and test results from Advanced Aerospace Solutions' TASAR flight evaluation and demonstration*
 - *Activities and deliverables identified [28], typically as part of the five-phase PSCP process, but only informally with the POI:*
 - i. *Informally complete the steps of the PSCP; FAA seems open to further engagements with the NASA TASAR team, even without a formal applicant. However a formal applicant would be beneficial when engaging with FAA.*
 - ii. *Agreed Type Certification Basis*
 1. *Detailed Compliance Check List*
 2. *Demonstration of compliance*
 3. *Compliance and conformance requirements verification*
 - a. *Completion of analyses, test plan submission, TIA (Type Inspection Authorization), conformities, flight test, AEG (Aircraft Evaluation Group) evaluations, critical issues resolution plan, and other items affecting the completion of the project*
 - b. *Completed test plans/reports, conformity requests, inspections, and compliance documentation*
 - c. *Compliance and conformance findings*

4. *Foundation for continued airworthiness activities and certificate management for the remainder of the product's life cycle (this is needed once certification approval has been obtained and is on-going life-cycle upkeep of the certification)*
 - a. *Airworthiness limitations*
 - b. *Maintenance and operations requirements*
 - c. *Design change data*
 - d. *Compliance Summary Document*
 - e. *Type Inspection Report*
 - f. *Instructions for Continued Airworthiness*
 - g. *Continued Airworthiness Management Plan*
- 3) *The following is a list of potential deliverables for TASAR:*
- i. *Software documentation and demonstration:*
Since software process and software development documentation do not require DO-178B for TASAR, documentation requirements are not excessive. The following steps are required for software development in this case (i.e., non-DO-178B):
 1. *Develop and review high-level requirements*
 2. *Develop architecture on low-level requirements; these do not have to be reviewed*
 3. *System requirements (all derived)*
 4. *Prove code meets high level requirements; no structural coverage needed to be demonstrated*
 5. *Ensure that high-level requirements*
 - a. *Comply with system requirements*
 - b. *Are accurate and consistent*
 - c. *Are traceable*

In addition, demonstration or proof of 1) how TASAR does not adversely affect other applications that may be integrated in the same EFB, and 2) how software revision downloads ensure that operation of the application is not adversely affected
 - ii. *Drawings and specifications of "installed" components of the TASAR EFB (e.g., aircraft mount, power connection, data connection, antennas, etc.). Whether conformity inspections are required is TBD.*
 - iii. *Airworthiness tests and results, e.g., electrical load testing of TASAR components with aircraft power sources, non-interference testing with avionics systems, etc.*
 - iv. *Data that describes the product design for COTS and installed components. Electrical and mechanical performance data. Installation specifications.*

Additional NASA / avionics vendor collaboration could be in the following areas:

- 1) *Validation of requirements*

- 2) *Growing the TASAR HMI concept to one using a map depicting the flight path, traffic, other airspace and environment information for increased pilot situational awareness and more effective use of TASAR for 1) operational benefit and 2) for more effective use of TASAR by the pilot / flight crew*

Note: NASA's update of the TAP HMI, specifically Version 4 (V4) address many of the recommendations made here and has been reviewed for impact on certification and operational approval, which is discussed in Section 4.2.5.

- 3) *Next generation TASAR, which includes writing to avionics, e.g., flight route from a trajectory change request recommendation to FMS, to reduce pilot workload*
- 4) *Transitioning TASAR from a decision aid making recommendations to a much higher integrity application toward supporting Autonomous Flight Rule operations.*

Note: As indicated throughout this document, the TASAR EFB application is a low-criticality flight-deck advisory capability and does not require very stringent certification and operational approval requirements. Our meeting with FAA confirmed the analysis results we provided. However, TASAR is expected to serve as an entry level flight-deck capability and can provide the basis for higher cost-benefit and higher criticality uses, e.g., for guidance and/or separation assurance intended functions. The PSCP guidance documentation in this report, while only partially required for TASAR, will be directly applicable for certification and operational approval of these more advanced applications that may be derived from extensions of TASAR and are thus documented in this report.

4.2.3.10 Additional TASAR Related Certification Discussion Topics

After initial certification and operational approval requirements were provided to NASA, NASA requested additional perspectives to these following 3 topics:

Topic #1: Delineation of EFB Software vs. EFB Hardware Approval Requirements

NASA requested clarification and further input on the somewhat blurry line between approvals of EFB software vs. EFB hardware. Also, since some operators will already have EFBs installed (with appropriate approvals) and may wish to consider TASAR as an add-on application, it would help to clarify the “delta” approvals required in this case.

Response: *With respect to the blurry line between EFB hardware and software, it is actually quite clear. For Type A and B applications, there are no software airworthiness requirements. Per FAA feedback (Section 4.3) TASAR is designated as a Type B application (related to performance and planning calculations), and thus falls into this category.*

From the hardware perspective, only installed elements of the EFB require airworthiness approval, e.g., the mounting, data connection (to avionics via an Aircraft Interface Device), connection to aircraft power, and internet communications via data links. AC 20-173 [16] provides the airworthiness requirements and points to other associated tests. The PED aspects of the EFB do not require airworthiness approval.

If hardware is already in place, this will have already undergone airworthiness approval of the installed components. No other airworthiness approvals will be needed. In the event any aspect of the hardware is not the same as the original installation, an applicant needs to show similarity to the initial installation and note what has changed and indicate how the change may affect things.

An example could be if a higher bus speed is used in the new installation (i.e., Mega-bits or Giga-bits per second). This could alter the sensitivity to EMI and one may have to retest those aspects and any other changes to installed components to ensure continued airworthiness.

From a software point of view, this will depend on what software functionality is preexisting and how TASAR is expected to be integrated into the existing software system (i.e., other already existing applications and the Operating System). If existing applications are also “hosted”, i.e., other Type A and B applications, then adding TASAR should not require any additional or significant precautions as software airworthiness is not required. Considerations would be whether one application will be performed at a time or if multiple concurrent applications would be in use. Some applications may run in the foreground, others could be running as background loops. However, while existing applications may serve as paper replacement or provide performance calculations, it is likely that one must show that TASAR (or any other new application) does not interfere with those applications (although no DO-178B process is required here).

If TASAR software is integrated with “approved” software (i.e., those developed and approved via DO-178B and likely supplementing some of the aircraft communications, navigation, and surveillance (CNS) functions), this has considerably more significant impact on ensuring that TASAR does not interfere in this case. Likely some appropriate level of partitioning will be needed (e.g., time partitioning, one application executing at a time, memory partitioning, separate OS’s, separate EFB processors, etc.). As more and more EFB applications find their way on-board the aircraft, some being “hosted” with others being “approved,” a partitioned EFB system approach, e.g., a dual EFB processor system, would likely be needed, requiring, for example, a DO-178B certified OS for approved applications, while a non-DO-178B OS could be used for the hosted applications. An AID will also be required to enable any interfaces to aircraft systems and avionics.

Topic #2: Typical Duration of Certification and Operational Approval Process

NASA Request #2: For similar-sized projects (i.e., other Type B applications) how long does certification and operational approval typically take; what issues must typically be dealt with?

Response: *Rockwell Collins has been working EFB-like products since at least 1999. Common to all of these product initiatives (whether or not they resulted in actual products), these development efforts laid initial groundwork on providing internet connectivity in the aircraft, providing information servers, services, and attendant applications for cockpit and cabin use, and performed the necessary steps toward certification and operational approval. Meetings were held with FAA, wherein engineering and certification personnel presented these development efforts, their plans for certification (i.e., certification project plans), and activities that had already been completed and were planned to be included as part of the approval process.*

An important point to consider is that when going to the FAA for the actual start of the certification project, much of the planning and homework can and should already have been accomplished for this level of certification (i.e., lower criticality levels of minor or below). This was confirmed by FAA at our technical interchange meeting (Section 4.3) and this should also be done for a TASAR Certification Project.

While no firm baseline estimates are available in terms of time and effort required, in consultation with DERs, typically the engineering effort for a project commences with either receiving or developing the requirements for the system being planned for development. Software and

hardware development processes are initiated, including their subsequent integration. Thus while application software development is ongoing, the development / acquisition of the AID, and installation of “installed components” would take place. Only minimal effort is required for the PED EFB as it is expected to be COTS.

While the software and hardware developments are ongoing, the PSCP with associated artifacts is also being developed. Once the PSCP is completed (from the applicant’s perspective), FAA is approached for commencing the Certification Project with the applicant.

Note: Based on the FAA meeting, for EFB applications such as TASAR (i.e., Type B), the PSCP is not of primary importance and may not even be required. FAA noted that the applicant may be able to engage directly with the POI for approval of the EFB mount and for previously installed EFB components (Section 4.3).

A notional 3-month certification time period is envisioned for TASAR, which represents the time period for periodic engagements with FAA in engaging with the POI and/or executing the PSCP (if utilized). If the initial inputs from the applicant indicate that the applicant has done homework and provided the required artifacts, the POI could allow use of the TASAR application in very short order (in the matter of a couple of weeks), allowing the go-ahead for the 6-month flight-use validation period with corresponding data collection. The validation time period may be shortened via approval by FAA for certification projects that are not excessively complex (in terms of certification level and/or no significantly new technologies or approaches being involved). TASAR would have good potential for a shortened validation period, but this is TBD with FAA. If the evaluation period is uneventful, then the operator will likely achieve full approval for use once the evaluation period is completed and a report documenting the results of this period is completed by the applicant and accepted by FAA. While this 3-month certification estimate is somewhat subjective (especially in lieu of the 6-month evaluation period), based on the successful meeting with FAA and feedback received, this 3-month estimate seems reasonable. A TASAR certification program should be relatively easy to achieve since it does not require certification of new technologies and has a low certification threshold (i.e., “Minor Effect” FEC).

Topic #3: Concluding Set of Recommendations

NASA Request #3: What further steps NASA could/should take without an actual applicant (e.g., an airline) or specific implementation (e.g., identified aircraft) to reduce the certification time and risk when such an applicant shows up. What materials can/should be developed that are not applicant specific? Are there additional steps a NASA/avionics vendor partnership could accomplish without an applicant?

Response: Section 4.2 and 4.3 and associated Appendices B and C provide significant certification and operational approval information, including inputs on the PSCP and DER feedback (which will be presented in the next section {Section 4.2}). Since the scope of the current work effort does not include the actual certification and approval of TASAR, actual certification and operational approval was not pursued here. However, significant details have been provided concerning the specific steps and associated artifacts that must be followed in achieving approval of the TASAR EFB application as a flight-deck advisory system. Specific recommendations have already been provided in Section 4.2.3.9 above under “Remaining, yet to be developed artifacts.”

This section examined FAA guidelines and regulatory requirements needed for the certification and operational approval of the TASAR EFB flight-deck application and provided a conceptual

plan expected to lead to successful certification and operational approval of TASAR. The next section provides results of a “dry run” review of these requirements with in-house DERs at Rockwell Collins.

4.2.4 DER “Dry Run” Review of Certification and Operational Approval Artifacts

This section examines elements associated with the certification and approval processes as they apply to the TASAR EFB application, which underwent a preliminary review with DERs for feedback whether the certification basis and means of compliance for approvals are appropriate. Specifically, this describes the following:

- 1) Representative artifacts and considerations of the TASAR certification and operational approval processes
- 2) A preliminary DER review, i.e., “dry run” of these artifacts and requirements
- 3) Results of this DER review, including feedback and recommended updates to these artifacts and certification requirements.

4.2.4.1 TASAR Artifacts Developed for DER Review

The majority of certification and operational approval artifacts utilized in the DER dry run reviews have already been discussed in Section 4.2.3 above. This section identifies additional artifacts that are more specific in nature and are provided in more detail in Appendix D.

Appendix D consists of several sub-appendices as follows:

- D.1 DO-178B Objectives Artifacts Requirements for Level D
- D.2 Tabletop EFB Evaluation (Detailed Check List #1)
- D.3 EFB Operational Evaluation (Detailed Check List #2)
- D.4 EFB Report Information Template
- D.5 EFB Line Evaluation Job Aid (Detailed Check List #4).

The DER reviewers represented both software and hardware certification disciplines and expertise. In general, without exceptions, DER reviewers were in concurrence with the information presented to them for TASAR certification requirements and offered additional advice, clarification, and perspective on a number of points as presented herein.

The following certification and operational approval artifacts and requirements were included in the information package discussed with the DER reviewers:

- 1) Overview of the certification and operational approval plan (i.e., PSCP)
 - a. Consisted of a brief overview of the five phases of the PSCP, i.e., conceptual design, requirements, compliance planning, implementation, and post certification phases
 - b. Brief review of the typical content of a PSCP
 - c. Review of the PSCP as applied to TASAR
- 2) Review of cornerstone EFB documents (FARs, regulatory, and guidance)
- 3) Certification approval considerations for the TASAR EFB application
 - a. TASAR EFB application assumptions
 - b. Review of current industry trends for EFB applications

- c. Key points and observations related to TASAR EFB certification approval
- d. Software-specific approval considerations and compliance
- e. Hardware-specific approval considerations and compliance

In addition to reviewing the above topics associated with achieving certification approval, the DER review also included several additional topics:

- 1) Discussed designee process used by FAA and responsibilities of the operator and FAA in the approval process
- 2) Discussed the TC, STC, TSO Authorization, Parts Manufacturer Approval (PMA), and the role of Conformity inspections
 - a. Type Design data (and processes) focused on the “Build” of the EFB system
 - b. Qualification data (and processes) focused on the “Airworthiness” of the EFB system.
- 3) Role of DO-178B for EFB applications like TASAR
- 4) Some potential risk reduction methods for:
 - c. Use of partitioning of system components to manage risks due to EFB system failures
 - d. Security considerations
 - e. Software revision considerations

4.2.4.2 DER Dry Run Review– Process Overview, Artifacts Discussion, and Feedback

The review of the TASAR certification operational approval artifacts from Section 4.2.4.1 was held with two experienced engineers from Rockwell Collins’ Certification Support Organization. One engineer is a DER designee with responsibilities related to certification of software-intensive systems. The other engineer is a soon to be “Systems and Equipment Unit Member” designee and is a subject matter expert in the area of certification of hardware-intensive systems.

Note 1: FAA is currently in the process of making changes to the “designee process” for approvals and is creating an Organizational Designation Authorization (ODA) Unit Member (UM) process. As it currently stands many DERs will eventually become Unit Members (UMs) with specialization in software, hardware, and/or systems.

Note 2: NASA has strong interest for further development and maturation of the TASAR EFB application and would ultimately like to see TASAR fielded as a flight-deck capability to provide flight path recommendations to the pilot, with the expectation to attain operational benefits for the end user operator. This will require gaining certification and operational approval from FAA and/or associated designees. The above mentioned requirements and artifacts from the subsections of Section 4.2 in this report and associated appendices are expected to be needed to determine the certification basis for TASAR and to provide the means for compliance for TASAR operational approval. As such, this project does not constitute an actual Certification Project and approval on its own but should enable a direct path to such approvals.

The DER review meeting commenced with a statement of the objective of the meeting, which was to present, review, and provide feedback on the information and artifacts that had been developed to identify and address TASAR-specific certification and operational approval requirements. The

TASAR operational concept and intended function were also briefly reviewed to provide context to the DER review. References to previous analyses that were already conducted that are relevant to the certification approval process addressed in the subsections of Section 4.2 were noted along with results of the major findings of these analyses.

The following topics were presented to and discussed with the DERs.

4.2.4.3 Overview of the Certification and Operational Approval Plan

The five phases of the certification process as provided by FAA guidance and the PSCP [27][28], both as a general review, and then with a TASAR-specific view of the PSCP, were presented as part of the DER dry run review.

DER Feedback: The DERs were in concurrence with the five-phase certification process. The DERs were also agreed that the PSCP elements had been adequately addressed at a high-level, including the TASAR-specific elements that were presented. It is noted that the TASAR-specific PSCP were limited to some but not all artifacts, since a fully executed TASAR PSCP would require completion of all steps to a sufficient level of detail and verification to achieve approval of an actual certification of the TASAR product, which is beyond the scope of this study.

4.2.4.4 Review of Cornerstone EFB FARs, Regulatory, and Guidance Documents

The following were identified as key documents that are fundamental to be considered for the certification of EFB products and applications:

The cornerstone FARs, regulatory and guidance documents for EFBs are as follows

- 1) Title 14 of the Code of Federal Regulations (14 CFR) parts 21, 23, 25, 27, 29, 43, 91F, 91K, 121, 125, and 135 [29]
- 2) Flight Standards Information System (FSIMS) – 8900.1 Change 47, Vol. 4, Chapter 15 – EFB Operational Authorization Process [14]
- 3) AC 120-76C, Guidelines for the Certification, Airworthiness, and Operational Approval of Electronic Flight Bag Computing Devices [13]
- 4) AC 20-173, Installation of Electronic Flight Bag Components [16]
- 5) FAA Order 8110.4C, Type Certification [27]
- 6) AC 21-16F, RTCA Document DO-160 “Environmental Conditions and Test Procedures for Airborne Equipment” [17]
- 7) AC 20-115, RTCA DO-178B, Software Considerations in Airborne Systems and Equipment Certification [20]

Note: A number of documents provide elements of potential additional approval requirements, i.e., compliance to certification requirements. These are primarily associated with hardware aspects of EFBs.

DER Feedback: The DERs agreed that this list represents the key documents that need to be carefully reviewed for deriving certification requirements that if met, will demonstrate knowledge and compliance by the applicant to FAA reviewers.

4.2.4.5 *Certification Approval Considerations for the TASAR EFB Application*

This section describes information provided to the DERs in a number of areas: 1) TASAR EFB assumptions affecting certification, 2) current industry trends for EFB applications, 3) key points and observations that affect TASAR certification, and 4) software-specific and 5) hardware-specific approval considerations for TASAR EFB compliance to the regulations.

4.2.4.5.1 TASAR EFB Assumptions Affecting Certification

The following TASAR EFB assumptions were presented to the DERs for consideration as part of the certification and approval process review:

- 1) Based on the Operational Hazards and Safety Requirements Analysis in [7], TASAR (as currently defined is anticipated to be designated as a “No Safety Effect” FEC, and should be limited to no greater than “Minor Effect” in the unexpected event that workload issues come to the forefront
- 2) TASAR is expected to be implemented as a Class 2 PED / portable EFB, with a read-only interface to on-board avionics systems, and will utilize antennas for accessible information sources via commercially available communication data links and networks
- 3) TASAR Class 2 EFB is expected to be installed as a “cockpit mount” in the flight deck
- 4) TASAR is expected to utilize an AID to serve as an intermediary interface to avionics systems
- 5) TASAR is viewed to be a Type B application.

DER Feedback: The DERs were in agreement with the assumptions noted in this section, without any corrective feedback or significant counterpoints.

4.2.4.5.2 Current Industry Trends for EFB Applications

Current trends for EFB applications were reviewed with the DERs and are summarized as follows:

- 1) EFBs and their software applications provide (or are expected to provide) a retrofit path for new, and increasingly more capable flight deck capabilities
 - a. The increased ability of COTS PEDs is providing impetus to add new capabilities economically
 - b. FAA has been relatively flexible in approving EFB applications but at times has become rigid in terms of what it is willing to allow for EFB implementations
- 2) Airlines are beginning to see cost benefits of EFBs, often with different business cases to equip. They see reduced pilot workload, simplified flight operations, and greater situational awareness as key benefits.
- 3) EFBs are becoming an essential tool in the flight deck, improving situational awareness and leading to improved pilot decision making. They allow the flight crew to connect in real time to rest of world (e.g. TASAR via data link connectivity to internet information sources for weather, traffic, airspace status data, etc.).
- 4) Currently, EFB requirements are in a state of flux. Some companies, in applying for certification approval, fall short of meeting FAA’s intended requirements. This at times results in FAA implementing new changes and adding new requirements.
- 5) While EFB hardware requirements and specifications are important, the future of EFBs is expected to largely depend on the capabilities offered by software applications.

- a. EFB hardware is expected to become commoditized.
 - b. Shift is towards development of more robust software applications.
- 6) Latest technological development for Class 2 EFBs is their ability to interface with aircraft systems and to provide an access point to wireless communications pipelines (similar to those planned for TASAR data connectivity).
- 7) Once ADS-B IN becomes available for display in aircraft, benefits of EFB become significant.
 - a. However, this raises the stakes for EFB software applications, which may go beyond Type A and Type B and may affect higher FEC (no longer “Minor Effect” or less).
- 8) TASAR is most closely aligned with Type B applications.
 - a. Consists of processing algorithms to provide recommended trajectory change requests to the pilot
 - b. TASAR is expected to be less critical than Type B applications associated with weight and balance and performance calculations.
- 9) While Class 1, 2, and 3 EFBs may be Windows XP-based, and Class 3 EFBs are generally the same as Class 2 EFBs in terms of hardware, Class 3 EFBs require more rigorous testing to meet FAA qualifications test.
- 10) Second generation EFB software continues to seek improved design to incorporate common workflow requirements, seeking reduced training time, and reduced number of touches, allowing more time for other tasks.
- 11) There is a likelihood that EFB systems with hosted Type A and Type B applications and with approved software (those designed using DO-178B) will be integrated in some installations.
 - a. This likely requires a dual processor EFB architecture, allowing partitioning of higher and lower criticality software applications
 - i. e.g., “approved” (i.e. DO-178B certified) software applications to be allocated to one EFB processor running DO-178B-certified Linux OS, and Type A and Type B “hosted” applications (developed without using DO-178B) running on a non-certified Windows OS (alternate architectures and approaches can be considered if equivalent in robustness).
- 12) TASAR, as a hosted application, may be integrated with other software applications (some hosted and perhaps some approved) and may be installed in a variety of EFB platforms including some with certified OS. The manner of integration and hosting of TASAR may affect the software certification requirements of its design.

DER Feedback: The DERs were in general agreement with the current trends in EFB applications without any corrective feedback or significant counterpoints.

4.2.4.5.3 Key Points and Observations Related to TASAR Cert. Approval

The following were noted to the DERs as being important elements of the certification process for TASAR:

- 1) The authorization process intended is for Part 121, 125, and 135 operations and require authorization from the FAA Principal Inspector (PI).
 - a. Part 91F operators do not require specific authorization for EFB operations, since TASAR does not replace any required systems.
- 2) Installed components of a Class 2 EFB (intended for TASAR) require approval as part of TC, ATC, STC, and ASTC via PMA. This allows FAA 145 repair stations to test, repair, and place a FAA serviceable tag on equipment.
- 3) Type A and Type B applications do not require DO-178B certification for applications software nor OS for Class 2 EFBs.
- 4) Airworthiness regulations only apply to installed EFB components and do not apply to portable EFB components (i.e., in reference to hardware).
 - a. Installed components for TASAR Class 2 EFB would include the mount (size and weight), power (maximum electrical load, voltage, and current frequency), and data connectivity (input/output data specifications and security).
- 5) Components of the Class 2 EFB include all hardware and software needed to support the EFB intended function.
 - a. Any EFB hardware not accessible to the flight crew on the flight deck (e.g., AID, antenna(s) for aircraft wireless), or not being portable must be installed in accordance with applicable airworthiness regulations (per AC 20-173 [16]).
- 6) Class 2 EFB hardware, internal components, and software do not require FAA airworthiness approval.
 - a. Type A and Type B applications are considered “hosted” because they have no requirement to be installed as part of an aircraft type design or as an alteration.
 - i. Such equipment would usually identify the hardware as miscellaneous, non-required equipment.

DER Feedback: The DERs were in general agreement with the elements identified in this section without any corrective feedback or significant counterpoints.

4.2.4.5.4 Software-Specific Approval Considerations

With TASAR being a software application hosted on an EFB platform, the DER review and associated discussions paid particular focus to software and its associated development requirements. As noted earlier in Section 4.2.3.6, “hosted” Type-B applications actually do not require airworthiness approval. In other words, these applications can be developed outside the development process specified by DO-178B, even for Design Assurance Level (DAL) “D.”

DER Feedback: As part of the DER review, there was considerable discussion about the extent and rigor required for software development of an EFB application such as TASAR.

At a minimum, the following steps were identified as being required for development of TASAR software, which does not required DO-178B:

- 1) Develop and review high-level requirements of the TASAR application software.

- 2) Develop the software system architecture based on low-level requirements. The low-level requirements do not need to be reviewed as part of any verification process.
- 3) Determine derived system requirements.
- 4) Prove that code meets high level requirements. No structural coverage needs to be demonstrated.
- 5) Ensure that high-level requirements:
 - a. Comply with system requirements
 - b. Are accurate and consistent
 - c. Are traceable.

The software development process for software similar to TASAR has rather minimal requirements associated with it in terms of rigor, artifacts, review process, and verification. The DERs recommended that one should strongly consider whether and the extent to which elements of the DO-178B process, particularly with respect to DAL D should be utilized. In the event of future updates and revision of the TASAR concept that could lead to a DO-178B requirement, by developing portions of the TASAR software using DAL D, one could make reuse of the code that has been developed to this DAL.

DO-178B DAL D has a requirement to meet 28 objectives for the various software development steps. These are described in Appendix D.1 for reference.

In summary, EFB software applications such as TASAR have a relatively low threshold of development required and do not require DO-178B to be applied. However, good software practices should be followed and depending on future reuse in higher certification levels, one may want to consider development of this software to DO-178B DAL Level D.

4.2.4.5.5 Hardware-Specific Approval Considerations

While TASAR is a software-enabled EFB application, the majority of certification-related requirement for compliance for the TASAR EFB system fall into the hardware domain.

Airworthiness regulations apply to installed EFB components and do not apply to the portable EFB components, including internal components of the EFB. For the TASAR EFB system, this primarily involves the installed components related to the following:

- 1) Mounting (size and weight)
- 2) Power (maximum electrical load, voltage, and current frequency)
- 3) Data connectivity (input/output data specifications and security).

EFB components are “installed” when they are incorporated into aircraft type design under 14 CFR part 21 or as a proper alteration under 14 CFR 43.3. All other EFB components are considered “portable,” regardless of how often they are removed from the aircraft.

EFBs may consist of modular components (e.g., computer processing unit, display, controls). Any EFB hardware not accessible on the flight deck by the flight crew or not portable must be installed and certificated equipment covered by a TC, amended TC, or STC. The one exception to being accessible on the flight deck is a remotely mounted antenna that provides signal reception to the EFB. The AID falls into this category of being installed and requiring type certification.

Major Class 2 EFB components (motherboards, processors, random access memory, video cards, hard drives, power supplies and connections) must be configuration controlled, with any changes requiring reevaluation to demonstrate that the intended function is still met, i.e., non-interference, and reliability requirements are still met. For sealed components one should use the manufacturer model / part number.

The following high-level hardware requirements are obtained from “*Flight Standards Information System (FSIMS) – 8900.1 Change 47, Vol. 4, Chapter 15 – EFB Operational Authorization Process*” [14]:

- A. With respect to the EFB display, e.g., TASAR, requirements must be met for legibility, brightness, viewing angle, etc., along with requirements associated with input devices (e.g., stylus, digitizer pen, touchscreen).

The following hardware test requirements must be addressed, as applicable, to the use of the EFB system:

- B. Rapid Decompression (RD) Testing
(should not be a significant consideration for TASAR)
- C. Electromagnetic Interference / Non-Interference Testing
(also required for TASAR as a T-PED)
- D. Antennas airworthiness requirements
- E. Power Sources airworthiness requirements
(TASAR likely to use aircraft power, but not a firm requirement)
 - a) Battery primary
 - b) Battery maintenance
 - c) Aircraft secondary power
 - d) Aircraft primary power
- F. Data Connectivity (Class 2 Only) airworthiness requirements (required for TASAR)
- G. Data Loading/Database Changes airworthiness requirements
(TBD for TASAR; likely not a safety requirement but a usability requirement)
 - 1. Class 1 or 2 EFBs must have a reliable means for revising the EFB databases
 - 1. Database currency is determined by what required aeronautical information the EFB is replacing.
 - 2. Each method of data revision must ensure integrity of the data being loaded and not negatively impact the reliability of EFB operation.
 - 3. Procedures must exist to protect the EFB from corruption, especially when internet and/or wireless means are used.
 - 4. Database revision does not include application software or operating system changes.
 - 5. Application software and/or operating system program changes must be controlled and tested prior to use in flight.
 - 6. Database and/or application software changes may not be performed during operations (taxi, takeoff, in-flight, landing).

Note: External drives for data loading are considered ancillary EFB equipment and not subject to specific requirements beyond those identified for data loading/database revision above.

H. Mounting Devices (Class 2 Only) airworthiness requirement (likely required for TASAR)

The EFB, when attached to its appropriately designed mounting device, must be evaluated to ensure operational suitability in all ground and flight operations and conditions (airborne use for TASAR).

- a) When attached to its mounting device, the EFB must not interfere with flight crew duties and must be easily and safely stowed when not in use.
- b) The attached EFB must not obstruct flight crew primary and secondary fields of view (See AC 120-76C).
- c) The attached EFB must not impede safe egress.

The above hardware requirements represent an overview of high-level hardware requirements needed to be met to demonstrate compliance with the FARs, regulatory and guidance documents for EFB systems. More specific requirements are found in AC 20-173, *Installation of Electronic Flight Bag Components* [16] and AC 21-16, *RTCA Document DO-160 “Environmental Conditions and Test Procedures for Airborne Equipment* [17].

DER Feedback: The DERs were in general agreement with the elements identified in this section without any corrective feedback or significant counterpoints.

4.2.4.6 DER Feedback

In general the DERs were satisfied with the level of compliance requirements presented toward the certification of EFB systems such as the TASAR EFB application, relative to the information provided and with respect to software and hardware aspects of EFBs. No major areas of concern or significant counterpoints were raised.

The DERs did offer some additional perspective in the following areas:

1. Discussed designee process used by FAA and responsibilities of the operator and FAA in the approval process
2. Discussed the TC, STC, TSO Authorization, PMA, and the role of Conformity inspections
3. Some potential risk reduction methods

4.2.4.6.1 FAA Designee Process

FAA utilizes the ‘Designee Process’ as an extension to their certification and operational approval organizations (e.g., Aircraft Certification Office {ACO} also referred to as AIR; Flight Standards {AFS}, the Aircraft Evaluation Group {AEG}, Manufacturing Inspection District Office {MIDO}, and others. Organizations and individuals with demonstrated expertise can be appointed as approval designees for portions of the certification approval process. Individuals from engineering and manufacturers may receive designee appointment, e.g., DER, DMIR, and DAR, who can address either manufacturing or maintenance airworthiness of a product. DERs may be appointed to software, hardware, or systems as part of the certification process. DMIRs may serve as inspectors of conformity, i.e., that products and associated parts are built to the required specifications and process. Designee may come from 3rd party organizations, be appointed from

small shops supporting certification for general aviation or from large manufactures for air transports, regional aircraft operators, and high-end business aviation.

4.2.4.6.2 TC, ATC, STC, ASTC, TSOA, PMA, Conformity Context

There are multiple means to certify a new product or a revised article. From an EFB system point of view, only installed components require a Type Certificate approval. The term Type Certificate can encompass a range of approvals, including TC, ATC, STC, and ASTC.

A TSO is a minimum performance standard, defined by the FAA, used to evaluate an article. An article can be a material, part, component, process, or appliance (refer to Title 14, Code of Federal Regulations, 21.1(b)(2)). Each TSO covers a certain type of article. When authorized to manufacture an article to a TSO standard, this is referred to as a TSO authorization (TSOA). Receiving a TSO authorization is both a design and production approval.

There are two aspects to achieving approval, 1) Type Design Data which contains information and data associated with “building the product”, and 2) the “qualification” aspects of the integrity of data, including software verification, which demonstrates “airworthiness.” Manufactures must have established and maintain approved quality systems and processes to support approvals to meet airworthiness requirements.

Conformity is typically a ‘one-of-a-kind’ inspection of an individual part that is used as part of an individual system being certified. When qualified, such a unit is issues an 8130 airworthiness tag. For a larger number of units being develop, this typically requires a Parts Manufacturer Approval, which is typically only issued to larger manufacturers.

4.2.4.6.3 Potential Risk Reduction Methods

The following three subtopics were discussed with the DERs as part of the DER review:

- 1) Use of partitioning of system components to manage risks due to EFB system failures
- 2) Security considerations
- 3) Software revision considerations

4.2.4.6.3.1 Partitioning of System Components to Manage Risks Due to EFB Failures

A key issue when integrating EFB applications such as TASAR with other software applications is the potential adverse effects of one application, e.g., the “hosted” typically non-approved software application with “approved” certified software applications. Several configurations are possible:

- 1) TASAR is standalone, with its own dedicated processor (own OS and application software) and dedicated display, this is will not require any partitioning or special protections
- 2) TASAR has its own dedicated processor, but shares a common display with other “Approved Software” applications / software. Recommended Display Standards, e.g., AC 25-11, Electronic Flight Deck Displays (for Part 25 aircraft) [30], and AC 23.1311-1, Installation of Electronic Display in Part 23 Airplanes [31] must be followed.
- 3) TASAR is hosted with other “approved” software applications in a shared processor. In this case, approved partitioning techniques must be followed. These techniques are

required to guarantee throughput and resources (e.g., memory, hard drive, avionics data, etc.) of Approved Software applications.

As EFB software use continues to increase, a dual EFB architecture, with separate OS and application software, segregated by hosted versus approved designations is a likely outcome. However it is accomplished, protections of processing time and memory space must be ensured to prevent one application from taking over and adversely affecting higher-criticality applications.

4.2.4.6.3.2 Security Considerations

While not expected to be a significant issue for TASAR, which utilizes a read-only interface to avionics systems and thus does not transmit and pose a security threat to aircraft systems, the DERs noted that security issues are becoming more paramount concerns for FAA. Mitigating techniques should be followed, such as maintaining read-only interfaces. In the case of transmit-only interfaces where the use of “polling” (e.g., once per second) for received inputs is used to manage the interface, techniques should be used to avoid disruption via a transmitter ‘babbling’ continuously and thus disrupting the I/O process.

The DERs noted that for security, one should also address threat scenarios in the safety assessment. As currently defined, TASAR is not expected to pose a security threat as it is read-only.

4.2.4.6.3.3 Software Revision Considerations

The DERs provided insight with respect to the field-loading of updated software. A key step in this process is that assurance is required that what was loaded into the EFB is what was intended to be loaded. Use of checksums via the program itself, or via procedural means are potential candidates to assure that proper software and operating systems are loaded into the EFB system.

4.2.4.7 DER Review Conclusions

As noted throughout this section, EFB applications such as TASAR have relatively minimal software-specific certification requirements and do not require DO-178B as part of their software development process to gain approval. EFB hardware-specific requirements are considerably more extensive and apply to the installed portions of the Class 2 EFB. Thus in many ways, EFB approval should be relatively straight forward for the TASAR Type B EFB application.

The DERs were in general agreement with the assessment presented to them for a TASAR-like EFB application. They provide some additional perspectives on the certification process related to the designee process, type certification, and risk reduction techniques relative to system partitioning, security, and the software revision process.

While TASAR has a relatively low certification approval threshold, gaining full approval for an EFB system requires one to address a wide range of approval requirements, as reflected in the questionnaires in Appendices D.2 through D5. These questionnaires were reviewed and TASAR-specific comments were entered into the questionnaires where applicable.

4.2.5 TAP HMI Version 4 Certification and Operational Approval Analysis

This section documents the results of a certification assessment of the Traffic Aware Planner (TAP) HMI, Version 4 (V4). The analysis examined all HMI elements that pose a potential increase in certification / operational approval requirements, with an emphasis on an assessment of regulations that may govern the graphical elements depicting aircraft navigation information

(e.g., routes, heading), traffic information, weather and airspace information, and wind information. The analysis includes recommendations, with regulatory reference, on specific HMI changes to reduce the threshold for certification and/or operational approval.

As background to this analysis, TAP represents the software engine of the TASAR EFB application that is being developed by NASA Langley Research Center and its research partners (refer to Figure 4). The TAP HMI V4 represents the latest version of the pilot interface in using the TASAR application, which incorporates updates and enhancements based on pilot feedback from 1) a HITL experiment conducted under this contract by the University of Iowa OPL [32], and 2) a flight evaluation of TASAR in a relevant operational environment conducted by Advanced Aerospace Solutions, LLC for NASA under another contract [8]. NASA developed an updated TAP HMI user interface, V4, to address comments received and to further mature the effectiveness of the TASAR application in terms of situational awareness, workload, and compatibility with other on-board flight-deck systems. Pilot comments and feedback from [32][8] that influenced NASA's update to the TAP HMI leading to V4 are described in Section 4.2.5.3.1.1 below. The TAP HMI V4 has undergone a second HITL evaluation [33] to determine its effectiveness of the revised HMI design.

The Operational Hazard and Safety Assessment in Section 4.2.1 has determined a FEC of "Minor Effect" (which has also been confirmed by FAA – Section 4.3) for the TASAR EFB Application. This section (Section 4.2.5) provides the results of a certification assessment of the TAP HMI V4 to determine if TAP display elements from V4 continue to be consistent with the "Minor Effect" designation of TASAR and to ensure that elements of the V4 HMI do not inadvertently raise any undo certification issues. The key guidance documents forming the basis of the certification and operational approval assessment of the TAP HMI V4 were FAA AC 120-76B [34] and Flight Standards Information System (FSIMS) – 8900.1 Change 47, Vol. 4, Chapter 15 – EFB Operational Authorization Process [14]. An updated version of AC 120-76, Version C [13] was reviewed to determine if any significant updates may affect the TASAR EFB certification assessment, particularly pertaining to the revisions made to the TAP HMI in V4.

