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SafeFlight 21 Master Plan

Version 1.0.2

July 14, 1999

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Section 1

Introduction

SafeFlight 21 is a cooperative government/industry effort to develop enhanced capabilities for Free flight based on evolving Communications, Navigation and Surveillance (CNS) technologies. SafeFlight 21 will demonstrate the in-cockpit display of traffic, weather and terrain information for pilots and will provide improved information for controllers. The new technologies on which this program is based include the Global Positioning System (GPS), Automated Dependent Surveillance – Broadcast (ADS-B), Flight Information Services (FIS), Traffic Information Service – Broadcast (TIS-B), and their integration with enhanced pilot and controller information displays. SafeFlight 21 will evaluate the safety, service and procedure improvements these technologies make possible.

1.1 Purpose

The purpose of this Master Plan is to present a SafeFlight 21 plan for incrementally specifying, developing and evaluating the operational enhancements called for in the RTCA Joint Roadmap[1]. This plan states the objectives of the SafeFlight 21 Program and the approach the FAA and industry will take to work on these operational enhancements.

As used in this document, *SafeFlight 21 Operational Enhancements* refers to the CNS-based capabilities that have been selected by the Free Flight Select Committee. The FAA is executing the *SafeFlight 21 Program* that supports the development of these operational enhancements. Major efforts by industry will also be expended in support of developing the *SafeFlight 21 Operational Enhancements*. The FAA and industry roles in SafeFlight 21 are complementary. Planning for the FAA's SafeFlight 21 Program requires a perspective that spans all organizations involved in SafeFlight 21 and their respective roles. This plan adopts this broader perspective. Within this context, activities by the FAA are noted and presented in greater detail.

This Master Plan provides a consistent picture of the SafeFlight 21 Program. It is a living document that supports the evolutionary process described in Section 2. As progress is made and knowledge about the systems is gained, the Master Plan will be updated to reflect the current state of the program. Future versions of the Master Plan will trace the connections between high-level objectives and critical low-level details that must be addressed in technical activities. Synopses of these connections will enable informed prioritization of SafeFlight 21 actions based on realistic, technically valid expectations. It is expected that the

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[1] RTCA Select Committee, Joint Government/Industry Roadmap for Free Flight Operational Enhancements, August, 1998.

entirety of these connections exceed what most individual decisions, stakeholders or participants require.

1.2 Background

This section describes the SafeFlight 21 program context and illustrates issues that have shaped the objectives and approach of the program.

1.2.1 CNS/ATM Evolution in the NAS, Task Force 3

In 1995 the FAA Administrator asked RTCA to develop an aviation community consensus regarding free flight implementation. The primary guiding principle for Task Force 3, the task force established to respond to the Administrator's request, was that the transition to mature free flight will be benefits-driven and time-phased. The mature free flight is a vision that will change over time and the community could not afford to wait for long-term development initiatives to produce the benefits. The most far-reaching recommendation out of this task force was for the establishment of a government/industry Free Flight Steering Committee. Out of that committee has come a process to establish implementation strategies and milestones, to review progress and to identify new free flight opportunities.

1.2.2 Flight 2000

The Flight 2000 was an aggressive initiative to deploy and evaluate selected planned air traffic management systems for the year 2005 NAS. The objectives of the Flight 2000 program were to demonstrate safety and efficiency benefits of new technology and improved procedures, to evaluate communication, navigation, and surveillance (CNS) transition issues, to streamline avionics development, certification, and installation, and otherwise reduce the risks for accelerated NAS modernization. These integrated demonstrations and validation activities would have begun in September 2000. This initiative was too encompassing, too far into the future and lacked stakeholder buy-in.

1.2.3 NAS Modernization Task Force

In November, 1997, the FAA Administrator appointed a Task Force to identify and address the needs of the aviation community for National Airspace System (NAS) modernization and the barriers to moving forward with such a modernization activity. One of the recommendations that came out of that task force was a need to refocus the CNS programs based on the observation that the CNS modernization goals were at risk. The CNS programs should take on a more risk reduction focus. One of the significant elements of risk was the level of interaction with the industry that must produce, install and use the new CNS capabilities. To minimize this risk, it was recommended that the RTCA provide the forum for identifying the high level requirements and coordinating the industry/FAA efforts.

1.2.4 Joint Roadmap

RTCA Flight 2000 Subgroup of the Free Flight Select Committee, working with representatives of the FAA Flight 2000 program developed the *Roadmap for Free Flight Operational Enhancements*.[2] This document defined nine CNS-based operational enhancements at a high level, identified types of potential benefits, gave examples of risks and issues to be resolved, and specified emphasis and locations. The *Roadmap* represents a common vision of 9 high priority enhancements that includes government, industry and user perspectives. The *Roadmap* also proposed a new collaborative way of doing business to enhance the NAS that is intended to gain and maintain buy-in and political support for FAA action on these 9 enhancements

Industry and user buy-in is critical for avionics-based NAS enhancements. The need for buy-in is compounded for enabling systems (such as ADS-B) whose performance and benefits are heavily dependent on breadth of equipage. The *Roadmap* identifies the risks of capabilities that require a considerable percentage of equipage before benefits accrue and the difficulty of justifying equipment purchases before if there is a significant delay before benefits materialize. This is a “chicken and egg” problem that must be addressed. The *Roadmap* also identifies additional benefits and synergies that are expected if multiple capabilities are implemented together.

1.2.5 SafeFlight 21

The FAA has responded to industry by establishing the SafeFlight 21 program in AND-500 as an umbrella for activities working toward the operational enhancements identified in the Roadmap. Those enhancements and the RTCA-recommended sites for their demonstration and evaluation are shown in Table 1-1.

The SafeFlight 21 Steering Group, a group under the purview of the RTCA Free Flight Select Committee, interpreted the enhancements in terms of a number of applications defined by the scope of the enhancements. It will be these applications that will be evaluated by the SafeFlight 21 program. The applications were adapted from the ADS-B applications in the ADS-B MASPS[3] as well as from other material related to weather in the cockpit and terrain avoidance. Table 1-2 lists the applications within each enhancement. A description of each of these applications can be found in Appendix A.

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2 RTCA Select Committee, Joint Government/Industry Roadmap for Free Flight Operational Enhancements, August, 1998.

3 ADS-B MASPS reference

Table 1-1. Operational Enhancements

	Operational Enhancement	Ohio Valley	Alaska
1	Weather and Other Information to the Cockpit		✓
2	Cost Effective CFIT Avoidance		✓
3	Improved Terminal Operations in Low Visibility	✓	
4	Enhanced See and Avoid	✓	✓
5	Enhanced En Route Air-to-Air Operations	✓	✓
6	Improved Surface Navigation for the Pilot	✓	✓
7	Enhanced Airport Surface Surveillance for the Controller	✓	✓
8	ADS-B Surveillance in Non-Radar Airspace		✓
9	ADS-B Separation Standards		✓

Table 1-2. SafeFlight 21 Applications

Enhancement	Problem Statement[4]	Metrics[5]	Ref #	Application Name
1 Weather and Other Information to the Cockpit	There is a significant amount of data in the National Airspace System that, if the pilot could have access to it in the cockpit, would make the flight safer through improved situational awareness (e.g., weather information) or more cost effective (e.g., knowledge of special use airspace restrictions). Without this information the pilot faces uncertain weather hazards and other operational inefficiencies.	• Reduced flight times by skirting adverse weather and SUA restrictions • Increased safety • Increased access to airspace • Increased utilization of aircraft not equipped with weather radar Reduced Flight Services workload	1.1.1	FIS-B (with NEXRAD, Lightning, METAR/TAF, and SIGMET/ AIRMET products.)
			1.1.2	FIS-B (with Icing, Turbulence, SUA-status, and Volcanic Ash products)

4 From the RTCA Select Committee, Joint Government/Industry Roadmap for Free Flight Operational Enhancements, August, 1998.

5 From the SafeFlight 21 Steering Group Cost/Benefits Subgroup.

Enhancement	Problem Statement[4]	Metrics[5]	Ref #	Application Name
2 Cost Effective CFIT Avoidance	In the recent past there have been many fatal accidents involving controlled flight into terrain (CFIT) due to poor situational awareness. CFIT accounts for a large part of all fatal accidents. Current CFIT technology is prohibitively expensive for certain classes of users.	• Reduced CFIT accidents • Decreased pilot workload	2.1	Low cost terrain situational awareness
			2.2	Increased access to terrain-constrained low altitude airspace

Enhancement	Problem Statement[4]	Metrics[5]	Ref #	Application Name
3 Improved Terminal Ops in Low Visibility	During approach operations there are a number of shortcomings: 1. On visual approaches a) it is often difficult to identify the aircraft to follow b) it is difficult to judge the distance and speed of the aircraft to follow. If the aircraft slows too soon, a go-around could be required. If the following aircraft slows too soon, spacing is larger than necessary. 2. IFR approaches are ofter required while still in VMC 3. During IFR approaches speed control is often left to the pilot resulting in go-arounds or inefficient spacing	• Increased access to airports during marginal weather • Reduced arrival delays • Increased predictability of arrival & departure times • Increased flexibility of arrival scheduling • Increased airport capacity • Increased safety for terminal approaches • Increased efficiency of terminal operations • Reduced go-arounds	3.1.1	Enhanced Visual Approaches (Visual Acquisition w/o Positive ID procedures using ADS-B only)
			3.1.2	Enhanced Visual Approaches (w/Positive ID procedures using ADS-B only)
			3.1.3	Enhanced Visual Approaches (w/Positive ID procedures using ADS-B and TIS-B)
			3.2	Final Approach Spacing
			3.3	Enhanced Parallel Approaches in VMC/MVMC
			3.4	Departure Spacing (VMC)

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Enhancement	Problem Statement[4]	Metrics[5]	Ref #	Application Name
4 Enhanced See & Avoid	There are limitations with today's system of "see and be seen." This results in safety and efficiency issues, especially at non-tower airports. It is not cost beneficial for most general aviation aircraft to carry TCAS equipment and they are not required to do so. However, it is advantageous to increase safety for all aircraft to maintain situational awareness of the traffic around them, even in IMC.	• Increased safety • Decrease in pilot/ controller workload	4.1.1	Enhanced Visual Acquisition of Other Traffic for See and Avoid (using ADS-B only)
			4.1.2	Enhanced Visual Acquisition of Other Traffic for See and Avoid (using ADS-B and TIS-B)
			4.2	Traffic Situational Awareness in Domestic Airspace
			4.3.1	Conflict Situational Awareness in Domestic Airspace (w/TA's)
			4.3.2	Conflict Situational Awareness in Domestic Airspace (w/RA's)

<table>
<tr><th>Enhancement</th><th>Problem Statement[4]</th><th>Metrics[5]</th><th>Ref #</th><th>Application Name</th></tr>
<tr><td rowspan="5">5
Enhanced
En Route
Air-to-Air
Operations</td><td rowspan="5">The lack of, and/or limitations of surveillance, separation standards and procedures limit efficiency.</td><td rowspan="5">• Increased flexibility in routes flown
• Increased en route capacity
• Increased predictability of flight times & distance flown
• Reduction in flight delays and distances flown
• Increased fuel efficiency
• Increased pilot workload
• Increased pilot flexibility
• Increased controller productivity</td><td>5.1</td><td>Climb & Descent in Non-Radar Airspace</td></tr>
<tr><td>5.2</td><td>Self-Separation in Non-Radar Airspace</td></tr>
<tr><td>5.3</td><td>In-Trail Spacing in En Route Airspace</td></tr>
<tr><td>5.4</td><td>Merging in En Route Airspace</td></tr>
<tr><td>5.5</td><td>Passing Maneuvers in En Route Airspace</td></tr>
</table>

Enhancement	Problem Statement[4]	Metrics[5]	Ref #	Application Name
6 Improved Surface Navigation for the Pilot	Many times, especially in low visibility, it is difficult for pilots to navigate the taxiways of the airport. If the pilot is not familiar with the airport, clearances may not be properly executed with the resulting safety implications. Furthermore, under reduced visibility conditions the pilots may not be able to see other traffic. If they could see the other traffic the safety of the surface operations would be increased.	• Increased safety during surface movements • Increased safety during landings and take-offs • Reduced taxi times • Increased predictability of taxi times • Increased airport capacity • Improved efficiency of gate management operations	6.1.1	Runway and Final Approach Occupancy Awareness (using ADS-B only)
			6.1.2	Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)
			6.2	Airport Surface Situational Awareness
			6.3	Enhanced IMC Airport Surface Operations

Enhancement	Problem Statement[4]	Metrics[5]	Ref #	Application Name
7 Enhanced Surface Surveillance for the controller	Under low visibility conditions it is difficult for the tower controllers to manage the aircraft and other vehicular traffic on the airport surface. For those locations with ASDE, the information on surface operations does not give complete information about the position, identification, and speed of all the vehicles on the airport surface.	• Increased safety for terminal surface areas • Reduction in taxi times • Increased predictability of taxi times • Increased airport capacity • Reduction in emergency response time • Improved surface operations • Reduced rate of pilot/air traffic control communications	7.1	Enhanced Presentation of Surface Target to Controller
			7.2	Surveillance Coverage at Airports without ASDE

Enhancement	Problem Statement[4]	Metrics[5]	Ref #	Application Name
8 ADS-B Surveillance in Non-Radar Airspace	There are areas outside of radar coverage where procedural separation is used. This type of separation limits airport and airspace capacity. The lack of surveillance information limits the ability of the controller to provide separation services.	• Increased capacity in airports and airspace • Reduced separation minima in comparison to procedural separation • Increased flexibility in route flown • Increased safety • Increased efficiency in aircraft operations • Increased predictability of flight times • Reduced flight delays	8.1	Expanded Surveillance Coverage in En Non-Radar Airspace
			8.2	Expanded Surveillance Coverage in Terminal Areas without Radar

Enhancement	Problem Statement[4]	Metrics[5]	Ref #	Application Name
9 **ADS-B Separation Standards**	Current automaton is limited in providing benefits to users based on existing radar accuracy.	• Increased flexibility in routing into terminal airspace • Increased access to airspace	9.1	ADS-B Enhancement of En Route Radar
			9.2	ADS-B Enhancement of Terminal Radar

1.3 Document Overview

This document is organized according to concepts in the Evolutionary Spiral Process (ESP) model[6]. ESP includes planning at two levels – 1) a high-level, long-term *spiral plan* for the overall program and, 2) a *cycle plan* corresponding to a single loop of the spiral that describes current activities.

The *spiral plan* anticipates learning from current activities to guide what is to be done in the future. *Spiral planning* is overall planning and general in nature. It is based on what is expected but is subject to change (by consensus) as experience and knowledge are gained. The *cycle plan* is for the immediate activities that will be undertaken. It is shorter-termed and more specific than the *spiral plan*. It reflects what is known now and what is needed to be known to support future efforts.

Section 2 of this document describes the process used by SafeFlight 21 in collaborative government/industry planning. Section 3 covers the multiyear cycle plan. Section 4 of this document describes cycle planning for fiscal year 1999.

1.4 Relationship to Other FAA and SafeFlight 21 Documents

This Master Plan has its genesis in the in the Joint Government/Industry Roadmap for Free Flight Operational Enhancements (August 1998). That document identified the need for evaluation of nine operational enhancements for which there was a consensus among the aviation community along with locations for the evaluations and an approximate timetable.

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6 Evolutionary Spiral Process Model Guidebook, Volume 2, Project Management with the Evolutionary Spiral Process Model, Software Productivity Consortium, SPC-91096, December 1993.

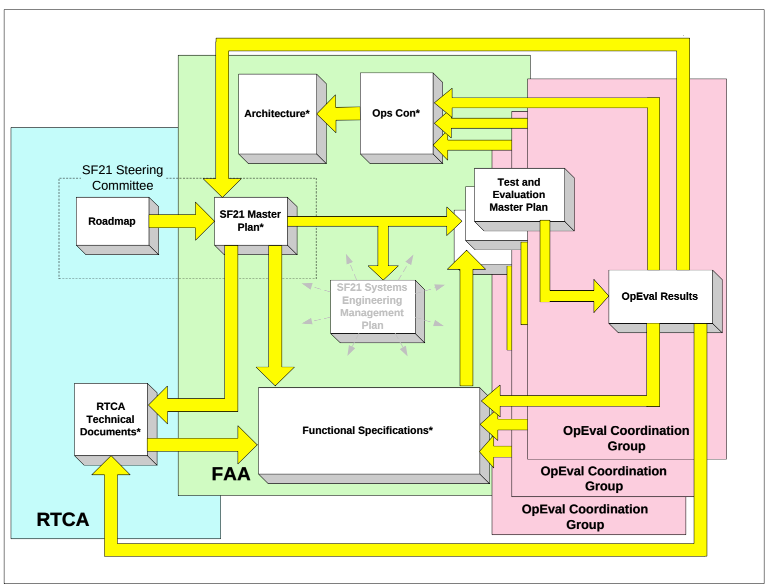
For information on specific ADS-B applications, this Master Plan has drawn on the ADS-B MASPS. For the concept of operations, inputs from the Draft RTCA SC-186 ConOps, the Joint ConOps and the Air Traffic 2005 ConOps were used. These documents have been identified by the SafeFlight 21 Steering Committee as the appropriate documents for ADS-B specifics. The information gained from the SafeFlight 21 Operational Evaluations will be fed back into the concept of operations and the system architecture.