4.2.5.1 TASAR HMI Requirements Assessment

While the TASAR EFB application has been designated with a "Minor Effect" FEC, this designation is silent with respect to the specific requirements to the TAP HMI. The following sections address HMI-specific approval considerations.

4.2.5.1.1 Display of Own Ship and Proximate Traffic Awareness

A key certification issue related to the EFB display of map, route, and / or traffic information is the depiction of own ship as part of the EFB application. FAA AC 120-76B [34] was strict in its view of depiction of own ship on the EFB display, forcing a "Major Effect" designation if own ship was displayed. FAA AC 120-76C [13] relaxes this requirement somewhat by allowing display of own ship in certain cases. Reference [13] allows the display of own ship on the EFB display when the aircraft is operating on the airport surface at speeds less than 80 knots. From [13] display of own ship is only allowed as an aid to situational awareness and is not authorized for use for surface navigation, surface alerting, time-based operations, guidance, maneuvering and control functions. Display of own ship on the airport surface as a Type B application is intended to help flight crews orient themselves on the airport chart / map, and to improve pilot positional awareness during taxi takeoff and upon landing. Type B EFB applications using display of own ship position

on the airport surface are not of sufficient certification pedigree to be used as the basis for operational guidance, maneuvering, and control.

Display of own ship when operating on the airport surface at speeds of 80 knots or greater, or when used in actual flight, elevates the FEC to “Major Effect” with a corresponding increase in software certification and operational approval requirements, e.g., requiring approved software per DO-178B.

From a TASAR HMI perspective, display of own ship is not allowed, as the TASAR intended function is strictly as an en route advisory tool for the pilot. The TASAR HMI V2 does not display own ship nor any other traffic information in any graphical depictions of route information (active nor preview of candidate trajectories).

V4 of the TASAR HMI provides a limited graphical indication of proximate traffic (not including its position) in relation to the preview route when the pilot is evaluating route improvement candidates using the TASAR Manual Mode. When TAP determines the presence of proximate traffic, serving as a traffic hazard, select information regarding this traffic hazard is depicted in the Visualization Panel to provide traffic awareness to the pilot. Presence of a traffic hazard would likely result in a clearance request being denied due to the traffic in question.

Own ship is not explicitly shown in the TAP HMI V4 and can only be approximately inferred from the EFB display to be located somewhere near the bottom center of the Visualization Panel. The TASAR HMI V4, including the TAP Manual Mode, and the depiction of traffic hazards on the Visualization Panel are discussed in more detail in Section 4.2.3.2 below. Certification assessment analysis results of the TASAR HMI V4 are described in Section 4.

4.2.5.1.2 Other HMI Approval Requirement

FAA Flight Standards Information System (FSIMS) – 8900.1 Change 47, Vol. 4, Chapter 15 – EFB Operational Authorization Process [14] provides specific guidance concerning areas that must be addressed by the applicant when requesting approval of an EFB application by the POI, including areas related to the HMI. This guidance is provided in the form of a number of questionnaires the applicant must answer for review by Flight Standards / POI to gain operational approval for the EFB application.

The following represents a summary of the specific focus areas of EFB HMI design as indicated by the EFB Evaluation Checklist 1 Questionnaire per Figure 4-79 [14] and provided in detail in Appendix D (D.1) that the operator must address with the POI pertaining to EFB display of information, i.e., the pilot Human Machine Interface.

Checklist 1 represents the Tabletop EFB Evaluation that must be demonstrated to the POI. It consists of approximately 100 questions that must be answered as Yes or No, that describe whether the EFB application being considered meets the intended evaluation requirements.

The checklist starts with 1) EFB hardware questions, then 2) presents general user interface questions, and 3) ends with specific application questions (if applicable). The checklist is designed so that any question answered as “No” requires a comment that may include, “Not Applicable.” After the operator has completed this checklist, the results are documented so the POI can review the results with the operator.

Hardware-Specific Questions address EFB readability in sunlight, labeling of controls, ease of providing inputs, EFB start-up, ability to reboot, ease of comprehension of failure modes (identification, annunciation), and ease of recovery when EFB fails.

General User Interface Questions address the following list of factors: Revision history and expiration dates to be clearly presented, responsiveness of EFB to inputs, EFB processing speed, use of busy / progress indicators, consistent user interface allowing selection and use of functions and navigating the display, display of needed information and ease of access (avoid missing or difficult to find information), common actions and timely access to critical functions, standard ways to perform common actions, uniformity of display and controls across the application and also other applications, color viewing and ability to distinguish in various lighting conditions, color coding / shading / highlighting for display of critical information, appropriate use of red and yellow colors (only use for warnings and cautions), readability of text (including in low-visibility conditions), contrast of text in relation to display background, use of upper and lower case frequency, ease of bringing out of view information into view, icon and symbol functions obvious and distinguishable / explained by label or other means, etc.

Application Software-Specific Questions include the following: Ability to quickly and accurately find information, consistency of information layout, ease of being able to read high-priority information, ease to determine open/active application(s), detection of incorrect information formats / data range, and error messages, crew training, etc.

The detailed Checklist 1 questionnaire is provided in Appendix D (D.1).

4.2.5.2 Review of Changes to AC-120-76C; Potential Effects on TASAR FEC

As part the TAP HMI V4 certification and operational approval review addressed in this report, FAA AC 120-76C [13] was examined for potential updates to approval requirements that could have an effect on TASAR (recall that the previous certification and operational approval analysis of TASAR were based on AC 120-76B). From this review the following represent notable changes from AC 120-76C:

- AC 120-76C explicitly constrains the use of Type A and B applications to FECs of “Minor Effect / Hazard” or less

Note: TASAR, as previously analyzed and confirmed by FAA approval authorities is a “Minor Effect” Type B, Class 2 EFB application. This report reviews TAP HMI V4 to determine if any updates adversely impact this designation (refer to Section 4 for results of this assessment)

- FAA clarified the ability and limitations of an applicant with respect to being able to display own ship position for their respective EFB application (EFB Class and Software Type)
 - Own ship can be displayed only on the airport surface, when operating at less than 80 knots
 - Own ship cannot be displayed when in flight when using Class 1 and 2 EFBs and Type A and B software. In flight display of own ship warrants a “Major Effect / Hazard” designation and requires a Class 3 EFB (or avionics) with Type C software.

- Own ship depiction that is allowed on the surface can only be used for situational awareness and not for operational guidance / maneuvering / control of the aircraft.

Note: TASAR is used during flight above 10,000 ft. altitude and can thus not display own ship position without adversely impacting its certification level (i.e., it would elevate the certification level to “Major Effect/Hazard” requiring Class 3 EFB / Type C Software designation).

- Section 11.e.4.c [13] notes that “data link EFB functions may display approved sources of weather for strategic / flight planning purposes” (thus removing the word “unapproved”)
- Section 11.e.4.d [13] notes that “data link graphical weather from sources ... may be from approved sources of advisory weather information and can only be used for strategic / flight planning purposes. Do not use data link graphical weather information for tactical decisions during critical phases of flight, because data quality is uncontrolled for aviation use. Do not use data link graphical weather data as a substitute for airborne weather radar or thunderstorm detection equipment.”

Note: The TAP HMI V4 provides weather hazard information for pilot situational awareness but does not replace the use of weather radar or thunderstorm detection equipment for tactical decisions. Since TAP HMI V4 utilizes display of weather hazard information for pilot situational awareness, this aspect is further analyzed in Section 4.3 for any impact on TASAR/TAP certification requirements.

- “Type C software applications are approved by the FAA using RTCA/DO-178 or another acceptable means. These are “non-EFB” software applications found in avionics and include intended functions for communications, navigation, and surveillance that require FAA design, production, and installation approval. Type C applications are approved software for surface and airborne functions with a failure condition classification considered to be a major hazard or higher.”

Note: This is not a new requirement from AC 120-76C. However, this requirement continues to indicate that applications related to surveillance, e.g., ADS-B enabled Cockpit Display of Traffic Information (CDTI) applications fall under the banner of Class 3 EFB (or avionics) / Type C software. Since TAP HMI V4 provides Traffic Hazard situational awareness, this aspect is further analyzed in Section 4.2 for any potential impact on TASAR / TAP certification requirements.

4.2.5.3 Overview and Comparison of TAP HMI V2 and V4

Before describing an overview and comparison of the TAP HMI V2 and V4, the next section summarizes some of the factors that led NASA to redesign the TAP HMI, leading to V4, which is analyzed in this report.

4.2.5.3.1 Summary of Pilot Comments and Feedback on TASAR TAP HMI

As already noted, TASAR and TAP HMI V2 was already analyzed in a HITL experiment (HITL-1 [32]), which served to inform the subsequent TASAR flight trial by Advanced Aerospace Solutions, LLC [8]. [32] and [8] provided pilot comments and feedback on the TAP HMI, which are summarized in the next sections.

4.2.5.3.1.1 Pilot Comments, Feedback on TAP HMI from HITL-1 and TASAR Flight Trial

The following summarize pilot feedback from HITL-1 [32] (Section 4.2.5.3.1.1.1) and the initial TASAR Flight Trial [8] (Section 4.2.5.3.1.1.2).

4.2.5.3.1.1.1 HITL-1 Feedback on TAP HMI V2

The results of the post-simulation questionnaire from HITL-1 [32] clearly indicate that the participants found the TAP interface easy to work with and useful to very useful. The participants generally rated the screen elements as useful to very useful and overall easy to understand. A few outliers existed concerning specific screen elements; however, the general consensus of the participants was that the TAP display as presented (V2) was useful and easy to use. Many of the narrative comments made by the participants directly affected the implementation of the TAP interface for the flight trial that was performed subsequent to this experiment [8] and for the development of the post-flight trial next generation of the TAP interface, i.e., TAP HMI V4.

Overall, the TASAR application was very well received by almost all of the pilots in HITL-1. Several of them were excited to have such a tool available to them in the cockpit environment and felt that it was long overdue to have access to such information.

From the post-simulation interviews and questionnaires completed by the 12 participants, the following comments and feedback on their use of the TAP HMI V2 were received:

- There was some confusion about two of the button sets available to pilots. The first set of buttons causing confusion was the AUTO and MANUAL buttons along the top. The pilots indicated that the buttons either need to be removed on some screens (such as the Selected Optimization Screen) or grayed out differently to make it clear what screen was still available to be selected or which screen was the current one.
- The buttons across the bottom of the Selected Optimization Screen also caused confusion in some pilots. These buttons were there to log the result of asking ATC for a flight path request that was generated by the TAP Auto Mode. Several pilots did not see the point of having these buttons and would prefer they were not there at all, claiming they did not add any value. The fact that these buttons were only visible in some modes caused additional confusion.
- Some pilots wanted to have more information available to them, in particular weather data to know why certain optimizations were being made. The pilots felt that it was not sufficient to simply know that a route optimization was being impacted by weather. Details such as approximate location and time until convective weather was to be encountered on the unmodified route are important factors that help give pilot situation awareness. The pilots also indicated that future builds of the TAP software should have more uniformity between the TAP Auto Mode and TAP Manual Mode screens, including the Route Display.

4.2.5.3.1.1.2 Flight Trial Feedback on TAP HMI

Advanced Aerospace Solutions, LLC conducted an initial flight trial of TASAR [8] with the goal to be able to demonstrate and evaluate TASAR functionality in an operational environment and to collect pilot assessment data of TAP operation and the TAP HMI. The following represent an overview of some of the key feedback received from pilots concerning the TAP HMI used in the flight trial (i.e., an updated version of V2 that incorporated some feedback from HITL-1).

As with HITL-1, pilots in the flight evaluation perceived TAP as easy to use and understand. Likert ratings on ease of use generally yielded good scores but allowed room for improvement on route visualization and understanding and indicated needed improvements on bearing and distance controls. Recommendations of the TAP HMI included:

- 1) Better visual depiction of optimized route, 2) request to add new airspace hazard classes (e.g., weather, SUA), 3) add speed control into optimizations.

From the flight test evaluation of TASAR specific comments for possible HMI improvement opportunities are as follows:

- Connection status of individual data connections is not necessary. If there is a problem, indicate it and provide ability to go to another screen with more details of the issue.
- Many pilots had difficulty finding what waypoint was currently set as the optimization limit
- Use color palette that is standardized for commercial aircraft
- Selected Optimizations need to be easier to set
- Show a line going around a SUA for better situational awareness
- Need better map depiction; pilots are generally visual. Show conflicts to be avoided, e.g., SUAs
- It would be nice to know what traffic TAP is considering
- Verify all suggested routes with map for reasonableness
- Make map consistent with Navigation Display, also North-up mode
- Need better visualization tools, i.e., map. Show traffic.
- Show full route waypoints/names and optimization names vs. 1, 2, 3
 - Show full current route, fix names on map, consider adding a title to every page
- Yellow text, e.g., SUA should be bold for visibility reasons
- Make conflicts stand out more; particularly meant for Manual Mode
- Solution filters need rework or removal
- Show own ship
- Intelligently finding off-route waypoints to use
- Need a more visual tool to select optimization
- Use touch screen capabilities to find waypoints on map
- Make it easier to remember to enter the Rejoin Waypoint
- Make it easier to clear any one part of the optimization
- Pilots want the “what” and “why” as part of displayed information
- Consider adding a profile view for vertical change solutions
- Add fix / bearing / distance tool
- Many wanted to see winds data
- TAP functions were well integrated, but a significant amount of inconsistency was noted

- Most pilot wanted an alert, although verbally in debrief they were split on whether it should be an audible or a pop-up
- Add volcanic ash advisory areas to avoid
- Solution filters are not necessary
- Provide ability to remove a specific constraint (e.g., second off-route waypoint, ...).

Based upon pilot comments and feedback from HITL-1 and the TASAR flight trial, NASA incorporated many features to the HMI redesign embodied in TAP HMI V4. The next section provides an overview of V2 and V4 of the TAP HMI.

4.2.5.3.2 TAP HMI Overview

This section provides an overview description and comparison of the NASA-developed TAP HMI V2 and V4. TAP HMI V2 underwent an evaluation during the HITL-1 experiment [32]. This version of the TAP HMI was also used in the initial flight trial evaluation [8]. TAP HMI V4 was developed by NASA in response to feedback and lessons learned from HITL-1, the flight trial, and additional maturation of the TASAR application. Improvement recommendations, many identified in the previous section (Section 4.1) were incorporated into TAP HMI V4. The TAP HMI V4 has undergone a second HITL evaluation (HITL-2), which is currently being analyzed.

TAP capabilities include an Auto Mode and Manual Mode that support the flight crew in receiving flight path improvement opportunities to the current flight plan. TAP utilizes on-board data sources for 1) aircraft state, FMS active route, etc., 2) ADS-B IN and other sources for traffic information, and 3) internet data for wind updates, convective weather hazards, and airspace constraint information in order to offer improvement opportunities for fuel and/or time savings.

In the Auto Mode TAP continually monitors the current flight trajectory and information sources to periodically (~1 minute intervals) provide lateral, vertical, and combination lateral/vertical trajectory changes that are free of hazards /conflicts, e.g., traffic and weather, and offer fuel consumption savings and / or reduced flight times over the current flight plan. Recommended trajectories are evaluated for compatibility of ATC constraints (e.g., traffic complexity / density, airspace constraints, location within the sector) with the goal to have a higher likelihood of clearance approval by ATC.

The Manual Mode of TAP allows the pilot to request specific trajectory changes for evaluation by TAP in seeking route improvement opportunities on their own initiative. In the Manual Mode, the pilot enters revisions to the current flight plan for evaluation by TAP. TAP then computes impact on fuel consumption and flight time and will also notify the pilot in the event the proposed trajectory is subject to traffic or weather hazard constraints. If no hazards or constraints exist and fuel and/or time savings can be achieved, the pilot, at his / her discretion can request a clearance from ATC for the new flight trajectory.

Upon power-up of the TASAR application, the pilot inputs initialization of TAP data and reviews checklist items to ensure TAP is properly configured and operational. The pilot also established the cost index and preferred altitude and cruise speed (e.g., ECON setting) that are compatible with the FMS-loaded flight plan.

4.2.5.3.2.1 Initialization (V2) and Startup Checklist (V4) Screens

TAP HMI V2 utilizes an Initialization Screen, shown in Figure 5a, while for TAP HMI V4 the initialization screen was redesigned and updated and is referred to as the Startup Checklist Screen, which is illustrated in Figure 5b.

For both versions, V2 and V4, the Initialization Screen (V2) and Startup Checklist Screen (V4) appear at startup of the TAP application.

As illustrated in Figure 5a, the Initialization Screen displays the status of data connections and provides data validity checks. Once all items have passed, signified by being green, the pilot then accepts the initialization screen.

The Initialization Screen from V2 was redesigned and enhanced for V4 and is now referred to as the Startup Checklist Screen (Figure 5b). The Startup Checklist Screen allows the pilot to perform the following tasks:

- 1) Ensure that TAP is configured properly
- 2) Confirm TAP's status and settings
- 3) Enter, verify, and correct route information for the flight.

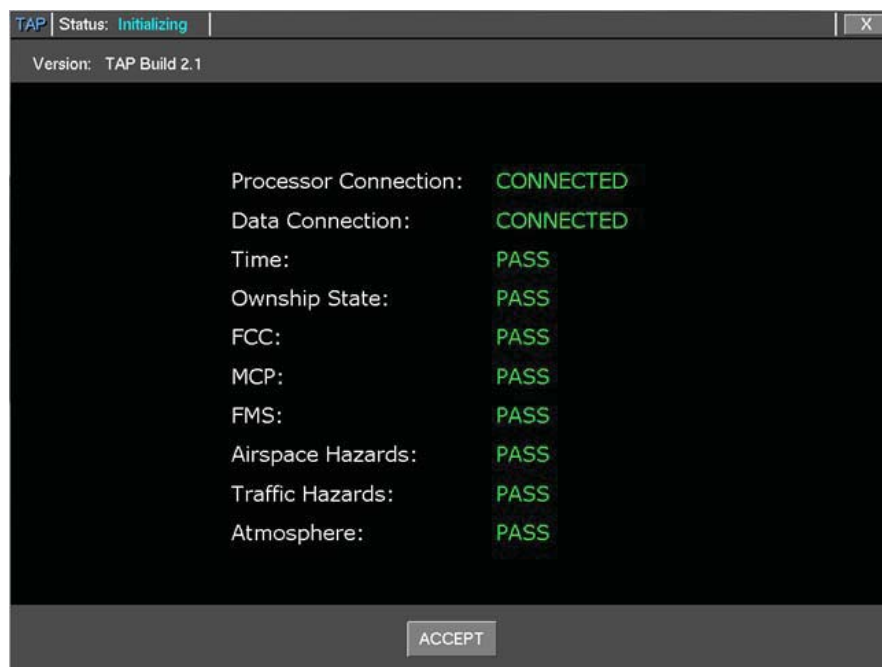


Figure 5a TAP HMI V2 Initialization Screen

The V4 Startup Checklist Screen provides greater integration of initialization items in the V2 Initialization Screen, eliminating some individual items, and aggregating them more globally. For example, information sources, e.g., Time, Own ship State, Flight Control Computer (FCC), Mode Control Panel (MCP), and FMS are no longer specifically highlighted and are handled by TAP automatically in the back ground.

The Checklist Complete tab in V4 replaces the Accept button in V2 and ensures that the pilot has verified that the correct Navigation Database and TAP versions are being used. The TAP Connection tab consolidates the various data sources and indicates that TAP data sources are available and operational. The Startup Checklist Screen contains additional information fields that are not included in the V2 Initialization Screen, and thus makes more effective use of available

display area, while integrating additional pertinent initialization information into one display screen. Also included in the Startup Checklist Screen (Figure 5b) are departure and arrival airport information and an input that allows the pilot to enter and verify the Route Waypoints along the flight plan. The Startup Checklist Screen also allows the pilot to select TAP optimization criteria, e.g., Cost Index, Cruise Altitude and Speed, and provides the Max Optimization Waypoint (WPT), representing the waypoint along the route to which TAP should seek trajectory improvement opportunities. The Checklist Complete tab allows the pilot to confirm that checklist items have been completed.



Figure 5b TAP HMI V4 Startup Checklist Screen

The V4 Startup Checklist Screen is considerably more consolidated in its information content and integrates additional pertinent information in one display screen when compared to the V2 Initialization Screen. In addition, the use of selection windows (e.g., drop-down/pop-up) and keyboard entry allow for clear and easy to use entry and selection of information by the pilot.

Upon completion of accepting (V2) or completing the checklist (V4), TAP checks whether or not the aircraft has achieved an altitude above 10,000 ft. TAP HMI V2 utilizes a Standby Screen (Figure 6) that is automatically displayed if the aircraft has not yet reached 10,000 ft. The current altitude is displayed to allow the pilot to readily see the flight status relative to the 10,000 ft. criteria. TAP HMI V4 eliminates the use of the Standby Screen and automatically transitions to the Auto Mode Screen that will be described in the next section. For V4 a “Standing by for 10,000 ft.” TAP message is displayed in the Message Window of the Auto Mode Screen when the flight has not yet reached 10,000 ft. altitude above the ground.

Once an altitude of 10,000 ft. is reached, V2 transitions from the Standby Screen to the Auto Mode Screen, while V4, already using the Auto Mode display, clears the “Standing by for 10,000 ft.” message in the Message Window.

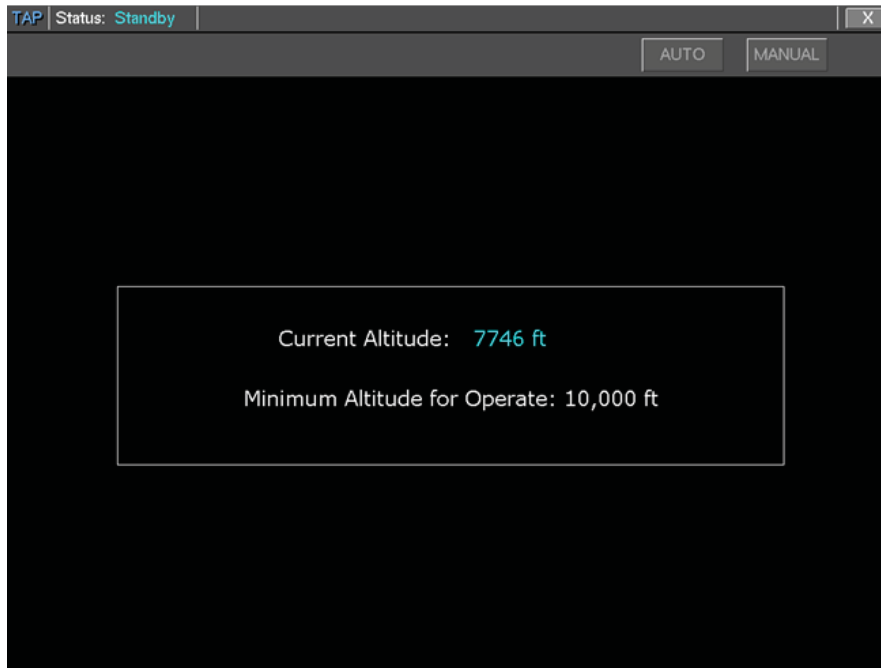


Figure 6 TAP HMI V2 Standby Screen

4.2.5.3.2.2 Auto Mode Screens

Figure 7 and Figure 9 illustrate the TAP HMI V2 and V4 Auto Mode Screens, respectively.

4.2.5.3.2.2.1 TAP HMI V2 Auto Mode Screen

For V2, the Auto Mode Screen provides designation of Mode (Auto or Manual) in the upper right corner, Controls across the top of the display for 1) selecting the number of Off-Route Waypoints (maximum of 0, 1 or 2) that TAP uses to compute trajectory improvement opportunities, 2) the optimization criteria of Time or Fuel, and 3) thresholds of lbs. of fuel saving and / or time savings used for filtering TAP solutions. The lower portion of the V2 Auto Mode Screen provides lateral, vertical, and combo (lateral and vertical) solutions on the left side, with outcomes of projected fuel and time impact (savings or losses) for each solution along the right side.

The pilot can select any solution from the V2 Auto Mode Screen and can freeze it for display on the Selected Optimization Screen, illustrated in Figure 8, for further assessment prior to making an ATC request for a revised clearance of the new trajectory. The Selected Optimization Screen displays the selected optimization candidate and its outcomes, along with a listing of the waypoints and their Track To heading and Distance on the left side of the display (see Figure 8). The right side of the display provides a graphical depiction of lateral and combination views of the trajectory being assessed (depicted in blue) for possible request to ATC and also provides the original flight plan being followed (depicted in magenta). No graphical view is provided for vertical candidate solutions.

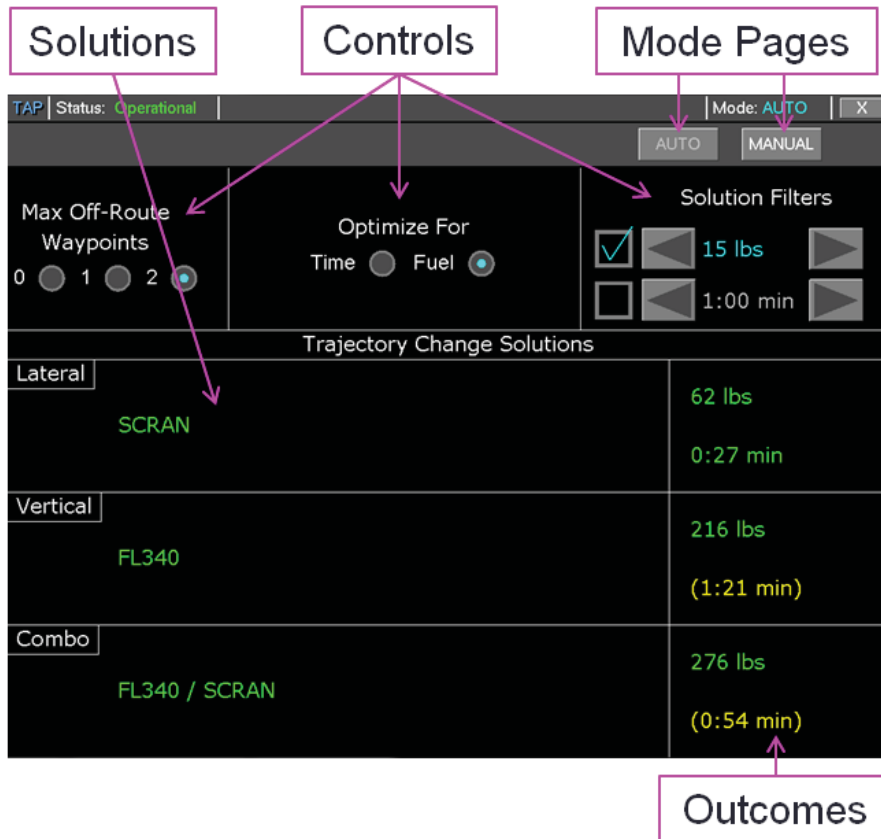


Figure 7 TAP HMI V2 Auto Mode Screen

4.2.5.3.2.2.2 TAP HMI V4 Auto Mode Screen

The TAP HMI V2 Auto Mode Screen has undergone significant revision for the TAP HMI V4 Auto Mode Screen (see Figure 9). From Figure 9, the V4 Auto Mode Screen consists of three panels: 1) the Solutions Panel in the upper left, 2) the Visualization Panel on the right half side, and 3) the Optimization Control Panel in the lower left of the Auto Mode Screen. In addition the Auto Mode Screen utilizes additional Top Bar and Bottom Bar status and control elements that increase pilot awareness of TAP operation (Cruise settings, Data Feeds, Auto Mode) and allows intuitive and easy control updates (display layers and wind flight level), and data recording (e.g., ATC Approved and ATC Denied). In addition, the Message Window on the middle left hand side informs the pilot of general TAP messages (e.g., “Standing by for 10,000 ft.”, “Updating Wind Data”, “Updating Active Route”), Auto Mode messages (e.g., “Processing”, “Monitoring for Optimal Solutions”, “No Predictions – Initial Turn Too Large”), and Manual Mode messages (e.g., “Ready to Create Route”, “Clear”, “SUA” / “Wx” / “Traffic” constraints / hazards impacting the candidate route, “Add Rejoin WPT”, “Unable to Rejoin Route at {waypoint name}”, “No Predictions – {waypoint name} Not Recognized”, “No Predictions – Excessive Turn at {waypoint name}”).



Figure 8 TAP HMI V2 Selected Optimization Screen of the Auto Mode

The V4 Auto Mode Screen effectively integrates two of the V2 Auto Mode Screens into a single display screen. V4 Auto Mode makes better use of the display area by effectively using display space without excessive information density, careful intuitive layout, and using color effects, shading and raised, 3D depth on tabs and display fields. Using these techniques, the V4 Auto Mode Screen combines both the V2 Auto Mode Screen (Figure 7) and the V2 Selected Optimization Screen (Figure 8) into a single V4 Auto Mode Screen, while also including Top Bar and Bottom Bar Controls and the Message Window (Figure 9).

From Figure 9, the Solutions Panel in the upper left portion of the V4 Auto Mode Screen effectively integrates the entirety of the V2 Solutions and Outcomes Panels. The V2 Auto Mode Screen - Controls Panel portion is also integrated into the lower left portion of the V4 Auto Mode Screen. In addition, the V2 Selected Optimization Screen from V2 is integrated into the right hand side of the V4 Auto Mode Screen as the Visualization Panel.

Figure 9 illustrates highlighting of the best solution using a green border that outlines the solution field (waypoints and outcomes). In addition Figure 9 illustrates the graphical depiction of the Preview Solution, from the Solutions Panel (upper left), into the Visualization Panel (right hand side); the double horizontal parallel lines, highlighted in lighter blue color, tie the textual Solution and Outcome to the graphically displayed Preview Solution (Cyan) in relation to the FMS active route (Magenta).

The V4 Auto Mode Visualization Panel provides much improved graphical depiction of route information providing scale and orientation and also provides zoom in / out and step capability for viewing the active and preview routes.

When using the Auto Mode, TAP only identifies and provides flight trajectory / route improvement candidates to the pilot that are clear of hazards / conflicts (e.g., traffic, weather, SUA). In the rare case that a hazard / conflict would be present and be observed by TAP and yet TAP offers the route

as a candidate solution, the hazard would be indicated in the Message Window and also in the graphical route depicted in the Visualization Panel.

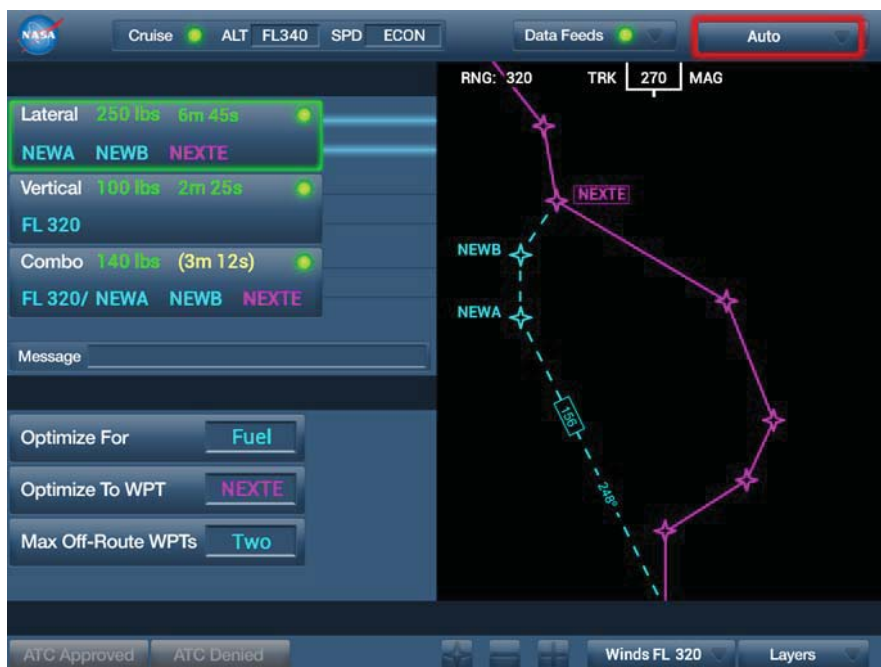


Figure 9 TAP HMI V4 Auto Mode Screen

- Note 1: As indicated above, presence of a hazard / conflict should not occur for solution candidates offered by TAP when operating in the Auto Mode. In the event of this unplanned, rare occurrence, display of the hazard in the Message Window and Visualization Panel serves to mitigate any adverse effects of potentially misleading information.
- Note 2: Unlike Auto Mode, when the pilot utilizes the TAP Manual Mode to explore potential trajectory route improvement opportunities, TAP will evaluate the pilot's route input for potential fuel and/or flight time savings, but in addition, will also evaluate the candidate route for potential hazards. When hazards are present that impact the desired route, this will be indicated in the Manual Mode Screen Message Window and also its Visualization Panel. The Manual Mode HMI is described below in the next section.
- Note 3: The description and comparison of the TAP HMI V2 and V4 provided above are relatively high-level and are intended to provide sufficient overview and insight into the TAP HMI design to allow identification of any issues that may affect certification of the TAP HMI for use as a flight-deck application. Additional details on the specific use of the TAP HMI (e.g., controls, status indications, use of drop-down and pop-up menus for selection purposes, and keyboard entries for input and editing) were derived from the respective pilot training presentations (in the form of PowerPoint slides and graphics) that were provided as training inputs to the pilots that participated in the two HITL experiments [32] for HMI V2 and [33] for HMI V4.

4.2.5.3.2.3 Manual Mode Screens

Figure 10 and Figure 11 illustrate the TAP HMI V2 and V4 Manual Mode Screens, respectively.

4.2.5.3.2.3.1 V2 Manual Mode Screens

The TAP HMI V2 Manual Mode Screen (Figure 10) is relatively basic in its use, providing the pilot a textual means to edit the active route to explore trajectory change candidates for fuel and / or time savings. The pilot must first specify the desired Reconnect Waypoint to which TAP will evaluate the proposed trajectory change. A pop-up window (not shown) lists the waypoints associated with the active route from which the pilot selects the Reconnect Waypoint. The pilot then selects 0, 1, or 2 off-route waypoints in creating the route that he or she wants to have TAP evaluate that can either be entered via keyboard or using the Find WPT tool for waypoint search. The pilot can also provide the desired flight-level change if he or she wants to evaluate a new flight level over the active route. At this pilot can choose to submit the entered route for evaluation by TAP.

Figure 11 illustrates the results of an example evaluation of a manual-mode entered route by the pilot. While the example provided is not reflective of a good selection, it serves to demonstrate the outcome of the solution in terms of fuel and time impact compared to the current active route, while also indicating that the route under evaluation is impacted by both traffic and weather hazards / constraints and should thus not be requested from ATC.

4.2.5.3.2.3.2 V4 Manual Mode Screen

As was the case for Auto Mode, the TAP HMI V2 Manual Mode Screen has undergone considerable revision for the TAP HMI V4 Manual Mode Screen (see Figure 12). From Figure 12, the V4 Manual Mode Screen consists of three panels: 1) the Entry Tools Panel in the upper left, 2) the Visualization Panel on the right half side, and 3) the Route Tray Panel in the lower left of the Manual Mode Screen. The Manual Mode Screen utilizes additional Top Bar and Bottom Bar status and control elements that increase pilot awareness of TAP operation (Cruise settings, Data Feeds, Auto Mode) and allows intuitive and easy control updates ((display layers and wind flight level), and data recording (e.g., ATC Approved and ATC Denied).

The TAP HMI V4 maintains overall compatibility between Auto Mode and Manual Mode Screens, with the notable exception relating to the fact that Manual Mode involves pilot entry of route information via the Entry Tools Panel and output of route evaluation results from TAP via the Route Tray Panel; otherwise the Auto and Manual Mode Screens are very consistent in their use and in their display representations for V4.

In the V4 Manual Mode Screen, the pilot utilizes the Entry Tools Panel (upper left in Figure 12) to select flight level (FL) changes if desired, can add 1 or 2 waypoints via the Add WPT tab and also provides the rejoin waypoint via the Rejoin WPT to enter the route for evaluation by TAP. The Route Tray (lower left in Figure 12) allows textual display of the Message Window, identifying status and potential hazards (e.g., Traffic, Weather), and providing estimated effect of the proposed route on fuel and /or flight time in the Outcome Window.

Figures 13, 14, and 15 provide several illustrations of the V4 Manual Mode Screen, with emphasis on the use of the Visualization Screen (right half of display area) using Preview Route, traffic hazard, and weather hazard depictions, respectively.

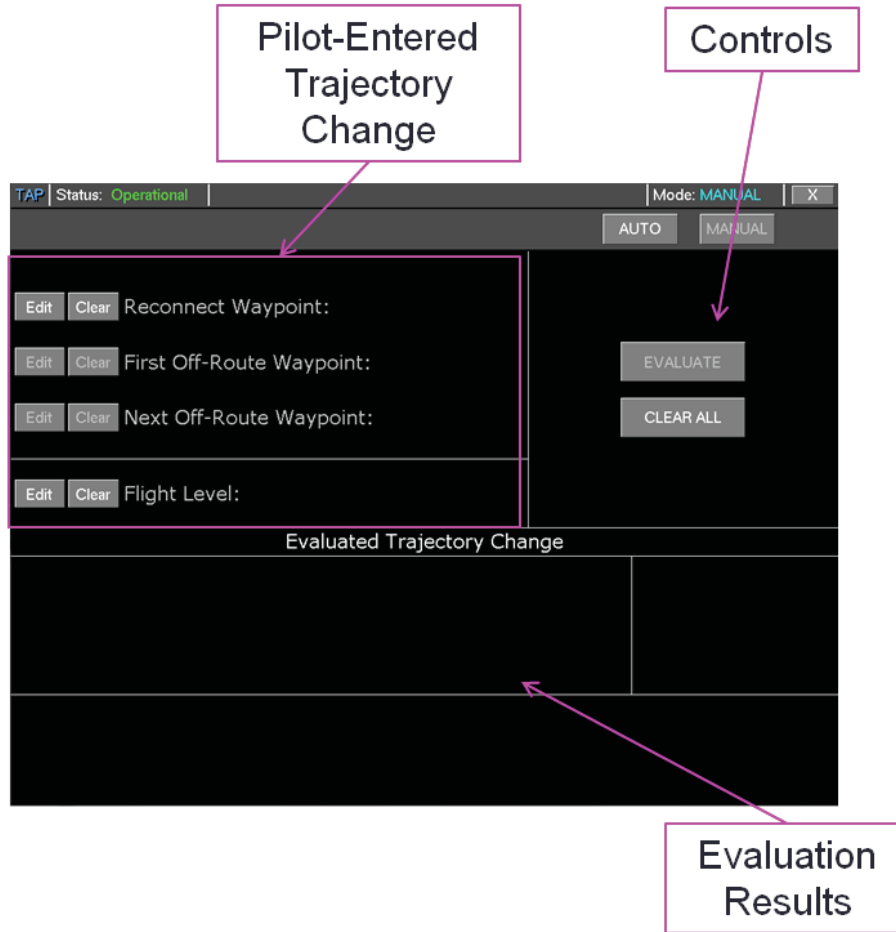


Figure 10 TAP HMI V2 Manual Mode Screen

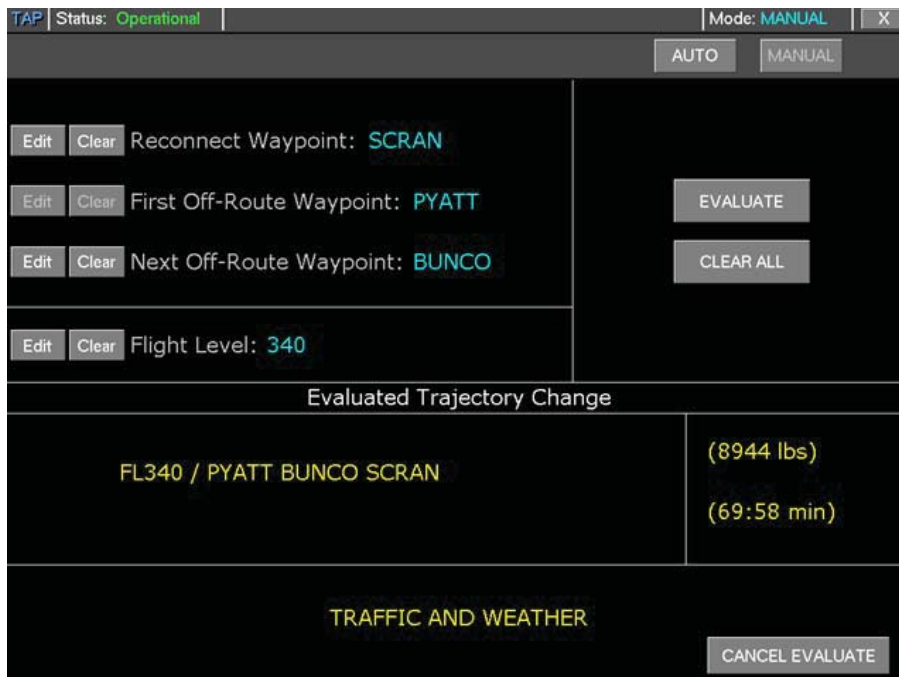


Figure 11 TAP HMI V2 Manual Mode Screen with Evaluation Results

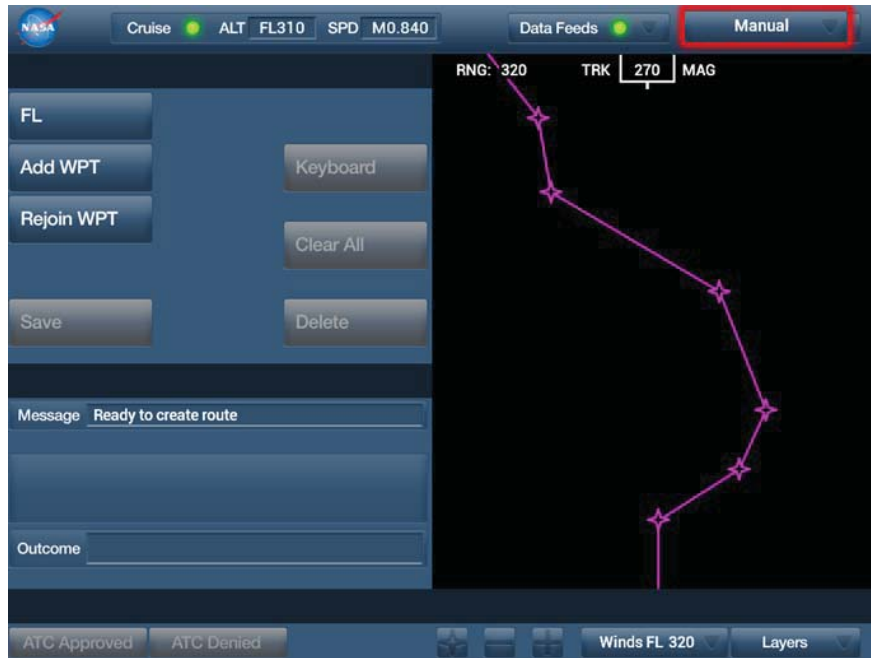


Figure 12 TAP HMI V4 Manual Mode Screen

Figure 13 illustrates the results of a manual route entered by the pilot using two off-route waypoints (NEWA and NEWB), rejoining the Active Route at NEXTE. Heading and distance are indicated to the next waypoint. The Route Tray provides depiction of the waypoints and indicates that they are free of hazards and indicated by the green simulated light-emitting diodes (LEDs). Also shown are the anticipated outcome for fuel and time savings.

Figure 14 illustrates the V4 Manual Mode Screen for the scenario where a traffic hazard is impacting the pilot-entered route. This does not necessarily indicate that the aircraft would be on an immediate collision course, however. It indicates only that traffic is in the vicinity with separation loss being a possibility (TAP uses a significant buffer on the minimum separation criteria). As noted in the dialog boxes in Figure 14 (not part of the actual TAP display symbology, but to help highlight the display elements), the traffic is depicted in the Visualization Panel by a white line that represents the current track, flight level, and vertical trend (in this case traffic is climbing). Also shown is the general portion of the pilot-entered route being impacted via the dashed yellow line terminating at the NEXTC waypoint, representing the portion of the route affected by the traffic hazard. This depiction of traffic intentionally does not show the actual or predicted location of traffic at any point in time, but is only intended to provide situational awareness to the pilot that traffic is in the vicinity and the general impact to the Preview Route that the pilot is considering for evaluation by TAP (direct to NEXTC in this case).

The Route Tray includes the Message Window which provides the textual indication of “Traffic” highlighted in yellow indicating the existence of the hazard; also contained in the Route Tray is the textual waypoint name impacted by the traffic hazard, i.e., NEXTC, with the status LED activated in yellow.

Figure 15 illustrates the V4 Manual Mode Screen for the scenario where a weather hazard is in the vicinity of the current route. The weather hazard is shown in the form of a polygon (shown in white); the yellow dashed line indicates the orientation and general direction and distance of the

weather hazard from the approximate location of own ship to the impacted waypoint along the current route (in this case NEXTE). This graphical depiction of the weather hazard provides the pilot with situational awareness and also allows the pilot to potentially request a candidate route using the manual mode for evaluation by TAP.

The Route Tray includes the Message Window which provides the textual indication of “Weather” highlighted in yellow indicating the existence of the hazard; also contained in the Route Tray is the textual waypoint name that would be impacted by the weather hazard, i.e., NEXTE, with the status LED turned yellow.

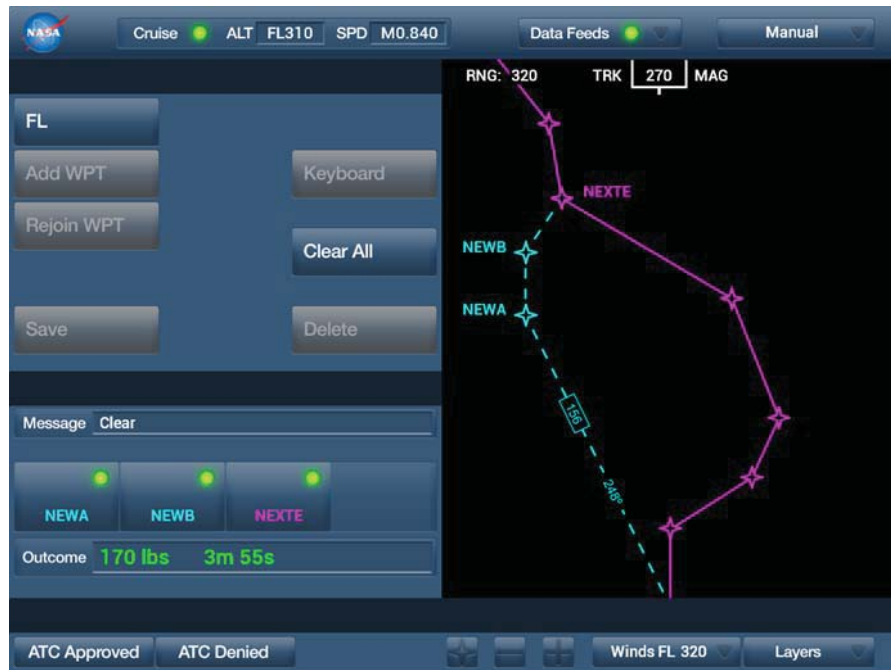


Figure 13 TAP HMI V4 Manual Mode Screen – Preview Route Depiction

This section has attempted to provide an overview of TAP HMI V2 and V4, with emphasis on V4. V4 currently represents the most mature HMI interface developed by NASA for the TASAR EFB application and incorporates pilot feedback from HITL-1 [32], the initial flight trial of TASAR [8], and other pilot engagements. TAP HMI V4 has undergone assessment in a second HITL evaluation (HITL-2) at the University of Iowa OPL. The data of HITL-2 is currently being analyzed.

Additional details of TAP HMI V4 are not covered in detail in this document as they are not viewed to impact certification of the TAP HMI. A more comprehensive description of TAP HMI V2 and V4 can be found on the respective pilot training presentations that were provided to pilots for the two HITL experiments [32][33].

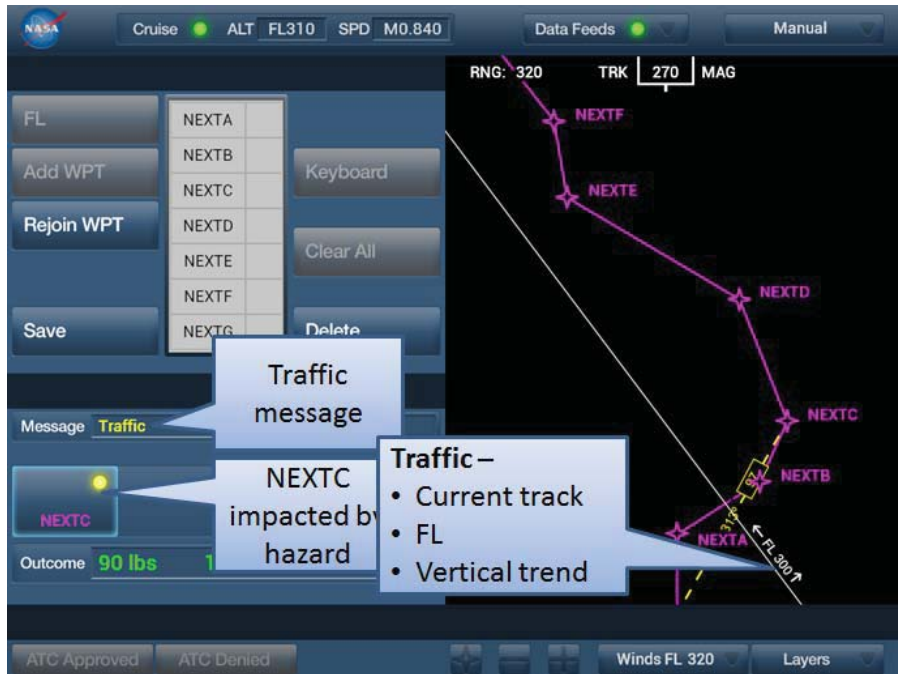


Figure 14 TAP HMI V4 Manual Mode Screen – Traffic Hazard Depiction



Figure 15 TAP HMI V4 Manual Mode Screen – Weather Hazard Depiction

4.2.5.4 *Certification Assessment of TAP HMI V4*

Thus far in this report it has been noted that TASAR is a “Minor Effect” Class 2 EFB Type B application, with supporting rationale summarized in Section 2 and Appendices A and B. Also noted is a list of references provided of pertinent of FAA regulatory, certification, and operational approval requirements that were cited as part of prior certification and operational approval requirements assessment. Included in this assessment was the TAP HMI V2. Additionally, Section 2.3 provided an update to changes to the cornerstone Advisory Circular (AC) 120-76C that could potentially affect TASAR certification.

Section 3 described both TAP HMI V2 and V4 and identifies pilot comments and feedback that led to many of the enhancements to the TAP HMI that are incorporated in TAP HMI V4.

4.2.5.4.1 *Certification Assessment of TAP HMI V4 Usability Features - General*

Many of the enhancements made resulting in TAP HMI V4 directly address the ease of use and understanding of the TAP HMI as noted by the pilots in HITL simulation evaluation [32] and during actual operational flight evaluation of TASAR [8]. In addition, the majority of enhancements in V4 address the checklist factors that the operator needs to specifically address with the POI in the Tabletop EFB Evaluation Checklist #1 [14]. This checklist addresses the following that must be satisfactorily answered as part of the HMI design:

- Revision history and expiration dates to be clearly presented
- Responsiveness of EFB to inputs
- EFB processing speed
- Use of busy / progress indicators
- Consistent user interface allowing selection and use of functions and navigating the display
- Display of needed information and ease of access (avoid missing or difficult to find information)
- Common actions and timely access to critical functions
- Standard ways to perform common actions
- Uniformity of display and controls across the application and also other applications
- Color viewing and ability to distinguish in various lighting conditions
- Color coding / shading / highlighting for display of critical information
- Appropriate use of red and yellow colors (only use for warnings and cautions)
- Readability of text (including in low-visibility conditions)
- Contrast of text in relation to display background
- Use of upper and lower case frequency
- Ease of bringing out of view information into view
- Icon and symbol functions obvious and distinguishable/explained by label or other means
- Ability to quickly and accurately find information
- Consistency of information layout
- Ease of being able to read high-priority information
- Easy to determine open/active application(s)
- Detection of incorrect information formats / data range, and error messages

Note: The detailed Checklist 1 questionnaire is provided in Appendix D (D.1).

TAP HMI V4 includes many updates and enhancements that are responsive to the pilot feedback from [32][8] and the above list of Checklist #1 Questionnaire used for POI review and approval [14]. While these are expected to significantly improve the TASAR EFB application, they are in themselves not critical with respect to having an adverse effect on to the TASAR FEC of “Minor Effect” that has already been established in our discussions with FAA approval authorities. The aggregate of changes made for the TAP HMI V4 from the list of items above all serve to improve the usability of the TAP HMI, but they do not raise any certification issues that impact the TASAR “Minor Effect” FEC. However, the updates to the TAP HMI V4 Visualization Panel as described in Section 3.2.3.2 were significant and require closer scrutiny with respect to potential certification impact to TASAR. The certification ramifications of these updates to V4 are discussed next.

TAP HMI V4 enhancements to the Visualization Panel, particularly for Manual Mode, but also potentially a factor in the Auto Mode are 1) the graphical depiction of traffic hazards (Figure 14), 2) graphical depiction of weather hazards (Figure 15), and 3) the implicit approximate location of own ship that can be inferred from the Visualization Panel, i.e., with own ship generally located near the bottom center of the Visualization Panel.

Note: While the pilot’s use of the Manual Mode to evaluate route improvement candidates may result in hazards being identified by TAP (e.g., traffic, weather, SUA), in rare cases, the Auto Mode may also result in the identification of hazards. In the Auto Mode, TAP processing is designed and intended to inhibit any hazard-impacted solutions being offered to the pilot via the TAP HMI, and thus should not contain hazard impacted route candidates. However, in the event of an unanticipated processing failure, a spurious hazard could potentially be displayed in the Auto Mode. The same certification assessment of the graphical depiction of hazards on the V4 Visualization can be applied to both Manual and Auto Modes.

Note: While not explicitly shown and considered in Section 3.2 in the description of the TAP HMI, indication of an active SUA region on the Visualization Panel, while not a hazard, represents an area that the aircraft must not enter, and can be treated similar to a weather hazard region. This is discussed further below.

4.2.5.4.2 Certification Considerations for TAP Depiction of Traffic Hazards

As discussed in Section 2.3 (from AC 120-76C [13]), applications supporting communications, navigation, and surveillance are viewed as “non-EFB” software applications by FAA, requiring Type C, certified software, and certified hardware platforms, e.g., avionics. For TASAR, the display of traffic information must be carefully considered to avoid crossing into the surveillance functions domain or equivalently into CDTI-based applications. Pilot feedback indicated a desire to be provided with the “what” and the “why” in using TAP, requesting to be shown the information concerning the potential hazards, e.g., traffic, that may arise in using the TAP Manual Mode.

The TAP HMI V4 was carefully designed by NASA to provide an indication of traffic hazards, as shown in Figure 14, by providing a sufficient level of traffic awareness, without showing precise, actual traffic location and speed information. In doing so, TAP does not encroach on explicitly displaying surveillance / CDTI-based information that may be (mis)used by the pilot for operational guidance, maneuvering, and control, but does serve to provide the situational awareness that the pilots have requested in their use and evaluation of the TAP HMI.

The TAP HMI V4 display of traffic hazard information does not raise any additional certification issues commensurate with the TASAR “Minor Effect” FEC. Even in the event that the traffic information is erroneously displayed on the TAP display, while undesirable, this does not adversely affect the safety of operations, as significant mitigations are in place in using the TASAR application. Section 4.6 reiterates some of the major mitigations that support the TASAR “Minor Effect” FEC.

4.2.5.4.3 Certification Considerations for TAP Depiction of Weather Hazards

AC 120-76C [13] indicates the following as it relates to the use and display of weather information for EFB applications:

“Section 11.e.4.c [13] notes that “data link EFB functions may display approved sources of weather for strategic / flight planning purposes”. Section 11.e.4.d [13] notes that “data link graphical weather from approved sources of advisory weather information can only be used for strategic / flight planning purposes”. “Do not use data link graphical weather information for tactical decisions during critical phases of flight, because data quality is uncontrolled for aviation use. Do not use data link graphical weather data as a substitute for airborne weather radar or thunderstorm detection equipment.”

Note 1: Pertaining to “*approved sources of weather*”, Air carriers and operators certificated under the provisions of 14 CFR Part 119 are required to use the aeronautical weather information systems defined in the Operations Specifications issued to that certificate holder by the FAA. These systems may utilize basic FAA/National Weather Service (NWS) weather services, contractor or operator-proprietary weather services and/or Enhanced Weather Information System (EWINS) when approved in the Operations Specifications. As an integral part of this system approval, the procedures for collecting, producing and disseminating aeronautical weather information, as well as the crew member and dispatcher training to support the use of system weather products, must be accepted or approved.

Note 2: The FAA has identified three distinct types of weather information available to pilots and operators:

- 1) **Observations** - Raw weather data collected by some type of sensor suite including surface and airborne observations, radar, lightning, satellite imagery, and profilers.
- 2) **Analysis** - Enhanced depiction and/or interpretation of observed weather data.
- 3) **Forecasts** - Predictions of the development and/or movement of weather phenomena based on meteorological observations and various mathematical models.

Not all sources of aviation weather information are able to provide all three types of weather information. The FAA has determined that operators and pilots may utilize the following *approved* sources of aviation weather information:

- 1) **Federal Government** - The FAA and National Weather Service (NWS) collect raw weather data, analyze the observations, and produce forecasts. The FAA and NWS disseminate meteorological observations, analyses, and forecasts through a variety of systems. In addition, the Federal Government is the only approval authority for sources of weather observations; for example, contract towers and airport operators may be approved by the Federal Government to provide weather observations

- 2) **Enhanced Weather Information System (EWINS)** - An EWINS is an FAA authorized, proprietary system for tracking, evaluating, reporting, and forecasting the presence or lack of adverse weather phenomena. The FAA authorizes a certificate holder to use an EWINS to produce flight movement forecasts, adverse weather phenomena forecasts, and other meteorological advisories. For more detailed information regarding EWINS, see the Aviation Weather Services Advisory Circular 00-45 and the Flight Standards Information Management System 8900.1.
- 3) **Commercial Weather Information Providers** - In general, commercial providers produce proprietary weather products based on NWS/FAA products with formatting and layout modifications but no material changes to the weather information itself. This is also referred to as "repackaging." In addition, commercial providers may produce analyses, forecasts, and other proprietary weather products that substantially alter the information contained in government-produced products. However, those proprietary weather products that substantially alter government-produced weather products or information, may only be approved for use by 14 CFR Part 121 and Part 135 certificate holders if the commercial provider is EWINS qualified. Commercial weather information providers contracted by FAA to provide weather observations, analyses, and forecasts (e.g., contract towers) are included in the Federal Government category of approved sources by virtue of maintaining required technical and quality assurance standards under Federal Government oversight.

Pilot feedback indicated a desire to be provided with the “what” and the “why” in using TAP, requesting to be shown the information concerning the potential hazards that may arise in using TAP, e.g., weather hazards and their location. The TAP HMI V4 Visualization Panel provides depiction of weather hazard polygons and their location relative to the active and preview routes (Figure 15).

The TAP HMI V4 display of weather hazard information does not raise any additional certification issues commensurate with the TASAR “Minor Effect” FEC, as pilots, supported by proper training, are only allowed to utilize this information as part of strategic / flight planning and for situational awareness purposes. They must utilize the out-the-window scan, weather radar and/or thunderstorm detection equipment to make any tactical decisions during critical phases of flight.

Even in the event that weather information displayed erroneously on the TAP display, while undesirable, this does not adversely affect the safety of operations as the pilot must utilize their weather radar and/or thunderstorm detection equipment for tactical decision making of the flight.

4.2.5.4.4 Certification Considerations for TAP Implicit Use of Own Ship

FAA AC 120-76B [34] was strict in its view of depiction of own ship on the EFB display, forcing a “Major Effect” designation if own ship was displayed. FAA AC 120-76C [13] relaxes this requirement somewhat by allowing display of own ship in certain cases. Reference [13] allows the display of own ship on the EFB display when the aircraft is operating on the airport surface at speeds less than 80 knots. However, [13] continues to maintain that display of own ship in flight (or on the surface at 80 knots or greater) will result in a “Major Effect” FEC, requiring the corresponding increase in software certification and operational approval requirements, e.g., requiring approved software per DO-178B.

From a TASAR application perspective, the TAP HMI must not display own ship position on the EFB display, as the TASAR intended function is strictly as an en route advisory tool for the pilot and cannot support surveillance functions. TAP HMI V4 does not explicitly depict own ship on the Visualization Panel, but implicitly assumes that own ship is generally in the near vicinity of the bottom center of the Visualization Panel (refer to Figure 14 or 15).

Note: AC 120-76 Appendix 2 [13] allows for Type B applications that utilize precomposed or dynamic interactive electronic aeronautical charts (e.g., en route, area and approach, and airport surface maps) including, but not limited to, centering and page turning, but without display of airborne aircraft/own-ship position. This is similar to the TAP Visualization Panel depicting traffic and weather hazards without explicitly depicting own ship position.

4.2.4.4.5 Certification Considerations for TAP Depiction of Special Use Airspace

As with traffic and weather hazards, pilots do want to have situational awareness of SUA areas for display on the TAP HMI. Unlikely weather, SUAs are not necessarily hazards, but they represent areas that must be circumvented by flights. Flight plans and vectors from ATC ensure that aircraft successfully avoid SUA when they are active. TAP provides situational awareness to the pilot for SUA(s) in the form of polygon shapes and locates them in the proper location and orientation relative to the active and preview routes. In the event of misleading information that may result in improper or missing depictions of SUAs on the TAP HMI, while undesirable, sufficient mitigations are in place to mitigate any safety effects. Proper training to follow the actual flight plan via the FMS, ATC clearances, and ATC monitoring of flight progress will prevent inadvertent entry into an active SUA.

4.2.5.4.6 Usability Considerations; TASAR Mitigations

With the TASAR application having a “Minor Effect” FEC, associated information sources must be of comparable quality (accuracy, timeliness, and integrity) to maintain the probability of missing and undetected misleading information in line with the “Minor Effect” designation. Information quality is not a safety issue for TASAR, but a usability issue. In order for the TASAR application to be accepted by pilots, it must be sufficiently available, consistent, and predictable in its advisory role to not create undue confusion and unnecessary workload; otherwise, the pilots will not utilize TASAR for its intended role of assisting the pilot to determine route improvement opportunities.

TASAR has a number of strong mitigations, both internal and external to the application, and is also supported by procedures that ensure safety. Reference [7] provides a comprehensive list of TASAR mitigations that support the “Minor Effect” FEC. Several of these mitigations are listed below:

- The pilot has responsibility to evaluate TASAR-provided trajectory change request candidates before making a change request to ATC, providing cross-check opportunities to detect spurious or false trajectory change request candidates offered by TASAR
- Pilot crosschecks of aircraft systems, e.g., FMS, weather radar, which serve as available, higher integrity information allowing quick check on acceptability and performance impacts of TASAR recommended change requests
- ATC provides separation assurance independent of TASAR

- Aircraft safety systems (e.g., Traffic Alert Collision Avoidance System {TCAS}, airborne Weather Radar {WxR}, and Terrain Awareness Warning System {TAWS}) provide hazard detection and alerting
- ATC monitors execution and intercedes
- Pilot Training

4.2.5.5 TAP V4 Certification Assessment - Conclusions

After careful review of the TAP HMI V4 improvements made by NASA in response to pilot feedback from the HITL-1 simulation evaluation [32], flight evaluation in an operational environment [8], and through pilot discussion forums, and review of the latest FAA guidance documents, e.g., AC 120-76C [13], this analysis concludes that the TASAR “Minor Effect” FEC is unaffected by the updates provided in V4. TAP HMI V4 is currently undergoing further evaluation and analysis in another HITL simulation experiment and in planned flight trial evaluations. It is anticipated that V4 improvements will continue to demonstrate that the TASAR application is 1) useful, understandable, and intuitive to operate, 2) provides situational awareness without adversely affecting workload, 3) does not interfere with the primary flight duties on the flight deck during nominal and off-nominal conditions, and 4) fits in nicely with flight deck operations, i.e., is a welcomed advisory tool that provides operational benefits of fuel and/or time savings. TAP HMI V4 has made many enhancements over initial TAP HMIs, addressing numerous pilot recommendations and is expected to bring NASA closer to eventual technology transition of TASAR as a flight-deck application.

4.3 FAA Certification and Operational Approval Technical Interchange Meeting

NASA and Rockwell Collins TASAR Principal Investigators met with key FAA decision makers regarding certification and operational approval for the NASA TASAR EFB application. A technical interchange meeting was held at FAA offices in Washington DC on July 24, 2013 with key FAA approvers of EFB and ADS-B avionics systems present, and with NASA Langley and Rockwell Collins participants. The meeting was scheduled for two hours duration; additional time was spent in dialog and demonstration of the TASAR EFB prototype. This section provides a summary of results from these discussions and notes any significant difference based on FAA feedback as compared to our original analyses.

In general it was confirmed by FAA that the results of our safety analyses and our analyses concerning certification and operational approval requirements for the TASAR EFB application were closely aligned with FAA’s guidance materials that already exist for TASAR. FAA feedback reaffirmed that we had analyzed the requirements correctly as applicable to TASAR.

Due to the “Minor Effect” FEC for TASAR as a Type B application, hosted on a Class 2 EFB, and the fact that existing FAA policies already fully cover the proposed TASAR EFB application, FAA noted that the full formalism of a Project Specific Certification Plan (PSCP) described in detail in this document will likely not be required. FAA noted that applicants can directly engage with the POI for operational approval of TASAR as currently defined, particularly in regard to the EFB mount and hardware installation.

The following is a meeting summary along with feedback, key discussion points, and observations based on the discussions held with the FAA. More detailed feedback from this meeting is found in Appendix E.

Meeting Highlights

FAA certification (AIR) and operational approval (AFS) personnel with approval authority for fielding of EFB applications and ADS-B avionics (IN and OUT) and representatives from the NASA TASAR team held a technical interchange meeting at FAA offices at L'Enfant Plaza on July 24, 2013. This meeting went very well from the NASA TASAR team's perspective and met and exceeded expectations. The meeting in essence served as validation of information that was provided concerning future approval requirements for TASAR, per the current application description and concept of use [3]. Presentations provided by NASA (David Wing, the TASAR Principal Investigator) and Rockwell Collins (Steve Koczo, analyst of TASAR Certification and Operational Approval Requirements) provided an introduction to the TASAR concept, a comprehensive, integrated presentation of TASAR safety analyses, and assessments of certification and operational requirements as documented throughout this report. These presentations were provided to FAA prior to the meeting, and it was apparent that members of the FAA team took advantage to review this information going into the meeting. Per FAA, we had succeeded in assembling the "right team" of approvers for TASAR technologies. FAA participants were actively engaged throughout the 2.5 hour meeting and offered additional insight. An FAA representative noted that the meeting was in essence a "trial run" for how to conduct a meeting with FAA for certification and operational approval.

The key result of the meeting is confirmation that existing policies already cover the proposed the TASAR application and we had correctly reviewed and analyzed FAA regulatory and guidance documents applicable for EFB applications such as TASAR. The following list summarizes feedback from FAA both confirming and helping to clarify some of our analysis results:

- TASAR is a Type B application and is appropriately hosted on a Class 2 EFB
- TASAR does not need to be added explicitly to the list of Type B applications in Appendix 2 of AC 120-76C [13]
- Type B applications running on non-certified hardware (e.g., Class 2 EFB) do not require DO-178B compliance
- TASAR will be viewed as a "Minor Effect" application due to potential pilot workload associated with TASAR due to misleading / bad data. From a loss-of-function standpoint, TASAR is viewed as "No Effect"
- TASAR is not an ADS-B IN applications, but rather a performance/planning application that leverages ADS-B IN data, if available
- There is not a need to establish a separate standard for TASAR, allowing freedom for users to implement the application to fit their individual needs
- If an operator already has an existing EFB installation, then the operational approval process is for the user to go directly to the POI.

For detailed feedback and discussion items from the FAA meeting refer to Appendix E.

Appendix A TASAR User Survey Results, Findings and Recommendations

This appendix provides the detailed results of the analysis of TASAR survey results conducted by Rockwell Collins. Analysis results are provided and organized as follows:

- A.1 examines current and planned systems that play a role in enabling early deployment of TASAR for the end user operator; operator equipage plans are considered for the possibility of early adoption of TASAR.
- A.2 presents an overview of the operations and demographics of the operators surveyed.
- A.3 examines survey responses related to challenges and disruptions to flight operations.
- A.4 reviews the change request process in requesting a revised clearance from ATC.
- A.5 examines tools used by pilots and dispatchers in flight planning and in-flight re-planning while en route.
- A.6 discusses information sources, including their effectiveness (or lack thereof) in current Dispatch and flight operations.
- A.7 identifies organizational policies, constraints, and cost factors associated with flight planning processes as obtained from survey responses.
- A.8 summarizes the survey results, observations and recommendations obtained from the analysis of the TASAR User Survey for early adoption of TASAR.

Note: The survey questions and corresponding responses were in many instances qualitative and subjective in nature. In addition, the responses represent only a small sample and thus cannot be used to make fundamental conclusions and extrapolations. However, the three operators represented in the survey and the comprehensive questions and responses from the various stakeholders involved in flight planning and flight execution do allow reasonable conclusions to be drawn that were used to inform the TASAR research team in developing updates to the TASAR application.

A.1 Current & Planned Systems Supporting Potential Deployment of TASAR

Figure A-1 provides a functional diagram of TASAR. The TASAR software, also known by the name “Traffic Aware Planner,” is hosted on the EFB and is enabled by information from own ship and via information derived via the internet and data link. Own ship data is provided via ARINC 429 Busses from on-board systems, including the Flight Management System (FMS) and the Traffic Computer (the platform for ADS-B IN). These data are provided to the Aircraft Interface Device (i.e., Data Concentrator) for input to the EFB using the Single Text Avionics Protocol (STAP) interface. The User Survey probed for operator equipage (current and planned) for systems needed to support TASAR. Before explicitly examining the equipage results from the User Survey, the results of a meeting of the NASA TASAR team with FAA certification and operational approvers for EFB and ADS-B IN systems are noted below, as the results of this meeting reinforced our assessments of the level of requirements that need to be met in order to gain approval for operational use of TASAR.

The TASAR User Survey requested inputs from three operators (a Global Network Carrier, Domestic Low-Cost Airline Carrier, and a Fractional Operator of Business Aircraft) on their equipage plans for the following capabilities:

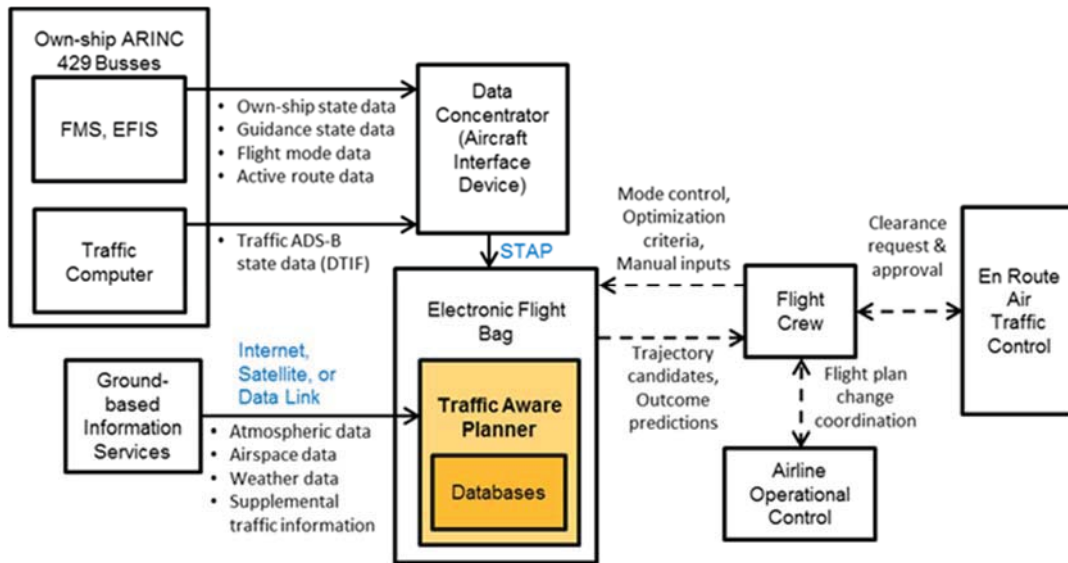


Figure A-1 TASAR Functional Diagram

- 1) ADS-B OUT (1090 MHz or UAT)
- 2) ADS-B IN (1090 MHz and/or UAT) – referred to as the Traffic Computer in Figure A-1.
- 3) EFB Class (1, 2 or 3)
- 4) EFB Operating System (Windows, Linux, iOS)
- 5) Internet access (terrestrial network, satellite network)
- 6) Data Comms (ACARS, CPDLC)

Survey results were reviewed for each capability and for each operator.

Note: Survey results were received during 2013; future plans and results of levels of equipage of the surveyed operators are subject to regulatory and market forces. The information below represents operator equipage and plans as of 2013 and reflect differences between operators and their respective markets.