[Add a paragraph describing the relationship of the SafeFlight 21 program to NAS Architecture 4.0]

Since planning for the first Operational Evaluation was underway when this Master Plan was started, the draft version of the Test and Evaluation Master Plan (TEMP) for the Ohio Valley OpEval provided information that is useful to this Master Plan. In general, however, the Master Plan defines the direction, scope and expectation for the TEMPs.

In the future, the Master Plan may draw on functional specification to illustrate system dependencies that might influence development and evaluation of specific issues and priorities.

The information flow in SafeFlight 21 and the relationship of the various documents are illustrated in Figure 1-1.



* Living Documents

Figure 1-1. SafeFlight 21 Information Flow

Section 2

System Engineering Process

2.1 SafeFlight 21 Scope

2.1.1 Program Objectives

The primary objective of the SafeFlight 21 program is to enable and expedite decisions by stakeholders on implementing the nine operational enhancements listed in Table 1-1. The program will do this by working with industry to reduce the risk to Communications, Navigation and Surveillance (CNS) modernization by demonstrating and evaluating these enhancements. In doing these demonstrations and evaluations, the enhancements will be refined. Prior to committing the FAA and the users to a full scale implementation of these enhancements, there needs to be a consensus among the stakeholders (including the FAA) of the feasibility and business case for the enhancements.

Another objective of the SafeFlight 21 program is to reduce the risk of implementing the enhancements listed above. Certification and obtaining operational approval from the FAA represent significant risks to achieving these enhancements. Thus, the program will have an objective to develop innovative processes to expedite the certification and operational approval of these enhancements when they are shown to be feasible and useful to the stakeholders.

2.1.2 Program Constraints

There are a number of general constraints that the SafeFlight 21 program must be cognizant of and take into consideration. First, stakeholder buy-in must be maintained. The FAA is not free to develop independent plans for this program without industry consensus. In fact, the FAA will not work on any of these enhancements unless there is a segment of the industry interested in working with the FAA on developing, demonstrating or evaluating the enhancement. Second, tangible progress on the enhancements must be demonstrated early. The enhancements that have been requested through the RTCA process affect the “bottom line” or the access to the National Airspace System (NAS) for many of the stakeholders. Delays in achieving these enhancements will adversely affect those stakeholders. As a corollary to the second constraint, these enhancements, because they require development, are best demonstrated and evaluated incrementally. This will reduce the risk of failure of achieving these enhancements

As with all FAA programs there are fixed funding limits set by the FY99 budget. This also includes limits on the contract support that the SafeFlight 21 program office can receive.

2.1.3 Program Stakeholders

The success of the SafeFlight 21 program depends on establishing a “win-win” situation for all stakeholders whose support is required to meet the program’s objectives. The program stakeholders from the perspective of the SafeFlight 21 program office are both external to the FAA and internal. The external stakeholders interface with the SafeFlight 21 program through the SafeFlight 21 Steering Committee whose members have been selected in coordination with the RTCA Free Flight Steering Committee drawing on membership of the Free Flight Select Committee.

The external stakeholders include the Cargo Airlines Association (CAA), the Alaskan Region Industry Council, air carriers who are evaluating CNS enhancements, avionics manufacturers, ground system manufacturers, the pilots’ unions (ALPA, Allied), general aviation (AOPA), the international community (ICAO), the FAA operating unions (NATCA, NAATS, PASS), the Department of Defense, and the public in general. Implementation of the program includes the participation of standardization and technical organizations (MIT Lincoln Labs, Volpe, NASA, CAASD).

The stakeholders internal to the FAA are the Air Traffic Service, Airway Facilities, AIR, ASR, the Alaskan Region, ASD, AND, and the upper level management of the FAA.

2.2 SafeFlight 21 Planning

2.2.1 Planning Concepts

The SafeFlight 21 planning process is an iterative approach to incremental because it is difficult to determine in advance the operational concepts that will deliver the most user benefit. This process is risk driven and supports the evolution of functional and performance requirements rather assuming all requirements can be fully known in advance.

Figure 2-1 illustrates the basic concepts of the SafeFlight 21 process, the activities leading up to the formation of the SafeFlight 21 program and the current cycle of the plan. The first activity in a cycle is to examine the environment to identify the stakeholders, the objectives, the known major constraints and the alternatives to meeting the program objectives This is accomplished in the “Understand the Context” part of the spiral. Then the risks of the alternatives are analyzed and a direction for the program is determined. The next segment, the plan for the cycle is developed. This is followed by the actual development of products. In the case of SafeFlight 21, the products are development, demonstrations and evaluations. After the work on the cycle is completed the planning of future cycles in the spiral is revised using the information gained.

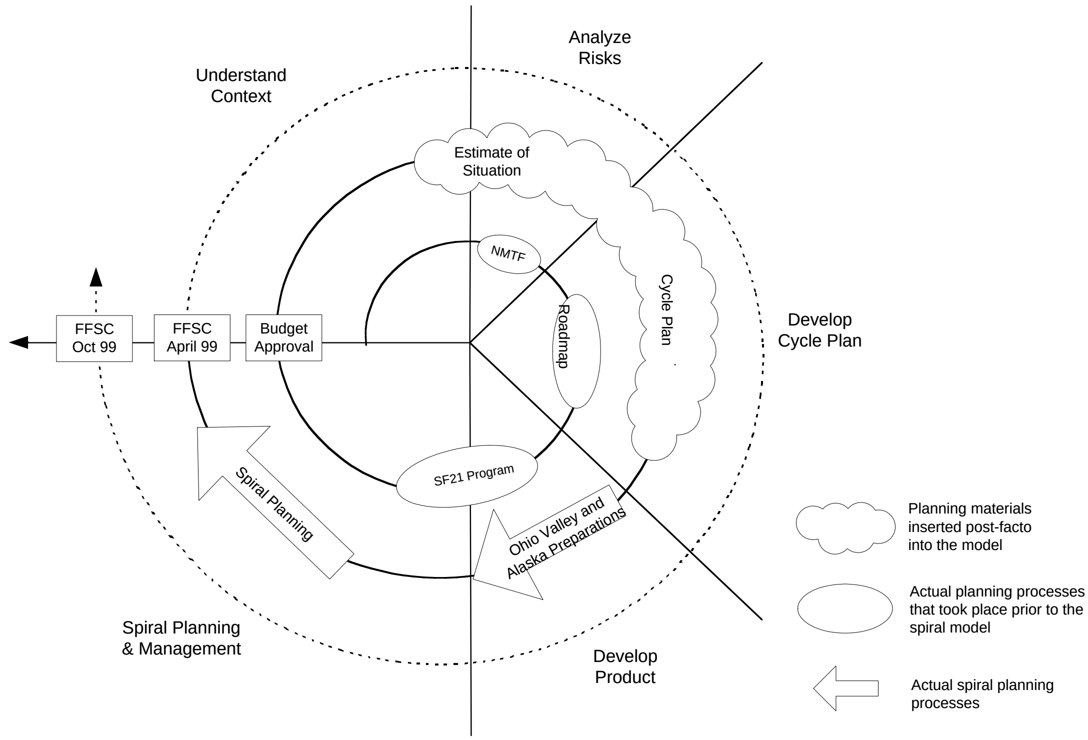


Figure 2-1. The SafeFlight 21 Planning Process

Since achievement of the primary objective of the program requires working with the stakeholders and maintaining a consensus with the stakeholders, the natural duration of the cycles within the spiral should correspond to gaining stakeholder approval and consensus for the program. The top-level coordinating body for stakeholders in SafeFlight 21 is the RTCA Free Flight Steering Committee (FFSC) which is the cognizant Federal Advisory Committee for CNS/ATM modernization for the FAA and includes industry, labor, user and FAA representatives. The FFSC meets three times per year. SafeFlight 21 cycles are timed to the FFSC's summer meetings.

Past events that have led up to the creation of the SafeFlight 21 program can be interpreted in terms of the cycle segments as shown in Figure 2-1. The NAS Modernization Task Force (NMTF) identified and assessed the risks of the NAS Modernization programs. This task force particularly assessed the risks of the Communication, Navigation and Surveillance (CNS) programs as high, leading to a recommendation for the FAA to work with industry to reduce these risks. The FFSC directed that the RTCA Select Committee (which supports it) develop a roadmap to guide development of CNS enhancements needed for Free Flight.

With endorsement by the stakeholders and funding by Congress, the roadmap led to the formation of the SafeFlight 21 Program.

At the time the program was being formed, the Cargo Airlines Association (CAA) was well on its way to defining its demonstration and evaluation process in the Ohio Valley. At the same time, the Alaskan Region Industry Council was defining its Capstone Project. Both of these activities address enhancements called for in the roadmap and both are now associated with and supported by SafeFlight 21.

Central to the spiral planning of SafeFlight 21 is the extension of incremental stakeholder consensus and buy-in. With each cycle of the spiral, shared understanding should be gained and commitment to the SafeFlight 21 process reinforced through small but ongoing wins in the iterative definition, development, and evaluation of the enhancements. New knowledge, with concomitant adjustments in stakeholder priorities and commitment, will cause revisions to the spiral plan and guide the definition of successive cycle plans. These occur with the oversight and participation of the stakeholders.

2.2.2 SafeFlight 21 Structure, Roles and Responsibilities

The program management structure for SafeFlight 21 as a whole has been generalized from that being used by the FAA, RTCA and the CAA to develop the initial set of Enhanced Visual Acquisition ADS-B applications. The RTCA's Free Flight Steering Committee is the focus of industry consensus on the new CNS capabilities. Through its Free Flight Select Committee the enhancements for SafeFlight 21 were defined and their development and evaluation will be monitored. On a day-to-day basis there is the SafeFlight 21 Steering Committee that is focused directly on the SafeFlight 21 activities. This relationship is shown in Figure 2-2. To move forward toward implementation, the evaluations must show that the enhancements are both feasible, useful and cost beneficial.

There are three subgroups under the SafeFlight 21 Steering Committee that address these issues: the Operations/Procedures subgroup, the Cost/Benefit subgroup, and the Technical/Certification subgroup. The roles for the steering committee and these subgroups have been defined in the SafeFlight 21 Steering Committee Terms of Reference.

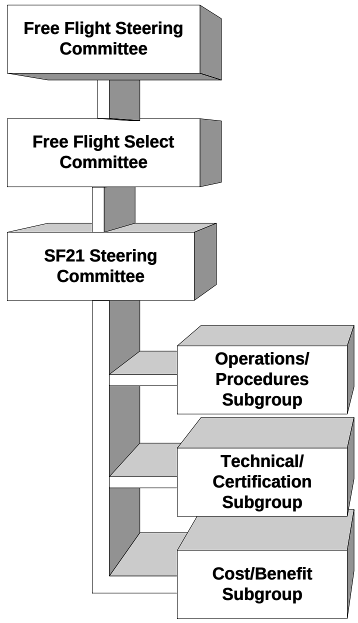


Figure 2-2. SafeFlight 21 Steering Committee Organization

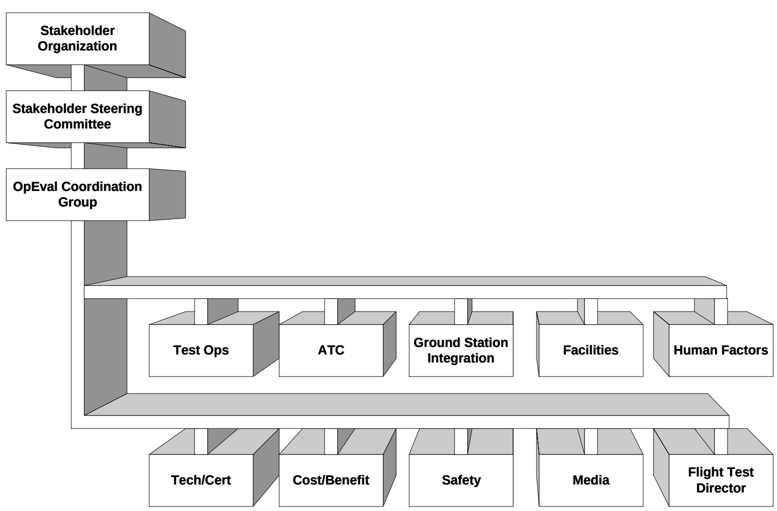


Figure 2-3. Stakeholder Operation Evaluation Organization

SafeFlight 21 Steering Committee

- Provides on-going guidance on the scope, priority, and schedule of evaluation activities for the nine operational enhancements.
- Oversees the objective assessment of candidate ADS-B technologies. The assessment will identify the capability, cost and ability of each technology to satisfy the requirments of the operational capabilities identified in the SafeFlight 21 Roadmap.
- Establishes metrics to be used in the evaluation of operational benefits and the assessment of costs.
- Analyzes the cost and benefit of the nine operational enhancements and makes recommendations to the Free Flight Select Committee on which enhancements or combination of enhancements yield the greatest return on investment in terms of safety, efficiency, capacity and human productivity.
- Should changes in the roadmap become necessary, the SafeFlight 21 Steering Committee will present specific recommendations and rationale to the Free Flight Select Committee for action.

Operations and Procedures Subgroup

The operations and procedures subgroup will provide guidance and oversight of procedures development for each of the evaluations beginning with the Cargo Airline Association (CAA) and Capstone initiatives. The subgroup will ensure that pilot, controller, operator, FAA air traffic management and flight standards issues are addressed. The group will also coordinate with RTCA SC-186 as appropriate. Special emphasis will be placed on operations in a mixed equipage environment. The group will work with the Technical/Certification subgroup to define how each of the technologies is used to gain a beneficial capability. Those definitions will be used as the basis for certification criteria.

Cost/Benefit Subgroup

The Cost/Benefit subgroup will collaborate with the other SafeFlight 21 subgroups, FAA System Engineering, manufacturers and the operators to obtain cost and benefit data and work with the FAA on a cost/benefit analysis. The analysis will provide information on the trade-off between the differing levels of capability and different architecture and technology options that are explored within SafeFlight 21. This analysis will serve as the basis for recommendations to the SafeFlight 21 Steering Committee. Initial focus will be placed on assessing the cost and benefits of the three candidate ADS-B/FIS systems as they pertain to the nine operational enhancements. The Cost/Benefit subgroup will collaborate with the Technical/Certification subgroup and manufacturers to define the costs of technical alternatives and with the Operations/Procedures subgroup to quantify and qualify economic and safety benefits derived from each capability and their integration.

Technology and Certification

The Technology and Certification subgroup will oversee the ADS-B system alternatives evaluation, define high-level system requirements (ground station/avionics), and coordinate requirements for equipment certification and operational approvals necessary for operational evaluations and ultimately NAS-wide implementation. The subgroup will assist the Cost/Benefit subgroup with defining avionics and group system costs, and will work with the Operations/Procedures subgroup to define the intended function of each technology as a basis for certification.

To actually conduct the evaluation, the stakeholders that have an interest in the enhancement will organize the evaluation effort. As shown in Figure 2-3 the stakeholders will form a steering committee to ensure that its interests in the evaluation are protected. The day-to-day activities of the planning and execution of the evaluation are managed by the OpEval Coordination Group (OCG). Beneath the OCG are subgroups that plan the various aspects of the evaluation.

The communication between the RTCA groups and the stakeholder groups is facilitated by the fact that the membership of the subgroups with the similar names are essentially common. FAA provides leadership, coordination and support to this process. The FAA assumes the co-chair role on the SafeFlight 21 Steering Committee and also on the OCG. SafeFlight 21 Program Office staff and representatives of stakeholder organizations within the FAA are members of the various subgroups.

As the SafeFlight 21 progresses and more of the enhancements are evaluated there could be multiple groups of stakeholders each developing various applications. As shown in Figure 2-4, the organizational model that was started with the CAA evaluation can be generalized. Each stakeholder organization will be concerned about its spiral process relating to the applications of interest while the SafeFlight 21 Steering Committee will have an overview of all the activities and will be concerned with the overall spiral **planning** process. In the meantime, the FAA's SafeFlight 21 Program Office will provide support, coordination and leadership in the various committees and groups.

2.2.3 SafeFlight 21 Information Flow and Decision Making

The activities and progress of SafeFlight 21 is based on stakeholder consensus. Therefore, the informational flow and decision making of this program is designed to involve the stakeholders. In the spiral process described above, near-term activities based on applications called out in the RTCA roadmap are known and well-defined. As operational evaluations of those applications are made, new information is learned which is used in subsequent planning for the next round of operational evaluations.

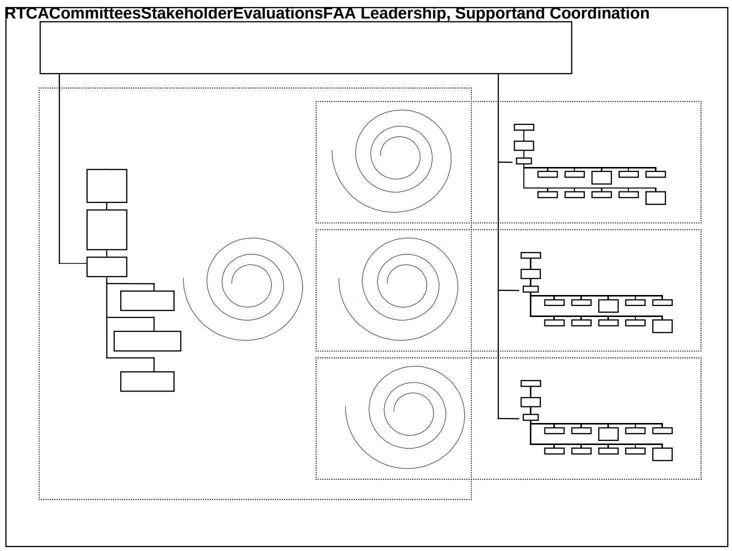


Figure 2-4. FAA, RTCA, Stakeholder Interaction

As depicted in Figure 2-5 the roadmap and the ADS-B MASPS are the main drivers of SafeFlight 21 activities. Of course the development of these documents was strongly influenced by the FAA's operational concept and architecture. This document (the SafeFlight 21 Master Plan) uses the material in the Roadmap and the MASPS to define the sequence of applications to be investigated. The control of this document is shared between the FAA and the RTCA SafeFlight 21 Steering Committee. The detailed schedules and program resource control mechanisms can be found in the SafeFlight 21 Systems Engineering Management Plan (SEMP), the FAA's internal management document.