A.1.1 ADS-B OUT

The Global Network Carrier surveyed is well on the path to equip toward the 2020 mandate of full ADS-B OUT equipage and tends to have relatively higher level of equipage already in place (40%), likely due their global operations footprint where ADS-B OUT is used more frequently (e.g., in Europe, Australia). While not explicitly stated, this operator will be 1090 MHz ADS-B as their entire fleet is Air Transport category aircraft, which will be 1090 MHz equipped per the ADS-B mandate.

The Low-Cost Airline surveyed is also working toward the 2020 mandate, but is less aggressive in equipping its fleet compared to the Global Network Carrier. While not explicitly stated, this carrier will be 1090 MHz ADS-B as their entire fleet consists of Air Transport category aircraft, which will be 1090 MHz equipped per the ADS-B mandate.

The Fractional Operator surveyed is currently not working toward the ADS-B OUT mandate, even indicating uncertainty for the 2020 mandate date. While unlikely, it is possible that some of their

aircraft could equip with UAT for ADS-B (for those operating below 18,000 ft.), but in all likelihood, this operator will also need to equip with 1090 MHz ADS-B.

General observations:

- Currently anticipated ADS-B OUT equipage levels for the three operators in the survey suggest a relatively slow deployment, resulting in a significant number of aircraft being unequipped, i.e., a mixed-equipage environment is expected all the way to the 2020 mandate.
- Aircraft not equipped with ADS-B OUT will consequently not be equipping with ADS-B IN, and thus these unequipped aircraft will not benefit from the ‘traffic aware’ benefits of TASAR. However, TASAR can be installed without “traffic awareness” if the business case warrants such an investment to equip.

Note: All aircraft must have ADS-B OUT (with a few minor exceptions for aircraft that do not have electrical systems when certified and a few other minor exceptions). All aircraft operating above 18,000 feet must utilize 1090 MHz ADS-B OUT.

A.1.2 ADS-B IN

Based on the survey responses, Global Network Carrier currently is not planning on ADS-B IN in the near-term and no clear decision have been made for 2020 equipage at this time.

The Low-Cost Airline is indicating intent to equip with ADS-B IN at levels comparable to their ADS-B OUT equipage plans, which is relatively slow.

The Fractional Operator surveyed currently does not indicate any plans for ADS-B IN equipage.

General observation:

- Without ADS-B IN, TASAR will not be able to benefit from quality ADS-B, TIS-B, and ADS-R (rebroadcast) traffic data. TASAR is not reliant on traffic data from ADS-B, as benefits are expected to be available without traffic information. However, having access to quality traffic information such as provided via ADS-B is highly desirable.
- With respect to TASAR creating a “pull” for operators to equip with ADS-B IN, this is yet to be determined. A strong cost-benefit case would be needed to create this “pull.”

A.1.3 Electronic Flight Bag (EFB)

The Global Network Carrier at present has 100% equipage of Class 2 EFBs, with some also equipped with Class 1. The survey response suggests that 2020 equipage plans for the class of EFB are not yet determined. This operator has no plans for Class 3 EFBs.

The Low-Cost Airline surveyed has 100% Class 2 EFB equipage but will move to 100% Class 3 EFBs in two years and beyond.

The Fractional Operator has 100% Class 1 EFB equipage today and plans to maintain it for the future (to 2020). This operator also indicates that ~50% of its aircraft are currently equipped with Class 3 EFBs (going to 60% in 2 years). Their 2020 plans for Class 3 EFBs are undecided at this time.

General observations:

- The operators have diverse plans for EFB use spanning all Classes of use and also use of Operating Systems (mix of Windows, LINUX, and IOS). All users should be able to utilize

their EFBs to host TASAR, although Class 1 EFBs will need to interface to an Aircraft Interface Device and will need to meet Transmit-PED (Portable Electronic Device) EMI/HIRF requirements for flight deck use). In the event operators integrate TASAR with a Class 3 EFB, or equivalently a certified Auxiliary Display System, additional approval steps will be required to ensure interoperability of TASAR with other approved software applications.

- The most direct path for quick and affordable user adoption of TASAR is via a Class 2 EFB installation with TASAR as a Type B application. The operators are generally well on their way to have this capability that would support early adoption of TASAR.

A.1.4 Data Connectivity

The Global Network Carrier, according to their survey response, has limited internet access (whether terrestrial or satellite) available, at least for flight deck use. However, they likely can have terrestrial internet service via Gogo, as they are offering that to their passengers for cabin use. They also are planning to offer increasing levels of satellite internet for international flights via Ku-band for cabin use, which could be used by pilots as well. All aircraft of the Global Network Carrier are equipped with ACARS and are beginning to be capable of CPDLC (20% now, up to 30% in 2 years).

The Low-Cost Airline, as a domestic carrier, is planning on full equipage of terrestrial internet service within 2 years (if not already in place). This operator also has full ACARS equipage and will begin to equip with CPDLC (20% in 2 years, 100% by 2020).

The Fractional Operator, as a business aircraft operator, already has a high-level of terrestrial internet equipage (80% today, 90 % in 2 years, 100% by 2020). They have only small amounts of ACARS and CPDLC equipage, which are typically used by air transports.

General observation:

- The two airline operators are fully equipped with ACARS and are beginning to equip with CPDLC (~20% in the near term). The Global Network Carrier has greater CPDLC likely due to its Future Air Navigation System (FANS) equipage needed as part of their international flight operations. The Fractional Operator, operating business aircraft, generally has limited ACARS and CPDLC (~10%), but has widespread terrestrial internet access. The Fractional Operator has, and within 2 years the Low-Cost Carrier will have, excellent internet access for their operations. The Global Network Carrier appears to be the most challenged in network connectivity for future TASAR use but could potentially leverage available cabin internet services they provide for passengers to support flight deck applications such as TASAR.

General observation:

- Given a favorable cost-benefit business case for TASAR, all three operators could quickly equip with full TASAR functionality. Per our analysis of TASAR's safety [7], certification and operational approval (Sections 4.2.2, 4.2.3, and 4.2.4) and subsequent meeting with FAA (Section 4.3 and Appendix E), the path to successfully implementing TASAR is straightforward with limited risk toward approval. The non-recurring expense for equipping with TASAR functionality is to be determined and would need to be addressed with each respective operator. In addition, the cost-benefit assessment likely would need to become more mature. The most significant cost item would be ADS-B IN equipage, when compared to the cost associated with EFB Class 2 hardware and internet connectivity services.

A.2 General Observations on Operator Operations and Demographics

This section characterizes and makes some initial high-level observations on the respective operator operations and their demographics; these will set the stage for more detailed review of User Survey results in order to draw conclusions that can help accelerate user adoption of TASAR.

The operators in the User Survey represent a spectrum from major Global Network Carrier, Low-Cost Domestic Airline, and Business Aircraft Fractional Operator. Two operate in primarily domestic airspace (i.e., the Low-Cost Airline and the Fractional Operator surveyed). The Global Network Carrier surveyed has both major domestic and international operations.

The two airlines surveyed are Air Transport operators and operate strictly Boeing and Airbus transport category aircraft. The Fractional Operator on the other hand operates a wide range of business aircraft types as part of their aircraft fleet.

Seventy percent of Fractional Operator flights are short haul (<2 hours), while ~sixty-seven percent of the two airline operations are medium to long haul (>2 hours), with forty percent being long haul (>4 hours). As a high-level generalization, TASAR provides greatest benefits during the en route phase of flight, with benefits diminishing as one transitions to the terminal area, as it becomes difficult to affect any flight re-planning at that point during the flight. While TASAR can provide benefits during the entire flight regime, the early part of the flight including immediately after take-off and climb should still have relatively up to date information on current environmental constraints. It is anticipated that TASAR provides the most benefits for medium to long haul flights. While all three operators can benefit from TASAR, the longer haul flights of the Global Network Carrier and the Low-Cost Airline should be expected to gain additional benefits.

All Global Network Carrier flights include at least one hub airport as a departing and/or arriving airport. 90% of the Low-Cost Airline flights have at least one hub as part of their departing and arriving airport. 60% of Fractional Operator do not involve a hub airport. Based on the Global Network Carrier and Low-Cost Airline route structures, a greater percentage of hub-to-hub airports flights would be expected. Since the Fractional Operator has a majority of its flights operating from/to non-hub airports, this removes a significant set of constraint factors related to ATC ground stops/holds, metering, etc. Thus while still beneficial, TASAR will not need to deal significantly with considering flight re-planning options to deal with ATC constraint factors. Both the Global Network Carrier and the Low-Cost Airline will require and benefit from TASAR's ability to recommend trajectory candidates that help alleviate the severity of ATC constraints.

General observation:

- Of the three operators, the Fractional Operator, with its mostly short-haul operations, between mostly non-hub airports, has reduced opportunities to take full advantage of operational efficiencies offered by TASAR. Benefits are still expected, but their reduced exposure to ATC constraints and the shorter duration of flights offer less opportunities to achieve efficiencies. The two airline operators on the other hand, with their exposure to ATC constraints at the hub airports to which they frequently operate from/to and their generally longer haul flights, offer more opportunities to derive TASAR benefits. Additionally, the Fractional Operator's lack of ADS-B IN equipage (at least in their current plans) reduces the "traffic-awareness" capabilities offered by TASAR.

A significant difference exists in the number of pilots, average and peak number of airborne flights, and the number of dispatchers utilized by the three operators, ranging from very large numbers for

the Global Network Carrier to relatively small numbers for the Low-Cost Airline and the Fractional Operator.

General observations:

- The Global Network Carrier has very large operations requiring many more dispatchers per airborne aircraft compared to the other operators surveyed. The Low-Cost Operator and Fractional Operator dispatchers tend to serve many aircraft per dispatcher at one time compared to Global Network Carrier. The Global Network Carrier likely must provide a greater expanse and diversity of services to support its broad, global operations. In addition, The Global Network Carrier's operational complexities tend to increase Dispatch requirements. The Low-Cost Airline and Fractional Operator have simpler route structures and scheduling complexity of their operations, with considerably less dependencies on supporting connecting flights. These operators require only two to five dispatchers to serve 26 to 100 peak aircraft operations (i.e., 10 to 20 aircraft per dispatcher). The Global Network Carrier, with aggregate operations support for the worldwide reach of its command center, requires approximately one dispatcher for every five airborne aircraft. Surprisingly, per the User Survey, the Global Network Carrier's Dispatch services airborne aircraft primarily when requested by the flight crew.
- The Low-Cost Airline outsources some of its airline operations and supplements its Dispatch service using a 3rd party optimization service (i.e., Sabre). The Global Network Carrier and Fractional Operator's Flight Operations are more self-managed. The Fractional Operator's operations control center coordinates with FAA to manage re-routing, weather, ground stops, landing slots, etc.

A.3 Challenges and Disruptive Factors to Flight Operations

This section analyzes User Survey responses that identify the factors, frequency of occurrence, and level of severity to flight operations, specifically disruptive factors affecting the "actual" flight as compared to the original flight plan. The survey probed pilots for the frequency of "minimally," "moderately" and "extremely" challenged flights they experienced during the past 12 months. Operator perspectives were sought for pilots, dispatcher, and flight operations personnel.

"Minimally" challenged implies a flight minimally impacted by environmental factors, i.e., devoid of convective weather, no occurrence of un-forecast winds, no airspace system disruptions, and no adverse traffic influences.

"Moderately" challenged implies a flight moderately impacted by environmental factors, e.g., regional convective weather, non-ideal winds, some airspace system disruptions, and some traffic delays.

"Extremely" challenged implies a flight with highly disrupted operations and severely impacted by environmental factors, e.g., widespread delays and diversions caused by weather, very adverse winds, airspace system disruptions, major traffic delays, and security events.

A.3.1 Pilot Perspective

Pilots indicated that ~2/3 of their flights during are past 12 months were minimally challenged / impacted, 25% were moderately; and 10% were extremely impacted.

The estimated impact to these flights in terms of additional flight time and additional fuel consumption were as follows:

- 2% time, 1.5% fuel impact for minimally challenged flights
- 8.7% time, 9.3% fuel impact for moderately challenged flights
- 17.7% time, 16.15 % fuel for extremely challenged flights

General observation:

- About 1/3 of flights are moderately or extremely impacted by adverse environmental factors, with ~9% to 17% impact on flight time and fuel impact. This suggests that there is considerable opportunity to gain operational efficiencies from decision aids such as TASAR.

Pilots were asked to characterize the impact of various ATC constraints on operational efficiency considering the flights they conducted during the past 12 months. The following ATC factors were rated by decreasing level of severity in impacting operational efficiency:

- Ground holds and ground stops were rated as most severe (5 out of 7, with 7 most severe)
- Metering or miles-in-trail, also airborne holding are next severe (4.3/4.1 of 7)
- Vectoring, speed control, re-routing due to weather are next (~4 of 7)
- Re-routing of arrival fix, ATC preferred route next (~3.4 of 7)
- Temporary Flight Restriction (TFR) /SUA (~2.7 of 7)

General observation:

- ATC holds and flow management are the primary adverse impacts on flight operations, followed by ATC routing. TFRs are not a significant impact. Weather was not mentioned excessively as key adverse effect.
- High quality (timely and accurate) ATC constraint information would strengthen the benefits case for TASAR.

A.3.2 Dispatch Perspective

This section analyzes the factors that adversely affect the original flight plan and the reasons that cause flight re-planning by dispatchers.

A.3.2.1 Factors Adversely Affecting the Original Flight Plan (Dispatcher View)

Given that Dispatch has planned an effective flight plan prior to departure, the following factors (in decreasing order of severity) were identified in the User Survey as adversely affecting the original flight plan (from the dispatcher's perspective).

- ATC metering and flow management (5.33 of 7, with 7 as highest impact)
- Three weather-related factors
 - En route weather is biggest factor for weather (4.92 of 7)
 - Destination airport weather is 4.42 of 7
 - Departure airport weather is 3.67 of 7
- Departure delays are less of a factor
 - Due to airport surface (3.75/7)
 - Departure system delays (3+ of 7)
- Failed on-time pushback from gate (2+ of 7)

General observation:

- TASAR, with good (i.e., pertinent, accurate, and timely) information on ATC metering / flow management and weather (especially en route and at the destination airport), has the potential to provide significant tactical re-planning capabilities for operational efficiency. With TASAR the key issue is its usability (i.e., providing benefits while at the same time being streamlined with operator dispatch, own ship flight procedures using the FMS, and with ATC's overall air traffic control paradigm {change request clearances, traffic flow management, arrival management, etc.}).

A.3.2.2 *Reasons for Flight Re-Planning (Dispatcher View)*

The following factors were rated by dispatchers as the reasons requiring re-planning of the flight (in decreasing order of priority):

- Significant Weather per Dispatch action is #1 reason (33%)
 - Also rated as the #3, 4, 5 reasons with decreasing # of responses
- Significant Weather per notification from pilot or ATC is #2 reason (41%)
 - Also 4 and 6 with decreasing responses
- Airspace Disruption (notified by ATC)
 - Broad spread from 2 to 7
- Aircraft equipment failure
 - Mostly at 6 or 7, but other responses with broad spread from high to low
- Dispatch initiated to save time, fuel, on-time arrival
 - 3 and 7 (25%) – spread over many priorities
- Airspace Disruption (monitored and detected by Dispatch)
 - 8 (25%), but broad spread from 2 to 7 (16%, 8%)
- Fuel Reserve
- In-flight emergency
 - Priority 8, many small hits across wide level of priorities
- Security Event
 - 9 (66%)

General observation:

- From the dispatcher's perspective, Significant Weather as observed by Dispatch or per notification from the pilot or ATC are the primary reasons for re-planning of the flight. Airspace disruption notification from ATC follows Weather as the key factors for re-planning. The remaining factors are all rated approximately the same, with in-flight emergency and security event rated the lowest.

A.3.3 Flight Operations Perspective

The following represent survey responses related to disruptive and adverse factors that impact flight operations.

A.3.3.1 *Disruptive Flight Factors (Flight Operations View)*

The following disruptive flight factors were identified by operator flight operations:

- Global Network Carrier view

- Airspace disruptions are biggest factor (6 of 7 with 7 most severe impact)
- Traffic Flow Management (TFM) Initiatives and poor forecast on location (5 of 7)
- To a lesser extent, poor wind forecast, icing forecast, SUA, Notices to Airmen (NOTAMS) (2 of 7)
- Low-Cost Carrier view
 - TFM Initiative is 7 of 7
 - Most others are 3 of 7 (poor wind, poor forecast at location, airspace disruptions)
 - Unexpected SUA/TFR and NOTAMS are 2 of 7
 - Poor icing forecast 1 of 7
- Fractional Operator view
 - Airspace disruption, TFM Initiatives (5 of 7)
 - Poor wind and forecast at location (4 of 7)
 - Icing 3 of 7
 - SUA/TFR and NOTAMS 2 of 7

General observations:

- TFM Initiatives and Airspace Disruptions were viewed as most disruptive, followed to a lesser extent by poor forecasts On Location and of Winds. Unexpected SUA/TFR, NOTAMS, and poor forecast on icing were not viewed to be as disruptive.
- No strong correlation between responses by operator is noted.

A.3.3.2 Actual Flight vs. Original Flight Plan (Flight Operations View)

The survey probed for a high-level assessment of how closely the actual flight was able to achieve the original flight plan performance (in terms of flight time, fuel burned, and on-time arrival) based on flights during the last 12 months.

Actual vs. Original Flight Plan

- With the exception of On-Time Arrival for the Global Network Carrier surveyed (4 of 7, meaning mixed results), all responses from all aircraft operators indicate 6 of 7 meeting the original plan (flight time, fuel, on-time).

General observation:

- According to the survey results, actual flights generally met expectations to original plan, On-Time Arrival being an exception for the Global Network Carrier.

A.3.3.3 Adverse Effects on Performance (Flight Operations View)

The following adverse effects on flight performance of actual flight relative to original flight plan were identified:

- Global Network Carrier
 - Failed on-time pushback (7 of 7)
 - Adverse weather at destination (6 of 7)
 - System delays, metering, adverse weather at departure airport (5 of 7)
 - Departure delay on airport surface (4 of 7)
 - Adverse weather en-route (3 of 7)
- Low-Cost Airline
 - Metering is highest impact (7 of 7)

- All others are 3 of 7 or less
- Fractional Operator
 - Most are 5 of 7 (departure delay on airport surface, system delays, adverse weather at departure airport, adverse weather at destination, metering)
 - Adverse weather en route (4 of 7)
 - Failed on-time at push back (1 of 7)

General observation:

- ATC factors seem to have adverse effects at a moderate level (5 of 7). Adverse en route weather, while an issue was rated ~4 of 7. Thus TASAR has modest improvement opportunities related to ATC factors and a bit less impact on en route weather.

A.4 Change Requests

This section closely examines change requests, i.e., the number per flight, type of request, coordination with dispatch, and typical ATC response to the change requests.

A.4.1 Total Number of Change Requests per Flight

The following are the number of change requests per flight.

- 1 or 2 per short flights (<2 hours)
- ~equal responses of 1 or 2 and 3 or 4 (for 2 – 4 hour flight)
 - Averages to 2 to 3, with bias to 2 per flight
- 3-4 or 5-6 (> 4 hour flight)
 - Averages to 4 to 5, with bias toward 4per flight

General Observation:

- Approximately one change request per flight hour regardless of length of flight (short, moderate, long haul).

A.4.2 Type of Change Requests

Pilots were asked of the type of change requests that are typical.

- Types of change requests
 - altitude, lateral route (100%)
 - heading (~90%)
 - combination (60% responses)
 - speed (30+% responses)

General Observation:

- Change requests for speed are least frequent.

A.4.3 Coordination of Change Requests with Dispatcher

The following results address the level and types of coordination pilots conduct with dispatchers as part of making change requests.

A.4.3.1 *Percent of Change Requests Coordinated with Dispatch*

- Percent of change requests coordinated with Dispatch

- 50% said <10% of time
- 30% said 10-30% of time
- 5% said 30-70% of time
- 12.5 % said 70-90% of time (most of time)
- Most pilots (80% said 30% or less of time), the rest tend to coordinate with Dispatch more frequently

General Observation:

- Only a small percentage of change requests are coordinated with Dispatch (~20%). A few pilots tend to check with Dispatch much more frequently. Not sure if this pertains to one specific operator.

A.4.3.2 *Type of Coordination with Dispatch*

The follow represent the type and level of coordination between pilot and dispatcher for change requests.

Type of Coordination with Dispatch:

- Dispatch initiated
 - <10% engagement
- Pilot initiated, before change request is made to ATC
 - ~10+%
- Pilot initiates change request; no coordination with Dispatch
 - ~10+%
- Pilot advise Dispatch after the fact
 - >30%

General Observation:

- Pilots generally initiate change requests without Dispatch input; advise Dispatch later or not at all. Dispatch initiates what leads to change requests very infrequently (<10%).

A.4.4 *ATC Response to Change Requests*

The following represent the typical responses and frequency from ATC to change requests.

A.4.4.1 *Type of ATC Response to Change Request*

ATC Response to change request:

- 4 of 7, with 7 representing ‘always’ and 1 representing ‘never’ are immediately approve
- 4.7 of 7 are cleared after standby
- 3.1 of 7 are amended
- 4.3 of 7 deferred to next controller
- 2.8 of 7 denied

General Observation:

- ~2/3 of time approved with conditions. Slightly less than 40% are denied or deferred to next controller.

A.4.4.2 Reason for ATC Denial of Change Requests

Reason for ATC Denial

- Traffic/traffic congestion, weather, metering, ATC workload:
 - Metering more often the occurrence
 - Controller workload, traffic congestion second, weather routing next

General Observation:

- No definitive trends are noted.

A.5 Tools

The following provides an overview of tools employed by dispatchers and pilots for flight planning/re-planning and monitoring. Effectiveness and short comings are also examined based on the survey results.

A.5.1 Dispatch Tools

A.5.1.1 Available Flight Planning Capabilities - Dispatch

Available Flight Planning Capabilities – Dispatch:

- Company personnel with tools (67%)
- Automated monitoring in-house (33.3%)
- Company personnel without tools (25%)
- 3rd party automated monitoring (16.7%)
- Minor reference to in-house weather department

General Observation:

- Most capabilities include tools (~75%).

A.5.1.2 Tools for Monitoring Flight Efficiencies (Dispatch Perspective)

The following tools for monitoring flight efficiencies were identified in the User Survey:

- Sabre flight planning (used by the Low-Cost Airline surveyed) – Sabre services include dynamic flight planning, i.e., ability to run route scenarios, double check winds, overfly fees, etc., and can re-optimize during flight. The exact means for how this operator utilizes Sabre’s services is not specifically addressed in the User Survey.
- Flight planning SW
- Flight Explorer
- Flight planning engine (Phoenix) – (not sure if this is used primarily pre-departure or also while aircraft is already en route)
- ATC weather feeds for big picture analysis
- Contact crews via phone if needed
- Flight status monitor (from FAA) – feed arrival/departure rates
- Dispatcher can inquire position reports from Flight Management Computer (FMC)
 - Real-time information on current flight parameters

- Very effective re-dispatch/re-evaluation tool (unclear how currently used en route)

General observation:

- Tools provide a range of strategic and tactical capabilities with respect to monitoring flight efficiencies. Tactical tool capabilities seem to focus on Dispatch gaining access to a specific aircraft's FMC for position reports associated flight parameter data and do not appear to provide a tactical integrated view of flight operations. TASAR has the ability to provide a more integrated tactical view from the specific own ship's perspective, factoring in environmental constraints with respect to the current flight path.

A.5.2 Pilot Tools

The previous section examined dispatcher tools, associated information elements, and their relative effectiveness (or shortcomings) in the flight planning and in-flight re-planning processes. This section addresses the same topics from the pilot's tools perspective for in-flight re-planning.

A.5.2.1 *In-flight Re-Planning Capabilities for Pilots*

The following represent in-flight planning tools available to pilots in decreasing order of use / utility as identified in survey responses.

- In-flight re-planning capabilities for pilot:
 - FMS (100% response, i.e., always used)
 - Company provided (75%)
 - Automatic cockpit tools (62.5%)
 - Manual cockpit tools (50%)
 - Almost no 3rd party support
 - Other minor contributors to capabilities are
 - In-flight internet weather (likely the Fractional Operator)
 - Boeing wind update program (likely air transports operator(s))
 - Ground weather radar data via internet (likely Flight Operations, or pilots bringing it on-board)
 - iPad Class 1 WiFi (likely provisioned by the Fractional Operator, or pilots bringing it on-board).

A.5.2.2 *Tool Effectiveness – Company Personnel Support without Tools*

- Tool Effectiveness – Company Support – without tools:
 - 60% of pilots do not use this approach
 - For those using this approach, this approach is viewed not to be very effective.

A.5.2.3 *Tool Effectiveness – Company Personnel Support with Tools*

- Tool Effectiveness – Company Support – with tools:
 - Much greater use than for case without tools (Section 7.2.2) (80+% use)
 - Considerably effective, particularly for Extremely Challenging and Moderately Challenging flights (the more challenged/impacted the flight, the more effective).

A.5.2.4 Tool Effectiveness – Automated Monitoring and Advisory Service, Company

- Tool Effectiveness – Automated Monitoring and Advisory Service, Company Resource:
 - Not used by 30 to 40% of respondent organizations
 - When used, effectiveness viewed best for most impacted flights
 - Very effective to effective in those cases.

A.2.5.5 Tool Effectiveness – Automated Monitoring and Advisory Service, 3rd Party

- Tool Effectiveness - Automated Monitoring and Advisory Service, 3rd Party Service:
 - ~80% do not use this approach of support
 - When used, effectiveness viewed best for most impacted flights, very effective to quite effective.

A.5.2.6 Tool Effectiveness – In-flight Re-Planning by Pilots with Tools

- Tool Effectiveness – In-flight re-planning by pilots, with tools:
 - Quite heavily used; >90%, with some drop off for extremely challenged flight, perhaps due to workload?
 - Very to moderately effective for all types of impacted flights.

A.5.2.7 Tool Effectiveness – In-flight Re-Planning by Pilots without Tools

- Tool Effectiveness – In-flight re-planning by pilots, without tools
 - Used ~70% of time
 - Somewhat effective at best.

A.6 Information Source Assessment – Dispatch

A.6.1 Dispatch Information Sources – Fundamental and Most Valuable Rating

The following information sources used by dispatchers are viewed as fundamental to the flight planning process. An effectiveness rating is also provided based on survey results.

Dispatch Information Sources – fundamental and most valuable rating:

- Convective weather info – all want accurate, timely info – viewed fundamental
- Airspace status – all want accurate and timely info – viewed fundamental
- Wind speed, direction, temperature (80+%) – also rated high as a fundamental need
- Airport facility status, weather / traffic info (80+%) also rated high as a fundamental need

All seek better information, not clear how good it is for them today from survey.

A.6.2 Importance of Information Sources for Dispatch

The following rate the importance of information for Dispatch in-flight re-planning (by decreasing order of priority):

- Accurate Convective Weather Forecasts and updates (58.3%) – Priority 1
 - Some rated it 2 (25%), 4 and 5 at 8.3% each
- Wind speed, direction temperature – Priority 4 (50%), some also 1, 2, 3, with 3 more prominent (25%) than 2 (16.7), and 1 (8.3%)

- Airspace Status was priority 2 and 3 (33.3%, 41.7%, respectively)
- Airport facility status, weather, traffic info – broad 1,2,3,4 priority with 3 (33.3%) the highest, and 2 and 4 right behind (25%).

General Observation:

- Convective Weather is the highest priority source; airspace status and airport facility information sources are approximately equal as the next highest priority, with wind rated of lowest priority.

A.6.3 Effectiveness of Information Sources for Dispatch

The following ratings were received regarding the effectiveness of information sources for in-flight re-planning.

Effectiveness of Information Source:

- Airspace Status - 5.7 of 7 (7 being most important)
- Accurate Convective Weather Forecasts and updates - 5.4 of 7
- Wind speed, direction temperature – 5.2 of 7
- Airport facility status, weather, traffic info – 5.1

General Observation:

- Airspace status is 1, Convective Weather 2, Wind 3, Airport facility 4 in terms of order of decreasing order of effectiveness. There is not a lot of differentiation among these sources per survey results.

A.6.4 Deficiencies of Information Sources

The following identifies what information is currently either lacking or of insufficient quality (e.g., in terms of its availability, accuracy, and/or timeliness), that prevents Dispatch from achieving effective en route re-planning to enable the unconstrained flight in changing environmental conditions.

Lacking info / insufficient quality rating of Information Sources for Dispatch:

- Convective Weather (Collaborative Collective Forecast Product – CCFP)
 - More frequent updates desired
 - Coverage of forecast areas often quite large
 - Level of resolution could be refined further
 - Anywhere in oceanic airspace

Suggests weather information improvement opportunities.

- Winds, speed/direction, temperature
 - Great value to have actual winds to utilize while in flight
 - Sabre Flight Plan Manager already provides updates 4 times a day (averages the 12 hour reading twice)

Suggests an opportunity for improved information.

- Airspace status (SUA, traffic management initiatives, etc.)
 - Real time information would be excellent (Opportunity?)

- Better integration with Flight Explorer or other Aircraft Situation Displays (Opportunity?) – This is more a Ground Display of the big picture, not a flight deck display.
- Information changes so rapidly, it is difficult to keep up when monitoring 10 to 25 flights
- Delays due to Overhead stream, aircraft limiting altitude
 - When aircraft re-file coming out of Airspace Flow Program (AFP), how does one know what routes may become available? (Opportunity?)
- Airspace facility status, weather, traffic
 - Real-time Airport Facility Braking Action web-site (similar to Runway Visual Range (RVR)) would be excellent; during snow storms
 - While improved, still have time lags in information pushed out to Users and Operations Control Center
 - This is probably due to validation processes required (Opportunity?)
 - Inbound holds – are they the result of just switching runway configurations or is there something bigger going on?
- Other
 - Current Pilot Reports (PIREP) information from other flights (Opportunity?)
 - Time due to workload is an issue for dispatch. Dispatch requires easy to use information systems with associated tools. This is consistent with feedback that Dispatch tends to focus on flights pre-departure and not as much for en route re-planning due to workload.

General Observation:

- Timeliness, accuracy, and breadth/extent of information must continue to improve to enable effective flight re-planning. At the same time information management is required to avoid dispatcher information overload of excessive information detail and rapidity of updates. This requires intelligent automation to support dispatchers to allow them to “manage” the planning and re-planning of flights while keeping workload at reasonable levels.

The following represent factors identified by dispatchers surveyed that constrain re-planning of the current flight (in decreasing order of severity):

- Fuel reserve is most significant constraint factor (4.4 of 7, with 7 as most severe impact)
- Lack of accurate and timely weather information (4.2 of 7)
 - TASAR Opportunity
- Lack of sufficient information on airspace status (3.6)
- Lack of sufficient flight status information (3-)
- Connecting flight (2-)

General observation:

- Clearly both Dispatch and the aircraft can benefit from improved information, particularly related to weather. Airspace information seems to be less of a factor. TASAR likely plays a tactical role in re-planning of the flight, while Dispatch is more strategic.

Effectiveness of Current Flight Optimization Capabilities (and available time):

- Only moderately effective (4+ of 7)
 - Slightly better for Minimally Impacted, slightly worse for Extremely Impacted Weather

General observation:

- Dispatchers overall rate current flight optimization capabilities, and available time to do so as moderately effective (~4 out of a best rating of 7).

A.6.5 Information that Would Significantly Improve the Flight Re-Planning Process

The following information elements and associated improvements were identified by dispatcher survey respondents that they believe would significantly benefit the flight re-planning process.

Beneficial Information Elements for Flight Re-Planning:

- Accurate convective weather forecasts, i.e., updates on already occurring weather
 - Areas of moderate to severe/extreme turbulence
 - When convective activity is expected to affect route
 - Movement and speed of storms
- Winds, speed and direction, temperature
 - Large change over short distances may help with turbulence forecast for a specific route
- Airport status (SUA, traffic management initiatives, etc.)
 - Real-time updates would be excellent
 - Airspace congestion, constraints, closure
 - Overhead stream issues
 - How long a wait versus filing another route; stuck in conga line – or another, better route for \$100 to \$200 additional cost
- Airport facility status, weather, and traffic
 - National Airport Facility Braking Action website
 - Aerodrome closures, take-off and landing runways in use; RVR information; Navigation and runway NOTAMS
 - If airport back-ups occurring, would like to know so could slow down and save fuel

General Observation:

- A number of improvement opportunities are identified. It would be beneficial to more closely evaluate the major aspects of flight planning / re-planning processes and how they translate into successful conduct of the flight. Further analysis on which and how improvements in information quality will provide improved flight planning and in-flight re-planning is warranted.

Additionally, the roles of Dispatch in planning and in-flight re-planning, in conjunction with the role of the flight deck (applications and flight crew capabilities) in performing in-flight re-planning using tools such as TASAR, should be clearly delineated and allocated synergistically for maximum benefit. In addition, re-planning in the presence of changing environmental

factors needs to be accomplished in a consistent way with current and future ATC processes and procedures, again to be synergistic in nature.

General observation:

- Tools are generally employed. Without tools, any support is not viewed as effective. Hands-on company support is used significantly (80+ %) and is moderately and at times very effective. Automated monitoring and advisory services are used less frequently but when used, are effective. Most (80%) do not use 3rd party automated monitoring and advisory service support. Effectiveness is always best for the more impacted flights (extremely and moderately challenged). Pilot in-flight re-planning with tools is heavily used (90%) and very to moderately effective (perhaps used a bit less when extremely challenged – perhaps due to pilot workload (?)). Without tools, pilots still attempt to try to consider re-planning, but only with somewhat effectiveness at best.

A.7 Flight Re-Planning Organizational Policies, Constraints, and Cost Factors

This section examines organizational policies and procedures utilized by the operators surveyed with respect to the pilot's ability to initiate in-flight re-planning of the current route. Also examined are constraints identified to the flight planning / re-planning process, and cost factors affecting operations.

A.7.1 Organizational Policies and Procedures for Flight Changes

Based on User Survey responses from dispatchers from the three operators, a broad range of organizational policies and procedures are utilized by the operators for flight changes.

More than half of the responses (7 of 12) indicate that pilot can initiate altitude and speed changes on their own discretion, while route changes must be done via dispatch.

A small number of respondents (2 of 12) indicated that no policies are in place (conjecture is that this is likely Flight Options, due to the nature of their more flexible and diverse nature of end users and transportation needs).

A small number of respondents (2 of 12) indicate that pilots may initiate (flight plan changes), but these must be approved by Dispatch.

One respondent indicated that the pilot can initiate a change request without Dispatch input as long as it is within the context of the predefined Operations Control Manual.

General observation:

- Pilots have considerable latitude for flight changes, particularly for altitude and speed changes, guided by the company Operations Control Manual. Request for route changes are more likely to require Dispatch approval. Sufficient pilot empowerment is in place at the surveyed operators to allow utilization of TASAR capabilities to seek improvements to the current flight plan.

A.7.2 Flight Optimization by Dispatchers

Dispatchers were asked regarding the extent of time they generally spend on optimization of each flight and to what thresholds of flight time savings and/or fuel savings they would consider re-planning of a flight.

A.7.2.1 *Time Spent on Flight Optimization*

Dispatchers were surveyed concerning time spent per flight on optimization of the flight:

- 50% answered less than 5 minutes
- 41.7% answered 5 to 10 minutes
- 8.3% answered 11 to 25 minutes

Note: One wonders about the trade-off on time spent versus savings achieved – if airlines are not focused on this (i.e., not spending more or sufficient time to improve efficiency of flights), then they either do not have the means to do better in the way of tools of available quality information, or it is not a big cost issue (or they are not business focused – which is unlikely).

A follow-up question would be concerning which flights should Dispatch expend more effort on optimization – long haul and/or international flights? Also, once operators are able to operate in more of a “free flight” airspace perhaps in NextGen, with fewer constraints imposed (versus the more rigid route structures of today’s operations), then more significant gains can be made, and greater focus on optimization by Dispatch may be warranted.

A.7.2.2 *Time and Fuel Savings Threshold for Re-Planning (Dispatch View)*

Dispatchers were asked at what level of savings (flight time and/or fuel) that they would consider an en route (in-flight) re-planning of a flight.

Time Savings Threshold for En Route Re-plan:

- Dispatchers responded with ~3 minutes average flight time savings (but also had wide variance in responses up to 15 minutes)

Fuel Savings Threshold for En Route Re-plan:

- Dispatchers responded with ~150 lbs. average flight time savings (but also had wide variance in responses up to 400 lbs.).

A.7.3 **Flight Planning Constraints**

This section examines survey responses related to constraints faced by Dispatch and Flight Operations in flight planning and for en route in-flight re-planning processes.

A.7.3.1 *Flight Planning Constraints (Inability to Achieve the Unconstrained Flight)*

Dispatchers were probed to identify the extent that ATC-preferred routes, TFM Initiatives, and SUA had on being able to achieve an unconstrained flight plan.

- Due to ATC Preferred routes, TFM Initiatives, SUAs
 - 50% of dispatchers indicated that flights are very to significantly constrained due to these factors
 - 25% indicate moderately constrained
 - 25% indicate no or little constrained flights (conjecture that this is likely an input from the Fractional Operator surveyed, who are viewed to be less impacted by ATC constraints due to their operations from/to non-hub airports.)

A.7.3.2 Company Constraints for En route Re-Planning (Flight Operations View)

The following represent the constraints and their priorities to be considered by pilots when initiating en route re-planning as viewed from the Flight Operations perspective:

- ‘Arrival time for critical connections’
 - This is the highest priority constraint for Global Network Carrier surveyed (1 of 7, with 1 being most significant constraint factor) due to their networked route structures needing to support connect flights.
 - The Low-Cost Airline only rates this (4 of 7)
 - The Fractional Operator rates this least important (7 of 7) since meeting connecting flights is not a factor for Flight Options.
- ‘Requirements for fuel stop’ are the highest constraint for the Low-Cost Airline (1 of 7), followed by the Fractional Operator (2 of 7), and Global Network Carrier (3 of 7).
- ‘Organization’s priority for the flight’ is the most important constraint for the Fractional Operator (1 of 7) due to their fractional ownership business model
 - Second most important to the Global Network Carrier (2 of 7)
 - Followed by the Low-Cost Airline (3 of 7).
- ‘Arrival time for gate availability’ and ‘arrival sequence with other organization flights’ are rated relatively low on constraint importance.

A.7.3.3 Cost Factor Rating

This section identifies and rates cost factors provided by Flight Operations personnel from the operators surveyed.

Flight Path Performance Cost Factors:

- Fuel cost is the #1 priority for all three operators
- Schedule integrity is tied for #1 for the Fractional Operator, #2 for the two airline operators
- Ride quality is also tied for #2 for the Global Network Carrier, #3 for the Low-Cost Airline, #4 for the Fractional Operator (may suggest that VIPs and other passengers for this operator are more ardent fliers able to understand and handle rougher flights compared to the general flying public on air transport aircraft (?))
- Flight time is #3 for the Fractional Operator, #4 for the two airlines surveyed

Revenue Impact:

- For the Low-Cost Airline – completion, on-time performance, and fuel efficiency are all 7 of 7 (7 being most important)
 - Ride quality for Low-Cost Airline is 5 of 7
- The Global Network Carrier – completion is 7 of 7, on time performance and fuel efficiency are 6 of 7, ride quality only 2 of 7
- For the Fractional Operator – completion and fuel efficiency are highest (6 of 7), on-time is 5 of 7, ride quality is 3 of 7.

A.8 Survey Review and Assessment Results Summary

Section 4.1.2 provided the review and assessment of results related to the TASAR User Survey, with the objective to provide “findings and recommendations for the TASAR concept and implementation strategies that would accelerate user adoption of TASAR.”

Recommendations and observations fall into two categories which are then summarized below:

- 1) Equipage for TASAR
- 2) TASAR cost benefits, usability, and synergy with Dispatch and ATC processes.

A.8.1 Equipage for TASAR

A positive finding, from an equipage perspective, is that the operators surveyed in many cases are beginning to equip with the type of avionics systems and associated EFB and data communication capabilities needed to enable TASAR. ADS-B OUT (primarily 1090 MHz), EFB Class (1, 2 or 3), internet access (via terrestrial and/or satellite networks) and Data Comms (ACARS, CPDLC) are already in their plans. ADS-B IN (1090 MHz and/or UAT) plans are considerably less certain.

In this regard, the Fractional Operator, with its fleet of business and regional aircraft, is already well equipped with data connectivity to ground systems. Air transport operators, particularly the Global Network Carrier, are more reliant on ACARS and Data Comms and are currently not as connected to internet data networks, but this is improving. It is recommended that data connectivity is strongly encouraged for all operators to provide the most effective information access for TASAR. While TASAR's traffic awareness is highly desirable, a prolonged period of mixed ADS-B equipage (both ADS-B OUT and ADS-B IN) is likely a reality for several more years. Cost benefits from TASAR may help with this, but these must be fairly significant to create the pull for ADS-B equipage on their own. More likely, additional beneficial ADS-B applications for NextGen will need to assist with this pull.

The most significant and encouraging findings are that the operators surveyed, representing a significant cross-section of aircraft operators, are beginning to have avionics and associated EFB and data communications capabilities capable of supporting early introduction of TASAR.

A.8.2 TASAR Cost Benefits, Usability, Synergy with Dispatch and ATC Processes

In order to achieve a positive business case for TASAR, two key requirements must be achieved:

- 1) Access to relevant, high quality (i.e., accurate, timely {sufficient update rates, sufficient latency}) information sources (both ground-based and flight-deck based)
- 2) Synergistic integration of TASAR with available flight (re)planning tools and processes used by dispatchers and pilots, while also being consistent with ATC processes (change requests, traffic flow management including arrival flows).

Without quality and complete information, TASAR is unlikely to provide reliable cost benefits. Pilot acceptance of TASAR is likely dependent on TASAR providing consistent and believable trajectory change recommendations with indicated savings in fuel and/or flight time. In addition, in the longer term, TASAR's utility should be integrated in a consistent manner with other flight planning, flight optimization processes utilized by Dispatch and should be consistent with ATC processes and procedures.

While initial studies indicate the benefits of TASAR [5], a thorough assessment of TASAR cost benefits is likely required. Current on-going and planned flight simulations (University of Iowa Operator Performance Laboratory pilot evaluations in the use of TASAR using a Boeing 777 flight simulator), flight evaluation (Advanced Aerospace Solutions' flight trial of TASAR using their Piaggio Avanti P180 aircraft), and planned HITL experiments by NASA can assist in development of the TASAR business case.

The following represent a collection of general observations and comments regarding current flight planning and in-flight re-planning procedures, tools, information sources and their effectiveness (or lack thereof) as determined from survey responses from pilots, dispatchers, and flight operations personnel from the operators surveyed:

- 1) From a Dispatch perspective, significant weather as observed by Dispatch or per notification from the pilot or ATC is the primary reason for re-planning of the flight. Airspace disruption notification from ATC follows weather as the next key factor for re-planning.
- 2) Dispatchers rate the effectiveness of current flight optimization capabilities (and the available time to perform those duties) as moderately effective. These capabilities were slightly more effective for “minimally impacted” flights and slightly worse for “extremely impacted” flights due to adverse environmental factors.
- 3) In assessing survey responses, it is observed that weather is a primary consideration for dispatchers, with ATC constraints, airspace disruptions and other constraints being somewhat secondary factors (still important but not at the level of weather). Conversely, for pilots, ATC constraints and airspace disruptions are larger factors, with en route weather being a secondary, less constraining factor in in-flight re-planning.
- 4) Tools provide a range of strategic and tactical capabilities with respect to monitoring flight efficiencies. Tactical tool capabilities seem to focus on Dispatch gaining access to a specific aircraft’s FMC for position reports and associated flight parameter data and do not appear to provide a tactically integrated view of flight operations. TASAR has the ability to provide a more integrated tactical view from the specific own ship’s perspective, factoring in environmental constraints with respect to the current flight path.
- 5) Timeliness, accuracy, and breadth of information must continue to improve to enable effective flight re-planning. At the same time, information management is required to avoid dispatcher information overload of excessive information detail and rapidity of updates. This requires intelligent automation to support dispatchers to allow them to “manage” the planning and re-planning of flights while keeping workload at reasonable levels.
- 6) It is evident that both dispatchers and the pilots can benefit from improved information, particularly related to weather. Airspace information seems to be less of a factor. TASAR likely plays a tactical role in re-planning of the flight, while Dispatch is more strategic.
- 7) From pilot survey inputs concerning use of tools, it is noted that tools are generally employed. Without tools, any support is not viewed as effective:
 - a. Hands-on company support is used significantly (80+ %) and is moderately and at times very effective. Automated monitoring and advisory services are used less frequently but when used, are effective. Most (80%) do not use 3rd-party automated monitoring and advisory service support. Effectiveness is always best for the more impacted flights (extremely and moderately challenged) due to adverse environmental conditions.
 - b. Pilot in-flight re-planning with tools is heavily used (90%) and very to moderately effective (used a bit less when extremely challenged – perhaps due to pilot workload). Without tools, pilots still attempt to try to consider re-planning, but only with somewhat effectiveness at best.

- c. Survey results and insight into the pilot tools used (except for FMS, which is always used), are not very specific and would require further investigation and dialog with pilots.
- 8) Pilots have considerable latitude for making flight changes, particularly for altitude and speed changes, guided by the company Operations Control Manual. Request for route changes are more likely to require Dispatch approval. Sufficient pilot empowerment is in place at the surveyed operators to allow utilization of TASAR capabilities to seek improvements to the current flight plan.
- 9) From a Dispatch perspective pertaining to time spent on flight optimization, there is a trade-off on time spent versus savings achieved; if airlines are not focused or motivated to spend additional time to improve the efficiency of flights, then they either do not have the means to do better (i.e., in the way of tools and available quality information), or it's not a big cost issue to be considered. It is unlikely that they are just not focused on seeking cost improvements due to lack of focus and is likely related tool availability.
 - a. A follow-up question would be concerning which flights should Dispatch expend more effort on optimization – long haul and/or international flights? Also, once operators are able to operate in a more “free flight” airspace perhaps in NextGen, with fewer constraints imposed (versus the more rigid route structures of today’s operations), then more significant gains can be made, and greater focus on optimization by Dispatch may be warranted.
- 10) Dispatcher can inquire position reports from FMC and derive additional real-time information on current flight parameters, which is viewed as a very effective re-dispatch and re-evaluation tool.
 - a. From survey responses, Dispatch tends to play a relatively limited role for in-flight re-planning. This is particularly the case for the Global Network Carrier surveyed, who only provides support services while the aircraft is in-flight when prompted by pilot requests.
 - b. A potential area of research is to determine to what extent should Dispatch focus on in-flight re-planning, which is currently not their focus, or should this be delegated to flight-deck tools, e.g., TASAR. What is the proper balance of Dispatch versus aircraft-based in-flight re-planning to ensure synergy? In addition, to what extent can TASAR take on flight planning typically done by dispatch, particularly in future NextGen operations that support “free flight” capabilities?
- 11) TASAR, with good (i.e., pertinent, accurate, and timely) information on ATC metering and flow management, and weather information (especially en route and at the destination airport) has the potential to provide significant tactical re-planning capabilities for operational efficiency. With TASAR the key issue is its usability (i.e., providing benefits while at the same time being streamlined with operator dispatch, own ship flight procedures using the FMS, and with ATC’s overall air traffic control paradigm (change request clearances, traffic flow management, arrival management, etc.).
- 12) A number of improvement opportunities are identified as a result of survey responses. It would be beneficial to more closely evaluate the major aspects of flight planning and re-planning processes and how they translate into successful conduct of the flight. Further

analysis on which information elements and how improvements in information quality will provide improved flight planning and in-flight re-planning is warranted.

- 13) Additionally, the roles of Dispatch in planning and in-flight re-planning, in conjunction with the role of the flight deck (applications and flight crew capabilities) in performing in-flight re-planning using tools such as TASAR, should be clearly delineated and allocated synergistically for maximum benefit. In addition, re-planning in the presence of changing environmental factors needs to be accomplished in a consistent way with current and future ATC processes and procedures, again to be synergistic in nature.

In summary from an aircraft equipage perspective, TASAR is poised to be readily achieved, with the possible exception of ADS-B IN. A positive cost benefit business case is a key requirement for operators to continue to equip and enhance their avionics, EFB and data communications level of equipage for their aircraft fleets. Perhaps the most significant challenge is the development of a more robust cost benefit assessment for TASAR that supports synergistic usability with Dispatch and ATC processes as part of the in-flight re-planning to achieve operational efficiencies in the presence of changing environmental conditions (e.g., weather and airspace disruptions).

Appendix B **TASAR EFB Standards Adherence Requirements**

This appendix documents the detailed results of the EFB standards adherence requirements assessment summarized in Section 4.2.2, with focus primarily on EFB hardware and software requirements, including installation considerations.

B.1 Determination of EFB “Class” Anticipated for TASAR

Before addressing EFB “Class” for TASAR, it is necessary to provide some context on the use of EFBs in the flight deck, including a few definitions provided by FAA on their intended and allowed use. FAA Advisory Circular AC 120-76C [13] serves as the key document providing Guidelines for Certification and Operational use of EFBs and associated applications.

With significant strides continually being made on increasingly capable and versatile portable computing devices (hardware, software, and applications), there is a strong desire by aircraft operators, aircraft manufacturers, and avionics manufacturers to leverage the computing power and connectivity offered by EFBs for applications that provide operational benefits and improved situational awareness in the flight deck. The relatively low-cost of these systems potentially provides an effective path for new flight-deck capabilities that supplement and complement traditional avionics systems that provide Communication, Navigation, Surveillance support for the pilot to conduct flight operations. These systems also potential offer a relatively low-cost path for system retrofit of new capabilities.

FAA has recently updated the original AC-120-76 document to the newly released AC 120-76C [13] and is already working on a future update. While trying to accommodate end user innovation for new EFB-based applications, FAA is also looking to ensure interference-free operation to on-board certified avionics functions. As such, FAA has established guidelines and definitions for the use of PEDs as EFBs (also referred to as Portable EFBs). These devices may be carried onboard and used by the pilot / flight crew or could be mounted for use in the cockpit. Computing devices may also be permanently installed in the flight deck (also referred to as Installed EFBs). Depending on the application and intended use, PEDs and EFBs may be used standalone or they may interface directly to or indirectly to (via an AID) to avionics systems. When interfacing to avionics, the PED/EFB can be read-only or may also transmit to onboard avionics systems. As such, FAA has defined requirements for PED/EFB use for these operations that will be identified below, with focus on applicability to TASAR.

The following definitions apply to PED/EFB use in the flight deck. It should be noted that many people tend to use the term EFB in a general sense, while FAA uses these terms in more specific context. While the user community envisions broad use of PEDs/EFBs for a wide range of increasingly capable applications, FAA currently restricts the definition of PEDs/EFBs to applications currently allowed to replace paper documents (i.e., Type A applications) or those that provide some sort of algorithmic processing, e.g., performance calculations (i.e., Type B applications). New applications that do not necessarily map directly into these defined categories (i.e., type of application, e.g., Type A, B, or C) may need to be developed, validated and evaluated by FAA certification and operational approval personnel for their intended function before gaining approval. EFB Types software is further examined in Section 4 below.

Definitions

The following definitions are currently used by FAA as part of EFB guidance document AC 120-76C and are applicable to the TASAR EFB assessment presented here:

Electronic Flight Bag (EFB) - an electronic display system intended primarily for flight deck use that includes the hardware and software necessary to support an intended function. EFB devices can display a variety of aviation data or perform basic calculations (e.g., performance data, fuel calculations). In the past, some of these functions were traditionally accomplished using paper references or were based on data provided to the flight crew by an airline's flight dispatch function. The scope of the EFB functionality may include various other hosted databases and applications. Physical EFB displays may use various technologies, formats, and forms of communication. An EFB must be able to host Type A and/or Type B software applications.

Portable Electronic Device (PED). Title 14 Code of Federal Regulations (14 CFR) Section 91.21; § 121.306; part 125, § 125.204; and part 135, § 135.144 refer to PEDs and place restrictions on the in-flight use of PEDs. There are two types of PEDs and two methods of compliance with these regulations.

(1) The non-EFB PED method of compliance with PED regulations is in the current edition of AC 91.21-1 [15], Use of Portable Electronic Devices Aboard Aircraft. Use of these PEDs is prohibited in instrument flight rules (IFR) flight operations, except in cruise flight.

(2) The EFB PED method of compliance with PED regulations is in FAA Order 8900.1 Flight Standards Information Management System (FSIMS) [14] and AC 120-76C [13].

Transmitting Portable Electronic Devices (T-PED). PEDs that have intended radio frequency (RF) transmission capabilities.

B.2 Classes of EFB – Hardware Perspective

Class 1 EFB Hardware - portable commercial off-the-shelf (COTS)-based computers, considered to be PEDs with no FAA design, production, or installation approval for the device and its internal components. Class 1 EFBs are not mounted to the aircraft, connected to aircraft systems for data, or connected to a dedicated aircraft power supply. Class 1 EFBs can be temporarily connected to an existing aircraft power supply for battery recharging. Class 1 EFBs that have Type B applications for aeronautical charts, approach charts, or an electronic checklist must be appropriately secured and viewable during critical phases of flight and must not interfere with flight control movement.

Portable Class 1 EFB components are not considered to be part of aircraft type design; i.e., not in the aircraft Type Certificate (TC) or Supplemental Type Certificate (STC.)

Class 2 EFB Hardware - portable COTS-based computers, considered to be PEDs with no FAA design, production, or installation approval for the device and its internal components. *Class 2* EFBs are typically mounted. They must be capable of being easily removed from or attached to their mounts by flight crew personnel. Class 2 EFBs can be temporarily connected to an existing aircraft power supply for battery recharging. They may connect to aircraft power, data ports (wired or wireless), or installed antennas, provided those connections are installed in accordance with AC 20-173.

Portable Class 2 EFB components are not considered to be part of aircraft type design; i.e., not in the aircraft TC or STC.

Class 3 EFB Hardware - EFBs installed in accordance with applicable airworthiness regulations. Refer to AC 20-173 for guidance on the installation of EFB components.

Based on the above FAA definitions of Classes of EFBs, it is noted that a PED is by definition not considered as part of the aircraft design (i.e., not part of a TC or STC). An Installed Electronic Device is by definition Class 3 and will require TC/STC approval.

The TASAR application, as described in Section 1, does not require to be hosted in an Installed EFB in the flight deck, but can be hosted in a PED, i.e., Portable EFB. Thus a Class 3 EFB is not required for TASAR. Note: If desired, TASAR could be integrated as part of a Class 3 EFB when integrated with other already approved software applications. It would need to be demonstrated that the TASAR software (operating system and application) would not adversely affect and interfere with already installed, certified software applications.

B.3 Typical EFB System Components

Figure B-1 illustrates typical components associated with an EFB (Figure B-1 is from FAA AC 20-173, “Installation of Electronic Flight Bag Components”, [16]).

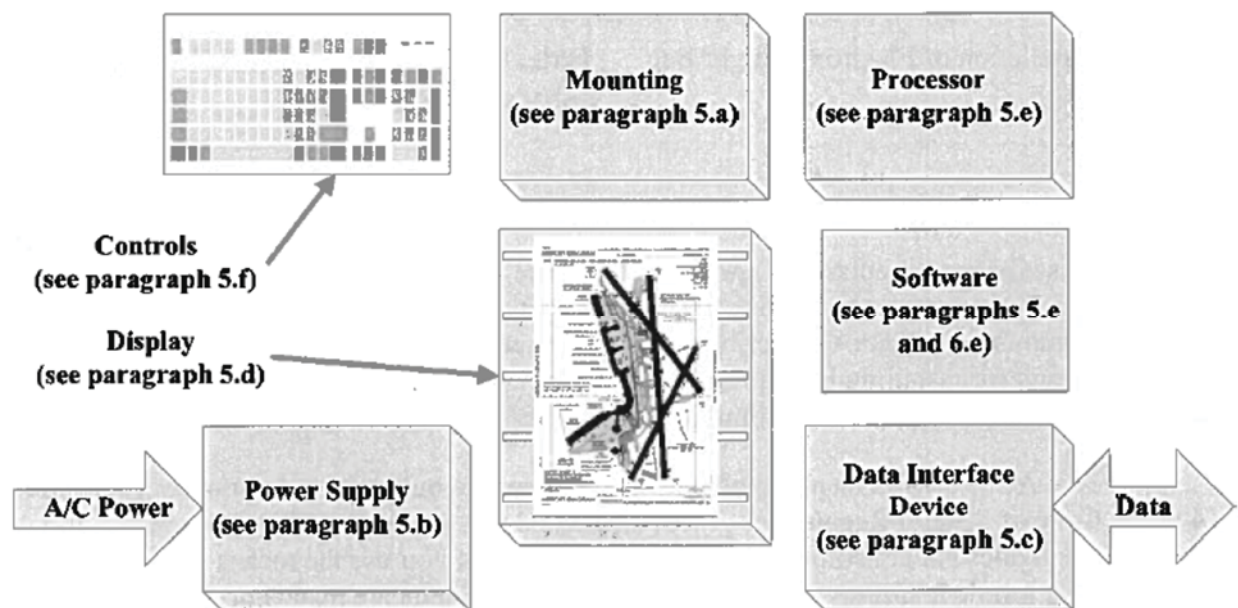


Figure B-1 Typical EFB System Components

When TASAR is implemented directly as an EFB, it will need to be a “mounted PED,” requiring interface (wired / wireless connectivity) to aircraft systems, and primary power from a source of aircraft power. This requires TASAR to be Class 2 EFB. When TASAR is implemented as a PED (i.e., display, processor) to be interfaced through an AID {referred to as Data Interface Device in Figure B-1), it could potentially be implemented as a Class 1 EFB/PED. In this case, the AID (i.e., Data Interface Device) takes over the burden of providing the necessary interfaces and protections to the aircraft systems and primary aircraft power. The assessment in this report treats the TASAR EFB as either a direct EFB implementation, or as an indirect interface to an AID, with the AID

being part of TASAR. Thus this assessment will only consider the EFB standard adherence requirements as a Class 2 EFB for TASAR.

The EFB system illustrated in Figure B-1 must ensure protection and isolation of the EFB application from installed avionics systems in terms of system security against vulnerabilities and threats, e.g., computer viruses, worms, unauthorized access, and malicious access.

B.4 Class 2 EFB Approval Requirements

This section examines the approval requirements for a Class 2 EFB for TASAR. In addition to AC 120-76C, another key guidance document for FAA EFB Authorization is FAA 8900.1 Change 47, Volume 4 “Aircraft Equipment and Operational Authorizations”, Chapter 15 “EFB Authorization for Use”, Section 1 “EFB Operational Authorization Process” [14].

B.4.1 High-Level Steps for Installation and Operational Approval of a Class 2 EFB

The following represents the high-level steps needed to be followed for the Installation and Operational Approval of a Class 2 EFB for TASAR:

1. Applicant must obtain approval via TC or STC for initial alterations related to:
 - a. mounting fixture installation
 - b. installation of power and / or data connectivity

Note: Any follow-on installation must use FAA-approved data.

2. Manufacturer, provider, or installer must assure via testing that the Class 2 EFB provides interference-free operation
 - a. If a data transmitter is used to transmit data to the Class 2 EFB, it must be tested to RTCA DO-160E, section 21, paragraph M. This ensures that conduction or radiation of emissions do not result in interference.

3. Applicant must obtain TC, STC approval or DER approval for installation of antennas that provide data to the EFB, e.g., navigation, weather data

Note: TASAR may fall into this category as it seeks to access information from network-enabled information services. However, since TASAR is of “Minor”, or “No Effect” FEC, the data integrity required may be relatively minor, and TC, STC, or DER approval requirements of installed antennas are to be determined with further analysis.

FAA Involvement in EFB Approval Process

The following FAA offices are involved in the EFB approval process, 1) Certification (AIR), 2) Aircraft Evaluation Group (AEG) - Flight Standards (AFS), and 3) the POI.

The role of AIR is to issue approval of type design of installation for inclusion in the TC/STC.

AEG may evaluate new EFBs and prepare an Operational Suitability Report (OSR).

The POI conducts reviews and issues authorization by Operational Specification (OpSpec) or by Management Specification (MSpec) and Letter of Authorization (LOA), A061.

Operator Requirements

The following are requirements to be met by the Operator for the intended function / new EFB capability, in this case TASAR:

1. Develops the program for usage
2. Completes an operational evaluation of the new capability
3. Ensures that the system performs its intended function
4. Documents non-interference per AC 91.21-1 [15]
5. Ensures non-interference with and isolation from aircraft systems during transmission and reception
6. Determines usage of hardware architectural features, persons, procedures, and equipment to eliminate, reduce, or control risks associated with hardware failure

Note: Installed elements of Class 2 EFB must be entered into aircraft records when added or removed

B.4.2 EFB Mounting Considerations

Before addressing the EFB standards adherence requirements associated with mounting the TASAR Class 2 EFB, the following definitions (from FAA AC 120-76C) are provided to support the discussion:

Mounted. Any portable device that is attached to a permanently installed mounting device.

Mounting Device. These include arm-mounted, cradle, clips, docking stations, etc.

Stowed. A portable device that is placed in a secure stowage location but is not available for use or view by the pilot in that location.

Viewable Stowage. A portable device that is secured in an existing provision with the intended function to hold charts or acceptable portable device viewable to the pilot (e.g., kneeboards).

From the TASAR application perspective, the TASAR EFB is expected to be mounted (either directly, or indirectly via an AID to provide the intended functions. The mounting device may be connected to data source(s), hardwired to an aircraft power source (or via a connector), and hardwired to an installed antenna.

The mounting device must be evaluated to ensure operational suitability in all ground and flight operations and conditions. As such, the mounting device must:

- 1) not interfere with flight crew duties
- 2) be easily stowed when not in use
- 3) must not obstruct primary or secondary fields of view
- 4) must not obstruct egress.

As the EFB is portable (i.e., not installed permanently as part of the flight deck), it must be easily removable, without tools, and by the pilot / flight crew member. The EFB must be accessible to the pilot / flight crew (if it is not accessible, then it must be installed via a certified installation via TC, amended TC or STC). The only exception to the accessibility criteria is for a remotely mounted antenna that provides signal reception to the Class 2 (also Class 1) EFB.

Two types of EFB mounts can be considered, 1) a yoke mount or 2) a cockpit mount. A yoke mount requires FAA AIR approval, either as a TC, STC or amended TC. DER or field approval is not permitted. A cockpit mount requires AIR airworthiness approval and cannot be Field Approved. A cockpit mount represents the preferred mounting approach for TASAR.

B.5 EFB “Type” Considerations

In order to address EFB standards adherence requirements with respect to the EFB “Type” (i.e., with respect to EFB software), the following definitions (again from AC 120-76C) are referenced:

Critical Phases of Flight. Includes all ground operations involving taxi, takeoff, and landing, and all other flight operations conducted below 10,000 feet, except cruise flight. Note: This definition of the critical phases of flight is per those in part 121, § 121.542.

Approved Software. Software approved by the FAA using the current edition of RTCA/DO-178, Software Considerations in Airborne Systems and Equipment Certification, compliance, or other acceptable means.

Note: As defined below for Type C Software – “Approved Software” applies to non-EFB Software that is major hazard or higher and thus requires DO-178 for certification approval.

Type A Software Applications. Type A applications are those paper replacement applications primarily intended for use during flight planning, on the ground, or during noncritical phases of flight. Examples of Type A software applications are listed in Appendix 1 in AC 120-76C.

Type B Software Applications. Type B applications are those paper replacement applications that provide the aeronautical information required to be accessible for each flight at the pilot station and are primarily intended for use during flight planning and all phases of flight. Type B applications include miscellaneous, non-required applications (e.g., aircraft cabin and exterior surveillance video displays, maintenance applications). Examples of Type B software applications are listed in Appendix 2 in AC 120-76C.

Type C Software Applications. Software approved by the FAA using RTCA/DO-178B compliance or another acceptable means. These are non-EFB software applications found in avionics and include intended functions for communications, navigation, and surveillance that require FAA design, production, and installation approval. Type C applications are for airborne functions with a failure condition classification considered to be a major hazard or higher.

Precomposed Information. Information previously composed into a static, composed state (non-interactive). The composed displays have consistent, defined, and verifiable content, and formats that are fixed in composition.

Hosted Application. Software running on an EFB that is not installed or considered part of aircraft type design.

Interactive Information. Information presented on the EFB that, via software applications, can be selected and rendered in a number of dynamic ways. This includes variables in the information presented based on data-oriented software algorithms, concepts of decluttering, and selectable composition as opposed to precomposed information.

Based on the above definitions, the following observations are made:

Type A applications are primarily intended for use during flight planning, on the ground, or during noncritical phases of flight and are electronic paper replacement (i.e., they do not consist of specific algorithms and processing, but strictly depict precomposed database information. (Refer to Appendix 1 in AC 120-76C for a detailed list of approved Type A applications).

Type B applications are intended for use during critical phases of flight or have software and/or algorithms that must be tested for accuracy and reliability by applicant. (Refer to Appendix 2 in AC 120-76C for a detailed list of approved Type B applications).

Sample Type B applications are 1) display of aeronautical charts viewable electronically and allows chart manipulation, 2) Electronic Checklists available in all phases of flight, 3) Weight and Balance calculations / algorithms, 4) performance calculations. These must be tested and proven by the applicant.

While TASAR is currently neither a Type A or Type B application (i.e., not on the approved list of applications per Appendix 1 and Appendix 2 in AC 120-76C), TASAR has some key characteristics related to Type B software applications: 1) intended for use during flight planning (in case of TASAR, primarily during en-route phase of flight, but potentially during the later stages of climb, and early stages of decent), 2) includes variables in the information presented based on data-oriented software algorithms (in case of TASAR, using a variety of information sources for subsequent processing to determine trajectory change candidates), and 3) failure classification of no more severe than “Minor” failure effects.

Note: While TASAR is similar to a Type B application, it is anticipated that it has a lesser threshold for acceptance / approval over traditional Type B applications; TASAR being an optional, supplemental, advisory support tool, that the pilot / flight crew can use at their discretion (i.e., can choose to ignore or disable at any time for any reason). Appropriate pilot training will ensure that pilot / flight crew will not be distracted by TASAR during flight operation while conducting normal operational tasks associate with the current flight.

Based on the above definitions, PEDs/Portable EFBs (i.e. EFBs of Class 1 and Class 2) are limited to perform Type A and B application, which are of “Minor” FEC. In addition, Type C display of own ship position application is permitted for taxi speeds below 40 kts but is not allowed for airborne use, otherwise this would require use of an installed Class 3 EFB and would require DO-178B Software certification. This is *not a consideration for the TASAR application, as own ship position is not part of the TAP HMI design* [3].

Type B Software Considerations

While TASAR is currently not defined as an EFB application, and is neither a Type A nor Type B software application, TASAR has many of the characteristics of a Type B application.

Type B applications may be hosted by any Class EFB (Class 1, Class 2, or Class 3). Type B applications do not require AIR design approval or AEG evaluation and do not require DO-178B software development and certification.

For Type B applications (and also anticipated for TASAR), the following responsibilities are identified for the various approvers and stakeholders in the approval process:

FAA POI Responsibilities

1. Verifies that:
 - a) application criteria and operator requirements are met
 - b) data updates follow maintenance manual and inspection program procedures
 - c) applicable job aids, including human factors evaluation are completed
 - d) training, checking, and currency programs are approved

- e) operational evaluation report from operator is appropriately reviewed
 - f) OpSpec or MSPEC A061 is issued upon completion of authorization process, as applicable
2. Ensures that the level of information integrity is commensurate with TASAR requirement – this is to be determined, but as noted, TASAR is anticipated to warrant a FEC of no more than “Minor”, and may even be of “No Effect” (refer to the “Analysis of TASAR Operational Hazards and Safety Requirements” [7]).

Flight Standards Service (AFS)

Flight Standards Service (AFS) provides initial operational authorization granted for hosted application(s) (e.g., performance and/or weight and balance applications) based on AIR recommendations and AEG determination of flight crew training, checking and currency requirements.

Operator Requirements

The Operator addresses the following requirements as part of the approval process:

1. Determines usage, architectural features, people, procedures, and equipment to eliminate, reduce, or control risks associated with an identified failure in a system
2. Performs 6-month operational validation per authority granted in OpSpec or MSPEC A061, as applicable
3. Uses both EFB device / system and conventional paper copies during evaluation
4. Submits final evaluation report to the POI, as appropriate after evaluation
5. Operating system and hosted application software meet criteria for appropriate intended functions and do not provide false or hazardously misleading information
6. Software revision loading will not corrupt data integrity of original software.

Note: Depending on how the TASAR application will be integrated in a PED / EFB will dictate the level of partitioning required:

1. If TASAR is standalone, with its own dedicated processor (own Operating System {O/S} and application software) and dedicated display, this is will not require any partitioning or special protections
2. If TASAR has its own dedicated processor, but shares a common display with other “Approved Software” applications / software (per above definition), recommended Display Standards, e.g., AC 25-11, Electronic Flight Deck Displays (for Part 25 aircraft) [30], and AC 23.1311-1, Installation of Electronic Display in Part 23 Airplanes [31] must be followed
3. If TASAR is hosted with other Approved Software applications in a shared processor, approved partitioning techniques must be followed. These techniques are required to guarantee throughput and resources (e.g., memory, hard drive, avionics data, etc.) of Approved Software applications.

B.6 Principal Operations Inspector (POI) Review Checklists

This section examines the items on the POI’s checklist used to review EFB applications. Guidance information for the POI checklist and review process is found in Flight Standards Information System (FSIMS) – 8900.1 Change 47, Vol. 4, Chapter 15 – EFB Operational Authorization Process [14].

The following represent the high-level categories addressed in the POI checklist review. This list of topics frames a much larger set of questions that may be asked by the POI to review and evaluate an EFB application to ensure that guidance documents, e.g. AC 120-76C are being followed by the applicant of the application to adhere to EFB standards requirements. In general the checklist questions are specific to initial installations and training for a given aircraft. This list of POI checklist questions is not repeated here due to their length, but can be found in [14]; four checklists are provided in Figures 4-79 to 4-82:

1. Figure 4-79 represents Checklist 1, "Tabletop Electronic Flight Bag Evaluation"
2. Figure 4-80 represents Checklist 2, "Electronic Flight Bag Operational Evaluation"
3. Figure 4-81 represents the "Evaluation Report Information Template"
4. Figure 4-82 represents Checklist 4, "Electronic Flight Bag Line Evaluation Job Aid".

The high-level POI checklist review for "General EFB" are as follows:

A. General Considerations

A first step is to research if any EFB hardware or software is covered by an existing Aircraft Evaluation Group (AEG) report by FAA AFS. If found, this can be used as an equivalent artifact(s) to expedite the approval process of the new application.

The general consideration also focuses on workload of using the EFB application. Determination of whether an in-flight evaluation will be necessary is made, in the event that evaluation of the EFB application cannot be accomplished on the ground to demonstrate the intended function. (For TASAR, it should be acceptable to demonstrate the application on the ground rather than an in-flight evaluation, given an appropriate set of Use Cases / scenarios to demonstrate flight crew use of the TASAR EFB. However, NASA intends to perform research in flight simulators and in flight trials to assess flight crew performance using TASAR.)

As part of the workload assessment, the POI will review the operator's responses to the workload-related questions in Checklist 2 (as noted in Figure 4-80 in [14]). The POI will also verify that procedures are published and available to all EFB users and maintainers, that preflight procedures and checklists are revised to include the EFB, and that procedures are established for EFB failures (e.g., single / dual EFB failures).

B. Physical Placement

This portion of the POI review process focuses on the design and placement of the "Structural Cradle" of the EFB mount. Numerous considerations are examined, e.g., 1) user procedures that specify location for EFB use and also stowage; 2) verification that EFB location does not a) obstruct visual or physical access to flight controls and/or displays; b) does not obstruct emergency egress path; c) provides security during flight; 3) mounting device a) documented per airworthiness documentation, b) locks in position easily, c) able to adjust to accommodate a range of pilot / flight crew preferences and physical abilities, d) is durable, and e) addresses crashworthiness considerations and restraint of EFB when in use.

C. Training/Procedures Considerations

- 1) ***EFB documentation and policy***: Verifies that a) written policy adequately address each specific EFB application and that published AEG recommendations have been incorporated into the operator's EFB program, b) procedures are in place to communicate upgrades of malfunctions of EFBs to users in a timely manner; c) EFB information from manufacturer is incorporated into operating procedures
- 2) ***EFB Training***: Verifies that a) initial EFB training includes evaluation of knowledge and skill requirements and include demonstration of key tasks; b) recurrent training includes evaluation of proficiency with the EFB; c) minimum training, checking, and currency requirements are specified; d) EFB training is customized to application being used.

D. Validation Phase and Continued Data Collection

- 1) This step verifies that a) the 6-month validation phase provides documentation by pilots / users of the EFB of feedback about the EFB and its performance; and b) procedures specify the personnel responsible for EFB maintenance and database management.
- 2) Also ensures that operator has an ongoing data collection and feedback / correction process that ensures suitability and reliability of data; ensures that data collection processes are in place and are factored into the operators Safety Management System (SMS).

E. SMS Interface

The SMS interfaced verifies that:

- 1) Hazards associated with use and integration of the EFB have been identified, eliminated, or controlled, to an acceptable level through the life cycle.

Hazards such as misuse, hazardous misleading information due to failure or malfunction, loss of information when needed, miscalculation, masking of information, confusion, corruption of data, excessive complexity of use, accidental damage, and human error in use, setup, and operation have been considered;

- 2) Applicant's SMS has procedures to mitigate identified hazards, e.g., availability, reliability of design, cross-checking of calculation/data, crew training, and misuse potential;
- 3) Applicant's SMS incorporates EFB hazard analysis, risk assessment and related safety reports.

F. Software Considerations

Verifies that procedures are established for testing software revision or database update prior to operational use.

G. Hardware Considerations

Verifies that:

- 1) Display lighting and reflectivity has been evaluated for acceptability in each aircraft model;

- 2) EFB maintenance procedures are in place for batteries, displays, display interaction devices, display pixel burnout, and component condition.