The operational requirements for evaluating ADS-B, CFIT, FIS-B, and TIS/TIS-B come from the RTCA Roadmap. The functional requirements for the enhanced capabilities are also outlined the Roadmap. From the operational and functional requirements the functional specifications are derived for the functions to be evaluated. This functional specification may be different than the functional specification for the function to be placed into production for two reasons. 1) There may be functions needed to conduct the evaluation that will not be needed in the production system (e.g., a data gathering and reduction function).

2) The evaluation function may need to be changed based on knowledge gained from the evaluation. For these reasons there is both Evaluation Functional Specifications and Production Functional Specifications.

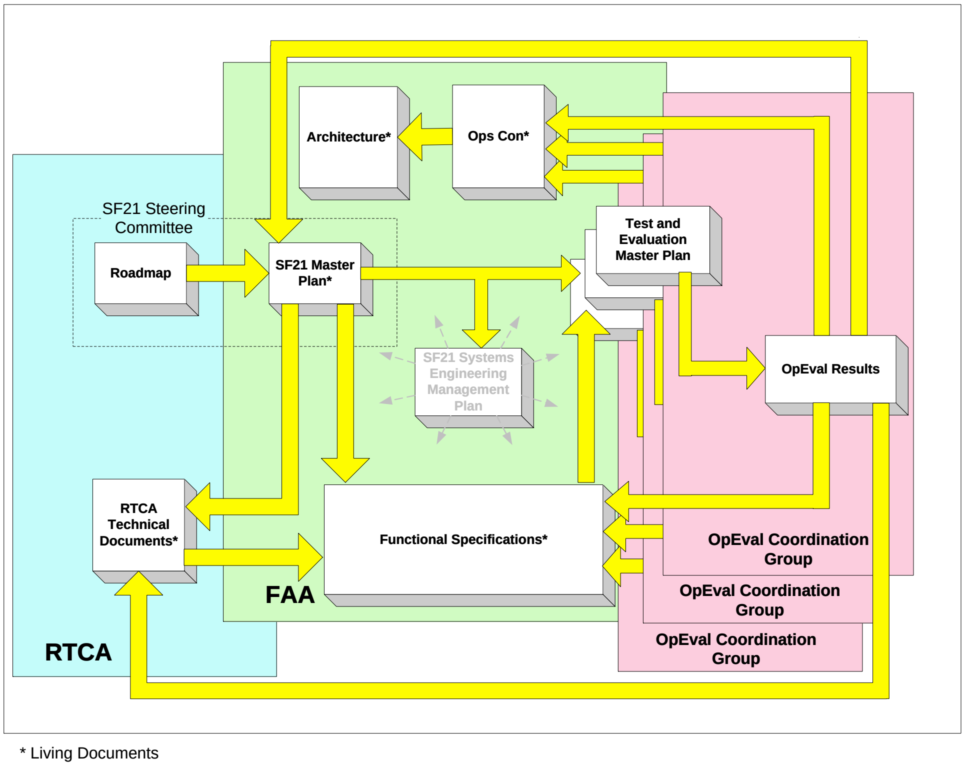


Figure 2-5. SafeFlight 21 On-Going Information Flows

For each Operational Evaluation there will be a Test and Evaluation Master Plan. The control of this document will be shared between the SafeFlight 21 program office and the

OpEval Coordination Group for the particular OpEval. The Test and Evaluation Master Plan (TEMP) has as its technical inputs the Evaluation Functional Specifications and as its scope input from the SafeFlight 21 Master Plan.

Out of each Operational Evaluation will come a set of results. These results include data, analyses of that data, and any consensus on what the operational capabilities should be and their benefits. This information is then fed back into the system Operational Concept (Ops Con). These validated, stakeholder embraced operational concepts will confirm (or identify corrections to) planned FAA and stakeholder architectures. The details of the results are also fed into the Production Functional Specification. In consonance with the spiral development process, the results are also fed back into the SafeFlight 21 Master Plan under the oversight of the SafeFlight 21 Steering Committee.

2.2.4 Generic Test and Evaluation Activities

There is a set of activities that should be undertaken to test, evaluate and ultimately implement each application. These activities can be considered as generic in both their description and schedule. As the SafeFlight 21 program considers each of these activities in detail for a given application they will be tailored to that application.

2.2.4.1 Generic Tasks

Each cycle in the SafeFlight 21 process will include a set of tasks leading to the evaluation of one or more applications. The tasks shown in Table 2-1 are generic in that most or all of them apply to each application in the SafeFlight 21 program. The grouping of these tasks and the tasks themselves have been taken from the RTCA SC186 Working Group 1 draft template for ADS-B applications development. While these tasks have been developed for ADS-B applications, they are applicable to any new applications involving new procedures and new avionics.

The information provided in Table 2-1 categorizes the tasks and names them. A full description of the tasks can be found in Appendix B. This information will be used, along with the priorities defined below to package the various applications in the cycles of the multiyear plan.

Table 2-1. Development, Evaluation and Implementation Tasks for SafeFlight 21 Applications

1. Operational Concept
1.1 Define operational concept
1.2 System Functionality
2. Benefits and Constraints
2.1 Cost/Benefit Estimates and Parameters
2.2 Quantitative Costs and Benefits
2.3 Cumulative Implementation Cases
2.4 Investment Decisions and Deployment Consensus
3. Maturity of Concept and Technology
3.1 Looks Feasible and Worth Developing?
4. Operational Procedures
4.1 Initial Definition of Procedures
4.2 Cockpit Simulation
4.3 Controller Simulations

4.4 Procedure Parameters
4.5 Procedures Training
4.6 Procedures Post-Full-Sim
4.7 Procedures Post-OpEval

5. Human Factors Issues (Pilot, Controller, Other)

5.1 Task Analysis
5.2 Initial Cockpit Human Factors
5.3 Initial Controller Human Factors
5.4 Human Factors Post-Full-Sim
5.5 Human Factors Post-OpEval

6. End-to-End Performance and Technical Requirements

6.1 Initial Performance Estimates
6.2 Performance Requirements
6.3 Supportability Requirements
6.4 Performance Validation

7. Interoperability Requirements for Air and Ground Systems

7.1 Interoperability Analysis
7.2 Interface Requirements Documents
7.3 Interoperable Prototypes
7.4 Interoperability Post-OpEval

8. Operational Safety Assessment

8.1 Rationale / Prelim Model
8.2 Validate Rationale/Preliminary Model
8.3 Full Collision Risk Model

9. Avionics and Ground Systems

9.1 Systems and Avionics for OpEval
9.2 Systems and Avionics for Certification And Approval

10. Operational Test and Evaluation

10.1 Limited Data Collection
10.2 Full Mission Simulation
10.3 Plans For OpEval
10.4 Operational Test and Evaluation

11. Equipment Certification (Aircraft and Ground Systems)

11.1 Develop a Certification Issues Paper
11.2 Develop Certification Plan

12. **Operational Approval (Flight Standards and Air Traffic)**

12.1 Develop Issues And Resolutions Document
12.2 Document Operational Regulations
12.3 Document the Human Factors Design Criteria And Guidelines
12.4 Document Air Carrier Operator Approvals And Authorizations

12.5 Document Approved Operational Data
12.6 Produce Approved Training Program Module
12.7 Develop Operations Manuals
12.8 Develop Operational Specification
12.9 Develop General Aviation Guidance Material
12.10 Document Validation and Proving Runs
12.11 Document Post Operational Approval/Certification Activities

13. Implementation Transition

13.1 Procedures In Service
13.2 Benefits In Service
13.3 Human Factors In Service
13.4 Performance In Service
13.5 Interoperability In Service

2.2.4.2 Generic Tasks Schedule

Each of the generic tasks listed above falls into a standard sequence leading up to the Operational Evaluation. That standard sequence is shown in Figure 2-6.

Task Category	Concept Definition OpEval Year -2	Technical Evaluation OpEval Year -1	Operational Evaluation OpEval Year	Decision Making OpEval Year +1
1 Operational Concept	1.1 Define Operational Concept 1.2 System Functionality			
2 Benefits & Constraints	2.1 Cost/Benefit Estimates, Params	2.2 Quantitative Costs and Benefits	2.3 Cumulative Implementation Cases	2.4 Investment Decisions and Deployment Consensus
3 Maturity of Concepts & Technology	3.1 Looks Feasible and Worth Doing?			
4 Operational Procedures	4.1 Initial Def. of Procedures 4.2 Cockpit Simulation 4.3 Controller Simulations	4.4 Procedure Parameters 4.5 Procedures Training	4.6 Procedures Post-Full-Sim 4.7 Procedures Post-OpEval	
5 Human Factors Issues (Pilot, Controller, Other)	5.1 Task Analysis 5.2 Initial Cockpit HF 5.3 Initial Controller HF		5.4 HF Post-Full-Sim 5.5 HF Post-OpEval	
6 End to End Performance & Tech Reqs	6.1 Initial Performance Estimates	6.2 Performance Reqts 6.3 Supportability Reqts	6.4 Performance Validation	
7 Interoperability Reqs for Air and Ground Systems	7.1 Interoperability Analysis	7.2 Interface Reqts Docs	7.3 Interoperable Prototypes 7.4 Interop Post-OpEval	
8 Operational Safety Assessment		8.1 Rationale / Prelim Model	8.2 Validate Rationale / Model	8.3 Full Collision Risk Model
9 Avionics and Ground Systems			9.1 Systems & Avionics for OpEval	9.2 Systems & Avionics for Certification and Approval
10 Operational Test and Evaluation		10.1 Limited Data Collection	10.2 Full Mission Simulation 10.3 Plans for Op Evals 10.4 Operational Test and Evaluation	

Figure 2-6. Generic Task Schedule

2.2.5 Scheduling Process

To arrive at the multiyear schedule for evaluating the SafeFlight 21 enhancements, a collaborative process involving the FAA and industry was pursued. It was recognized early in the program that the budget and other resources would constrain the speed at which the enhancements could be evaluated. Therefore, the stakeholders, as represented by the SafeFlight 21 Steering Group, prioritized the enhancement applications and this drove the resulting schedule within the resource constraints. The process used to schedule the multiyear SafeFlight 21 program is described below.

2.2.5.1 Initial Schedule Estimate

The goal of the SafeFlight 21 program is to conduct an operational evaluation of each of the nine enhancements as represented by the applications (see Table 1-2). To construct the initial schedule estimate the following definition pertain.

Definitions

Evaluations and Demonstrations

The SafeFlight 21 program's objective is to demonstrate and evaluate various new capabilities using enhanced CNS technologies and new procedures. The goal of the program is to achieve an operational evaluation of the capability. However, there are other activities in this program that lead up to an operational evaluation. The following are definitions used by the SafeFlight 21 program to describe these activities.

An <u>Operational Evaluation</u> addresses all major operational, technology and acceptance issues that impact the feasibility and benefit of the capability. Significant effort will still be needed to complete the certification and approval of the capability, but there would be no remaining "show-stoppers" after a successful operational evaluation.

A <u>Technical Evaluation</u> addresses a subset of major issues and may be conducted before other major issues are understood or resolved.

A <u>Demonstration</u> illustrates systems and partial concepts without integration into the operational context.

Technology Adoption Model

Each of the applications has been judged to fall into one of three phases of technology. There is the "early" phase where immediate benefits can be achieved without others equipping. These applications require no changes to the air traffic management procedures and they are usually advisory only. The "middle" phase is characterized as the application achieving benefits from a mixed equipage environment. In this phase there may be limited enhancements to the air traffic management procedures. Although the acceptance of these applications requires accuracy improvements, the effectiveness of the application can tolerate some unavailability. The applications that are classified as "late" require nearly full equipage to achieve benefits or acceptability. "Late" applications may also require major changes to the air traffic management procedures or responsibilities or acceptance of the application may require very high confidence that the benefits will be achieved. For a more detailed discussion of the technology adoption model, refer to Appendix J.

Potential Benefits

The magnitude of the potential benefits from an application is rated as either high, medium or low. The high benefit applications are those that have the potential to show a large improvement in primary safety or efficiency. The medium applications have the potential to show moderate improvement in safety or efficiency or large improvements in non-safety or efficiency areas. The low benefit applications are those that are expected to provide little improvement or improvement in areas of little concern.

Because delivered benefits from these applications is yet to be evaluated (and will be selected for evaluation based on prioritization), benefits assessments are based on the magnitude of the problem each application is intended to address. This potential benefit will always be an upper bound on delivered benefit, but it can be evaluated prior to development and evaluation of the application.

Difficulty

This is an estimate of how difficult or hard it will be to define, develop, evaluate, prototype, integrate, and gain acceptance to the degree needed for Operational Evaluation. If the uncertainties are great the difficulty will be greater. The scale is from 1 to 5 with 5 being the most difficult. The scale considers the maturity and work completed to date, the procedure complexity, acceptance issues, human factors, avionics and ground system availability, integration and complexity, the safety validation needed and how difficult it will be to define the metrics and measure the benefits of the application.

Benefited Stakeholders

For the purposes of this analysis, the stakeholders have been grouped according to the categories in Table 2-2. These categories are used to identify who would receive potential benefits for each application.

Table 2-2. Benefited Stakeholder Categories

Category	Description
GA	Part 91 Ops or aircraft, VFR (includes many Alaskan air taxis
Taxi	Part 135 carriers
Heavy	Part 121 carries
ATC	Air Traffic Control personnel, FAA
Airports	Municipalities or major airport authorities
All AC	Part 91, 121, 135 operators
Fleets	Co-owned aircraft operated in geographic proximity
Oceanic	Part 121 carriers in Oceanic, Alaska, Gulf of Mexico
Non-TCAS	All aircraft without TCAS
Cat-3 Autoland	Carriers equipped for zero-visibility approach

The goal of the SafeFlight 21 program is to conduct an operational evaluation of each of these applications. The operational evaluation may be preceded by demonstrations and technical evaluations as defined above, but the operational evaluation is the goal of the program. Using the factors of technology adoption, potential benefits, difficulty and application synergy, an initial schedule for each of the application was made to estimate the target year for its operational evaluation. In general, if the application requires full equipage, or the benefits are low or the difficulty is high the operational evaluation will be later. The results of these estimates are discussed in Section 3.

2.2.5.2 Prioritization

The construction of the initial schedule, as described above, considered the factors of technology adoption, potential benefits, difficulty and application synergy. It did not necessary account for what the stakeholders really want. Therefore, the SafeFlight 21 Steering Group performed an exercise whereby they simultaneously expressed their opinions on the importance of each application and the basic timing of the evaluation of the application. Each stakeholder was given a number of "votes" which they could place on the applications. The number of votes they placed on an application indicated the importance and the position on the application card indicated whether the initial schedule for that application should be moved earlier, later, or remain the same. The importance score was normalized to a range from 0 to 10 (10 being the highest importance). The results of this exercise will be discussed in Section 3.

2.2.5.3 Schedule Feasibility Considerations

Even though the stakeholders (via the SafeFlight 21 Steering Group) expressed their desires for when the applications should be evaluated, the possibility of achieving such a schedule is not guaranteed. The first step in determining the feasibility of the schedule was to apply the generic tasks to each application and determine which tasks should have already been completed, or at least started, in FY99 based on the target year identified by the SafeFlight 21 Steering Group. It turns out that several applications would have required significant progress on many tasks in order to achieve the desired schedule. The target years for operational evaluation were moved into the next year for these applications. This did not do irreparable harm to the schedule since the SafeFlight 21 Steering Group qualified the definition of the target year as not necessarily completing the entire operational evaluation but at least having the application operating in the field.

2.2.1.4 Laboratory Constraints

The prioritized schedule could be achievable if there were no resource constraints. To develop and evaluate a SafeFlight 21 application one needs to consider the simulation time that is required. There are a limited number of simulation facilities at the disposal of the SafeFlight 21 program to conduct this development. The simulation effort for each application (or its combination with other similar applications) was estimated along with the annual capacity of each simulation facility. As it became apparent that a simulation facility would be overburdened during a given year, the applications importance for that facility with the lowest were moved to the next year and inserted in the list of applications above those applications with the same or less importance. The same analysis was performed on each succeeding year resulting in a couple of applications moving out beyond the end year of the SafeFlight 21 program (2002).

2.2.1.5 Budget Constraints

The other resource constraint that must be considered is the budget. For some applications there is equipment to buy or significant development to do. In this analysis the generic tasks are tailored to the particular applications and costed. With estimates for the outyear budgets, the tasks for the lower importance applications will be scheduled later.

The results of these scheduling analyses will be discussed for each application in Section 3.

It is expected that as information is gained from one operational evaluation and funding levels are changed from year-to-year, parts of this process will have to be repeated. Figure 2-7 shows the relationship between the scheduling process, the updates to this Master Plan and the Operational Evaluations.

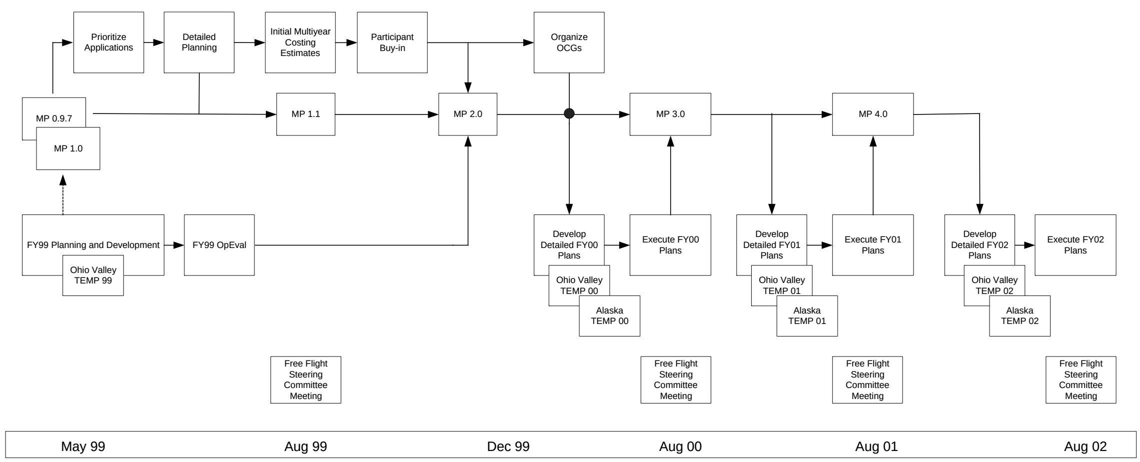


Figure 2-7. Multiyear Planning Cycle

2.2.6 SafeFlight 21 Risk Management[7]

Throughout the SafeFlight 21 program there will be a continuous process of risk management. This process will identify those issues that represent risk to the program then ensure that each risk is addressed in a prioritized plan to minimize the impact to SafeFlight

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7 The concepts in this section are based on the *FFP1 Risk Assessment Guidelines and Analysis Schema*, 25 February 1999 prepared by the FFP1 Program Office, Integration Management Team.

21 and the CNS portion of NAS modernization. Risk management forms the basis for the Evolutionary Spiral Process that is being used to minimize modernization risks.

2.2.4.1 Risk Management Approach

The SafeFlight 21 Program Office is the focal point for risk management. The manager of each OpEval, Application, or system will address risks that are entirely applicable to their portion of the effort. To maintain a clear picture of the overall risk to the SafeFlight 21 program, the program office will identify, analyze, track, and control all program risks. Where identified risks are crosscutting and affect more than one SafeFlight 21 activity, the program office will work with the affected managers to plan how and when the risk will be addressed. Some risks will be dealt with in the current cycle but for some, the most appropriate time will be in later cycles of the spiral. A SafeFlight 21 risk management process has been defined and is being implemented based on standard risk management techniques. Figure 2-8 depicts the approach to risk management.

2.2.4.2 Risk Identification

There are a large number of issues concerning the operational evaluation and eventual deployment of Safe Flight capabilities. In general risks fall into three categories:

- Technical – Current technology does not support the required capability and/or the development of new technology is breaking new ground.
- Operational – Viable procedures have not been defined for the capability and/or those defined appear flawed.
- Acceptance – The capability involves sufficient uncertainty or departure from accepted practice that one or more required stakeholders may refuse to accept it.
- Benefit – The value of the capability to stakeholders is sufficiently uncertain that implementation decisions are not adequately informed.
- Cost – Current funding is insufficient to meet the needs of an activity
- Schedule – Current schedule does not allow sufficient time to meet SafeFlight 21 requirements

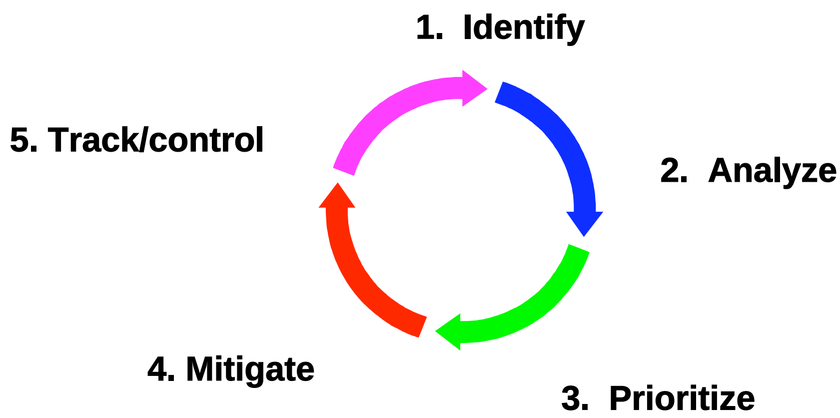

Figure 2-8. SafeFlight 21 Risk Management Approach

Risk identification extends to interdependent programs supporting SafeFlight 21. When a supporting program has risks, these risks must be assessed for impact on SafeFlight 21 technical, cost and schedule performance.

The SafeFlight 21 Program Office will ensure that all issues are screened for potential risk and that, once a risk is identified, it is maintained in a database of program risks to be addressed during the risk management process. Standard techniques and procedures will be developed to strengthen and standardize the SafeFlight 21 risk management approach including:

- Checklists
- Standard methods for assessment such as structured interviews
- Standard risk reporting forms
- Risk tracking database

2.2.4.3 Risk Analysis

Risk analysis is performed by analysts who assign probabilities and impacts to each risk. This determines the risk exposure to SafeFlight 21 from each risk. This is the first step toward prioritization.

2.2.4.4 Risk Planning and Prioritization

Once risks are evaluated and assigned exposure values, a series of discussions involving managers and stakeholders will be conducted to set the priority of all program risks and identify appropriate actions to reduce or mitigate the risks. These decisions will be documented in the risk database and, once a prioritized list of all SafeFlight 21 risks is developed the candidates for mitigation will be identified. A risk plan will be developed that includes the mitigation action and its place in the current cycle or spiral.

Risks that require significant SafeFlight 21 resources or that significantly threaten stakeholder interests will be identified in the cycle plan in this Master Plan, and will be re-evaluated with the stakeholders each planning cycle.

2.2.4.5 Risk Mitigation

Risk mitigation includes actions that can reduce or eliminate risks. Possible actions include:

- Accepting the risk if it the exposure is acceptable, the mitigation activity is very expensive, or it is completely outside of the control of the program
- Avoiding the risk e.g., avoiding development risk by using COTS
- Reducing the risk to an acceptable level through executing an action plan

These risk action plans will be recommended by the SafeFlight 21 Program Office or any stakeholder and executed by the appropriate organization. Risk triggers will be identified to indicate when action plans should be executed.

Stakeholders are an integral part of the risk mitigation approach and participate quarterly program reviews at which risk mitigation status and progress will be reported and discussed.

Current risk mitigation approaches will be described in the risk management section of the cycle plan within this Master Plan, which will be updated each planning cycle.

2.2.4.6 Tracking and Control

The SafeFlight 21 Program will establish a tracking and control function as part of the risk management activity. Risks will be continuously monitored and reported and discussed with stakeholders as status changes. The initiation and completion of action plans will be monitored and reported in the SafeFlight 21 quarterly reviews and posted in the risk database.

The progress made by SafeFlight 21 in mitigating risks will be documented in the estimate of situation section of the cycle plan in this Master Plan and will be updated and coordinated with the stakeholders each planning cycle.

Section 3

MultiYear SafeFlight 21 Plan

The multiyear plan for the SafeFlight 21 program provides a global view of the context in which the program is operating and an indication of the direction that the program is heading at this time. As more becomes known after each cycle of this plan, the multiyear plan may change to take advantage of that new information.

3.1 SafeFlight 21 Operational Enhancements and Applications

Table 3-1 summarizes the SafeFlight 21 enhancements and applications from Table 1-2.

Table 3-1. SafeFlight 21 Operational Enhancements and Applications

Enhancement		Applications
1 Weather and Other Information to the Cockpit	1.1.1	FIS-B (with NEXRAD, Lightning, METAR/TAF, and SIGMET/AIRMET products)
	1.1.2	FIS-B (with Icing, Turbulence, SUA-status, and Volcanic Ash products)
2 Cost Effective CFIT Avoidance	2.1	Low cost terrain situational awareness
	2.2	Increased access to terrain-constrained low altitude airspace
3 Improved Terminal Operations in Low Visibility	3.1.1	Enhanced Visual Approaches (Visual Acquisition w/o Positive ID procedures using ADS-B only)
	3.1.2	Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B only)
	3.1.3	Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B)
	3.2	Final Approach Spacing
	3.3	Enhanced Parallel Approaches in VMC/MVMC
	3.4	Departure Spacing (VMC)

Enhancement	Applications
4 Enhanced See and Avoid	4.1.1 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B only) 4.1.2 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B) 4.2 Traffic Situational Awareness in Domestic Airspace 4.3.1 Conflict Situational Awareness 4.3.2 Strategic Conflict Resolution
5 Enhanced En Route Air-to-Air Operations	5.1 Closer Climb & Descent in Non-Radar Airspace 5.2 Extended See and Avoid 5.3 In-Trail Spacing in En Route Airspace 5.4 Merging in En Route Airspace 5.5 Passing Maneuvers in En Route Airspace
6 Improved Surface Navigation for the Pilot	6.1.1 Runway and Final Approach Occupancy Awareness (using ADS-B only) 6.1.2 Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B) 6.2 Airport Surface Situational Awareness 6.3 Enhanced IMC Airport Surface Operations
7 Enhanced Surface Surveillance for the Controller	7.1 Enhanced Presentation of Surface Targets to Controller 7.2 Surveillance Coverage at Airports without ASDE
8 ADS-B Surveillance in Non-Radar Airspace	8.1 Expanded Surveillance Coverage in En Route Non-Radar Airspace 8.2 Expanded Surveillance Coverage in Terminal Areas without Radar
9 ADS-B Separation Standards	9.1 ADS-B Enhancement of En Route Radar 9.2 ADS-B Enhancement of Terminal Radar

3.2 Enhancement and Application Schedules

As described in Section 2, the SafeFlight 21 Steering Group prioritized the SafeFlight 21 applications. The results of the prioritization is shown in Table 3-2 in the "Import" (importance) column. On this scale, 10 is the highest importance.

The result of distributing the simulation workload among several laboratories is also shown in Table 3-2. The simulations are identified as is cockpit-based only (pilot), ground-based only (controller) or both cockpit and ground-based (end-to-end). The type of simulation and the application to be simulated limited the potential laboratories at which the simulation could be performed. In the column labeled "Location and Sim Events" the laboratory and an estimate of the number of multi-day sessions needed are listed. If the number is followed by a slash and another number, this means that more than one application could be simulated together. In this case, the "Sim With" column lists the other application(s). If a particular ground system is involved in the application it, too, is listed. Based on a limit of approximately 8 sessions per year per laboratory, the applications with the lowest importance were moved to the next year. The result of constraining the simulations with the laboratory capacity is shown in Table 3-2.

Table 3-2. Simulation Constraint Analysis

Applications Name (with development phase if needed)	Ref#	OpEval Schedule	Import	Human in Loop Sim Type	Location & Sim Events	Sim With:	Ground Systems
Enhanced Visual Acquisition of Traffic for See-And-Avoid (using ADS-B only)	4.1.1	1999	7	Pilot	I-lab 4/2	3.1.1	---
hanced Visual Approaches (Visual Acquisition w/o positive ID procedures using ADS-B only)	3.1.1	1999	2	End to End	I-lab 4/2	4.1.1	---
FIS-B (with NEXRAD, Lightning, METAR/TAF, and SIGMET/AIRMET products)	1.1.1	2000	10	Pilot	U-AK 5/2+	4.1.1,2.1	FIS-B
Enhanced Visual Acquisition of Traffic for See-And-Avoid (using ADS-B and TIS-B)	4.1.2	2000	7	Pilot	I-Lab 3/3	3.1.2,3.1.3	TIS-B
Conflict Situational Awareness	4.3.1	2000	6	Pilot	I-Lab 3		---
Enhanced Visual Approaches (w/ Positive ID Procedures using ADS-B only)	3.1.2	2000	5	End to End	I-Lab 3/3	4.1.2,3.1.3	---
Low cost terrain situational awareness	2.1	2000	4	Pilot	U-AK 5/2+	4.1.1,1.1.1	---
Expanded Surveillance Coverage in En Route Non-Radar Airspace	8.1	2000	4	Controller	Tech-Ctr 4		Rcvr+ATM
Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B)	3.1.3	2000	4	End to End	I-Lab 3/3	4.1.2,3.1.2	TIS-B
FIS-B (with Icing and SUA-status products)	1.1.2	2001	10	Pilot	U-AK 2		FIS-B
Increased access to terrain-constrained low altitude airspace	2.2	2001	9	End to End	U-AK? 3		?
Runway and Final Approach Occupancy Awareness (using ADS-B only)	6.1.1	2001	5	Pilot	Nasa? 5/2	6.2	---
Airport Surface Situational Awareness	6.2	2001	3	Pilot	Nasa? 5/2	6.1.1	? (TIS-B)
Enhanced Presentation of Surface Targets to Controller	7.1	2001	3	Controller	Tech-Ctr 3		Rcvr+ATM
Traffic Situational Awareness in Domestic Airspace	4.2	2000	2	Pilot	Nasa? 4		?
Final Approach Spacing	3.2	2001	2	End to End	I-Lab 5		? (TIS-B+)
Extended See-and-Avoid	5.2	2002	8	End to End	I-Lab 4		---
Flightpath Deconfliction *(was Strategic Conflict Resolution)*	4.3.2	2002	6	End to End	I-Lab 4		?
Expanded Surveillance Coverage in Terminal Areas without Radar	8.2	2002	4	Controller	Tech-Ctr 5		Rcvr+ATM
ADS-B Enhanced Terminal Radar	9.2	2002	3	Controller	Tech-Ctr 2		Rcvr+ATM
Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)	6.1.2	2002	3	Pilot	Nasa? 3		TIS-B
Enhanced IMC Airport Surface Operations	6.3	2002	2	End to End	Nasa? 4		?
Closer Climb & Descent in Non-Radar Airspace	5.1	2003+	2	End to End	I-Lab 2		---
Enhanced Parallel Approaches in VMC/MVMC	3.3	2003+	3	End to End	I-Lab 3/2	3.4	---
Departure Spacing in VMC	3.4	2003+	3	End to End	I-Lab 3/2	3.3	---
Surveillance Coverage at Airports without ASDE	7.2	2003+	2	Controller	Tech-Ctr 4		Rcvr+ATM
In-Trail Spacing in En Route Airspace	5.3	2003+	1				---
Merging in En Route Airspace	5.4	2003+	1				---
Passing Maneuvers in En Route Airspace	5.5	2003+	1				---
ADS-B Enhanced En Route Radar	9.1	2003+	1				Rcvr+ATM

The analysis described in Section 2 to arrive at the SafeFlight 21 schedule for evaluating the applications and enhancements is summarized in Table 3-3. Each application and its schedule will be discussed in the following sections.