In addition to the above “General EFB” areas that the POI will review, the POI will also review the following areas, 1) Electronic Documents, 2) Electronic Check Lists, 3) Weight and Balance, Flight Performance calculations, 4) Electronic Charts. These areas are in reference to current Type A and Type B applications and are not specific to TASAR and are thus not addressed in additional detail.

In addition to these above noted review categories, the POI will also assess the EFB Validation Phase. The POI will verify that procedures are established to collect user data for normal and abnormal EFB functions during the validation phase; also that the user provides a written report of reliability and problem resolution prior to authorization, e.g., for paperless operation (or other intended uses of the EFB application).

Appendix C Certification and Operational Approval Guidelines and Regulatory Requirements for TASAR; Project Specific Certification Plan

Appendix C describes the 5 phases of a certification project as documented in “The FAA and Industry Guide to Product Certification (CPI Guide)” [28]. Section C.2 describes the Project Specific Certification Plan (PSCP) as applied to the TASAR EFB flight-deck application. Section C.3 represents a high-level Compliance Check List supporting the PSCP for TASAR.

C.1 Phases of Certification Project

C.1.1 Conceptual Design (Phase 1)

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 PSCP. This is an opportunity to develop a mutual understanding of potential new projects.

C.1.1.1 Phase 1 Tasks

- Early Familiarization Meetings on design concepts

C.1.1.2 Phase 1 Required Information

- New designs, technology, materials, processes, etc.
 - Likely not applicable for TASAR
- Proposed certification basis and means of compliance
- Supplier relationships
 - TASAR EFB related hardware, software, data connectivity suppliers, if applicable/selected
- Initial safety assessments

C.1.1.3 Phase 1 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
- Preliminary certification basis considering the intended means of compliance, initial safety assessments, and relevant policy material and begin formulation of a PSCP
 - Identifies regulatory compliance required for the TASAR EFB application based on a “No Effect” or “Minor” failure effects designation

Note: After meeting with FAA, TASAR will be designated as “Minor Effect” due to potential pilot workload associated with TASAR due to misleading /bad data (Section 4.3).

- 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.
 - Not expected to large extent for TASAR. TBD
- Identify core team for commitment to developing the PSCP elements to ensure continuity
- Phase I Evaluation Checklist (See Appendix VII of [28]).

C.1.1.4 Phase 1 Criteria for Success

- Commitment to the signed Partnership to Safety Plan (PSP) for the pending certification project.

C.1.2 Requirements Definition (Phase 2)

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 PSCP is developed.

C.1.2.1 Phase 2 Tasks

- Meetings to refine product definition, requirements, and develop the PSCP
- Preliminary Certification Board Meeting

C.1.2.2 Phase 2 Required Information

- Applicant's descriptive design and production data
- Critical issues definition
- Refined safety assessments
- Proposed schedule

C.1.2.3 Phase 2 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 PSCP including project milestones and related events such as program status reviews
- Agreement of TC 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 (See Appendix VII of [28])

C.1.2.4 Phase 2 Criteria for Success

- Commit to the early development of the PSCP.

C.1.3 Compliance Planning (Phase 3)

During this phase a PSCP is completed. The plan is a tool to which the responsible parties commit and use to manage the product certification project.

C.1.3.1 Phase 3 Tasks

- Project planning and PSCP development meetings

C.1.3.2 Phase 3 Required Information

- Initial Failure Mode and Effects Analysis (FMEA)/Safety Assessments
- Stakeholder identification
- Refined critical issues
- Production processes

C.1.3.3 Phase 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 PSCP
- Project schedule with established FAA/applicant milestones for completion of analyses, test plan submission, Type Inspection Authorization (TIA), conformities, flight test, AEG 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 (See Appendix VII [28])

C.1.3.4 Phase 3 Criteria for Success

- Commit to agreement on the PSCP

C.1.4 Implementation (Phase 4)

During this phase the applicant and FAA work closely in managing, refining, and achieving their agreed PSCP to ensure that all agreed upon product specific certification requirements are met.

C.1.4.1 Phase 4 Tasks

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

C.1.4.2 Phase 4 Required Information

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

C.1.4.3 Phase 4 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 plan submission, TIA, conformities, flight test, AEG 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 (See Appendix VII of [28])

C.1.4.4 Phase 4 Criteria for Success

- Manage to the PSCP
- Conduct frequent project schedule and compliance checklist status reports, team and management reviews, and make revisions as needed to PSCP.

C.1.5 Post Certification (Phase 5)

During this phase close-out activities provide the foundation for continued airworthiness activities and certificate management for the remainder of the product's life cycle.

C.1.5.1 Phase 5 Tasks

- Project follow-up and closure
- Certificate management

C.1.5.2 Phase 5 Required Information

- Airworthiness limitations
- Maintenance and operations requirements
- Project lessons learned
- Relevant safety data
- Type Certificate Data Sheet
- Evaluation findings
- Design change data

C.1.5.3 Phase 5 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 (See Appendix VII of [28]).

C.1.5.4 Phase 5 Criteria for Success

- Work together for continuous improvement
- Manage to the PSCP with a focus on continued operational safety
- Provide proper levels of technical project and management leadership with frequent reviews to ensure project close-out to schedule and resolution of significant post-TC issues.

C.2 PSCP with TASAR Content

This section applies details of TASAR to the PSCP described in outline form in Section 4.2.3.4. Before addressing the TASAR-specific content of the PSCP, Figures C-1 and C-2 are provided from FAA Order 8110.4C [27] that overview the Typical Type Certification Process (Figure C-1) and the Implementation Phase of this process (Figure C-2). In addition, Figure C-3 is provided from FAA Order 8900.1 CHG 47, Volume 4, Chapter 15 on the EFB Operational Authorization Process [14]. Figure C-3 illustrates the high-level interactions and activity flows between the FAA and the applicant as part of the product certification and approval process.

The following is a more TASAR-specific version of a PSCP (the outline repeated from Section 4.2.3.4).

1) Purpose or Introduction

This Project Specific Certification Plan (PSCP) represents the project plan intended to be used by the applicant (TBD name) and FAA for the certification and operational approval of the TASAR Electronic Flight Bag (EFB) system. TASAR is a Type B application to be installed in TBD aircraft using a Class 2 EFB (e.g., the Goodrich SmartDisplay™ EFB currently being used by the TASAR team for flight evaluation) along with an associated Aircraft Interface Device (AID) that provides read-only access to avionics such as the FMS, etc.

2) Description

The following is a high-level application description of TASAR system as developed by the NASA TASAR team.

TASAR is a flight deck-based Decision Support Tool, consisting of algorithms and automation processing, intended as an optional, advisory-only service (i.e., in the form of recommendations) to the pilot crew to seek trajectory improvement opportunities over the current flight plan. TASAR is expected to be hosted as an application on a portable Class 2 EFB as a Type B application. TASAR requires read-only access to avionics systems via an AID. In addition, the TASAR HMI [3], as currently defined does not make use of depiction of a map of the flight plan, own ship position, or other geo-referenced depictions of the external environment that may affect the flight plan. The TASAR HMI primarily offers recommended updates of proposed trajectory changes to be considered by the pilot for possible request of a change request to Air Traffic Control (ATC) to the current flight plan.

Figure C-4 illustrates a high-level functional diagram of the TASAR application. Based on inputs provided by 1) the pilot (in the form of flight objectives and optimization criteria), 2) on-board avionics systems, and 3) via data link and network-enabled communications, the TASAR application computes available trajectory change request candidates that may improve the current flight plan. Trajectory change request candidates provided by TASAR are intended to have a relatively high probability of ATC approval if requested by the pilot, as TASAR seeks to provide conflict free recommended trajectory candidates that also anticipate ATC and airspace constraints.

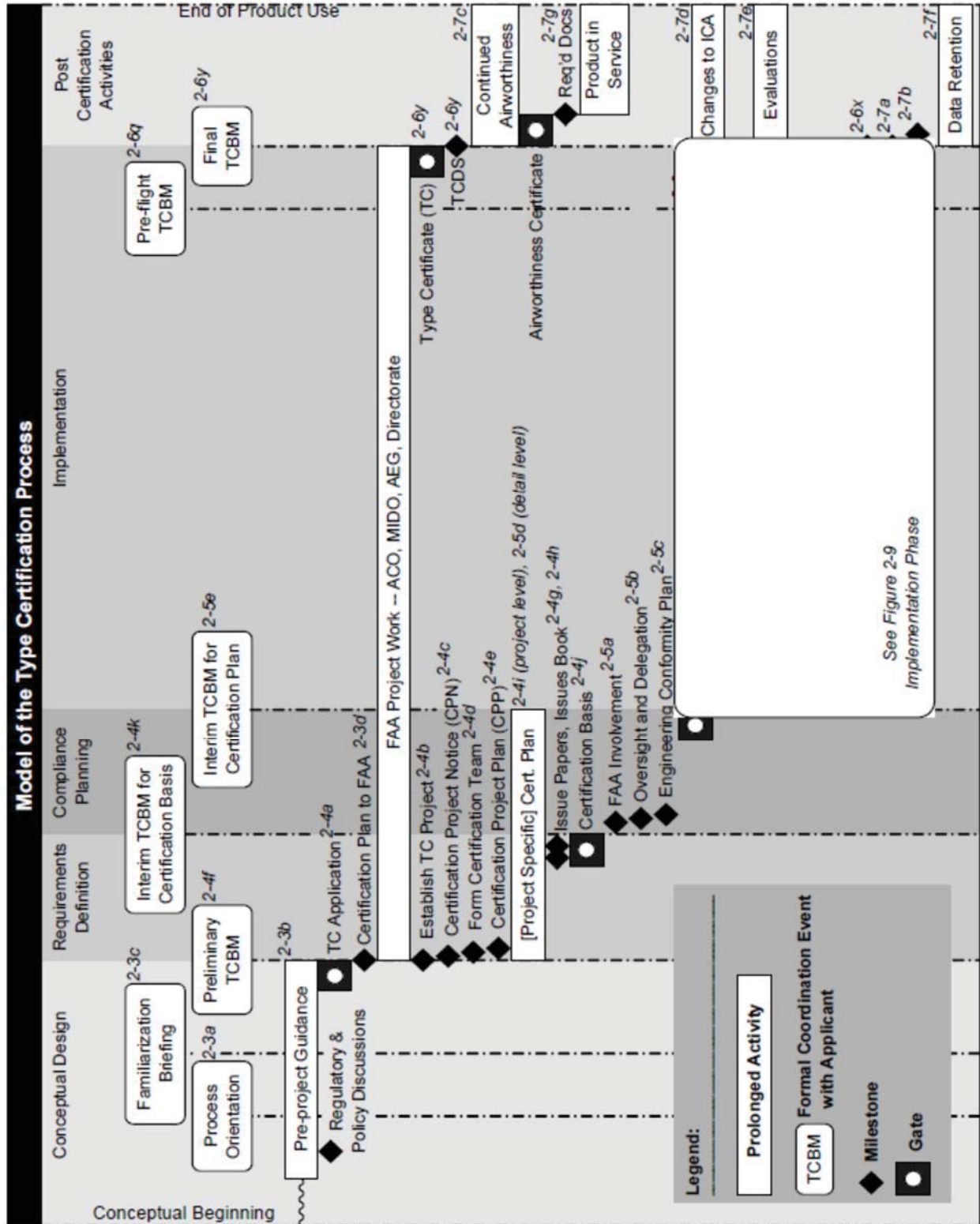


Figure C-1 Typical Type Certification (TC) Process

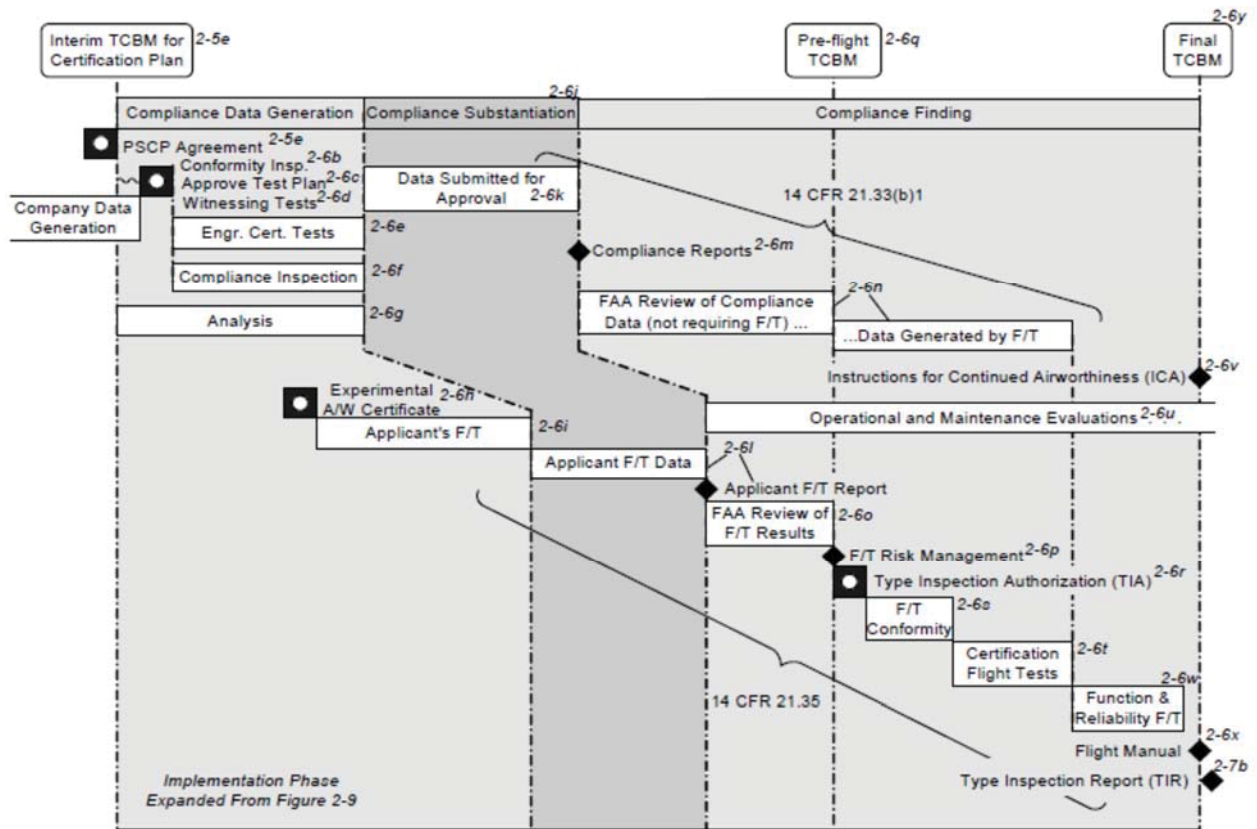


Figure C-2 Implementation Phase of TC Process

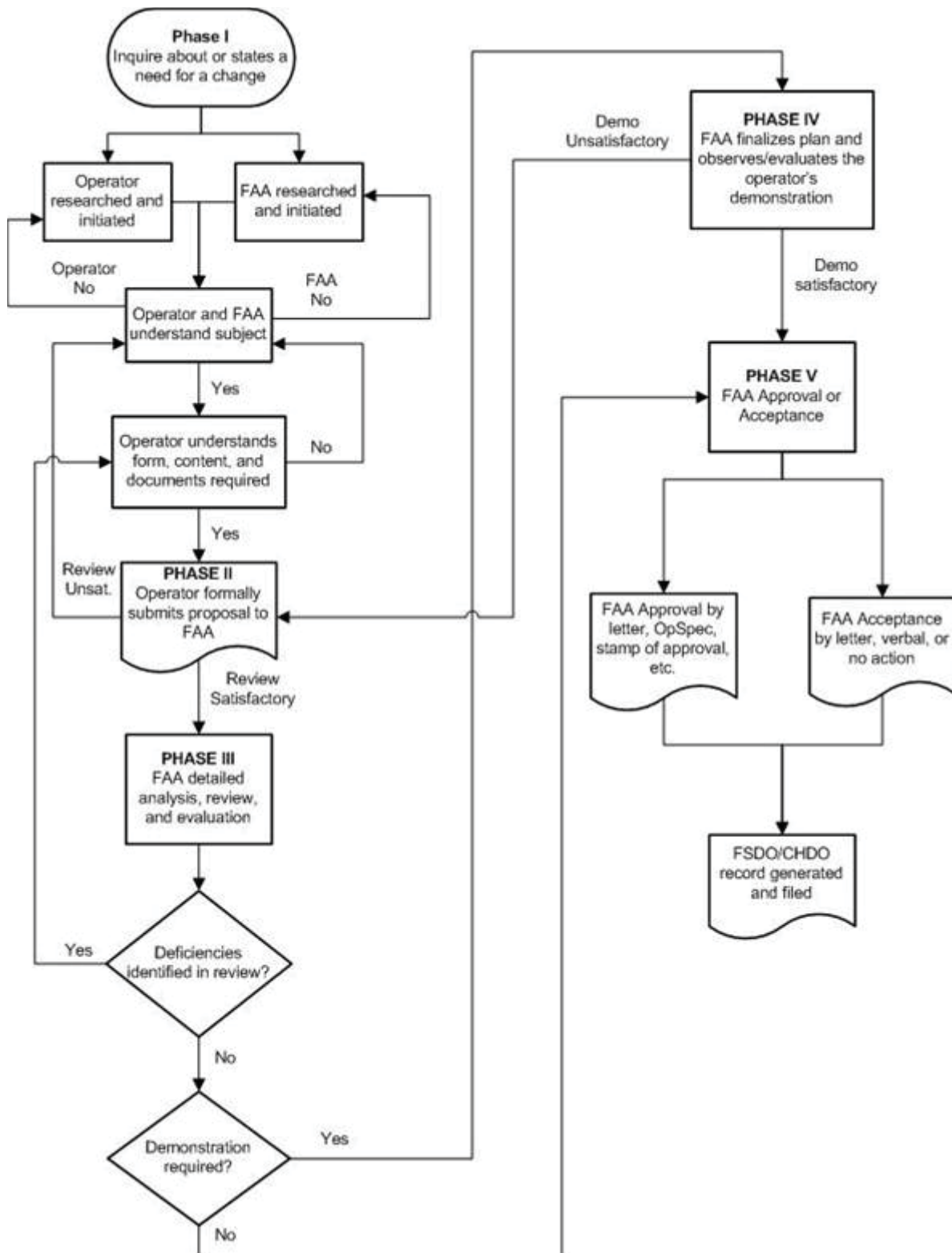


Figure C-3 Approval/Acceptance Process Flow Diagram

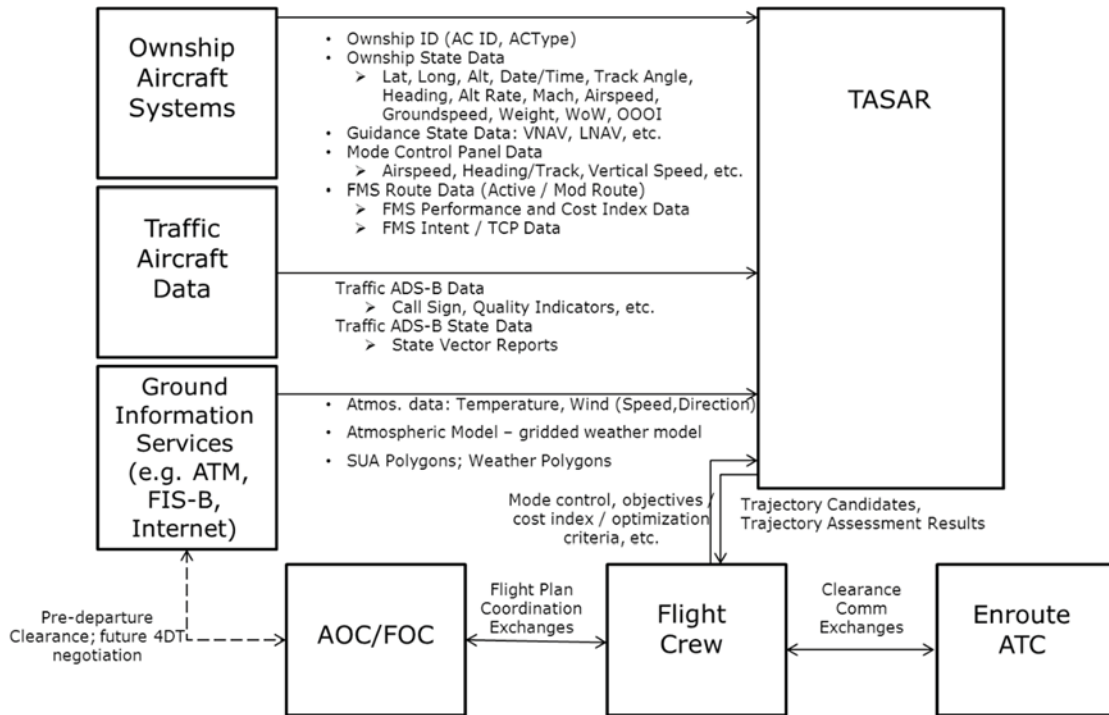


Figure C-4 TASAR Functional Diagram

The pilot has full discretion on the use of trajectory change request information provided by TASAR. They can choose to use TASAR recommended trajectory change request candidates as part of a change request to ATC, or they can choose to ignore them. TASAR can be manually inhibited at any time, for any reason.

TASAR is a supplemental system intended to provide operational benefits, without adversely impacting safe operations and does not replace any aircraft systems or avionics functions required for flight operations.

TASAR information sources are as follows:

1. Own ship information, e.g., flight identification (Flight ID), aircraft state (position, velocity, altitude), guidance / Mode Control Panel settings, flight plan and intent information, cost index and performance information, etc.
2. Other traffic information via ADS-B IN, TIS-B, and/or other available sources of traffic information, including aircraft state, and if available, intent information.

Note: After meeting with FAA, it was indicated that TASAR is not an ADS-B IN application, but rather a performance/planning application that leverages ADS-B IN data, if available (Section 4.3).

3. Air Traffic Management (ATM) system status and forecast (e.g., sector use, sector configuration, Traffic Management Initiatives, Special Use Airspace, etc.)
4. Weather information (current and forecast)
5. Wind information (current and forecast)

6. Airline Operational Communications (AOC) / Flight Operations Center (FOC) information, including operator flight planning, preferences, objectives.

TASAR is described in detail in the following documents currently under development by NASA and NASA contractors; Concept of Operations [1][2], and TAP Application Description [3]. An Operational Hazard Assessment of the TASAR intended function has been conducted [7]. Based on the above description of TASAR and its intended function, the TASAR Operational Hazard Assessment indicates that TASAR may be implemented with a “No Effects” FEC, with a worst case “Minor” FEC. With this level of safety requirement and the nature of TASAR application processing being well aligned with a Type B EFB software application, it is expected that certification and operational approval should be commensurate with prior EFB application approvals of similar type.

Note: After meeting with FAA, TASAR will be designated as “Minor Effect” due to potential pilot workload associated with TASAR due to misleading / bad data (Section 4.3).

3) FARs

Section 7 provides a high-level Compliance Check List to the applicable Federal Aviation Regulations (FARs) and associated regulatory and guidance documents from FAA for TASAR. No exemptions, equivalent levels of safety, or special conditions are anticipated for TASAR (to be verified).

4) Compliance

Compliance is expected to be shown by providing results from analyses (e.g. the Operational Safety Assessment), tests (e.g. non-interference testing of installed EFB components), documented results from the 6-month validation period, any conformity inspection results for the EFB mount, and review and demonstration of EFB use questionnaires of the intended function. At this point, no new and unique methodologies are expected to be used for TASAR, as this is expected to be closely aligned with certification approval of Type B applications.

Refer to the Schedule in 12) below for reference to some of these deliverables.

5) Conformity

Installation of the EFB mount, aircraft power, and antennas to broadband wireless systems are likely candidates for conformity. Some of these components may be developed by 3rd party vendors and will require testing and inspection, whether as part of conformity, or TBD other Compliance requirements.

6) Data

Refer to the Schedule in 12) below for reference to some of the data deliverables.

7) Airplane Flight Manual (AFM)

It is expected that a revision to the AFM or AFM supplement will be required for TASAR. This is TBD at this time.

8) Type Certificate Data Sheet

Indicate if this document is affected and how it will be revised. TBD.

9) Proposed DER(s)

A TBD Designated Engineering Representative is expected to be FAA designee for the both the hardware and software aspects of the TASAR system.

10) Master Minimum Equipment List (MMEL)

TASAR does not affect the MMEL.

11) System Criticality

An Operational Hazard Assessment of the TASAR intended function has been conducted [7]. Based on the above description of TASAR and its intended function, the TASAR Operational Hazard Assessment indicates that TASAR may be implemented with a “No Effects” FEC, with a worst case “Minor” FEC. With this level of safety requirement and the nature of TASAR application processing being well aligned with a Type B EFB software application, it is expected that certification and operational approval should be commensurate with prior EFB application approvals of similar type. Refer to [7] for specific details on operational hazards and failure effects of TASAR.

Note: After meeting with FAA, TASAR will be designated as “Minor Effect” due to potential pilot workload associated with TASAR due to misleading / bad data (Section 4.3).

12) Schedule

The PSCP schedule addresses the activities, milestones, and deliverables that guide the certification process from initial Type Certificate application by the applicant to the FAA until final certification approval is achieved. Several characteristics of the PSCP and associated process make it difficult to develop a detailed PSCP plan for TASAR at this time:

- Engineering is an iterative process and thus requires multiple phases of effort
- Few projects will traverse the time line from left to right
- Planners work with limited information; as the project progresses, the plan should be kept flexible and revised as necessary

It is at this point difficult to provide even a notional schedule for TASAR certification and operational approval. However, Figure C-1 (overall schedule view) and Figure C-2 (implementation phase schedule view) presented in Section 6 provide a guidance of a general schedule with activities, milestones, and decision gates.

The following is list of potential deliverables for TASAR:

- Software documentation and demonstration

Since software process and software development documentation do not require DO-178B for TASAR, documentation requirements are not excessive. A description of requirement based on the topics listed in Section 5.4 should be included. In addition, demonstration or proof of 1) how TASAR does not adversely affect other applications that may be integrated in the same EFB, and 2) how software revision downloads ensure that operation of the application is not adversely affected.

- Drawings and specifications of “installed” components of the TASAR EFB (e.g., aircraft mount, power connection, data connection, antennas, etc.). Whether conformity inspections are required is TBD.
- Airworthiness tests and results, e.g., electrical load testing of TASAR components with aircraft power sources, non-interference testing with avionics systems, etc.
- Data that describes the product design for COTS and installed components. Electrical and mechanical performance data. Installation specifications.
- Need for any special inspections (unlikely to be required for TASAR)
- Any issues papers (none expected for TASAR at this time (TBD)).

The schedule must account for the various meetings that need to be conducted, including the Type Certification Board Meeting (TCBM) (not sure how many TCBMs may be required for TASAR due to the relatively small size of EFB certification projects), coordination meetings between the FAA and applicant engineers and other participants should be identified. Dates for tests and required participants for observing the test need to be scheduled.

More specific information may be gained via an initial Informational and / or Pre-Certification Meeting with FAA representatives. Such a meeting(s) would include 1) a presentation of the high-level TASAR concept to FAA, 2) a joint dialog about the concept with some initial observations and notable points that may impact a future TASAR certification project, 3) guidance from FAA on expectation of a notional certification project for TASAR, and 4) input from FAA on documentation, tests (ground-based, flight test, etc.) and steps to be followed as part of a future certification project and subsequent approval.

C.3 Compliance Check List

This section represents a high-level Compliance Check List supporting the PSCP for TASAR.

C.3.1 Cornerstone EFB Documents

The following represent the primary, higher-level documents supporting the certification basis of TASAR. Numerous additional documents representing the FARs, regulation, and guidance documents apply to provide the detailed EFB approval requirement. These lower-level but important requirements will be provided in a future report that documents the results of a “Dry Run” review with Designated Engineering Representatives (DER) of TASAR-related PSCP information.

- 1) Title 14 of the Code of Federal Regulations (14 CFR) parts 21, 23, 25, 27, 29, 43, 91F, 91K, 121, 125, and 135 [29]
- 2) Flight Standards Information System (FSIMS) – 8900.1 Change 47, Vol. 4, Chapter 15 – EFB Operational Authorization Process [14]
- 3) AC 120-76C, Guidelines for the Certification, Airworthiness, and Operational Approval of Electronic Flight Bag Computing Devices [13]
- 4) AC 20-173, Installation of Electronic Flight Bag Components [16]
- 5) FAA Order 8110.4C, Type Certification [27]
- 6) AC 21-16F, RTCA Document DO-160 “Environmental Conditions and Test Procedures for Airborne Equipment” [17]
- 7) AC 20-115, RTCA DO-178B, Software Considerations in Airborne Systems and Equipment Certification [20].

C.3.2 Compliance Check List – High-level Items

The following certification and operational approval compliance requirements for EFBs and associated software applications, with focus toward TASAR, are derived from FAA Order 8900.1 Change 47, Vol. 4, Chapter 15 – “*EFB Operational Authorization Process*” [14]. This document represents the FAA Principal Investigators guidance for such approvals. In addition to these high-level requirements to achieve certification and operational approval for TASAR, there are numerous additional regulatory documents that provide specific details to these requirements. These more fine-grained requirements will be addressed in a future document of the DER “Dry Run” review of the TASAR certification process noted above.

Note: The following references in the next section, e.g. “4-1643” refer to specific portions of EFB Operational Authorization Process document of FAA Order 8900.1 Change 47 [14].

C.3.2.1 4-1643: EFB Hardware Classes

B. Class 2 EFB (i.e., TASAR)

- Typically mounted to the aircraft by a mounting device, may be connected to a data source, a hardwired power source, or an installed antenna
 - All these apply to TASAR
- Represents a portable PED/EFB

- Must be located on the flight deck and controlled by the flight crew during all flight operations
 - For TASAR, primarily used for en route, late stage of climb, early stage of descent
- Must be accessible to the flight crew at all times and must be removable by a crew member without the use of tools
- Attached to the aircraft via a mounting device
 - Cockpit mount is likely choice for TASAR (yoke-mount should be avoided as this becomes a much more complex approval)
- Components of the Class 2 EFB include all the hardware and software needed to support EFB intended functions (of TASAR)
 - Portable EFBs are limited to hosting Type A and Type B software applications or TSO functions limited to “Minor” FEC
 - Airport Moving Map Display with own ship position is an exception to this as a “Major” application – can only be used for ground operations below 40 kts.
- EFB may consist of modular components (e.g., computer processing unit, display, controls)
 - Any EFB hardware not located on the flight deck and not accessible by the flight crew must be a certified installation via TC, amended TC, or STC.
 - Any EFB hardware not accessible on the flight deck by the flight crew and/or not portable must be installed and certificated equipment covered by a TC, amended TC, or STC.
 - The one exception to being accessible on the flight deck is a remotely mounted antenna that provides signal reception to the EFB.
 - The AID falls into this category of being installed and requiring type certification.

C.3.2.2 4-1644: Hardware Specifications - Class 2 EFBs

2. Major Class 2 EFB components (motherboards, processors, RM, video cards, hard drives, power supplies and connections) must be configuration controlled
 - Any changes will require reevaluation to demonstrate intended function still met
 - Non-interference, reliability requirements still met
 - For sealed components use manufacturer model / part number
- A. Display considerations
(likely TASAR requirements, TBD for input devices listed below)
 - Must meet Legibility requirements
 - Must meet Brightness requirements
 - Viewing Angle
(see AC 120-76C, paragraph 10b(3) for important issues concerning viewing angle)

- **Stylus.** For a stylus screen, there must be an easily accessible stowage position for the stylus and an accessible spare stylus (or substitute stylus) must be available.
- **Digitizer Pen.** When a digitizer pen is used to operate the EFB, the digitizer pen must have an easily accessible stowage position and be tethered. A spare digitizer must be immediately available and adjusted for use on each EFB.
- **Touch Screen.** If a touch screen is used, it must be evaluated for ease of operation. The touch screen must be responsive and not require multiple attempts to make a selection, but not be so sensitive that erroneous selections occur.

B. Rapid Decompression (RD) Testing

C. Electromagnetic Interference/Non-Interference Testing

- Also for TASAR as a Transmitting PED (T-PED)

D. Antennas airworthiness requirements

E. Power Sources airworthiness requirements

(TASAR likely to use aircraft power, but not a firm requirement)

- Battery primary
- Battery maintenance
- Aircraft secondary power
- Aircraft primary power

F. Data Connectivity (Class 2 Only) airworthiness requirements

(required for TASAR)

G. Data Loading/Database Changes airworthiness requirements (TBD for TASAR)

- Class 1 or 2 EFBs must have a reliable means for revising the EFB databases
 - Database currency is determined by what required aeronautical information the EFB is replacing
 - Each method of data revision must ensure integrity of the data being loaded and not negatively impact the reliability of EFB operation
 - Procedures must exist to protect the EFB from corruption, especially when internet and/or wireless means are used
 - Database revision does not include application software or operating system changes
 - Application software and/or operating system program changes must be controlled and tested prior to use in flight
 - Database and/or application software changes may not be performed during operations (taxi, takeoff, in-flight, landing).

Note: External drives for data loading are considered ancillary EFB equipment and not subject to specific requirements beyond those identified for data loading/database revision above.

H. Mounting Devices (Class 2 Only) airworthiness requirement

(likely required for TASAR)

- The EFB, when attached to its appropriately designed mounting device, must be evaluated to ensure operational suitability in all ground and flight operations and conditions (airborne use for TASAR)
 - When attached to its mounting device, the EFB must not interfere with flight crew duties and must be easily and safely stowed when not in use
 - The attached EFB must not obstruct flight crew primary and secondary fields of view (See AC 120-76C)
 - The attached EFB must not impede safe egress. (See AC 120-76C)

C.3.2.3 4-1645: EFB Software Specification

Figure 4-77, Flowchart for Determining Electronic Flight Bag Software Application Type, is provided to aid in the determination of the EFB software application type.

B. Type B. Type B applications are applications that are intended for use during critical phases of flight or have software and/or algorithms that must be tested for accuracy and reliability. AC 120-76C, Appendix 2 may be referred to for examples of Type B applications.

TASAR is viewed to be a Type B application..

C. Type C. These software applications are RTCA DO-178B, Software Considerations in Airborne Systems and Equipment Certification, compliant and require Aircraft Certification design approval. (NA for TASAR).

C.3.2.4 4-1646: Operational Suitability Requirements

Entry into aircraft records is required to add or remove installed elements (also for TASAR)

The user/operator is responsible for ensuring that a Class 1 or Class 2 EFB, along with Type A and B applications, will reliably perform its intended function while not interfering with other aircraft equipment or operations. (Required for TASAR)

A. Application Documentation. The user/operator must present application documentation to the POI demonstrating that the EFB meets its intended function.

The attached flowcharts illustrated in Figure 4-75 and Figure 4-77 [14] will assist the user/operator with the identification and documentation of EFBs.

Determining the operational suitability of a particular EFB is the responsibility of the user/operator and may be subject to specific guidelines from the applicable AEG reports.

A. When an operator has completed the evaluation of a Class 1 or 2 EFB, the operator must submit an application requesting authorization to use the EFB

The POI will review the application submitted by the operator and authorize/not authorize the use of the EFB based on the findings of the POI Review Checklist 3, illustrated in Figure 4-78, POI Review Checklist [14].

2) When a new aircraft model is added to an existing EFB authorization, the suitability of the EFB for that aircraft must be addressed as part of aircraft conformity using this evaluation process. When a new EFB is added to an existing EFB authorization, the suitability of the new EFB must be addressed using this same evaluation process.

B. Operational Evaluation of Class 1 or 2 Hardware/Type A or B Software. The user/operator must evaluate the EFB for suitability of intended functions in each aircraft model. (TASAR requires avionics to support its intended function; depends on aircraft equipage)

The user/operator must use the checklist as illustrated in Figure 4-79 [14], Checklist 1, Tabletop Electronic Flight Bag Evaluation, to evaluate the operational suitability of the proposed EFB intended functions and aircraft model suitability. The intended functions of software applications must be appropriate to the individual aircraft make and model. (TASAR suitability).

The user/operator should use the checklist shown in Figure 4-80, Checklist 2 Electronic Flight Bag Operational Evaluation, to develop a flight scenario for final EFB testing when initial EFB use is being evaluated

Operators requesting initial EFB authorization must include their POI in the flight/simulator evaluation of an initial EFB implementation.

Operational evaluations for subsequent additions of EFBs or aircraft models need not conduct flight/simulator evaluations provided intended functions remain substantively the same as previously evaluated EFBs.

C.3.2.5 4-1647: EFB Procedures.

(Required for TASAR)

The operator's operations and maintenance procedures must be specific to each EFB and the operations conducted.

The operator's manual must identify each model of EFB authorized and each model of aircraft.

A. EFB Configuration Control. (Required for TASAR)

Standard EFB configuration control must be established and base-lined (i.e., initial hardware and software version at time of application) along with procedures to ensure that the EFB configuration control is maintained during system updates/revisions.