Table 3-3. SafeFlight 21 OpEval Schedules

		Adoption			Benefit					OpEval Year					
	Application Name	Early	Middle	Late	High	Medium	Low	Hard (1-5)	Importance	Initial	SF21 StG	Schedule Feasibility	Lab Constraints	Detailed Planning /Budget	Stakeholder Buy-in
	Weather and Other Information to the Cockpit														
1.1.1	FIS-B (with NEXRAD, Lightning, METAR/TAF, and SIGMET/AIRMET products)	X			GA, Taxi	(Heavy)		1 (3)	10		2000	2000	2000		
1.1.2	FIS-B (with Icing, Turbulence, SUA-status, and Volcanic Ash products)	X			GA, Taxi	(Heavy)		2 (3)	10		2001	2001	2001		
	Cost Effective CFIT Avoidance														
2.1	Low cost terrain situational awareness	X			GA AK Taxi	Taxi		1	4	2000	2000	2000	2000		
2.2	Increased access to terrain-constrained low altitude airspace	X			GA AK Taxi			2	9		2001	2001	2001		
	Improved Terminal Operations in Low Visibility														
3.1.1	Enhanced Visual Approaches (Visual Acquisition w/o Positive ID procedures using ADS-B only)	X				Fleets		1-2	5	1999	1999	1999	1999	1999	1999
3.1.2	Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B only)	X				Fleets		1-2	5		2000	2000	2000		
3.1.3	Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B)	X				Fleets		3	4		2000	2000	2000		
3.2	Final Approach Spacing	(VMC)		IMC	Fleets	(Fleets)		(3) 4	2	2003+	2001	2001	2001		
3.3	Enhanced Parallel Approaches in VMC/MVMC		(MVMC)	IMC	Fleets			(3) 4	3	2003+	2002	2002	2003+		
3.4	Departure Spacing (VMC)	(VMC)		IMC			Fleets	(3) 4	3	2003+	2002	2002	2003+		
	Enhanced See and Avoid														
4.1.1	Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B only)		X			All Aircraft		1	7	1999	1999	1999	1999	1999	1999
4.1.2	Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B)	X				All Aircraft		2	7	2000	2000	2000	2000		
4.2	Traffic Situational Awareness in Domestic Airspace		X			All Aircraft		1	2	2000	2000	2001	2001		
4.3.1	Conflict Situational Awareness		X			Non-TCAS		3	6	2000	2000	2001	2000		
4.3.2	Flight-Path Deconfliction		X		Non-TCAS Fleets			5	6		2001	2002	2002		
	Enhanced En Route Air-to-Air Operations														
5.1	Closer Climb & Descent in Non-Radar Airspace		X			Oceanic AK		2	3	2001	2001	2001	2003+		
5.2	Extended See and Avoid			X	GA	Oceanic GoMex		4	8	2002	2001	2002	2002		
5.3	In-Trail Spacing in En Route Airspace		X				ATC Heavy	3	1	2003+	2003+	2003+	2003+		
5.4	Merging in En Route Airspace			X			ATC Heavy	3	1	2003+	2003+	2003+	2003+		
5.5	Passing Maneuvers in En Route Airspace			X			Heavy	3	1	2003+	2003+	2003+	2003+		
	Improved Surface Navigation for the Pilot														
6.1.1	Runway and Final Approach Occupancy Awareness (using ADS-B only)		X			All Aircraft		1	5	2001	2000	2001	2001		
6.1.2	Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)	X				All Aircraft		2	3	2001	2002	2002	2002		
6.2	Airport Surface Situational Awareness	X				Taxi, Heavy		2	3	2001	2001	2001	2001		
6.3	Enhanced IMC Airport Surface Operations			X	CAT-3 Autoland	Taxi, Heavy		3	2	2002	2002	2002	2002		
	Enhanced Surface Surveillance for the Controller														
7.1	Enhanced Presentation of Surface Targets to Controller		X			ATC		2	3	2002	2001	2001	2001		
7.2	Surveillance Coverage at Airports without ASDE			X		All Aircraft, ATC		3	2	2003+	2002	2002	2003+		
	ADS-B Surveillance in Non-Radar Airspace														
8.1	Expanded Surveillance Coverage in En Route Non-Radar Airspace		X			All Aircraft, ATC		2	4		2000	2000	2000		
8.2	Expanded Surveillance Coverage in Terminal Areas without Radar		X			All Aircraft, ATC		3	4	2001	2002	2002	2002		
	ADS-B Separation Standards														
9.1	ADS-B Enhancement of En Route Radar			X			ATC	3	1	2003+	2003+	2003+	2003+		
9.2	ADS-B Enhancement of Terminal Radar			X			ATC	3	3	2003+	2002	2002	2002		

3.2.1 Enhancement 1 – Weather and Other Information to the Cockpit

In geographic areas where Flight Information Service (FIS) is available, FIS is a good candidate for early adoption. FIS can provide immediate benefits to equipped aircraft independent of other aircraft's equipage. Use of FIS for weather situational awareness does not require changes in ATM procedures, and can begin based on modest confidence. This will support better avoidance of hazardous weather which is of particularly high benefit to aircraft without onboard weather radar: part 91 and 135 (GA and air taxi). This would also support beneficial optimization of routes for part 91 aircraft. (There is little analogous benefit for commercial aircraft that are supported by dispatchers.)

After additional experience, FIS may allow some relief from regulations on commercial aircraft. In the mid term, availability of current weather data may improve terminal operations by reducing the need for a ground observers at destination airports. Later, as confidence and coverage for FIS grow, it may benefit Part 121 operations by augmenting, providing back-up for, or even replacing expensive on-board weather radar.

Implementing FIS for applications that do not affect procedures appears straight forward, and reducing terminal observer requirements appears only incrementally more difficult. Changes to regulations for Part 121 would require experience levels and area coverage that are beyond the scope of SafeFlight 21.

For these reasons, FIS with current procedures should be operationally evaluated by FY00, with improvements in terminal operations operationally evaluated in FY01. The other FIS applications should be omitted by SafeFlight 21.

3.2.2 Enhancement 2 – Cost Effective CFIT Avoidance

- Significant early adoption potential
  - Benefits not dependent of overall equipage
- Identified primary area of concern in Alaska, significant GA concern elsewhere
  - Potential cost reduction for commercial aircraft: reduce need for radar altimeters
- Difficulty appears modest
  - Terrain data requirements for civil aviation not agreed upon

3.2.3 Enhancement 3 – Improved Terminal Operations in Low Visibility

This enhancement includes multiple applications that can be evaluated at different levels of sophistication in both procedures and underlying systems. The simplest is for enhanced visual approaches using CDTI for increased pilot situational awareness only. This use is advisory, with minimal impact on procedures. If the CDTI relies solely on ADS-B, benefits to typical users would accrue only when pair-wise equipage became significant. However, a special case of high equipage occurs at the hubs of equipped fleets that is magnified for cargo operations at night. In this case, benefits associated with (nearly) full equipage would be gained by equipping a hubbed fleet. The potential safety benefit to a non-TCAS fleet is at least moderate, and the potential efficiency benefit (regardless of TCAS) is also moderate from increased pilot confidence and faster response to traffic call-outs. This application is low difficulty, is a step-stone to other applications, and is given high priority: it will be operationally evaluated in 1999.

The potential efficiency benefits of pilot situational awareness can be expanded by small changes to procedures. Controllers would provide traffic call-outs with call signs, which match the CDTI and are confirmed by pilots. This difficulty of this change in procedures is modest; it should be operationally evaluated in 2000.

The availability of benefits can be expanded beyond the special case (hubs, night) by augmenting ADS-B with Traffic Information Service Broadcast (TIS-B) of radar surveillance data for use in CDTI. This enables immediate benefit to individual aircraft operating in the TIS-B coverage area before other aircraft are equipped. The potential for using TIS-B to accelerate the benefits of equipage is shared by other SF21 applications, and use of TIS-B here is a step-stone. The difficulty of specifying and developing an initial TIS-B appears to be modest. TIS-B may differ from ADS-B in accuracy and update-rate, and the difficulty of characterizing the impact of these differences on procedures and human-factors appears modest for enhanced visual approaches. This should be operationally evaluated in 2000.

Use of CDTI for final approach spacing is an IMC application that promises high benefits from increased predictability of operations, particularly in fleet and hub operations where the efficiency improvement for individual aircraft is compounded. IMC use requires very high confidence in the CDTI and supporting systems, extensions to the CDTI (such as spacing alerts and indication of velocity changes), and development and validating sophisticated procedures (including recovering from anomalies). These are difficult, and would be accepted only in the late phases of adopting ADS-B/CDTI technology. (The other IMC terminal applications appear equally difficult, and offer less benefit.) These IMC applications should not be planned for operational evaluation before 2003.

A step-stone toward IMC final approach spacing is to develop the CDTI extensions and use them as an aid to pilot awareness of spacing in VMC and marginal VMC. This offers moderate potential benefit at moderate difficulty, and can provide early adoption benefits for either cargo-hub or TIS-B situations. It builds upon enhanced visual approaches. VMC final approach spacing should be operationally evaluated in 2001.

Enhanced Parallel Approaches in VMC/MVMC - description of analysis not yet available.

3.2.4 Enhancement 4 – Enhanced See and Avoid

- Significant early adoption potential using TIS-B
  - Otherwise significant equipage needed for benefit
- Moderate benefit levels to all adopters
  - Conflict Situational Awareness benefits non-TCAS operations

- Difficulty is limited/moderate assuming TIS-B
  - Limited w/o TIS-B; Moderate to add Conflict / Traffic Alerts
- FY99 OpEval for CAA special-case; FY00 with TIS-B
  - Conflict / Traffic Alerts: FY01(algorithm development , confidence, integration w/ TIS-B)

3.2.5 Enhancement 5 – Enhanced En Route Air-to-Air Operations

- Little early adoption potential: benefits require significant occurrence of pair-wise equipage
  - Merging and passing maneuvers require high confidence
  - Cockpit-based separation: major revision of roles & procedures
- Moderate benefits for non-radar ops; small for radar airspace
- Difficulty moderate except for cockpit-based separation
- Non-radar ops: FY01; Cockpit separation: FY02(contingent on stakeholder sponsorship)
  - In-radar operations: >2002 (ATC workload, small benefit)

3.2.6 Enhancement 6 – Improved Surface Navigation for the Pilot

- Potential early adopt for VMC at Fleet/Hubs or with TIS-B
  - IMC operations require very high confidence
- Significant benefits to all aircraft
  - IMC ops: high benefit if equipped for zero visibility approach
- Limited to moderate difficulty
  - TIS-B, enhanced GPS, integration, increase system complexity
  - IMC needs high confidence, but recovery from operational anomaly is simplified (AC can stop). Maturity? <NASA>
- FY01 with ASDE/TIS-B and moving maps
  - FY00 for ADS-B -only runway/final - CAA special-case
  - FY02 for IMC (contingent on stakeholder participation)

3.2.7 Enhancement 7 – Enhanced Surface Surveillance for the Controller

- Little early adoption: benefits require significant equipage
  - Controller complexity / workload issues for mixed equipage
  - ADS-B as ASDE or for SMGCS needs near total equipage
- Benefit over ASR-ASDE fusion limited to gap fill; less w/mixed equip
  - Large Pseudo ASDE benefits rare, (largest needs met by ASDE)
- Moderate difficulty: very high confidence systems, and require procedures tolerant of almost full equipage
- ASDE/ADS-B fusion (for gap fill) on controller display: FY02(mixed equipage complexity/workload, limited benefit)
  - Fusion *processing* needed for TIS-B functions

- Other uses by controllers: >2002

3.2.8 Enhancement 8 – ADS-B Surveillance in Non-Radar Airspace

(Benefits from ops: surveillance analyzed with procedures)

- Reduced ATC comm and workload for procedural separation may begin in mid range of mixed equipage
  - With sufficient confidence, pseudo radar separation may also begin to be acceptable at mid equipage for pair-wise / group-wise separation at modest volume "one-in/one-out" airports
- Moderate difficulty: high confidence, mixed equipage ops.
- FY01 for surveillance and procedural separation, FY02 for "one-in/one-out" airports

3.2.9 Enhancement 9 – ADS-B Separation Standards

- Little early adoption: benefits require significant equipage
  - Controller surveillance benefit limited by complexity and workload impact of mixed resolution
  - Wake vortex: extremely high confidence at high complexity
- Benefits appear limited except for hypothetical capacity increases from wake-vortex
- Moderate difficulty (automation slightly easier)
  - Many unknowns and concerns on wake-vortex
- Assign to >2002: low benefit or high difficulty, no early adoption

3.3 Overview of the Test and Evaluation Master Plans (TEMPs)

3.3.1 Generic Tasks

Each cycle in the SafeFlight 21 process will include a set of tasks leading to the evaluation of the applications. The tasks shown in Table 2-1 are generic in that most or all of them apply to each application in the SafeFlight 21 program. The descriptions of these tasks can be found in Appendix B. The grouping of these tasks and many of the tasks themselves have been taken from the RTCA SC186 Working Group 1 draft template for ADS-B applications development. While these tasks have been developed for ADS-B applications, they are applicable to any new applications involving new procedures and new avionics.

3.3.2 Generic Tasks Schedule

There is a natural progression of these generic tasks through the development and evaluation of an application. As the generic schedule shows in Figure 2-6, it could take up to 3 years to define the operational concept of the application through operationally evaluating it. The actual length of time required for a task and the year in which the task will be accomplished will vary from application to application.

3.3.3 Application Schedules

Table 3-4 below summarizes the fiscal year by which the tasks described above should be completed for each of the SafeFlight 21 applications and partial applications. After assigning the most likely OpEval year, the generic schedule was applied to arrive at the dates in this table. For any given application the actual dates may be different. This will be reflected in the current year cycle plan section of this Master Plan as the Master Plan is up dated each year.

Table 3-4. Application Tasks Schedule

SF21 Tasks, Years, and Status (Updated 7-01-99)
Revised from 6-11 SF21-SIG Guidance
with gray OpEval years at "Flight Test Year"+1
g=done, y=working, r=not-started, b=unknown

Roadmap Enhancement	SF21 Ref	Application	OpEval Year	Operational Concept		Benefits & Constraints				Maturity of Concepts & Technology	Operational Procedures							Human Factors Issues (Pilot, Controller, Other)					End to End Performance & Tech Reqs				Interoperability Req for Air and Ground Systems				Operational Safety Assessment			Avionics and Ground Systems		Operational Test and Evaluation			
				1.1	1.2	2.1	2.2	2.3	2.4	3.1	4.1	4.2	4.3	4.4	4.5	4.6	4.7	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	7.1	7.2	7.3	7.4	8.1	8.2	8.3	9.1	9.2	10.1	10.2	10.3	10.4
1 Weather and Other Information to the Cockpit	1.1.1	FIS-B (with NEXRAD, Lightning, METAR / TAF, and SIGMET / AIRMET products)	2000	99	99	99	99	00	01	99	n/a	99	n/a	n/a	99	00	00	99	99	99	00	00	99	99	99	00	99	99	00	00	99	00	01	00	01	99	00	00	00
	1.1.2	FIS-B (with Icing, Turbulence, SUA status, and Volcanic Ash products)	2001	99	99	99	00	01	02	99	n/a	99	n/a	n/a	00	01	01	99	99	99	01	01	99	00	00	01	99	00	01	01	00	01	02	01	02	00	01	01	01
2 Cost Effective CFIT Avoidance	2.1	Low cost terrain situational awareness	2000	99	99	99	99	00	01	99	99	99	99	99	99	00	00	99	99	99	00	00	99	99	99	00	99	99	00	00	99	00	01	00	01	99	00	00	00
	2.2	Increased access to terrain-constrained low altitude airspace	2001	99	99	99	00	01	02	99	99	99	99	00	00	01	01	99	99	99	01	01	99	00	00	01	99	00	01	01	00	01	02	01	02	00	01	01	01
3 Improved Terminal Operations in Low Visibility	3.1.1	Enhanced Visual Approaches (Visual Acquis. w/o Positive ID procedures, ADS-B only)	1999	99	99	99	99	99	00	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	n/a	n/a	n/a	n/a	99	99	00	99	00	99	99	99	99
	3.1.2	Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B only)	2000	99	99	99	99	00	01	99	99	99	99	99	99	00	00	99	99	99	00	00	99	99	99	00	n/a	n/a	n/a	n/a	99	00	01	00	01	99	00	00	00
	3.1.3	Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B)	2000	99	99	99	99	00	01	99	99	99	99	99	99	00	00	99	99	99	00	00	99	99	99	00	99	99	00	00	99	00	01	00	01	99	00	00	00
	3.2	Final Approach Spacing	2001	99	99	99	00	01	02	99	99	99	99	00	00	01	01	99	99	99	01	01	99	00	00	01	99	00	01	01	00	01	02	01	02	00	01	01	01
4 Enhanced See and Avoid	4.1.1	Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B only)	1999	99	99	99	99	99	00	99	99	99	n/a	99	99	99	99	99	99	99	99	99	99	99	99	99	n/a	n/a	n/a	n/a	99	99	00	99	00	99	99	99	99
	4.1.2	Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B)	2000	99	99	99	99	00	01	99	99	99	n/a	99	99	00	00	99	99	99	00	00	99	99	99	00	99	99	00	00	99	00	01	00	01	99	00	00	00
	4.2	Traffic Situational Awareness in Domestic Airspace	2001	99	99	99	00	01	02	99	99	99	99	00	00	01	01	99	99	99	01	01	99	00	00	01	99	00	01	01	00	01	02	01	02	00	01	01	01
	4.3.1	Conflict Situational Awareness	2000	99	99	99	99	00	01	99	99	99	n/a	99	99	00	00	99	99	99	00	00	99	99	99	00	99	99	00	00	99	00	01	00	01	99	00	00	00
	4.3.2	Strategic Conflict Resolution	2002	00	00	00	01	02	03	00	00	00	00	01	01	02	02	00	00	00	02	02	00	01	01	02	00	01	02	02	01	02	03	02	03	01	02	02	02
5 Enhanced En Route Air-to-Air Operations	5.2	Extended See and Avoid	2002	00	00	00	01	02	03	00	00	00	00	01	01	02	02	00	00	00	02	02	00	01	01	02	n/a	n/a	n/a	n/a	01	02	03	02	03	01	02	02	02
6 Improved Surface Navigation for the Pilot	6.1.1	Runway and Final Approach Occupancy Awareness (using ADS-B only)	2001	99	99	99	00	01	02	99	99	99	99	00	00	01	01	99	99	99	01	01	99	00	00	01	99	00	01	01	00	01	02	01	02	00	01	01	01
	6.1.2	Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)	2002	00	00	00	01	02	03	00	00	00	00	01	01	02	02	00	00	00	02	02	00	01	01	02	00	01	02	02	01	02	03	02	03	01	02	02	02
	6.2	Airport Surface Situational Awareness	2001	99	99	99	00	01	02	99	99	99	99	00	00	01	01	99	99	99	01	01	99	00	00	01	99	00	01	01	00	01	02	01	02	00	01	01	01
	6.3	Enhanced IMC Airport Surface Operations	2002	00	00	00	01	02	03	00	00	00	00	01	01	02	02	00	00	00	02	02	00	01	01	02	00	01	02	02	01	02	03	02	03	01	02	02	02
7 Enh. Surface Surveillance for the Controller	7.1	Enhanced Presentation of Surface Targets to Controller	2001	99	99	99	00	01	02	99	99	n/a	99	00	00	01	01	99	n/a	99	01	01	99	00	00	01	99	00	01	01	00	01	02	01	02	00	01	01	01
8 ADS-B Surv. in Non-Radar Airspace	8.1	Expanded Surveillance Coverage in En Route Non-Radar Airspace	2000	99	99	99	99	00	01	99	99	n/a	99	99	99	00	00	99	n/a	99	00	00	99	99	99	00	99	99	00	00	99	00	01	00	01	99	00	00	00
	8.2	Expanded Surveillance Coverage in Terminal Areas without Radar	2002	00	00	00	01	02	03	00	00	n/a	00	01	01	02	02	00	n/a	00	02	02	00	01	01	02	00	01	02	02	01	02	03	02	03	01	02	02	02
9 ADS-B Sep. Stds.	9.2	ADS-B Enhancement of Terminal Radar	2002	00	00	00	01	02	03	00	00	00	00	01	01	02	02	00	00	00	02	02	00	01	01	02	00	01	02	02	01	02	03	02	03	01	02	02	02

Delayed due to current progress
Delayed due to lab resources

Table 3-5 contains the same information as Table 3-4 except it is sorted by the fiscal year in which the operational evaluation should be completed and by the importance of the application.

Table 3-5. Application Tasks Schedule Sorted by OpEval Year and Importance

SF21 Tasks, Years, and Status (7-07-99)
Revised from 6-11 SF21-SIG Guidance
with gray OpEval years at "Flight Test Year"+1
g=done, y=working, r=not-started, b=unknown

Ref. #	Application	OpEval Year	Importance	Operational Concept		Benefits & Constraints				Maturity of Concepts & Technology	Operational Procedures							Human Factors Issues (Pilot, Controller, Other)					End to End Performance & Tech Reqs				Interoperability Req for Air and Ground Systems				Operational Safety Assessment			Avionics and Ground Systems		Operational Test and Evaluation			
				1.1	1.2	2.1	2.2	2.3	2.4	3.1	4.1	4.2	4.3	4.4	4.5	4.6	4.7	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	7.1	7.2	7.3	7.4	8.1	8.2	8.3	9.1	9.2	10.1	10.2	10.3	10.4
4.1.1	Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B only)	1999	7	99	99	99	99	99	00	99	99	99	n/a	99	99	99	99	99	99	99	99	99	99	99	99	99	n/a	n/a	n/a	n/a	99	99	00	99	00	99	99	99	99
3.1.1	Enhanced Visual Approaches (Visual Acquis. w/o Positive ID procedures, ADS-B only)	1999	2	99	99	99	99	99	00	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	n/a	n/a	n/a	n/a	99	99	00	99	00	99	99	99	99
1.1.1	FIS-B (with NEXRAD, Lightning, METAR / TAF, and SIGMET / AIRMET products)	2000	10	99	99	99	99	00	01	99	n/a	99	n/a	n/a	99	00	00	99	99	99	00	00	99	99	99	00	99	99	00	00	99	00	01	00	01	99	00	00	00
4.1.2	Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B)	2000	7	99	99	99	99	00	01	99	99	99	n/a	99	99	00	00	99	99	99	00	00	99	99	99	00	99	99	00	00	99	00	01	00	01	99	00	00	00
4.3.1	Conflict Situational Awareness	2000	6	99	99	99	99	00	01	99	99	99	n/a	99	99	00	00	99	99	99	00	00	99	99	99	00	99	99	00	00	99	00	01	00	01	99	00	00	00
3.1.2	Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B only)	2000	5	99	99	99	99	00	01	99	99	99	99	99	99	00	00	99	99	99	00	00	99	99	99	00	n/a	n/a	n/a	n/a	99	00	01	00	01	99	00	00	00
2.1	Low-cost terrain situational awareness	2000	4	99	99	99	99	00	01	99	99	99	99	99	99	00	00	99	99	99	00	00	99	99	99	00	99	99	00	00	99	00	01	00	01	99	00	00	00
8.1	Expanded Surveillance Coverage in En Route Non-Radar Airspace	2000	4	99	99	99	99	00	01	99	99	n/a	99	99	99	00	00	99	n/a	99	00	00	99	99	99	00	99	99	00	00	99	00	01	00	01	99	00	00	00
3.1.3	Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B)	2000	4	99	99	99	99	00	01	99	99	99	99	99	99	00	00	99	99	99	00	00	99	99	99	00	99	99	00	00	99	00	01	00	01	99	00	00	00
1.1.2	FIS-B (with Icing, Turbulence, SUA-status, and Volcanic Ash products)	2001	10	99	99	99	00	01	02	99	n/a	99	n/a	n/a	00	01	01	99	99	99	01	01	99	00	00	01	99	00	01	01	00	01	02	01	02	00	01	01	01
2.2	Increased access to terrain-constrained low altitude airspace	2001	9	99	99	99	00	01	02	99	99	99	99	00	00	01	01	99	99	99	01	01	99	00	00	01	99	00	01	01	00	01	02	01	02	00	01	01	01
6.1.1	Runway and Final Approach Occupancy Awareness (using ADS-B only)	2001	5	99	99	99	00	01	02	99	99	99	99	00	00	01	01	99	99	99	01	01	99	00	00	01	99	00	01	01	00	01	02	01	02	00	01	01	01
6.2	Airport Surface Situational Awareness	2001	3	99	99	99	00	01	02	99	99	99	99	00	00	01	01	99	99	99	01	01	99	00	00	01	99	00	01	01	00	01	02	01	02	00	01	01	01
7.1	Enhanced Presentation of Surface Targets to Controller	2001	3	99	99	99	00	01	02	99	99	n/a	99	00	00	01	01	99	n/a	99	01	01	99	00	00	01	99	00	01	01	00	01	02	01	02	00	01	01	01
3.2	Final Approach Spacing	2001	2	99	99	99	00	01	02	99	99	99	99	00	00	01	01	99	99	99	01	01	99	00	00	01	99	00	01	01	00	01	02	01	02	00	01	01	01
4.2	Traffic Situational Awareness in Domestic Airspace	2001	2	99	99	99	00	01	02	99	99	99	99	00	00	01	01	99	99	99	01	01	99	00	00	01	99	00	01	01	00	01	02	01	02	00	01	01	01
5.2	Extended See and Avoid	2002	8	00	00	00	01	02	03	00	00	00	00	01	01	02	02	00	00	00	02	02	00	01	01	02	n/a	n/a	n/a	n/a	01	02	03	02	03	01	02	02	02
4.3.2	Strategic Conflict Resolution	2002	6	00	00	00	01	02	03	00	00	00	00	01	01	02	02	00	00	00	02	02	00	01	01	02	00	01	02	02	01	02	03	02	03	01	02	02	02
8.2	Expanded Surveillance Coverage in Terminal Areas without Radar	2002	4	00	00	00	01	02	03	00	00	n/a	00	01	01	02	02	00	n/a	00	02	02	00	01	01	02	00	01	02	02	01	02	03	02	03	01	02	02	02
9.2	ADS-B Enhancement of Terminal Radar	2002	3	00	00	00	01	02	03	00	00	00	00	01	01	02	02	00	00	00	02	02	00	01	01	02	00	01	02	02	01	02	03	02	03	01	02	02	02
6.1.2	Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)	2002	3	00	00	00	01	02	03	00	00	00	00	01	01	02	02	00	00	00	02	02	00	01	01	02	00	01	02	02	01	02	03	02	03	01	02	02	02
6.3	Enhanced IMC Airport Surface Operations	2002	2	00	00	00	01	02	03	00	00	00	00	01	01	02	02	00	00	00	02	02	00	01	01	02	00	01	02	02	01	02	03	02	03	01	02	02	02
3.3	Enhanced Parallel Approaches in VMC/MVMC	—	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3.4	Departure Spacing (VMC)	—	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.1	Closer Climb & Descent in Non-Radar Airspace	—	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	n/a	n/a	n/a	n/a	-	-	-	-	-	-	-	-	-
7.2	Surveillance Coverage at Airports without ASDE	—	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.3	In-Trail Spacing in En Route Airspace	—	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.4	Merging in En Route Airspace	—	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.5	Passing Maneuvers in En Route Airspace	—	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9.1	ADS-B Enhancement of en Route Radar	—	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Delayed due to current progress
Delayed due to lab resources

3.3.4 Task Schedules for Each Test and Evaluation Master Plan

With each cycle corresponding roughly to the fiscal year and each Test and Evaluation Master Plan addressing those applications to be evaluated in either the Ohio Valley or Alaska it is appropriate to refer to each TEMP as the Ohio Valley (or Alaska) xxxx TEMP where xxxx stands for 1999, 2000, 2001 or 2002. From Table 3-5 one can lay out the tasks that should be addressed in each TEMP. With the evaluation activities centering in the Ohio Valley and Alaska, one can also determine from Table 3-5 which tasks need to be completed in a particular year for each application in a location (Ohio Valley or Alaska) so that the operational evaluation of that application remains on schedule. The schedule of these tasks have been laid out in Appendices C through J according to Table 3-6.

Table 3-6. Task Schedules for Each Location and Year

	1999	2000	2001	2002	2003
Ohio Valley	Appendix C	Appendix D	Appendix E	Appendix F	Appendix G
Alaska	Appendix H	Appendix I	Appendix J	Appendix K	Appendix L

3.4 Related (Non-SafeFlight 21) Activities

3.4.1 DFW

There is an effort to use ADS-B to track vehicles on the airport surface. *More complete explanation TBD.*

3.4.2 SFO

The FAA is in the process of signing a CRDA with United Airlines to develop close spaced approaches based on an ADS-B procedure. *More complete explanation TBD.*

3.4.3 Gulf of Mexico

This has to do with oil rig helicopters using ADS-B for situational awareness (and also the ground controllers using ADS-B for flight following?) *More complete explanation TBD.*

3.5 Cross-Cutting Activities

3.5.1 Link Evaluation

TBD

3.5.2 Definition of Synergistic Sets of Applications

TBD

3.5.3 Assessment of Stakeholder Implementation Cases

TBD

Section 4

FY99 Cycle Plan

This section of the SF21 Master Plan describes FY99 activities to evaluate the nine enhancements defined by the Joint Industry Government Roadmap for Free Flight Operational Enhancements.

This *Cycle Plan* is organized according to spiral planning concepts. Subsection 4.1 is an *Estimate of the Situation* for SF21 that provides the current context – from which actions can be taken. Subsection 4.2 is *Risk Analysis* to identify issues requiring action and describe strategies to address them. The following subsections are *Plans* based on these issues and strategies: 4.3 and 4.4 describe actions leading to the FY99 Ohio Valley Operational Evaluation and to the Alaska Demonstration (respectively), and 4.5 describes FY99 actions leading to OpEvals in future years. The final subsection, 4.6, illustrates potential needs to *Update the Spiral Plan* that may be identified when the results of FY99 actions are known.

4.1 Estimate of the Situation

Planning for FY99 depends on knowing the current situation. This includes the status of SF21, its objectives for FY99, the interests of stakeholders as they relate to these objectives, and constraints on how these objectives can be addressed.

4.1.1 Summary of SafeFlight 21 Status

SafeFlight 21 has established effective collaboration between industry, user and government stakeholders and participants. When SF21 was established, efforts on the Alaska Capstone initiative and the CAA Ohio Valley OpEval were already underway before formal planning documents for SF21 existed. These efforts have expanded collaboratively, and progress has been made in parallel on both planning and execution of the program. This summary of status incorporates the results of work through May 1999. These results are taken into account in defining the SF21 program for the remainder of the year.

Planning

As described in Section 2 above, planning for SF21 is undertaken at multiple levels. The top level of this planning is reflected in this Master Plan. More detailed levels of planning are refected in Test and Evaluation Master Plans and in the FAA's Systems Engineering Management Plan.

The consensus described in the original RTCA Roadmap has been significantly broadened and deepened, and much of this is described in the SF21 Master Plan. Collaborative organizational structures and roles and responsibilities have been established, and the SF21

Steering Committee (including its Tech/Cert subgroup) and the OCG are working effectively. The Cost/Benefit and Operations/Procedures subgroups of the steering committee are getting started. Consensus on the scope and specifics of applications within the 9 enhancements has largely been achieved, but details on FIS and CFIT avoidance applications are yet to be agreed upon. There is a broader understanding of the development and evaluation status of the different applications, and there is an emerging consensus on the relative priorities and high-level time-frame for their full evaluation. Initial efforts at using a generic (template-of-tasks based) scheme as a schedule start-point are underway, but this has not yet been validated or the results broadly agreed to. Validation of priorities in terms of strategic (or latent) benefit, synergies, program resources, and the needs of consensus, is pending. The mechanics of risk management to be used by SF21 are also pending. Consensus on over-all planning strategy (spiral planning) is established.

Plans for the 1999 Ohio Valley Operational Evaluation are nearing completion, including both the activities leading up to operational flight evaluations, and the flight evaluations themselves. This planning, as captured in the TEMP, will be fully adequate for enabling successful activities.

Plans for 1999 demonstrations in Alaska are evolving. The primary focus of efforts for Alaska is acquisition of capabilities that promise immediate safety and efficiency benefits based on lower-risk / obvious-benefit applications. Because of this, less formalized analysis and planning have been adequate to date. This exists in the form of a high-level program plan and supporting briefings. Development of a TEMP for the 1999 Alaska activities is pending.

Execution

TBD

4.1.2 Objectives for the FY99 Cycle

4.1.2.1 Ohio Valley Objectives

There are three phases to the Cargo Airline Association's program supporting SafeFlight 21 in the Ohio Valley. Only Phase I Initial where only 12 CAA member aircraft will be equipped is being pursued in FY99. The primary objectives for this phase are:

P1 Validate/Support the request for FAA operational approval for fleetwide equipage of the CDTI for use as a tool for the following ADS-B application:

- Enhanced visual acquisition of other traffic for "see and avoid"

P2 Obtain credit towards future request for FAA operational approval for the following additional applications:

- Airport surface situational awareness (VFR & Night)

- Departure spacing
- In trail climb and descent (ITC/ITD) in oceanic, en route, and remote non-radar airspace
- Lead climb and descent (LC/LD) in oceanic, en route, and remote non-radar airspace
- Station keeping in oceanic, en route and remote non-radar airspace
- Traffic situational awareness in all airspace
- Final approach spacing
- Enhanced visual approaches

P3 Provide RF data link performance data as required to support the fleetwide equipage data link configuration selection.

In addition, the CAA is very interested in supporting other research, development and implementation of ADS-B applications. Accordingly, two secondary objectives have also be identified:

S1 Demonstrate ADS-B/CDTI feasibility for application in additional Free Flight Operational Enhancements as listed in the RTCA Free Flight Select Committee Special Report

S2 Provide opportunity for non-CAA activities to capitalize on the OpEval environment to display additional ADS-B enhancements or supporting technologies in order to broaden support base/industry consensus.

4.1.2.2 Alaska Objectives

The first objective of the Capstone Program in Alaska is to improve aviation system safety, capacity, and efficiency through the introduction of new communications, navigation, and surveillance (CNS) technologies that enable pilots to cope with weather and terrain hazards and potential traffic conflicts.

The second objective is to provide answers to technical and cost/benefit questions that are needed to enable decision makers in the FAA and industry to make key new CNS technology choices.

4.1.3 Stakeholders

4.1.3.1 Ohio Valley Stakeholders

The Ohio Valley stakeholders are listed in Table 4-1.

Table 4-1. Ohio Valley Stakeholders[8]

Stakeholder	Interest
CAA	Project Leadership/Coordination
FedEx	Test Operations
UPS	Test Operations, Public Relations
Airborne Express	Facilities, Radios, Maintenance, Fuel, Public Relations, Computers, Flight Safety, Flight Control, Ground Safety, Ramp
AND-500	SafeFlight 21 Program Management, Public Relations, Planning
MITRE/CAASD	Test Operations, Ground Station, Human Factors, Technical/Certification, Planning
ATO-400	Air Traffic Control
Lockheed Martin	Test Operations, Ground Station, Public Relations
NASA	Test Operations, Human Factors
AOPA	Test Operations, Planning
ACT-370	Test Operations, Ground Station, Safety
AFS	Test Operations
ATO-410	Test Operations, Air Traffic Control
Dayton TRACON	Air Traffic Control
Airborne Pilot Union	Test Operations, Facilities
FedEx Pilot Union	Test Operations
ILN Controllers	Facilities, Air Traffic Control
ZID Controllers	Air Traffic Control
NATCA	Air Traffic Control, Test Operations
ARW-100	Air Traffic Control
Harris	Ground Station
Sensis	Ground Station
Trios	Ground Station, Planning
II Morrow	Cockpit Avionics
PMEI	Technical/Certification
EUROCAE	Technical/Certification
MIT/LL	Technical/Certification

[8] CAA/SF21 Test & Evaluation Master Plan (TEMP), Version 3.0, March 17, 1999.

Swedavia	Technical/Certification
AIR	Technical/Certification
ASD	Technical/Certification
ASR	Technical/Certification

4.1.3.2 Alaska Stakeholders

The Alaska stakeholders are listed in Table 4-2.