Class 1 or 2 EFB configuration affects usability and battery life through setup of suspend/sleep modes.

All classes of EFBs must have established standard operating procedures (SOP) to ensure reliable use of hardware and software.

Procedures must be established for EFB database revision. This should include verification of continued intended function prior to use in flight operations following an EFB database revision.

Note: Software updates, especially in the EFB operating system, must have extensive test procedures prior to use in flight operations.

Software revision procedures must be comprehensive to ensure continued reliability of the EFB and verification of reliable intended function.

B. Normal and Abnormal Operating Procedures. (Required for TASAR)

1) Normal procedures for flight operations must be developed for all flight operations with EFBs.

Preflight must address battery charging, EFB database revision and data currency, EFB configuration control, and SOP for EFB setup.

In-flight procedures must include standard application operating procedures and EFB standard flight operating procedures for use.

- 2) Abnormal procedures must be established to address likely EFB function failures. Procedures for single and dual EFB failure must be established.
- 3) Class 1 or Class 2 EFB operating procedures and limitations must be established if the EFB being used has not demonstrated Rapid Decompression (RD) testing while on and operating. (See subparagraph 4-1644B above)
- 4) Checklists must be established or revised to include normal and abnormal EFB procedures to be used by pilots in flight. This may be accomplished by amending checklists when approved operator-customized cockpit checklists are used or by creating an EFB checklist supplement when aircraft manufacturer cockpit checklists are used.

C. Minimum Equipment List (MEL).

(NA for TASAR; TASAR does not affect the MMEL)

D. Maintenance. Regular maintenance procedures are required for Class 1 and 2 EFBs, including measures to ensure the continued readability of the viewing screen. EFB battery maintenance needs to be addressed to ensure battery life, change intervals, and safety. TBD if TASAR has any instructions for continued airworthiness (ICA).

E. Risk Mitigation. Procedures must be established for a transition to paperless authorization. Initial procedures establish an independent backup during the EFB validation period. Procedures must be established for continuous reporting of problems with EFBs. There must be procedures in place for the user/operator to review these reports periodically to mitigate potential unreliability issues and correct operating procedures where necessary. Procedures must be established to notify flight crews of EFB problems or use issues. (For more information on risk mitigation, refer to Volume 10, Chapter 1.)

F. Training. The operator must develop EFB training for all personnel involved with EFB use, database servicing, and maintenance. EFB training must comply with training identified in AC 120-76C and be FAA-approved where applicable.

Note: Training was noted as a requirement for approval of TASAR during the meeting with FAA. NASA noted that TASAR likely would require approximately 30 minutes of training based on its relative complexity compared to other similar applications, e.g., the In-Trail Procedure application, which requires 30 minutes of training. FAA did not openly object with that estimate for training for TASAR (i.e., it is probably in the ball park of what is appropriate).

C.3.2.6 4-1648: Airworthiness Requirements

This paragraph outlines the airworthiness and return to service (RTS) requirements for installed components or provisions of Class 1 or Class 2 EFBs. These airworthiness requirements are applicable to all installed provisions capable of supporting EFB functions at flight crew stations, regardless of any other stated intended function.

The installer remains responsible to ensure that all certification and airworthiness requirements are met for each installation. For provisional installations, each installer remains responsible for compliance with EFB airworthiness requirements, and each

operator is responsible for EFB operational use requirements of the installed provisions capability. All Class 3 EFB installations require certification under TC, amended TC, or STC prior to installation.

Note: Per FAA feedback, for Class 2 EFBs, the only certification requirements would be for mounting / installation of the EFB, getting one-way, read-only access to certified systems data (e.g., via ARINC 429 busses), and partitioning and protections for non-interference with certified systems. The AID is intended to accomplish much of this. FAA did not see the need for a PSCP for the TASAR software, just for the installation. If they already have an existing installation, then the operational approval process is for a user to go directly to their POI.

A. EFB Power Source.

2) Class 2 EFB Power Source.

(TASAR requirement is TBD)

This is aircraft power used as the primary EFB power supply and requires the power supply to be hardwired or connected with certified connectors to ensure reliability.

This is an EFB that continuously depends on connection to aircraft power to perform its intended function (no sustaining battery power)

The aircraft power for Class 2 EFB power supplies must be designed to remain available at an acceptable level for required flight information, in the event of aircraft electrical malfunctions.

Class 2 EFB power supplies require design approval by AIR under TC, amended TC, or STC, thus not eligible for field approval.

B. EFB Data Connectivity. (TASAR requirement)

This read-only data is provided to an EFB from the aircraft's systems (e.g., flight management system (FMS), Global Positioning System (GPS), air data, fuel system) through a certified ARINC 429, RS-232, RS-485, or other compatible interfaces or certified router.

EFB data connectivity does not include raw antenna reception data from an installed antenna going directly to the EFB. EFB data connectivity must include isolation to preclude the EFB from interfering with any aircraft system, and all associated wiring must be protected from damage and secured. EFB data connectivity requires design approval. Such design approval must be accomplished under TC, amended TC, or STC by AIR and excludes the installation from eligibility for field approval.

Note: Data converters (e.g., ARINC 429 to RS-232) that are capable of supporting EFB functions at flight crew stations must have design approval issued by the FAA.

C. EFB Mounting Devices.

(For TASAR, avoid yoke mount as this is a flight-critical installation.)

- 2) Cockpit-mounted EFBs are Class 2 EFBs mounted in the cockpit other than on the control yoke. The EFB mounting device requires airworthiness approval by AIR. FAA policy excludes this installation from eligibility for field approval.

D. Installed Antennas. (TBD for TASAR)

Installed antennas are those antennas permanently installed in the aircraft. Portable antennas attached to a portable EFB, but not attached to the aircraft, are not subject to these airworthiness requirements. Portable antennas and temporary antenna holders, like suction cups, are subject to EFB evaluation requirements only. Installation of antennas capable of supporting EFB functions at flight crew stations must be accomplished using existing guidance for antenna airworthiness considerations.

- 1) Antennas combining reception for both aircraft navigation and EFB must be TSO-approved for this intended function, providing isolation to preclude the EFB from interfering with antenna reception for aircraft navigation.
- 2) TSO- or STC-approved antennas may be used to independently provide GPS and/or satellite weather for an EFB in accordance with existing installation airworthiness requirements.
- 3) Portable EFB-only antennas without a TSO may be used to provide a GPS or satellite weather signal for EFB-only use. Non-interference testing by the installer is required.

E. Installed Satellite Receivers (e.g., Weather Radar (WX), XM Weather, WSI Inflight). (TBD for TASAR)

If any component of a weather receiver is installed in an aircraft separate from a portable EFB on the flight deck, it is subject to avionics installation requirements and may not be considered a PED. If the result of the received weather data is capable of being displayed on an EFB, the individual components of the weather receiver system cannot be installed as STC provisions only because the installation cannot meet 14 CFR part 43 requirements for testing of non-interference without performing its intended function. (See the current edition of FAA Order 8110.4, Type Certification, for more information on this subject.) The weather receiver must be non-interference tested with the intended EFB installed and operative even though the installation only applies to the weather receiver. The airworthiness for the weather receiver installation is independent of EFB/PED suitability responsibility of the user/operator. The user/operator is responsible for EFB non-interference as a PED and the installer is responsible for non-interference for the weather receiver as part of installation requirements. This installation requires design approval under TC, amended TC, or STC, which excludes the installation from eligibility for field approval.

C.3.2.7 4-1649: Authorization Process.

The operator is responsible to ensure that all operational requirements are met for an EFB. The operator must submit documentation demonstrating compliance with all operational requirements for EFBs to their POI. The FAA evaluation process for an EFB follows the general process for approval and acceptance as described in Volume 3, Chapter 1.

A. Phase One - Initiation. Phase one of the process begins when the operator requests authorization to use the EFB from the FAA. During this phase, the FAA and the operator reach a common understanding of the role of the FAA and what documents and actions the operator is responsible for during each phase of the authorization process.

B. Phase Two - Required Application Information. Phase two begins when the operator submits a formal EFB plan to the POI for evaluation. The plan is reviewed for completeness, and the POI facilitates coordination with other inspectors and FAA offices, as necessary. During phase two, the POI may coordinate with the appropriate AEG for guidance on EFBs that have functions not addressed in this guidance. Once the plan is accepted, the operator follows that plan to produce a complete EFB program. The operator must submit the following information in the application package:

- EFB hardware and application specification (Figure 4-76) and Evaluation Report Information Template (Figure 4-81) [14]
- EFB operator procedures/manual revisions
- EFB cockpit procedures checklists
- EFB training program
- EFB evaluation report (Figure 4-79 and Figure 4-80) [14]
- Rapid Decompression test data (when required)
- Completed non-interference test results
- Airworthiness documents for Class 2 equipment (mounting device, aircraft data connection, aircraft power primary, remote antenna).

C. Phase Three — POI Review. The POI must use the checklist found in Figure 4-78 [14] to conduct a review of the application submitted by an operator. All POI specialties should coordinate the review of an operator's EFB program.

The POI should participate in the simulator evaluation or flight evaluation (TBD for TASAR) of an EFB when a user/operator is requesting initial EFB authorization.

Additional simulator/flight evaluations are not required for adding a new EFB to an existing authorization unless there is a substantial change in EFB intended functions.

When a new aircraft is added to a certificate with existing EFB authorization, the suitability of the EFB for that aircraft must be addressed as part of aircraft conformity and configuration control process.

Inspectors should examine the technical content and quality of the proposed EFB program and other supporting documents and procedures. The user's/operator's program for EFB management is critical to EFB reliability (TBD for TASAR) and must be well documented for EFB users.

D. Phase Four - Temporary Authorization to Use an EFB.

An interim EFB authorization is granted to allow the certificate holder/operator/program manager to proceed with the required EFB 6-month operational validation testing.

Note: The 6-month validation test formally begins when the certificate holder/operator/program manager is issued this A061 temporary authorization. Use Figure 4-82, Checklist 4 - Electronic Flight Bag Line Evaluation Job Aid [14], for data collection during the validation phase. Validation testing should follow the guidelines in AC 120-76C.

- 1) **Unacceptable Validation Results.** If the POI finds the proposed EFB reliability and/or function to be unacceptable by the conditions of this EFB guidance, then the POI should contact the operator for corrective action. EFB deficiencies must be corrected and the EFB function revalidated before proceeding to Phase Five.
- 2) **Acceptable Validation Results.** If at the completion of the EFB 6-month validation test, the POI finds the proposed EFB reliability and/or function to be acceptable based on validation data, then the certificate holder/operator/program manager can proceed to phase five of the EFB A061 authorization process.

E. Phase Five—Authorization to Use an EFB. The certificate holder/operator/program manager subject to regulations under 14 CFR parts 91K, 121, 125 (including 125 Letter of Deviation Authority (LODA) holders (125)), and 135 is granted authorization to use an EFB through OpSpec/MSpec/LOA A061 after acceptable completion of validation testing in phase four. The POI will remove the “temporary authorization” annotated in the restrictions and limitations column of Table 1. Any subsequent change to EFB hardware or intended functions must be validated at a level appropriate to the effect of the change on the EFB program.

C.3.2.8 POI Checklists for EFB Evaluations

The following is a compressed version of the comprehensive questionnaires utilized by the FAA POI in reviewing the applicant’s EFB implementation and operational use.

Note: Refer to Tables 4-79 through 4-82 in [14] for the detailed list of questions.

Successful completion and acceptance to the responses to these questionnaires are an integral part of gaining approval of the TASAR EFB application.

1. Checklist 1 Tabletop Electronic Flight Bag Evaluation (Figure 4-79 in [14])

Checklist 1 contains a list of questions for operators to use during a tabletop evaluation of the EFB focusing on the EFB hardware and software applications. The checklist includes the following subtopics:

- EFB Hardware
- General User Interface
- General Software Applications
- Electronic Documents (If Applicable)
- Electronic Charts (If Applicable)
- Electronic Checklists (ECL) (If Applicable)

- Performance Calculations (If Applicable)

After the operator has completed this checklist, the results should be documented so the POI can review the results with the operator.

2. Checklist 2—Electronic Flight Bag Operational Evaluation (Figure 4-80 in [14])

Checklist 2 contains a list of questions for operator consideration during an operational evaluation of the EFB, its documentation, procedures, and training. The first four pages contain questions that can be answered in a training or operational environment by pilots, instructor/evaluators, or other operational personnel. The last page contains sample crew performance questions that can be addressed in a simulation environment.

After the operator has completed this checklist, the POI will review the results with the operator.

- General EFB Hardware
- Stowage (If Applicable)
- Unsecured EFB (If Applicable)
- General User Interface
- Software Applications
- EFB Procedures
- Procedures for Keeping EFB Content/Data Current
- Procedures for User Feedback
- Procedures for Specific Applications (If Applicable)
- EFB Training
- Training for Charts (If Applicable)
- Training for ECL Systems (If Applicable)
- Training for Flight Performance Calculations (If Applicable). (NA for TASAR)
- Crew Performance: Preflight Planning
- Crew Performance: Takeoff
- Crew Performance: Cruise
- Crew Performance: Descent
- Crew Performance: Approach/Landing
- Crew Performance: Destination Ground Operations

3. Checklist 3— Evaluation Report Information Template (Figure 4-81 in [14])

This outline is used by the user/operator to ensure that the minimum content requirements of the evaluation report have been met. The format of the report is optional. However the information in the detailed questions must be included, as a minimum.

4. Checklist 4— EFB Line Evaluation Job Aid (Figure 4-82 in [14])

This checklist is used for data collection during validation period.

- Describe system configuration description and flight conditions
- Overview questions concerning the main aspects to be assessed in validation period
- General.
- Electronic Charts, Documents, and Checklists. (NA for TASAR)
- Flight Performance Data/Calculations (NA for TASAR).

- General Conclusions.

The following approval signature and entry items are completed after reviewing the four checklists. Refer to [14] for details on these checklists.

Assigned Aircraft: _____ Date: _____ Print Observer Name: _____

Observer Signature: _____ Certificate Number: _____

Appendix D DER “Dry Run” Review and Artifacts Details

D.1 DO-178B Objectives Artifacts Requirements for Level D

This appendix provides a summary of the 28 objectives that must be satisfied for the DO-178B Level D software design assurance level for the various software development process steps. While TASAR does not required DO-178B to be applied for software approval, consideration should be given whether some elements of TASAR software should be developed to DAL Level D for possible future reuse in the event TASAR is upgraded and requires a more formal process.

- 1) Software planning related – 2 objectives
 - a. Software development and integral processes activities are defined
 - b. Additional considerations are addressed
- 2) Software development process related – 7 objectives
 - a. High-level requirements are developed
 - b. Derived high-level requirements are derived
 - c. Software architecture is developed
 - d. Low-level requirements are developed
 - e. Derived low-level requirements are defined
 - f. Source code is developed
 - g. Executable object code is produced and integrated in the target computer
- 3) Verification of outputs of software requirements process – 3 objectives
 - a. Software high-level requirements comply with system requirements
 - b. High-level requirements are accurate and consistent
 - c. High-level requirements are traceable to system requirements
- 4) Verification of outputs of software design process – 1 objective
 - a. Software partitioning integrity is confirmed
- 5) Verification of outputs of software coding and integration processes – 0 objectives
- 6) Testing of outputs of integration process – 3 objectives
 - a. Executable object code complies with high-level requirements
 - b. Executable object code is robust with high-level requirements
 - c. Executable object code is compatible with target computer
- 7) Verification of verification process results – 1 objective
 - a. Test coverage of high-level requirements is achieved
- 8) Software configuration management process – 6 objectives
 - a. Configuration items are identified
 - b. Baselines and traceability are established
 - c. Problem reporting, change control, change review, and configuration status accounting are established
 - d. Archive, retrieval, and release are established

- e. Software load control is established
 - f. Software life cycle environment control is established
- 9) Software Quality Assurance Process – 2 objectives
- a. Assurance is obtained that software development and integral processes comply with approved software plans and standards (with independence)
 - b. Software conformity review is conducted (with independence)
- 10) Certification Liaison Process – 3 objectives
- a. Communication and understanding between the applicant and certification authority is established
 - b. The means of compliance is proposed and agreement with the Plan for Software Aspects of Certification is obtained
 - c. Compliance substantiation is provided.

As indicated, the above 28 objectives i.e., required activities to be performed, in item (8) above (with two objectives having independence requirements, i.e., where a second individual reviews the work of the person who created the original artifact) represent the Level D design assurance level as part of the software development process required by RTCA DO-178B. Table D-1 provides a summary of all levels of DO-178B in terms of the number of objectives and the extent of independence required. As is expected, the higher the design assurance level (Level A being the highest), the more intensive and rigorous will be the software development process.

Note: While it is desirable to have the lowest design assurance level possible while meeting the safety requirements, the designer needs to consider what portions of the software development may need to be repeated at a future time at a higher design assurance level. In some cases, the designer may choose to develop portions of the software system to a more stringent design assurance level, allowing future reuse of such code. In the case of TASAR, it is not expected that DO-178B needs to be used in the software development process, and thus has a considerably reduced level of formal steps in its development. This would expedite the development and reduce the overall cost of the system. In the event TASAR functionality is upgraded in future applications, it is possible that a higher design assurance level may arise, requiring a redevelopment of the software to the higher-level of design assurance using the DO-178B objectives.

Table D-1 Summary of DO-178B Objectives Required per Design Assurance Level

Level	Failure condition	Objectives	With independence
A	Catastrophic	66	25
B	Hazardous	65	14
C	Major	57	2
D	Minor	28	2

D.2 Tabletop EFB Evaluation (Detailed Check List #1)

Note 1: The following represents the detailed checklist utilized by the POI as part of the EFB Application approval process for the “Tabletop EFB Evaluation”. The list is taken from Figure 4-79 in FAA Order 8900.1 Volume 4 “Aircraft Equipment and Operational Authorizations” [14].

Note 2: While this document provides information concerning the certification and document-ation approval process for TASAR, it does not on its own address and achieve the actual certification and operational approval. Some observations are offered to assist this future process in looking through the list of questions provided in the Appendix.

Tabletop Electronic Flight Bag Evaluation – Checklist 1 (Figure 4-79) [14]

1. If the EFB is to be used outside of the flight deck, can the EFB display be read under direct sunlight? No Yes

While intended for cockpit use, it is conceivable that the pilot could access TASAR pre-flight to program and select the operational goals and objectives of how they want TASAR to support the upcoming flight. EFB use outside of the cockpit is not required but may be desirable for some users.

2. Is the display brightness and contrast adjustable? No Yes

3. Is the display brightness acceptable when it adjusts automatically? No Yes

4. Are there any display artifacts such as jagged lines that impair functionality? No Yes

NA

5. Are controls labeled appropriately to describe their intended function? No Yes

6. Are buttons and labels visible and readable under all flight deck illumination conditions? No Yes

7. Can EFB inputs be made quickly and accurately in any operational environment? No Yes

8. Does the input device provide sufficient tactile feedback in all environmental conditions? No Yes

9. Are inadvertent or multiple activation of controls minimized? No Yes

10. Does the EFB start up in a predictable state? No Yes

11. Can the EFB be rebooted when power is cut to the EFB? No Yes

TBD. Should be able to be rebooted.

12. Does the EFB function correctly when rebooted? No Yes

13. Are all the EFB failure modes easy to see and identify? No Yes

14. Is the failure annunciation/message appropriate for the EFB function that has failed? No Yes

15. Are EFB recovery means easy to remember and apply when the EFB fails? No Yes

Provide the Number and a Comment for Each EFB Hardware Question Checked as “No.”

See above for each answer

General User Interface

16. Is the revision information and currency expiration date available and presented clearly? No Yes

17. Does the device respond immediately to user inputs?	<input type="checkbox"/> No	<input checked="" type="checkbox"/> Yes
18. Is the processing speed always appropriate for normal use?	<input type="checkbox"/> No	<input checked="" type="checkbox"/> Yes
19. Are appropriate busy or progress indicators displayed when processing is delayed?	<input type="checkbox"/> No	<input checked="" type="checkbox"/> Yes
20. Is the user interface, including functions and navigation, consistent throughout the EFB?	<input type="checkbox"/> No	<input checked="" type="checkbox"/> Yes
21. Is all information that is needed displayed and easily accessible? Is there missing or difficult to find information?	<input type="checkbox"/> No	<input checked="" type="checkbox"/> Yes
<i>User interface provides access to all information relevant to TASAR with easy access.</i>		
22. Are common actions and time-critical functions easy to access?	<input type="checkbox"/> No	<input checked="" type="checkbox"/> Yes
23. Are there standard ways to perform common actions?	<input type="checkbox"/> No	<input checked="" type="checkbox"/> Yes
24. Are the displays and controls used on the EFB similar across applications? Are a common set of controls and graphical elements used?	<input type="checkbox"/> No	<input type="checkbox"/> Yes
<i>The answer should be yes. At this point this project has addressed TASAR as a standalone application and has not examined how it may be integrated with other EFB applications. A windows-like operation between applications is possible or some equivalent means may be considered. Future actions required to address this question more specifically.</i>		
25. Can all colors be distinguished under the various lighting conditions?	<input type="checkbox"/> No	<input checked="" type="checkbox"/> Yes
26. Is color coding implemented with a secondary code such as shading or highlighting when used to display critical information?	<input type="checkbox"/> No	<input type="checkbox"/> Yes
<i>TBD. TASAR on its own does not involve critical information.</i>		
27. Are the colors red and yellow used appropriately only for warnings and cautions?	<input type="checkbox"/> No	<input type="checkbox"/> Yes
<i>TBD. TASAR on its own does not require warning and cautions colors.</i>		
28. Is the text easily readable?	<input type="checkbox"/> No	<input checked="" type="checkbox"/> Yes
29. Do the characters stand out against the display background?	<input type="checkbox"/> No	<input checked="" type="checkbox"/> Yes
30. Are upper case and italic text used infrequently?	<input type="checkbox"/> No	<input checked="" type="checkbox"/> Yes
<i>Actually this is TBD as part of the detailed design but the answer should be Yes.</i>		
31. Is text that may be used in low-visibility conditions appropriate in size and easy to read?	<input type="checkbox"/> No	<input checked="" type="checkbox"/> Yes
32. Is it easy to zoom in on text or graphics when they are too small?	<input type="checkbox"/> No	<input checked="" type="checkbox"/> Yes
33. Is it obvious when information is out of view and can it easily be brought into view?	<input type="checkbox"/> No	<input checked="" type="checkbox"/> Yes
<i>May be NA for TASAR - TBD</i>		
34. Is the spacing between characters appropriate?	<input type="checkbox"/> No	<input checked="" type="checkbox"/> Yes
35. Is the vertical spacing between lines appropriate?	<input type="checkbox"/> No	<input checked="" type="checkbox"/> Yes
36. Are icons and symbols legible?	<input type="checkbox"/> No	<input checked="" type="checkbox"/> Yes
37. Are icon and symbol functions obvious?	<input type="checkbox"/> No	<input checked="" type="checkbox"/> Yes
38. Are the icons and symbols distinguishable from one another?	<input type="checkbox"/> No	<input checked="" type="checkbox"/> Yes

39. Is each icon's meaning explained by a label or other means? No Yes

40. Are the EFB icons and symbols consistent with their paper equivalents? No Yes

TASAR is not a paper replacement application – NA.

41. Do EFB alerts and reminders meet the requirements in the appropriate regulations as noted in the current edition of FAA Advisory Circular (AC) 120-76, Guidelines for the Certification, Airworthiness, and Operational Approval of Electronic Flight Bag Computing Devices, paragraph 10 (i.e., The Human Factors Considerations for EFBs)? No Yes

TASAR is not expected to require alerts and reminders. In the event a requirement for this arises it needs to be documented and meet the applicable requirement – NA or TBD.

42. Are alerts and reminders consistent across all applications? No Yes

TBD – see answers to 24 and 41.

43. Are alerts and reminders implemented so as not to distract? No Yes

Should be if it becomes an issue. See answers to 24 and 41.

44. Is there control over when, and whether, the audio or video is activated? No Yes

TBD for TASAR. Answer should be yes if applicable.

45. Is it easy to reset parameters to their default when they have been customized? No Yes

46. Is EFB customization controlled through an administrative control process? No Yes

Provide the Number and a Comment for Each General User Interface Question Checked as “No.”

See above for each answer _____

General Software Applications

47. Can required information be found quickly and accurately within all applications? No Yes

48. Is the information within applications organized consistently? No Yes

49. Is information layout consistent with the paper equivalent? No Yes

Paper replacement for TASAR is NA

50. Is the layout of information appropriate for all applications? No Yes

51. Is high priority information easy to read? No Yes

52. Is it easy to tell which application is currently open/active? No Yes

53. Is it easy to switch between applications? No Yes

54. Is extra acknowledgement required to open applications that are not flight related? No Yes

55. Do all open applications function as intended on an individual basis? No Yes

56. Is access or links to related information appropriately supported? No Yes

57. Are similar types of information accessed in the same way? No Yes

58. Is it easy to return to the place where the user started from? No Yes

59. Is printing supported, and if so, is the hard copy usable? No Yes

NA for TASAR

60. Can a portion of a document be selected to be printed? No Yes

NA for TASAR

61. Can a print job be terminated immediately? No Yes

NA for TASAR

Provide the Number and a Comment for Each General Software Applications Question Checked as “No.”
See above for each answer. Many answers assume multiple applications to coexist and thus provide anticipated use.

Electronic Documents (If Applicable)

62. Is it easy to tell where one is in relation to the full document? No Yes

63. Is it easy to move between documents quickly? No Yes

64. Is it easy to tell what document is currently in view? No Yes

65. Is there a list of available documents to choose from? No Yes

66. Is the document search function appropriate? No Yes

67. Are tables, especially complex ones, readable and usable? No Yes

68. Are figures readable and usable? No Yes

Electronic Charts (If Applicable)

69. Is there a way to pre-select specific charts for easy access during a particular flight? No Yes

70. Is there more than one way to search for a chart? No Yes

71. Is it easy to access charts when a last minute change is necessary? No Yes

72. If the chart application uses aircraft location to facilitate access to charts, is this function appropriate (i.e., either approved by Aircraft Certification or explicitly allowed by AC 120-76)? No Yes

73. Is it easy to switch between a decluttered and normal display if decluttering is supported? No Yes

74. Is there a clear indication when any chart elements are suppressed? No Yes

Provide the Number and a Comment for Each Electronic Documents and Charts Question Checked as “No.”
Questions 62 thru 74 are NA for TASAR (not paper nor chart replacement)

Electronic Checklists (ECL) (If Applicable)

75. Are normal checklists available in the appropriate order of use? No Yes

76. Can checklists be accessed individually for review or reference? No Yes

77. During non-normal conditions, are relevant checklists easy to access? No Yes

78. During non-normal conditions, does the device indicate which checklists and/or checklist items are required and which are optional? No Yes

79. Is it clear where to find all checklists, whether on the EFB or on paper? No Yes

80. Is the location of a paper document provided when it is referred to by the ECL? No Yes

- | | | |
|-----------------------------------------------------------------------------------------------------------|-----------------------------|------------------------------|
| 81. Does each checklist have a constantly visible title distinct from other checklists? | <input type="checkbox"/> No | <input type="checkbox"/> Yes |
| 82. Is it easy to select a checklist from a set of open checklists? | <input type="checkbox"/> No | <input type="checkbox"/> Yes |
| 83. Is there a reminder to review incomplete items when closing an incomplete checklist? | <input type="checkbox"/> No | <input type="checkbox"/> Yes |
| 84. Can an incomplete checklist be closed after acknowledging it is not complete? | <input type="checkbox"/> No | <input type="checkbox"/> Yes |
| 85. Does the ECL discourage two or more checklists from being used simultaneously? | <input type="checkbox"/> No | <input type="checkbox"/> Yes |
| 86. Is progress through the ECL clear? | <input type="checkbox"/> No | <input type="checkbox"/> Yes |
| 87. It is easy to reset the ECL to start over again? | <input type="checkbox"/> No | <input type="checkbox"/> Yes |
| 88. Does the checklist provide appropriate reminders for tasks that require a delayed action? | <input type="checkbox"/> No | <input type="checkbox"/> Yes |
| 89. Does the checklist clearly highlight decision branches? | <input type="checkbox"/> No | <input type="checkbox"/> Yes |
| 90. Can you return to the checklist from links or related information in one step? | <input type="checkbox"/> No | <input type="checkbox"/> Yes |
| 91. Is there an indicator of which item in the checklist you are working on? | <input type="checkbox"/> No | <input type="checkbox"/> Yes |
| 92. Is the checklist's active item clearly indicated? | <input type="checkbox"/> No | <input type="checkbox"/> Yes |
| 93. Can the status of an item be easily changed? | <input type="checkbox"/> No | <input type="checkbox"/> Yes |
| 94. Does the next item automatically become active when the previous one is complete? | <input type="checkbox"/> No | <input type="checkbox"/> Yes |
| 95. Can the current item be deferred without completing it? | <input type="checkbox"/> No | <input type="checkbox"/> Yes |
| 96. Is it easy to view other items, even in a long checklist, without changing the active item? | <input type="checkbox"/> No | <input type="checkbox"/> Yes |
| 97. Is it easy to move between items within a checklist? | <input type="checkbox"/> No | <input type="checkbox"/> Yes |
| 98. Does the active item change to the next after an item is completed? | <input type="checkbox"/> No | <input type="checkbox"/> Yes |
| 99. Is there a clear indication that all items as well as the whole checklist are complete when finished? | <input type="checkbox"/> No | <input type="checkbox"/> Yes |

Provide the Number and a Comment for Each ECL Question Checked as "No."

Questions 75 thru 99 are NA for TASAR (not paper nor chart replacement)

Performance Calculations (If Applicable)

- | | | |
|--------------------------------------------------------------------------------------------------------------------------------|-----------------------------|-----------------------------------------|
| 100. Does the device identify entries that have an incorrect format or type and does it generate an appropriate error message? | <input type="checkbox"/> No | <input checked="" type="checkbox"/> Yes |
| 101. Does the error message clarify the type and range of data expected? | <input type="checkbox"/> No | <input checked="" type="checkbox"/> Yes |
| 102. Are units for performance data clearly labeled? | <input type="checkbox"/> No | <input checked="" type="checkbox"/> Yes |
| 103. Do the labels used in the EFB match the language of other operator documents? | <input type="checkbox"/> No | <input checked="" type="checkbox"/> Yes |
| 104. Is all the information necessary for a given task presented together or easily accessible? | <input type="checkbox"/> No | <input checked="" type="checkbox"/> Yes |
| 105. Can the crews modify performance calculations easily, especially when making last minute changes? | <input type="checkbox"/> No | <input checked="" type="checkbox"/> Yes |
| 106. Are outdated results of performance calculations deleted when modifications are entered? | <input type="checkbox"/> No | <input checked="" type="checkbox"/> Yes |

107. Does the display and/or crew training provide information to the crew on the assumptions on which the calculations are based? No Yes

108. Are crews trained to identify and review default values and assumptions about the aircraft status or environmental conditions? No Yes

109. Are the assumptions made about any calculation as clear to pilots as similar information would be on a tabular chart? No Yes

Provide the Number and a Comment for Each Performance Calculations Question Checked as “No.”

Note: The answers to the question in the above section are made in the spirit that while TASAR is not a Performance Calculation applications, the questions are analogous to what may be required for the TASAR pilot decision aid.

[14] Checklist 1 contains a list of questions for operators to use during a tabletop evaluation of the Electronic Flight Bag (EFB) focusing on the EFB hardware and software applications. The checklist starts with EFB hardware questions, then presents general user interface questions, and ends with specific application questions (if applicable). *The checklist is designed so that any question answered as “No” requires a comment that may include, “Not Applicable.” – This approach is used in answering the questions below.* After the operator has completed this checklist, the results should be documented so the POI can review the results with the operator.

D.3 EFB Operational Evaluation (Detailed Check List #2)

Note 1: The following represents the detailed checklist utilized by the POI as part of the EFB Application approval process for the “EFB Operational Evaluation.” The list is taken from Figure 4-80 in FAA Order 8900.1 Volume 4 “Aircraft Equipment and Operational Authorizations” [14].

Note 2: While this document provides information concerning the certification and documentation approval process for TASAR, it does not in on its own address and achieve the actual certification and operational approval. Some observations are offered to assist this future process in looking through the list of questions provided in the Appendix.

Checklist 2—Electronic Flight Bag Operational Evaluation (Figure 4-80) [14]

Checklist 2 contains a list of questions for operator consideration during an operational evaluation of the Electronic Flight Bag (EFB), its documentation, procedures, and training. The first four pages contain questions that can be answered in a training or operational environment by pilots, instructor/evaluators, or other operational personnel. The last page contains sample crew performance questions that can be addressed in a simulation environment. The checklist is designed such that any question answered as “No” requires a comment that in some cases may be “Not Applicable.”

After the operator has completed this checklist, the POI will review the results with the operator.

General EFB Hardware

1. Is there a backup source in the flight deck for EFB information? No Yes

NA for TASAR

2. Is the EFB display readable under all typical flight-deck lighting conditions? No Yes

3. Does each type of EFB failure have minimum impact to crew tasks and workload? No Yes

4. Is the EFB installation appropriate for use in high workload phases of flight? No Yes

Not expected to be an issue for TASAR. Primarily used en route and potentially during late portion of climb and early stage of descent, workload permitting.

5. Are there appropriate Master Minimum Equipment List (MMEL)/minimum equipment list (MEL) items to handle EFB failures? No Yes

TASAR does not affect MMEL as it is optional and not required to support flight operations.

6. Have EFB failure items been incorporated into FAA-approved checklists? No Yes

Not expected to be an issue for TASAR. More of a training issue to ignore / turn off TASAR if it unnecessarily distracts the pilot.

7. Does the EFB mount allow appropriate access to flight controls and displays? No Yes

8. Does the EFB mount allow appropriate access to the emergency egress path? No Yes

9. Are crews able to adjust and lock the EFB for optimal viewing? No Yes

10. Is there appropriate access to all flight controls during both ground and in-flight operations when the EFB is positioned for optimal viewing? No Yes

11. Is there appropriate room to manipulate the EFB controls and to view its display? No Yes

12. Are all EFB hardware components that are routinely used easy to access? No Yes

13. Are the EFB hardware components usable and suitably durable for the flight deck? No Yes

Provide the Number and a Comment for Each General EFB Hardware Question Checked as “No.”
See above for each answer, which are the anticipated outcomes resulting from the operational evaluation. Whether this requires a flight test or if a ground test and demonstration is sufficient is TBD. It is anticipated that a ground test would be adequate pending FAA approvals.

Stowage (If Applicable)

14. Is there a stowage area for the EFB? No Yes

15. Is the stowage securing mechanism simple to operate? No Yes

16. Is the stowage securing mechanism unobtrusive when not in use? No Yes

17. Does the stowage system allow appropriate access to flight controls/displays and egress routes? No Yes

18. Is the design of the stowage area acceptable? No Yes

19. Can the EFB be moved easily to and from the stowage area without blocking access to flight displays/controls? No Yes

20. Are the device and/or the stowage area unlikely to be damaged under normal use? No Yes

Unsecured EFB (If Applicable)

21. Is there appropriate access to flight controls/displays when the unsecured EFB is in use? No Yes

22. Is there an acceptable place to put an unsecured EFB when in use? No Yes

23. Is there an acceptable place to put an unsecured EFB when not in use? No Yes

24. Can the kneeboard EFB be positioned such that the pilot has full control authority? No Yes

25. Is the kneeboard EFB comfortable for the pilot to wear under normal conditions? No Yes

Provide the Number and a Comment for Each Stowage and Unsecured EFB Question Checked as “No.”
See above for each answer. The answers to the above are conceptual in nature and are expected to reflect an appropriate implementation of TASAR. The exact nature of use mounted or unsecured are TBD at this time. Both should be acceptable. It is conjectured that due to the longer duration of en route operations, mounted use would be more desirable.

General User Interface

26. Is the workload using the EFB the same or less than the current process? No Yes

TASAR represents a new capability and is expected to be easily managed per proper design.

27. Is the workload acceptable when there is an EFB failure? No Yes

In event EFB failure, TASAR operations are simply unavailable and terminated (unless a second EFB is available to choose to continue using TASAR. TASAR use is optional.

28. Are other than critical EFB messages inhibited during high workload phases of flight? No Yes

TASAR use is at the discretion of the pilot. There is not an expectation for excessive messages from TASAR, but in the unanticipated event for this to occur, they are either ignored by the pilot (per training) or disabled.

29. Is the EFB user interface consistent with other flight deck systems? No Yes

30. Does the EFB use terms, icons, colors and symbols consistent with other flight deck systems? No Yes

Software Applications

31. Is the workload acceptable when configuring electronic charts while flying a procedure? No Yes

NA for TASAR.

32. Does using the electronic checklist (ECL) produce the same crew actions that using the paper equivalent would? No Yes

NA for TASAR

Provide the Number and a Comment for Each User Interface and Application Question Checked as “No.”
See above for each answer. The answers to the above are conceptual in nature and are expected to reflect an appropriate implementation of TASAR

EFB Procedures

33. Are there procedures for starting up and shutting down the EFB? No Yes

34. Are there appropriate procedures for all the EFB failure modes? No Yes

35. Are there EFB procedures for when other aircraft system failures could render the EFB unusable? No Yes

36. Are there procedures for using EFB backup information? No Yes

NA for TASAR as TASAR is optional.