Table 4-2. Alaska Stakeholders[9]

Stakeholder	Interest
AAL-1	Capstone Program Management
AAL-7	Legal
AAL-40	Budget
AAL-200	Flight Standards
AAL-300	Medical
AAL-400	Airway Facilities
ANI-700	
AAL-500	Air Traffic
AAL-600	Airports
ACE-115	Engineering
AND-470	SafeFlight 21 Program Management
AUA-200	MicroEARTS modifications
Avionics Manufacturers	Cockpit Avionics
Weather Providers	FIS data
NASA	CDTIs
DoD	SUA coordination
Alaska DOT	Alaskan Transportation
Alaskan Air Carrier	Commercial Users
Alaskan Airmen’s	Pilots
Alaskan Air Safety	Safety
AOPA	General Aviation Users
ALPA	Pilots
University of Alaska	Training

9 Capstone Program Plan, Version 1.0, March 10, 1999.

4.1.4 Constraints

TBD

4.2 Risk Analysis

4.2.1 Critical Risks, Issues, and Dependencies

TBD

4.2.2 Risk Management Strategies

TBD

4.3 Planning for '99 Ohio Valley Operational Evaluation

4.3.1 Program Planning

The Ohio Valley effort has been organized into several teams under the guidance of the OpEval Coordination Group (OCG). The working groups are: Test Operations, Air Traffic Control, Ground Station Integration, Facilities, Human Factors, Technical/Certification, Cost/Benefit, Safety and Media. There has also been a Flight Test Director identified. Figure 4-1 shows a schedule for the activities supporting the Ohio Valley Operational Evaluation.

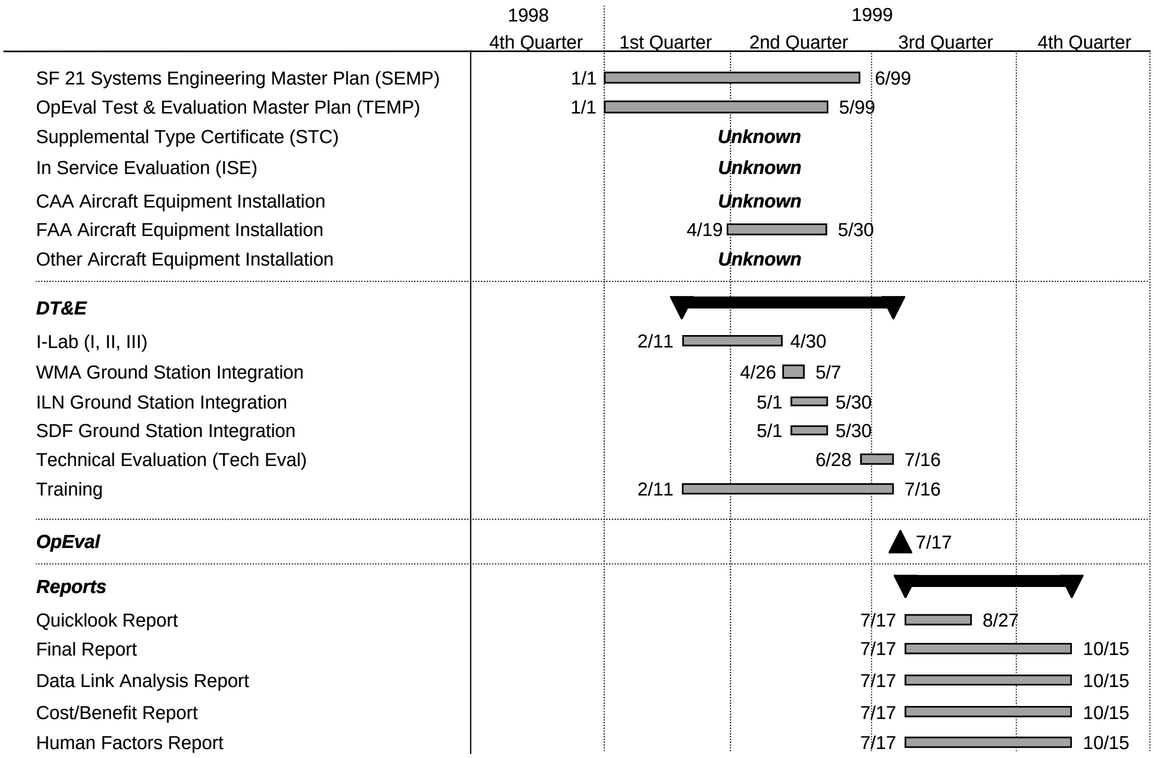

Figure 4-1. Ohio Valley FY99 Schedule

4.3.2 Development Planning

Prior to the Operational Evaluation, the application specific procedures and scenarios that will be flown need to be developed and tested. The planning that has been done provides for a number of interactive simulations to test the procedures and cockpit instrumentation. There will also a number of DT&E tests of the airborne ADS-B equipment that have been planned. The data collected during the evaluation will use an ADS-B ground station. This system will also be tested. After each of these components have been satisfactorily tests, several integration test will be performed. These include ground tests and overflight tests to test coverage and end-to-end performance. There will also be a technical evaluation to gather data in support of the data link comparison (since multiple data links will be used) and to verify the operational maneuvers to be performed during the OpEval day. The pilots also will be trained on the procedures.

4.3.3 Evaluation Planning

Even though the evaluation is not directly evaluating new procedures, it will collect data supporting the development and operational approval of new procedures. The scenarios that will be flown need to be scripted and the success criteria identified. The scheduling of the facilities, the specific aircraft and the interface with the media are being planned as well as the identification of the responsible parties for each element of the evaluation.

4.4 Planning for '99 Alaska Demonstrations

4.4.1 Program Planning

The Capstone Program Office has been formed under the direct authority of the Alaskan Regional Administrator. The office has been staffed with a program manager and other staff. This staff has written the Capstone Program Plan (Version 1.0, March 10, 1999) and has developed the program schedule shown in Figure 4-2. Coordination with the SafeFlight 21 Program Office is being accomplished.

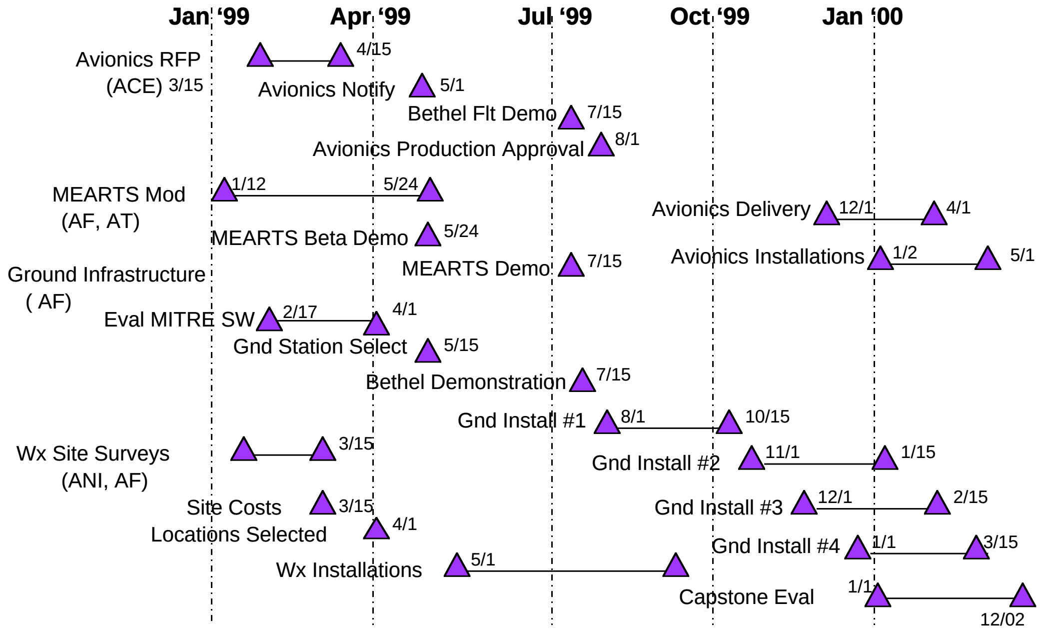

Figure 4-2. Alaska FY99 Schedule

4.4.2 Development Planning

The primary development activities involve buying avionics and getting them installed on 200 aircraft that will fly into several airports in Alaska and be shown on a MicroEARTS radar screen. Leading up to this, ten airports have been identified for IFR operations in the Capstone Program. GPS surveys have been completed at these ten airports. A request for information (RFI) has been released to avionics manufacturers and the MicroEARTS contract has been modified to develop software to display ADS-B position reports. Coordination with the community has taken place with a town meeting at Bethel.

The Capstone Program is currently in the process of making siting assessments for the weather equipment. A Request for Offer (RFO) for avionics has been released and the offers are being evaluated with results in the near future. A survey of the aircraft that will be using these avionics is being conducted. Discussions have started with the University of Alaska concerning the training program that they will run and the safety assessment that they will perform to support the Capstone Program.

4.4.3 Evaluation Planning

Since the Capstone program is in its “acquisition phase” and the first Alaska Operational Evaluation is in 2000, minimal progress has been made toward the development of the Test and Evaluation Master Plan.

4.5 Planning for ’99 Activities to Support Future Operational Evaluations

TBD

4.6 Updating the Spiral Plan

TBD

Appendix A

SafeFlight 21 Operational Enhancements and Applications

The following lists the nine enhancements from the RTCA roadmap document, the associated applications and a description of each application in terms of a high level operational concept.

1 Weather and Other Information to the Cockpit

1.1.1 FIS-B (with NEXRAD, Lightning, METAR/TAF, and SIGMET/AIRMET products)

The FIS-B application provides in-flight information for pilots presented in the form of graphics or text on a multi-function cockpit display. The information included in the initial phase of FIS-B is based on products that exist today. For VFR operation this includes ceiling, visibility, winds and temperatures aloft, and hazardous weather advisory areas. For IFR operation this also includes convective weather, precipitation, lightning.

1.1.2 FIS-B (with Icing, Turbulence, SUA-status, and Volcanic Ash products)

The second phase of FIS-B is based on information and products that are not yet readily available or distributed. Graphical icing products will be highly valuable in Alaska and in CONUS. Real-time SUA status graphics will aid in extended VFR operations. Volcanic ash information will benefit aircraft operating in potential hazard areas including Alaska and the Aleutian chain and the Pacific Northwest.

2 Cost Effective CFIT Avoidance

2.1 Low cost terrain situational awareness

Display to pilots the position of terrain and obstacles relative to their aircraft based on GPS in combination with an affordable on-board data-base. Multiple levels of display capability may be warranted, including incorporation of terrain and obstacles on a multi-function display.

2.2 Increased access to terrain-constrained low altitude airspace

In most cases, the tools used by small aircraft pilots for awareness of terrain and obstacles are limited to maps and visual identification. Automated display and alerting functions based on GPS-navigation and on-board terrain/obstacle data-bases should improve the accuracy and reliability of judging the separation from terrain and obstacles while decreasing the workload of pilots for this task. This may make practical the safe operation of aircraft at smaller separation from terrain and obstacles, which would increase access to airspace that is constrained by these.

3 Improved Terminal Operations in Low Visibility

3.1.1 Enhanced Visual Approaches (Visual Acquisition w/o Positive ID procedures using ADS-B only)

This application uses CDTI based on ADS-B to aid in the transition to a visual approach, enabling the procedure to be used more often and more efficiently. Visual approaches are the backbone of operations at major airports in the US and in certain other parts of the world. During visual approaches, traffic advisories are issued to pilots, and once the pilot confirms acquisition of traffic, a visual approach clearance is issued. The process of issuing traffic advisories and waiting for confirmation is more workload intensive than if visual approaches were not conducted; however in current operations the increase in pilot and controller workload is accepted because of the significant gains in capacity. Most facilities have specific established minima to which visual approaches can be conducted; however, specific environmental conditions such as haze, sun light, and patchy clouds may result in the suspension of visual approaches at higher ceiling and visibility values. CDTI may help enhance visual approach operations in one of several ways including:

- Improved visual traffic acquisition
- Reduction in pilot and controller workload
- Reliably conducting visual operations to established minima
- Reducing the minima to which visual approaches are conducted

This first phase of the application avoids significant changes to ATM communications procedures by not including traffic call-outs by controllers using the flight ID shown on CDTI and ATC displays.

3.1.2 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B only)

This second phase of the application extends current pilot/controller procedures for visual approaches to take explicit advantage of the positive identification of traffic that is supported by ADS-B/CDTI. This is expected to further enhance the safety and efficiency of visual approaches.

3.1.3 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B)

In this third phase of the application, non-equipped aircraft appear on the CDTI based on a Traffic Information Service Broadcast of ground radar-based data. This makes the application more broadly usable in situations of mixed equipage.

3.2 Final Approach Spacing

The approach spacing task involves station keeping at or near minimum radar separation standards. There is some evidence that pilots are already utilizing the existing TCAS traffic displays for some degree of self-spacing on final approach. This CDTI application (based on ADS-B and possibly TIS-B) would provide tools to conduct such a procedure adequately. The pilot may receive radar vectors from ATC to intercept the final approach course, and at an appropriate time, a desired spacing interval at the threshold or final approach fix behind the preceding arrival will also be issued by approach control. The pilot would identify the aircraft ahead by flight identification, azimuth, distance, and altitude as called by ATC and verified on own aircraft's traffic display. The pilot would then modify the own aircraft's speed as necessary to establish the desired interval and to match the speed profile of the lead aircraft. Optimized protect from wake vortex induced by the lead aircraft is a critical consideration that may be improved by further enhancements to the CDTI.

3.3 Enhanced Parallel Approaches in VMC/MVMC

During visual approaches to parallel runways the controller will point out traffic to both runways the to the pilot. Once the pilot confirms visual acquisition of the preceding traffic on own runway and (if the runways are separated by less than 4300 feet) visual acquisition of the traffic on the parallel runway, a visual approach clearance is issued. If a visual approach cannot be conducted the controller must provide the appropriate radar separations. The use of CDTI based on ADS-B and possibly TIS-B will be used to assist the pilot in acquiring and identifying the other traffic so that visual approaches to parallel runways can be made more often in VMC and MVMC.

3.4 Departure Spacing (VMC)

Often minimum spacing is not obtained on departure because of controller workload, pilot response time, and/or limitations of radar surveillance. However, if CDTI can aid pilots in departing and maintaining spacing behind a leading aircraft, the controller may be able clear the aircraft for departure based on CDTI spacing and gain additional throughput over the departure routes.

4 Enhanced See and Avoid

4.1.1 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B only)

A primary task for pilots is to maintain awareness of nearby air traffic by maintaining a constant visual scan. If traffic is sighted, the pilot must first assess the threat posed by the intruder aircraft then, if necessary, maneuver to avoid the other aircraft. This strategy for collision avoidance is termed "see-and-avoid." The effectiveness of see-and-avoid depends on the ability of a pilot to visually acquire the intruder aircraft early enough in the encounter to enable threat assessment and avoidance. A CDTI based on ADS-B assists the pilot with see-and-avoid by providing a display of nearby equipped traffic.

4.1.2 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B)

This is an extension of Enhanced Visual Acquisition of Other Traffic for See And Avoid w/ADS-B/CDTI Only. In those areas where significant numbers of aircraft are not ADS-B equipped, the effectiveness of using ADS-B only for acquisition of traffic will be very limited. With the introduction of TIS-B the position and estimated ground speed of the other traffic that is known to the controller can be supplied to the pilot. This will assist the pilot with see-and-avoid by providing a display of all the nearby traffic within the area supported by TIS-B.

4.2 Traffic Situational Awareness in Domestic Airspace

With the ability to display equipped proximate aircraft, the CDTI may be used as a situational awareness tool. Traffic situational awareness is a basic function of a traffic display, however, display capabilities and requirements may vary depending on the operational domain. For example, in the approach domain a pilot would need to distinguish arriving aircraft and other traffic in relation to the airport and approach paths.

4.3.1 Conflict Situational Awareness

This application builds on the safety benefits of using CDTI for traffic situation awareness by providing a Traffic Alert (TA) function that warns pilots of potential conflicts, enabling coordinated action to be taken to avoid the conflict.

4.3.2 Strategic Conflict Resolution

This second phase of the application allows for expedited recovery from conflict events by advising maneuvers to resolve the conflict.

5 Enhanced En Route Air-to-Air Operations

5.1 Closer Climb & Descent in Non-Radar Airspace

CDTI based on ADS-B would enhance the climb and descent procedures when one aircraft wishes to climb or descend through the flight level occupied by another aircraft in non-radar airspace. The current separations for climbs and descents range from 10 nmi to 10 minutes depending how far the aircraft are from fixes or whether they are using DME. With ADS-B these procedures could be tightened up allowing the aircraft to reach their desired altitude faster and minimize fuel burn.

5.2 Extended See and Avoid

This application would allow for the responsibility of separation to shift from the controller to the pilots. With both aircraft equipped with ADS-B/CDTI the controller would instruct the flight crew to maintain a specific distance from a lead aircraft prior to entering the non-radar airspace. After assuring that both aircraft have each other "in sight on the CDTI", the separation responsibility is transferred to the pilots as they enter the non-radar airspace.

5.3 In-Trail Spacing in En Route Airspace

Current ATC practices often utilize control instructions to establish and maintain specific miles-in-trail distances at chosen fixes or boundaries for smoothing air traffic flows. This CDTI application (based on ADS-B and possibly TIS-B) anticipates providing increased operational flexibility to pilots and reduced workload for the controller by allowing the pilot to establish these in-trail distances. It anticipates the pilot of one aircraft to use a speed adjustment to change the current in-trail spacing behind a lead aircraft to an ATC-specified value, and then match the known speed of the lead aircraft. Initially, after the interval and speed have been established, track monitoring of the desired interval and separation would continue to be an ATC responsibility. Later, the pilot would be given the responsibility for maintaining this separation. The application requires the use of spacing intervals greater than the minimum separation standards. The benefits are expected to be more accurate in-trail intervals in traffic flows, reduced controller workload, potential fuel savings, and greater pilot involvement with the air traffic control process in planning and execution, resulting in improved situational awareness. Improved spacing to better manage wake turbulence from lead aircraft may be possible with CDTI enhanced for that purpose.