37. Are there procedures to mitigate EFB workload? No Yes

TASAR is optional for use and via training, the pilot will disregard or disable TASAR if it affects workload in an adverse manner.

38. Are there procedures for establishing which source of information is primary? No Yes

TASAR information is used only for recommendations to the pilot and should not be used in lieu of other sources supporting flight operations.

39. Are there appropriate procedures for using EFB in high workload phases of flight? No Yes

TASAR is primarily intended for en route use or late part of climb segment and early stages of descent. If flight operations become high workload for any reasons, the pilot via training will cease to use TASAR until reduced workload allows pilot to choose to use TASAR again if desired.

40. Are there procedures that specify what data to use when data is redundant or different form the EFB? No Yes

TASAR information is used only for recommendations to the pilot and should not be used in lieu of other sources supporting flight operations.

41. Are there procedures for removal of a kneeboard EFB during emergency landing or egress (If Applicable)? No Yes

Provide the Number and a Comment for Each EFB Procedures Question Checked as “No.”

See above for each answer. The answers to the above are conceptual in nature and are expected to reflect an appropriate implementation of TASAR.

Procedures for Keeping EFB Content/Data Current

42. Are there procedures to ensure data is accurate and current for each software application? No Yes
43. Are changes to content/data appropriately documented? No Yes
44. Are there procedures to notify crews of EFB updates? No Yes
45. Are there procedures to ensure that the correct information is installed when EFBs use information that is specific to the aircraft type or tail number? No Yes
46. Are operational control procedures consistent with regulations concerning preventative maintenance? No Yes
- TBD if applicable for TASAR.
47. Is there a procedure to avoid corruption/errors during changes to the EFB device? No Yes
48. Is there a procedure to ensure that all EFBs have the appropriate content/data installed when there are multiple EFBs on the flight deck? No Yes
49. Is there a procedure to ensure that EFB data in use is approved for use in flight? No Yes
50. Is there a procedure for when the database is not approved for use in flight? No Yes
51. Is there a procedure to ensure that all customized values are cleared from the EFB? No Yes

Procedures for User Feedback

52. Is there a procedure for EFB users to provide feedback? No Yes
53. Is there a procedure for the operator to monitor feedback, correct EFB deficiencies, and/or notify the EFB manufacturer? No Yes
54. Are there procedures or built-in limits that prevent defining customized color schemes that conflict with flight deck color conventions? No Yes
55. Is there a policy regarding the use of supplemental audio and/or video in flight? No Yes
- NA for TASAR as currently defined.
56. Is the EFB audio set to minimize any interference with higher priority communications? No Yes
- NA for TASAR as currently defined.

Procedures for Specific Applications (If Applicable)

57. Are there specific policy/procedures for using the electronic charts application? No Yes
- NA for TASAR
58. Does the policy specify what other EFB applications can be used while a procedure using the electronic charts is actively being flown? No Yes
- NA for TASAR. However, with respect to TASAR, use of other applications is TBD but is considered feasible.
59. Are there procedures on how to use the electronic charts when the EFB uses aircraft status data to configure chart elements? No Yes

NA for TASAR.

60. Are there procedures to ensure that navigation/approach charts required for the flight are installed and available? No Yes

NA for TASAR.

61. Is there a procedure to identify the controlling copy of Weight and Balance (W&B)? No Yes

NA for TASAR.

62. Is there a procedure to establish responsibility for completion of W&B software? No Yes

NA for TASAR.

63. Are there procedures to maintain required W&B records? No Yes

NA for TASAR.

64. Is there a procedure to ensure that EFB performance data can be stored outside the EFB? No Yes

NA for TASAR.

Provide the Number and a Comment for Each of the above EFB Procedure Question Checked as “No.”
See above for each answer. The answers to the above are conceptual in nature and are expected to reflect an appropriate implementation of TASAR.

EFB Training

65. Are there appropriate EFB training, checking, and currency requirements? No Yes

66. Does the EFB training program address all EFB intended functions and applications? No Yes

67. Is there training on how to use unique features of the software applications? No Yes

68. Are crews proficient on the EFB at the completion of EFB training? No Yes

69. Is EFB training customized for new users? No Yes

70. Is the manufacturer’s EFB documentation sufficient? No Yes

71. Does the EFB training device provide an appropriate degree of fidelity when the actual EFB is not used? No Yes

It is envisioned that the TASAR EFB applications also serves as the EFB training device.

72. Does the EFB training device simulate the key aspects of the task? No Yes

73. Does the EFB training appropriately address the meaning of icons and symbols? No Yes

To the extent applicable to the TASAR user interface – TBD.

Training for Charts (If Applicable)

74. Is training on the use of electronic charts appropriate? No Yes

NA for TASAR.

75. Is there training on unique features of the electronic charts? No Yes

NA for TASAR.

76. Is there training on differences in map scale, orientation, and data quality between the electronic charts and other flight deck displays? No Yes

NA for TASAR.

77. Is there training on the limitations of own aircraft position when it is displayed? No Yes

NA for TASAR.

78. Is there training on policies pertaining to use of the electronic charts? No Yes

NA for TASAR.

79. Can crews use the electronic charts as well as paper charts? No Yes

NA for TASAR.

80. Can crews use the electronic charts to orient themselves and track their progress as they fly required procedures? No Yes

NA for TASAR.

Training for ECL Systems (If Applicable)

81. Is there appropriate training on how to use ECLs? No Yes

NA for TASAR.

82. Is there training on how to use unique features of the ECLs (e.g., how the EFB indicates that a checklist item has been deferred)? No Yes

NA for TASAR.

83. Is there training on which checklists are supported electronically and which are not? No Yes

NA for TASAR.

84. Is there training on the limitations of ECL automation when it uses aircraft status data? No Yes

NA for TASAR

Training for Flight Performance Calculations (If Applicable).

85. Is there appropriate training on how and when to use the flight performance application? No Yes

NA for TASAR.

86. Is there training on critical performance calculation assumptions (e.g., runway length, W&B)? No Yes

NA for TASAR.

87. Is there training to review default values for aircraft status and environmental conditions? No Yes

NA for TASAR.

88. Is there training on how to enter information required by the performance software? No Yes

NA for TASAR.

89. Is there training on how to interpret and use results of the flight performance calculations? No Yes

NA for TASAR.

90. Is there training on where to obtain values when their normal sources are not available? No Yes

NA for TASAR.

91. Is there training on coordinating the roles of dispatchers and flight crews? No Yes

NA for TASAR (from the perspective of flight performance calculation, which are not part of the TASAR concept).

Provide the Number and a Comment for Each Training Question Checked as “No.”

See above for each answer. The answers to the above are conceptual in nature and are expected to reflect an appropriate implementation of TASAR.

Crew Performance: Preflight Planning

Do crews with the EFB perform as well or better than crews with paper documents when—

92. Calculating aircraft W&B, takeoff, climb, and maneuvering speeds? No Yes

NA for TASAR.

93. Crews maintain critical data for immediate reference? No Yes

NA for TASAR.

94. There is a runway change and a need to reference deicing fluid requirements or an MEL item? No Yes

NA for TASAR.

95. There are time critical adjustments prior to block out/taxi and takeoff? No Yes

NA for TASAR.

Crew Performance: Takeoff

Do crews with the EFB perform as well or better than crews with paper documents when—

96. There is a takeoff on a runway that requires briefing a special operator engine-out procedure? No Yes

NA for TASAR.

97. There is complex Standard Instrument Departure (SID) with an abnormal or an emergency during the departure climb-out? No Yes

NA for TASAR.

98. There is an emergency that requires a return to the departure or alternate departure airport? No Yes

NA for TASAR.

99. One EFB fails, requiring one pilot to rely on the EFB of the other pilot immediately after takeoff? No Yes

NA for TASAR.

Provide the Number and a Comment for Each Preflight and Takeoff Question Checked as “No.”

The above questions are NA for TASAR.

Crew Performance: Cruise

Do crews with the EFB perform as well or better than crews with paper documents when—

100. There is an engine failure/fire with possible condition of destination below weather minimums? No Yes

NA for TASAR.

101. There is electrical smoke in the cockpit requiring use of smoke mask/goggles while completing checklists or using EFB for approach briefing? No Yes

NA for TASAR.

Crew Performance: Descent

Do crews with the EFB perform as well or better than crews with paper documents when—

102. There are conditions that require reference to Surface Movement Guidance and Control System (SMGCS) taxi routing or a complex clearance? No Yes

NA for TASAR.

103. Reported runway conditions require reference to operational limitations? No Yes

NA for TASAR.

Crew Performance: Approach/Landing

Do crews with the EFB perform as well or better than crews with paper documents when—

104. There is runway change or the need to re-compute landing weight and V speeds during approach? No Yes

NA for TASAR.

105. There are poor weather conditions or airports with complex taxi routes? No Yes

NA for TASAR.

106. There is a request for a specific taxiway turn during rollout after landing? No Yes

NA for TASAR.

Crew Performance: Destination Ground Operations

Do crews with the EFB perform as well or better than crews with paper documents when—

107. There is an EFB partial failure or erroneous output requiring maintenance discrepancy to be entered? No Yes

NA for TASAR.

Provide the Number and a Comment for Each Crew Performance Question Checked as “No.”

The above questions are NA for TASAR.

D.4 EFB Report Information Template

Note 1: The following represents the detailed template used by the user / operator and reviewed by the POI for the information captured as part of the Evaluation Report. The list is taken from Figure 4-81 in FAA Order 8900.1 Volume 4 “Aircraft Equipment and Operational Authorizations” [14].

Note 2: While this document provides information concerning the certification and documentation approval process for TASAR, it does not in on its own address and achieve the actual certification and operational approval. Some observations are offered to assist this future process in looking through the list of questions provided in the Appendix.

Evaluation Report Information Template (Figure 4-81) [14]

This outline is used by the user/operator to ensure that the minimum content requirements of the evaluation report have been met. The format of the report is optional, however the information below must have been included, as a minimum:

1. Electronic Flight Bag (EFB) evaluation identified by EFB make/model and aircraft make/model.

While any number of Portable PEDs/EFBs, along with associated Aircraft Interface Devices, may be used for TASAR to provide the required Class 2 (or higher) EFB functionality, one particular EFB is being used by the TASAR research team for flight testing. The Goodrich SmartDisplay™ EFB and ARINC 828 Aircraft Interface Device is a representative EFB for TASAR.

2. The manufacturer’s name and model number of the mounting system evaluated.

TBD for TASAR.

3. EFB location and stowage suitability.

TBD for TASAR.

4. EFB display lighting and reflectivity.

TBD for TASAR.

3. Suitability of procedures for EFB use during all phases of flight.

Specific procedures for TASAR are TBD for this report. A pilot assessment of the use of the TASAR EFB application is part of other research currently being conducted by the TASAR team.

4. Suitability of procedures to follow when one unit fails and when both units fail to include alternate means of accessing data.

TASAR being optional, its use will cease in the event of failure of the EFBs. No procedures required to provide an alternate means or mitigation.

5. A revision process procedure/method that ensures appropriate database accuracy and currency.

TBD for TASAR.

6. Training effectiveness and typical acceptable training course completion.

TBD for TASAR.

9. Usability of each application (for example):

a. Electronic documents' functional suitability;

NA for TASAR.

b. Aircraft performance, Weight and Balance (W&B), and speeds reference functional suitability; and

NA for TASAR.

c. Electronic charts' functional suitability.

NA for TASAR.

10. Usability of multiple applications at one time.

TBD for TASAR.

11. Crew workload and currency for proficient use.

TBD for TASAR.

5. Effectiveness of procedures that govern the distribution of application software updates to the aircraft and confirmation of the aircraft EFB configuration.

TBD for TASAR.

6. Flight report—when and how reports of malfunctions or anomalies are reported and resolved.

TBD for TASAR.

D.5 EFB Line Evaluation Job Aid (Detailed Check List #4)

Note 1: The following represents the detailed checklist utilized by the POI as part of the EFB Application approval process for the “EFB Line Evaluation”. The list is taken from Figure 4-82 in FAA Order 8900.1 Volume 4 “Aircraft Equipment and Operational Authorizations” [14].

Note 2: While this document provides information concerning the certification and documentation approval process for TASAR, it does not in on its own address and achieve the actual certification and operational approval. Some observations are offered to assist this future process in looking through the list of questions provided in the Appendix.

Checklist 4—Electronic Flight Bag Line Evaluation Job Aid (Figure 4-82) [14]

USED FOR DATA COLLECTION DURING VALIDATION PERIOD

This tool provides a starting point for Electronic Flight Bag (EFB) line operations evaluations. The questions are primarily designed to aid the POI but may also be useful to the operator for the collection of a structured set of observations about the use of the EFB before and during the 6-month validation phase. Use of this tool can be customized as appropriate for the situation. This is a final check to ensure that there are no problems with the EFB design/interface, training, or procedures prior to the authorization for use.

The questions below encompass the operations and safety evaluation. In cases where a system shows weaknesses or limitations, mitigations must be developed in consultation with the applicant.

In some cases, an EFB may add to the complexity of flight operations. The key questions to be answered are:

- 1) Can the flight be conducted as safely with an EFB as with the methods/products it is intended to replace?
- 2) Does the EFB add an *unacceptable* level of complexity for any critical activity or phase of flight?

In order to answer these questions, it is helpful to consider more specific aspects of EFB usage, which are covered in Sections II through V below. Space is also provided in Section I to record general notes about the system and the evaluation.

I. Describe system configuration description and flight conditions:

Details of the TASAR system configuration sought for certification and operational approval will be determined once an applicant initiates this process and makes the appropriate design decisions to support their intended use to achieve operational benefits. TASAR may be implemented in a number of ways; as a standalone EFB application or may be integrated and operate concurrently with other EFB applications, in either a single or dual EFB system.

The TASAR team will be conducting flight trials of the TASAR EFB prototype using a Piaggio Aero P180 Avanti test aircraft (per Engility and its AdvAero partner on the NASA TASAR research team).

Currently, flight operations and flight trials will consist of several scenarios, based on short-term flight segments that will evaluate the TASAR concept (i.e., the Traffic Aware Planner (TAP) application). Several scenarios have been identified in initial planning:

- *Data Scenarios: designed to ensure that the TAP engine is receiving the correct data from the aircraft.*
- *Functionality Scenarios: designed to exercise the TAP engine through each of its modes and capabilities.*
- *Pilot Interaction Scenarios: designed to have the test subject exercise each of TAPs capabilities to gather subjective operational feedback on the capability and user interface, as it pertains to the in-flight environment.*
- *ATC Interaction Scenarios: designed to have the test subject generate an optimization using TASAR, request the route change from ATC and, with the help of the safety pilot, execute the route change.*

As currently envisioned, the TASAR Flight Trials will involve 10 flights based at Newport News/Williamsburg International Airport (KPHF) near NASA Langley Research Center. Each flight will be planned to fly a route as if en route to a destination. This destination will change from flight to flight to optimize the traffic and/or weather conditions for the given day. Approximately mid-way through the flight, the aircraft will be re-routed back to KPHF.

The Pilot Interaction and ATC Interaction scenarios will be executed on flights 3 - 10. One new test subject is planned for each flight. The test subject qualifications are to be a currently licensed IFR pilot with a valid medical, and to not have been involved in the TASAR project (for independence).

During the approximately 120 minute period of each flight, the test subject will execute 11 scenarios, each exercising different TAP functionalities. The intention is to gather and demonstrate subjective feedback directly about each of the TAP functionalities.

The final two scenarios involve generating a proposed route modification and coordinating it with ATC. One of these scenarios will involve a mock ATC operator in the cabin of the aircraft, and the second will involve a live ATC request, following through with execution of the request, if it is approved. Since it is not realistic for ATC to approve multiple requests for route changes through the course of a relatively short flight, the decision was made to hold off making any live ATC requests until after the other scenarios are complete, and following through if approved.

While the test subject is performing the 11 scenarios, flight test engineers in the cabin of the aircraft will be performing functionality scenarios. These scenarios will put TAP through its paces using the scenarios being flown by the test subject. The intent here is to test TAP in various real-world operational scenarios, piggy-backing on the flight scenario being executed by the test subject. This piggy-backing will be on a non-interference basis.

Results such as those obtained from the described flight trials are expected to allow any necessary refinements to TASAR, but can also serve as flight evaluation results that could be offered to FAA in a future certification and operational approval process.

Note: In addition to the flight trials noted above, additional research is planned to be conducted to evaluate pilot performance in a flight-deck simulator to assess and evaluate pilot performance in using the TASAR human-machine interface (to be conducted in the University of Iowa Operator Performance Laboratory {OPL}). In addition, NASA Langley is planning to perform part-task simulations of TASAR to further evaluate pilot workload and the effectiveness of TASAR.

II. Overview. The main aspects to be assessed are encompassed by the following questions:

1. Was training adequate to ensure that the pilot(s) could perform in a safe and efficient manner? No Yes
 - Were individual pilot knowledge and skills adequate to allow normal coordinated flight deck activities?
 - Was pilot knowledge regarding observed software applications adequate?
2. Are adequate procedures in place to ensure that the EFB is integrated into the crew's/operator's system (e.g., normal and abnormal/emergency operations and maintenance functions)? No Yes
3. Was the EFB hardware or software adequate and appropriate during the flight? If there were any problems, particularly in a critical phase of flight, describe in the notes space below. No Yes
4. Could the pilot(s) recover from usage errors without undue distraction or discussions? If usage errors were frequent or a distraction, describe in notes below. No Yes
5. Was the workload required for completing a task with the EFB equal to or less than the workload for completing the task with the conventional method? If no, specify phase of No Yes

flight and task for any marginal or unacceptable increases in workload in notes space below.

Describe any problems noted as “No” above:

TBD for TASAR based on planned flight trials and associated evaluations of pilot performance.

III. General.

6. Was each pilot able to use the cursor, track ball, touch screen, etc., for menu and functionality without frequent errors? No Yes
7. Was the device appropriate and operational when exposed to environmental factors (e.g., turbulence, cold weather, vibration)? No Yes
8. Was the device free of significant limitations in regard to display (e.g., off-axis view angles or various different lighting conditions)? No Yes
 - The device had easy and adequate dimming functions in low light (nighttime) conditions?
 - The device was adequately backlit and/or was viewable by flight deck lighting in low-light (nighttime) conditions?
 - The device was clearly visible in bright sunlight conditions?
9. Was the device display clear (adequate resolution)? Confirm that the display was never misinterpreted because of viewing limitations. If so, record issues in notes space below. No Yes
10. Did the pilot(s) ensure proper stowage and security (i.e., between flights, etc.) of the EFB per standard operating procedures (SOP)? Temperature limitations acknowledged? No Yes
11. Does the display continue to be usable after prolonged use in the flight deck environment (if applicable)? No Yes
12. Normal functions (e.g., shutdown, startup) are adequate and do not require undue pilot attention or concern? No Yes
13. Were procedures adequate for identifying currency of EFB data? No Yes
14. Could the pilot(s) easily find and use required items and functions? No Yes
15. Were the abbreviations and/or icons easy to understand? No Yes
16. If multiple applications are supported, could the pilot(s) easily switch between critical applications? No Yes
17. If critical (e.g., abnormal or emergency checklists) applications are authorized in the EFB configuration basis, is their use at least equal to or better than previously approved methods? No Yes
 N/A
18. The time to complete normal tasks was appropriate. No Yes

19. The audio features did not cause pilot distraction and/or were adjustable and appropriate for the flight deck environment. No Yes
 N/A

Describe any problems noted as “No” above:

TBD for TASAR based on planned flight trials and associated evaluations of pilot performance.

IV. Electronic Charts, Documents, and Checklists.

20. Were all necessary documents (including charts, checklists, and manuals) found, identified, and easily viewed by the pilot(s) without undue distraction? No Yes
21. Was information contained in electronic charts, documents, and checklists complete, equal in quality to previously provided products, and easily accessible and understandable? No Yes
22. Was pilot knowledge of chart/document/checklist selection and viewing adequate? No Yes
23. Could the pilot(s) easily rearrange content on the screen to meet needs (e.g., by zooming, panning, or otherwise customizing the view)? No Yes
24. If printers are used, are printouts acceptable? No Yes
25. Did the pilot(s) exhibit adequate knowledge of EFB functions to efficiently brief and fly required procedures? No Yes
26. Did the pilot(s) exhibit adequate knowledge of the software revision process procedure/method that ensures appropriate database accuracy and currency? No Yes
27. Did the pilot(s) exhibit adequate knowledge of contingency procedures? In the event of a failure of a single device. In the event that both devices fail. No Yes
28. Were both pilots able to monitor necessary electronic chart displays during critical phases of flight? No Yes
29. Did the EFB allow quick entry of updates for last minute changes (e.g., flight plan/runway changes)? No Yes
30. For electronic checklists (ECL), was it easy to track completed items? No Yes
 N/A

Describe any problems noted as “No” above:

TBD for TASAR based on planned flight trials and associated evaluations of pilot performance.

V. Flight Performance Data/Calculations.

31. Could the pilot(s) interpret and use flight performance data/calculations efficiently and accurately? No Yes
 N/A

32. Did the device allow quick entry of updates for last minute changes (e.g., flight plan/runway changes)? No Yes
 N/A
33. In the event that the Weight and Balance (W&B) and/or performance calculation software is not approved by the Aircraft Certification Office (ACO), all crewmembers are aware of the software's limitations and understand that only approved calculation methods may be used as a primary means of computation. No Yes
 N/A

Describe any problems noted as "No" above:

NA for TASAR.

VI. General Conclusions.

34. Were any unique safety issues or events caused or exacerbated by using the EFB during this evaluation? No Yes

TBD for TASAR pending flight evaluation or ground demonstration as agreed to between applicant and FAA per Certification Plan.

35. Can the flight be conducted as safely with an EFB as with the methods/products it is intended to replace? No Yes

TBD for TASAR pending flight evaluation or ground demonstration as agreed to between applicant and FAA per Certification Plan.

36. Does the EFB add an unacceptable level of complexity for any critical activity or phase of flight? No Yes

TBD for TASAR pending flight evaluation or ground demonstration as agreed to between applicant and FAA per Certification Plan.

Assigned Aircraft: _____ **Date:** _____ **Print Observer Name:** _____

Observer Signature: _____ **Certificate Number:** _____

Appendix E FAA Technical Interchange Meeting Details

This appendix provides details of the technical interchange discussions between the FAA team of EFB and ADS-B certification and operational approval experts and NASA TASAR research representatives (i.e., David Wing, the NASA TASAR Principal Investigator, and Steve Koczo, Rockwell Collins Principal Investigator supporting NASA in the TASAR certification and operational approval analyses).

David Wing of the NASA Langley Research Center, Crew Systems and Avionics Operations Branch, and Steve Koczo of Rockwell Collins Advanced Technology Center traveled to Washington DC on July 24, 2013, to brief NASA's TASAR concept and technology to FAA officials responsible for policy setting, certification, and operational approval of EFB (Electronic Flight Bag equipment, EFB software, and ADS-B (Automatic Dependent Surveillance-Broadcast) IN applications. The seven FAA officials described themselves as being "all the right people" for assessing the TASAR application from the perspectives of certification and operational approval.

NASA TASAR concept for "Traffic Compatible Flight Optimization" received favorable FAA review. The outcome of the meeting was very successful, with widespread agreement of NASA's and Rockwell Collins' briefing materials and results from analyses, indicating TASAR has minimal certification and operational approval requirements.

The FAA host for the meeting with the NASA TASAR team, and one of the key approvers of EFB applications from a flight standards and operational approval perspective, provided the following post-meeting exchange: "I want to thank you both for the presentation yesterday on TASAR. Overall, I believe the meeting was very productive. If you have any questions in the future, please do not hesitate to contact us. Also, if there's any confusion, when displaying this technology to stakeholders, on whether or not this is an EFB function, please let me know. I want to ensure that these performance calculations are considered EFB software applications. Thanks again for your great presentation."

As a major conclusion to the meeting, it was noted that existing policies already cover the proposed application, and an applicant (e.g. an airline) should have no difficulty getting approval to implement TASAR from their standpoint. This finding supports NASA's objectives of developing a near-term, low-cost application for in-flight optimization of trajectories using ADS-B IN traffic data to increase the likelihood of approval. The application enables airspace users to gain early benefits of ADS-B IN at minimal investment risk, while also paving the way for the emergence of more advanced airborne surveillance applications with even greater operational benefits.

The following represents major points and discussion results from the technical interchange:

1. TASAR meets the definition of a Type B application and does not need to be added explicitly to the list of Type B applications in Appendix 2 of AC 120-76C [13]. Type B applications running on non-certified hardware (e.g., Class 2 EFB) do not require DO-178B compliance.

The FAA clearly considers TASAR a Type B software application ("performance applications"). They understood and agreed with the "Type B Lite" description although no such qualification is needed. It is not a problem that TASAR is not listed in AC 120-76C Appendix 2 (Type B applications), and it does not need to be added.

2. It was solidly agreed that TASAR is not considered an “ADS-B IN application” but rather a performance / planning application that leverages ADS-B IN data, if available.

A key element in FAA’s view is that traffic is not displayed. AC 120-76B will soon have “Change 1” allowing own ship to be displayed on Type B applications on the airport surface only.

3. No need was identified to establish a TASAR standard.

Such a standard would have ensured that different avionics vendors would produce compatible TASAR systems, but they saw no benefit in this.

4. TASAR should be viewed as a “Minor Effect” application because of potential pilot workload associated with TASAR due to misleading/bad data. From a loss of function standpoint, TASAR is viewed as “No Effect.”

5. If an end user already has an existing EFB installation, then the operational approval process is for the user to go directly to the POI to demonstrate that TASAR is safe (including the workload issues) and provide a training program.

David Wing offered a training estimate of 15 minutes for TASAR (using the In-Trail Procedure {ITP} of 30 minutes as a reference), which did not raise any objections.

6. Existing policies already cover the proposed TASAR application.

The following represents additional feedback, discussion points, and observations from the active discussions among all participants:

- It was confirmed that TASAR software would not require DO-178B compliance. In fact, no certification of the TASAR software is required at all provided it resides on non-certified hardware (e.g. Class 2 EFB).
- The only certification requirements would be mounting/installation of the EFB, getting one-way, read-only access to the certified systems data (e.g., via ARINC 429 busses), and partitioning and protections for non-interference with certified systems. The AID is intended to accomplish much of this partitioning/protection.

It was noted that even a one-way, receive (read)-only connection could short an ARINC 429 bus, but this can be managed. An applicant must show isolation and non-interference between the EFB and certified systems.

- FAA did not see the need for a PSCP for the TASAR software, just for the installation. If they already have an existing installation, then the operational approval process is for a user to go directly to their POI. It may be worth talking to a POI about TASAR to better understand this process.

The FAA host noted that our technical interchange meeting was in essence a “trial run” for how to conduct a meeting with all FAA involved (indicating that we had the right group together).

- The whole idea of a “Class 3” EFB is going away. It will be considered an installed “Auxiliary Display”.

For TASAR software installed on such a system, the software would be considered “Minor Effect” but would require DO-178B conformance (i.e., Design Assurance Level “D”).

Asked whether new software is required or whether existing TASAR software (R&D code) could be certified, FAA indicated that existing code could still be used depending on how it was designed, developed and documented (i.e., the implication being that software was designed with DO-178B design objectives being considered up front).

- FAA recommends using existing guidance for designing cockpit applications, e.g. human factors guidelines, and related to quality requirements of data.
- If the EFB is to be shared by TASAR and other applications, human factors issues may need to be addressed regarding transferring back and forth, particularly if certified applications are involved.
- The FAA certification authority on traffic surveillance asked whether TASAR would use TIS-B and TCAS traffic, and inquired on requirements for data content and accuracy. TIS-B has notoriously bad velocity data, and TCAS has none. Both also have limited range (TIS-B in particular). However a receiver can distinguish between and filter for only ADS-B data if desired. He recommended that we determine whether either of these systems would meet the performance requirements of TASAR. Somewhat related questions were raised on whether ground-based sources of traffic data (e.g. commercial sources) actually exist that could work, i.e. support TASAR.
- It was recommended we talk with WSI about access to weather products.
- The only other application using ADS-B IN data besides TASAR that does not employ a CDTI is TSAA (Traffic Situation Awareness with Alerts) which uses audio cueing rather than visual cueing.
- FAA had no concern with TASAR's map display on the "selected optimization" screen. Their only comment on the display was a preference to *avoid use of yellow or amber* if possible, as these are generally reserved for higher levels of hazard.
- Benefit numbers from the NASA TASAR benefits study were viewed as very significant. FAA asked where the big hitter benefits arise from; we noted that wind route, weather (pop-up and when it dissipates) were key factors
- It was suggested that TASAR could function in the General Aviation market without avionics connectivity (TBD).

Potential areas of concerns and additional discussion items were noted for further consideration:

- Some concerns were raised regarding whether TASAR solutions would be at odds with arrival flow planning and routing, particularly for Operational Evolution Plan (OEP) airports (i.e., largest 35 US airports)
Destinations other than OEP airports were not viewed to be a problem. An open question is how TASAR would know the arrival constraints for a particular airport, e.g., an OEP airport.
- FAA Flight Standards representative for traffic surveillance – could this (TASAR) lead to too many change requests to ATC?
- FAA representative - what about future Trajectory Based Operations (TBO), i.e., point-to-point locations at specific times, will TASAR and TBO clash?

- Discussion about Top of Descent (TOD) and inward (i.e., approaching the terminal area), with future greater use of Optimum Profile Descent (OPD), Required Time of Arrival (RTA) at metering fix, FAA noted that TASAR may work for smaller airports but what about East Coast corridor? David Wing noted that this is where use of constrained waypoint(s) would be in order for TASAR; also RTA
- FAA made reference to the National Route Program (NRP), and that it is typically discouraged to deviate from the NRP (implication being how does this affect TASAR use)
- FAA comment – “not one size fits all” with respect to airspace operations, users, and implication of TASAR use
- FAA asked about “throttle jockeying”, whether TASAR is reading the actual fuel flow in making route optimization decisions (we answered we did not think so, but were not fully sure; this would be a question to be directed to Engility in their algorithm design)
- It was asked if we had talked to Air Traffic Controllers. We responded we had not.
- FAA representative responsible for EFB certification made the following comments - TASAR application is almost like a workstation; airlines will want to automate it, i.e., more data link, auto download to FMS
 - He also noted that the Air Traffic Organization should also consider a TASAR like tool for ATC, i.e., meaning looking/factoring in data like weather, traffic, etc., in making route suggestions
 - Made a comment about “making the gray line more solid”, with respect to EFB regulatory policy and guidance
 - He also commented about bringing additional on-board displays into the cockpit (implication that this is an unwanted proliferation, e.g., pilots bringing PEDs on-board {perhaps multiple} for additional apps – suggesting some sort of integration of displays needs to occur to halt proliferation)
 - Should not be second display – do not want to keep bringing on additional displays
- The FAA host noted that POI is authorized to approve the EFB mount (which is not certified); while AID, which is certified, must follow AC 20-173
- 2,200 OpsSpecs are already in existence, which can be leveraged for future approval if they are equivalent to any new intended applications. The references to these OpsSpecs are for iOS and android type EFB applications
- AC 120-76B Change 1 will be out before end of calendar year 2013, will allow own ship on surface as a Type B application. Currently in signature cycle
- FAA noted that EASA (FAA’s certification counterpart in Europe) looks at EFBs as portable vs. installed; blackening the line seeking to remove ambiguity.

David Wing provided a brief demo of TASAR on the mobile prototype system that he brought to the meeting. The demonstration provided an excellent view of the TASAR application and its intended use and was very well received.

Acronyms

AC	Advisory Circular
ACARS	Aircraft Communications Addressing and Reporting System
ACO	Aircraft Certification Office
ADS-B	Automatic Dependent Surveillance – Broadcast
ADS-R	Automatic Dependent Surveillance - Rebroadcast
AE	Abnormal Event
AEG	Aircraft Evaluation Group
AFM	Airplane Flight Manual
AFS	FAA Flight Standards Service
AIAA	American Institute of Aeronautics
AID	Aircraft Interface Device
AIR	FAA Aircraft Certification Service
ALT	Altitude
AMMD	Airport Moving Map Display
AOC	Airline Operational Communications
AOSP	Airspace Operations and Safety Program
ARMD	Aeronautics Research Mission Directorate
ARP	Aerospace Recommended Practice
ASA	Aircraft Surveillance Applications
ASAS	Aircraft Surveillance Applications System
ASOR	Allocation of Safety Objectives and (Safety) Requirements
ASP	Airspace Systems Program
ASTC	Amended Supplemental Type Certificate
ATC	Air Traffic Control
BC	Basic Cause
CCFP	Collective Forecast Product
CDTI	Cockpit Display of Traffic Information
CFR	Code of Federal Regulations
COTS	Commercial of the Shelf
CP	Certification Plan
CPDLC	Controller Pilot Data Link Communication

CPI	Certification Process Improvement
CPP	Certification Project Plan
CR	Contractor Report
CTD	Concept and Technology Development
DAL	Design Assurance Level
DAR	Designated Airworthiness Representative
DCE	Data Concentrator Emulator
DER	Designated Engineering Representative
DMIR	Designated Manufacturing Inspection Representative
EASA	European Aviation Safety Agency
ECL	Electronic Checklist
ECON	FMS Economy Setting
EFB	Electronic Flight Bag
EMI	Electro-Magnetic Interference
EUROCAE	European Organization for Civil Aviation Equipment
EUROCONTROL	European Organization for Civil Safety of Air Navigation
EWINS	Enhanced Weather Information System
FAA	Federal Aviation Administration
FANS	Future Air Navigation System
FAR	Federal Aviation Regulation
FCC	Flight Control Computer
FEC	Failure Effects Classification
FMC	Flight Management Computer
FMEA	Failure Mode and Effects Analysis
FMS	Flight Management System
FOC	Flight Operations Center
FSIMS	Flight Standards Information System
GAMA	General Aviation Manufacturers Association
GPS	Global Positioning System
HIRF	High Intensity Radiated Fields
HITL	Human-in-the-Loop
HMI	Human Machine Interface
ICA	Instruction for Continued Airworthiness

IEEE	Institute of Electrical and Electronic Engineers
IFR	Instrument Flight Rules
ITP	In-Trail Procedure
LED	Light Emitting Diode
LOA	Letter of Authorization
LODA	Letter of Deviation Authority
LVC	Live Virtual Constructive
MACS	Multi-Aircraft Control System
MCP	Mode Control Panel
MEL	Minimum Equipment List
MIDOS	Manufacturing Inspection District Offices
MMEL	Master Minimum Equipment List
MSpec	Management Specification
NASA	National Aeronautics and Space Administration
NOTAM	Notice to Airmen
NRA	NASA Research Announcement
NRP	National Route Program
NWS	National Weather Service
ODA	Organizational Designation Authorization
OE	Operational Effect
OEP	Operational Evolution Plan
OH	Operational Hazard
OHA	Operational Hazard Assessment
OPD	Optimum Profile Descent
OPL	Operator Performance Laboratory
OS	Operating System
OSA	Operational Safety Assessment
OSD	Operational Service and Environment Definition
OSR	Operational Suitability Report
PC	Production Certificate
PED	Portable Electronic Device
PIREP	Pilot Reports
PMA	Parts Manufacturer Approval

POI	Principal Operations Inspector
PSCP	Project Specific Certification Plan
PSP	Partnership to Safety Plan
RD	Rapid Decompression
RF	Radio Frequency
RTA	Required Time of Arrival
RTCA	Radio Technical Commission for Aeronautics
RTS	Return to Service
RVR	Runway Visual Range
SAE	Society of Automotive Engineers
SC	Severity Class
SID	Standard Instrument Departure
SMGCS	Surface Movement Guidance and Control System
SMS	Safety Management System
SO	Safety Objective
SOP	Standard Operating Procedures
SPD	Speed
SPR	Safety Performance (and Interoperability) Requirements
ST	Safety Target
STAP	Single Text Avionics Protocol
STC	Supplemental Type Certificate
STI	Scientific and Technical Information
SUA	Special Use Airspace
SW	Software
T-PED	Transmitting Portable Electronic Device
TAP	Traffic Aware Planner
TASAR	Traffic Aware Strategic Aircrew Requests
TAWS	Terrain Awareness and Warning System
TBO	Trajectory Based Operations
TC	Type Certificate
TCAS	Traffic Alert Collision Avoidance System
TCBM	Type Certification Board Meeting
TFM	Traffic Flow Management

TFR	Temporary Flight Restriction
TIA	Type Inspection Authorization
TIS	Traffic Information Service
TIS-B	Traffic Information Service – Broadcast
TOD	Top of Descent
TSAA	Traffic Situation Awareness with Alerts
TSO	Technical Standard Order
TSOA	Technical Standard Order Authorization
UAT	Universal Access Transceiver
UM	Unit Member
W&B	Weight and Balance
WPT	Waypoint
Wx	Weather
WxR	(Airborne) Weather Radar
XM	Satellite Data Link Service Provider

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