5.4 Merging in En Route Airspace

The merging aid application of CDTI (based on ADS-B and possibly TIS-B) is similar to establishing an in-trail spacing interval; however, it consists of the more dynamic task of establishing an interval while merging onto a track in relation to another aircraft. This could be a vertical or a lateral merge. Potential benefits may be reduced controller workload and increased flexibility for the pilot.

5.5 Passing Maneuvers in En Route Airspace

More efficient operations can be accomplished between mixed-performance aircraft by use of passing maneuver. Applications of CDTI (based on ADS-B and possibly TIS-B). These applications include allowing climbs or descents between aircraft that are within standard separation and slowly converging to the same route. Lateral passing would allow a higher performance aircraft to pass a slower and lower performance aircraft. These applications would help efficiency and potentially capacity in the airspace.

6 Improved Surface Navigation for the Pilot

6.1.1 Runway and Final Approach Occupancy Awareness (using ADS-B only)

This application uses CDTI (based on ADS-B) to provide pilots on final approach and on the runway with awareness of other aircraft that are on or approaching the runway. This initial phase of the application provides awareness only of equipped aircraft, and will be of benefit primarily in situations where all or nearly all aircraft are equipped. This application will be evaluated initially based on the capabilities of un-augmented GPS and basic CDTI.

6.1.2 Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)

This second phase of the application expands the usefulness of the application to include situations with significant numbers of non-ADS-B-equipped aircraft. The ADS-B data to the CDTI is augmented with TIS-B data from ground-based terminal and surface radar, enhancing pilot awareness of equipped and non-equipped aircraft, vehicles, and obstructions.

6.2 Airport Surface Situational Awareness

This application is intended to aid pilot situational awareness by alerting the pilot to the presence of other aircraft, vehicles, and obstacles around the airport surface using CDTI (based on ADS-B and possibly TIS-B). It is not, however, intended to replace visual navigating the airport surface. Display requirements would include an overlay map of the airport. LAAS would not be required for this application.

6.3 Enhanced IMC Airport Surface Operations

IMC surface operations with CDTI builds on the surface situational awareness application to allow maneuvering around an airport using a traffic/map display while in IMC. Visual acquisition of proximate aircraft, vehicles, and obstacles may be required. However, potentially all navigation may be performed solely with a traffic/map (based on on-board databases, ADS-B and possibly TIS-B).

7 Enhanced Surface Surveillance for the Controller

7.1 Enhanced Presentation of Surface Targets to Controller

Equip aircraft and ground vehicles in the airport movement area with ADS-B using augmented GPS-derived positions that are received by ground automation. For those locations with ASDE this will provide the position, identification, and speed of all equipped aircraft and fill gaps in ASDE coverage. The local and ground controllers in the tower would then monitor the position and speeds of all the traffic.

7.2 Surveillance Coverage at Airports without ASDE

Airport Surveillance Detection Equipment (ASDE) provides increased safety at airports during low visibility conditions by monitoring aircraft positions and reducing the chance of collisions on the surface. ADS-B and multilateration of other radars could be cost effective means of implementing ASDE-like capabilities at airports without ASDE. This would increase safety monitoring, enhance crash, fire, and rescue capabilities, as well as improve ground ATC.

8 ADS-B Surveillance in Non-Radar Airspace

8.1 Expanded Surveillance Coverage in En Route Non-Radar Airspace

There are large portions of non-radar airspace in the lower altitudes of the domestic en route environment as well as in remote areas inside and outside the US. ADS-B could provide a cost effective alternative for extending surveillance coverage in this airspace. This would increase safety as well as improve capacity by allowing radar-like separation standards.

8.2 Expanded Surveillance Coverage in Terminal Areas without Radar

With adequate ADS-B aircraft equipage and ground receivers, “pseudo” radar-separation can be applied by the controller between ADS-B equipped aircraft pairs on approach or departure from non-radar airports. Without changing current procedures or separation standards, the tower controller could monitor the progress and conformance of aircraft on non-radar procedural approaches. This application would help eliminate 1-in 1-out airports as well as reduce holding while awaiting descent/approach clearance. This could create “pseudo” Class D airspace control via ADS-B remote to TRACONs and Centers. Assuming pair wise equipage, “pseudo” radar-separation may be applied throughout airspace and would result in increased airline productivity (especially for regionals) due to more efficient ATC.

9 ADS-B Separation Standards

9.1 ADS-B Enhancement of En Route Radar

The current en route primary radar and SSR systems could benefit from the fusion of ADS-B surveillance information. This augmenting of the current system would provide an independent source for verifying radar surveillance as well as provide more accurate surveillance data, higher update rates, and additional intent information. This better information may enable improved conflict alerting to controllers and/or the reduction of separation standards and hence increase airspace safety, capacity and throughput.

9.2 ADS-B Enhancement of Terminal Radar

The current terminal primary radar and SSR systems could benefit from the fusion of ADS-B surveillance information. This augmenting of the current system would provide an independent source for verifying radar surveillance as well as provide more accurate surveillance data, higher update rates, and additional intent information. This better information may enable improved conflict alerting to controllers and/or the reduction of separation standards and hence increase airspace safety, capacity and throughput.

Appendix B

Generic Tasks for Developing and Evaluating Applications

The generic tasks mentioned in the body of this Master Plan are defined in Table B-1.

Table B-1. Generic Task Definitions

1 Operational Concept

1.1	Define Operational Concept	SF21 program to provide technical and operational support to RTCA special committees and working groups defining operational concepts for some SF21 applications. Product is extensions to the relevant operational concept documents (or new concept documents) needed to define operational roles and responsibilities, procedures.
1.2	System Functionality	Drawing on the Ops Concept, identify and characterize the systems and functionality required to support the application, and propose an initial functional decomposition that assigns functions to systems. Coordinate the proposed functionality and decomposition with the cognizant RTCA special committee. Incorporate these descriptions into a preliminary functional specification.

2 Benefits & Constraints

2.1 Cost/Benefit Estimates and Parameters	Develop plans for operational analysis, performance metrics, data collection, and identify the tools and models necessary to analyze the application. Identify the constraints and parameters affecting the analysis and how these constraints and parameters should be characterized (through additional measurement and analysis) to more accurately estimate benefits as the application is further developed and evaluated. Perform high-level analysis of the costs and benefits of the application by estimating potential avionics and systems costs and by estimating potential benefit outcome metrics to service providers and users of the airspace system. Coordinate the analysis with metrics/benefits experts/organizations such as the C/AFT and AOPA. Estimates of potential benefit will be used by the SF21 Steering Group in updating SF21 applications priorities, and by the FAA in considering potential funding profiles for future implementation. The constraints and parameters that need to be characterized will be used in planning application development and evaluation activities.

2.2 Quantitative Costs and Benefits	Perform detailed investment analysis of costs and benefits, taking into account information on constraints and parameters that are quantified as the application is developed and evaluated. Estimate costs and benefit outcome metrics to service providers and users of the airspace system associated with local, regional, or national implementation. When critical parameters (such as equipage) are not yet characterized, analyze over a range of potential values. Coordinate the analysis with metrics/benefits experts/organizations such as the C/AFT and AOPA. The cost and benefit analyses for the application will be used to evaluate cases for implementing sets applications together. Results on critical parameter trade-offs may be used to plan subsequent refinement of the application.

2.3	Cumulative Implementation Cases	Analyze the distribution of benefits to different classes of NAS users, and to those who do or do not equip, if the application were implemented locally, regionally, and nationally. Considering the application *with* other applications, characterize the equipage decisions that will face different classes of NAS users, and in collaboration with users, characterize the likelihood and rate of equipage. From this, estimate costs and benefit outcome metrics to service providers and users of the airspace system associated with local, regional, or national implementation. Coordinate the analysis with metrics/benefits experts/organizations such as the C/AFT and AOPA. Implementation cases for sets of synergistic applications will be used by SF21 to define and validate the capability of integrated avionics, ground systems, and procedures proposed for implementation. The case for a proposed implementation will be incorporated into decision making by the FAA, Users, and Industry.
2.4	Investment Decisions and Deployment Consensus	Summarize benefits, costs, implementation cases, and coordinate findings with joint FAA/User/Industry forum in preparation for investment decisions as required by the FAA Acquisition Management System and to support business decisions by Users and Industry.

3 Maturity of Concepts & Technology

3.1	Looks Feasible and Worth Developing?	In coordination with industry, user, and FAA organizations make decision that the application is feasible and worth developing for operational evaluation

4 Operational Procedures

4.1	Initial Definition of Procedures	Define procedures
4.2	Cockpit Simulation	Perform initial procedure evaluation using medium fidelity cockpit.
4.3	Controller Simulations	Perform initial procedure evaluation using appropriate level of ATC / controller simulation.
4.4	Procedure Parameters	Based on simulations (and analyses as needed), define preliminary limits to variable parameters the affect the acceptability and/or performance of the procedure. Examples of parameters include: visibility, separation between parallel runways, percentage of equipped aircraft in a controller's airspace, accuracy of acceptable CDTIs, inclusion of a velocity indicator on CDTIs.
4.5	Procedures Training	Define and formalize pilot and controller training and training materials.
4.6	Procedures Post-Full-Sim	Review and validation of procedures based on data from full-mission cockpit/ATC simulation.
4.7	Procedure Post-OpEval	Validate procedures based on data from operational evaluation

5 Human Factors Issues (Pilot, Controller, Other)

5.1	Task Analysis	Pilot/controller human factors task analysis. In coordination with SAE and RTCA, this contributes to standards definition needed for operational approval.
5.2	Initial Cockpit Human Factors	Cockpit human-factors evaluation and improvement as part of simulation for procedure development. In coordination with SAE and RTCA, this contributes to standards definition needed for operational approval.
5.3	Initial Controller Human Factors	Controller human-factors evaluation and improvement as part of ATC / controller simulation for procedure development. In coordination with SAE and RTCA, this contributes to standards definition needed for operational approval.
5.4	Human Factors Post-Full-Sim	Validate human factors acceptability based on data from full-mission simulation w/ high fidelity cockpit and ATC (required integration of ATC and cockpit simulations TBD)
5.5	Human Factors Post-OpEval	Validate human factors acceptability based on data from OpEval.

6 End to End Performance &Tech Reqs

6.1	Initial Performance Estimates	Drawing on knowledge of current prototypes, related systems, general engineering knowledge, and general operational knowledge, draft initial performance estimates for systems supporting the application.

6.2	Performance Requirements	Fast-time simulation and other analytic tools should be used to determine/ substantiate the data and performance requirements. In coordination with RTCA, this contributes to standards definition needed for certification. For example: RF performance analysis for aircraft-to-aircraft and air-to-ground (while aircraft are airborne and on the airport surface. A full-stress RF performance simulation to high equipage levels in dirty RF environment need to be performed to justify spectrum allocation/authorization.
6.3	Supportability Requirements	Define the approach to support and maintenance of systems supporting the application. Characterize the required support and maintenance functions and activities.
6.4	Performance Validation	Data should be collected throughout the simulations and operation flight evaluation to be used to validate the data and performance models. In coordination with RTCA, this contributes to standards definition needed for certification.

7 Interoperability Requirements for Air and Ground Systems

7.1	Interoperability Analysis	Perform a system interoperability analysis between various air-to-air and air-to-ground interfaces. In coordination with RTCA, this contributes to standards definition needed for certification.

7.2	Interface Requirements Documents	Based on specific functional and performance requirements, generate interface requirements documents. In coordination with RTCA, this contributes to standards definition needed for certification.
7.3	Interoperable Prototypes	Validate air-air, air-ground and ground-ground interoperability of systems and prototypes through simulation, laboratory testing, and off-line field-testing. In coordination with RTCA, this contributes to standards definition needed for certification.
7.4	Interoperability Post-OpEval	Validate interoperability based on data from operational evaluation.

8 Operational Safety Assessment

8.1	Rationale/Prelim Model	High-level safety rationale needs to be written for non-safety critical/non-hazardous applications. (1 month, 1 Staff Month)For safety critical applications develop a preliminary collision risk model and/or safety risk assessment prior to operational evaluation.
8.2	Validate Rationale/Preliminary Model	Data collected throughout simulations and operation flight evaluation are analyzed to feed/validate the safety assessment models.
8.3	Full Collision Risk Model	For safety critical applications develop a full collision risk model and/or safety risk assessment prior to implementation.

9 Avionics and Ground Systems

9.1	Systems and Avionics for OpEval	Develop or acquire ground systems and avionics as required to upport operational evaluation of the SF21 application(s) according to the functionality specified in the operational concept.
9.2	Systems and Avionics Certification and Approval	Develop or acquire ground systems and avionics as required to support avionics certification and operational approval of the SF21 application(s) according to the functionality required for the defined operational procedures
10	**Operational Test and Evaluation**	
10.1	Limited Data Collection	Plan for and gather data during field testing, or in the targeted OpEval of another application, that assists in defining, evaluating, or partially validating an application or parts of an application.
10.2	Full Mission Simulation	Plan and conduct full mission pilot and ATC simulation.
10.3	Plans for OpEval	Through analysis and coordination, develop detailed plans for operational evaluations. Includes: test and evaluation program restrictions, defined success criteria, knowledge and procedures training, and policies on participation and access to data by organizations.
10.4	Operational Test and Evaluation	Targeted operational test and evaluation to validate the application as a precursor to operational approval and avionics certification.

11 Equipment Certification (Aircraft and Ground Systems)

11.1 Develop a Certification Issues Paper	
11.2 Develop Certification Plan	Certification plan (for SF21 sponsored avionics.)

12 Operational Approval (Flight Standards and Air Traffic)

12.1 Develop Issues and Resolutions Document	Issues and resolutions document / documentation to support approvals.
12.10 Document Validation and Proving Runs	Validation / proving runs (air carrier and perhaps GA).
12.11 Document Post Operational Approval/Certification Activities	Post operational approval / certification activities including continued airworthiness (e.g., dispatch / MEL issues, need for periodic inspections).
12.2 Document Operational Regulations	Develop documentation on the operational regulations involved including current enabling regulations and new required regulations
12.3 Document the Human Factors Design Criteria and Guidelines	Enabling human factors design criteria and guidelines (I/O).
12.4 Document Air Carrier Approvals and Authorizations	Air carrier operator approvals and authorizations for flight crews, dispatch, and maintenance (avionics).
12.5 Document Approved Operational Data	Approved operational data including minimum Equipment List (MEL).
12.6 Produce Approved Training Program Module	Approved training program module

12.7	Develop Operations Manuals	Operations manuals including General Operations Manual (GOM), Flight Operations Manual (FOM), Aircraft Flight Manual (AFM) and AFM Supplement as appropriate.
12.8	Develop Operational Specification	Operational specifications / authorizations.
12.9	Develop General Aviation Guidance Material	General aviation guidance material including advisory circulars, FAA handbook order changes, equipment usage and flight training, and pilot judgment training requirements.

13 Implementation Transition

13.1	Procedures In Service	Implement the procedure and evaluate it in actual use. (In many cases, this is be done incrementally as the limits for the accepted procedure are gradually extended.)
13.2	Benefits in Service	Evaluate the benefits of the procedure in actual use. (In many cases, this is be done incrementally as the limits for the accepted procedure are gradually extended.) .
13.3	Human Factors In Service	Validate human factors acceptability based on data from air and ground systems and procedures in actual use. (In many cases, this is be done incrementally as the limits for the accepted procedures are gradually extended.)
13.4	Performance In Service	Validate data and performance acceptability based on data from in service evaluation.
13.5	Interoperability In Service	Validate interoperability based on data from in service evaluation.

Appendix C

Ohio Valley Tasks for 1999

Activity	Task	Application	OpEval Year
Operational Concept			
	1.1 Define Operational Concept		
		3.1.1 Enhanced Visual Approaches (Visual Acquisition w/o Positive ID procedures using ADS-B only)	1999
		4.1.1 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B only)	1999
		3.1.2 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B only)	2000
		3.1.3 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B)	2000
		4.1.2 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B)	2000
		4.3.1 Conflict Situational Awareness	2000
		3.2 Final Approach Spacing	2001
		4.2 Traffic Situational Awareness in Domestic Airspace	2001
		6.1.1 Runway and Final Approach Occupancy Awareness (using ADS-B only)	2001
		6.2 Airport Surface Situational Awareness	2001
		7.1 Enhanced Presentation of Surface Targets to Controller	2001
	1.2 System Functionality		
		3.1.1 Enhanced Visual Approaches (Visual Acquisition w/o Positive ID procedures using ADS-B only)	1999
		4.1.1 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B only)	1999
		3.1.2 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B only)	2000
		3.1.3 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B)	2000
		4.1.2 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B)	2000
		4.3.1 Conflict Situational Awareness	2000
		3.2 Final Approach Spacing	2001
		4.2 Traffic Situational Awareness in Domestic Airspace	2001
		6.1.1 Runway and Final Approach Occupancy Awareness (using ADS-B only)	2001
		6.2 Airport Surface Situational Awareness	2001
		7.1 Enhanced Presentation of Surface Targets to Controller	2001
Benefits & Constraints			
	2.1 Cost/Benefit Estimates and Parameters		
		3.1.1 Enhanced Visual Approaches (Visual Acquisition w/o Positive ID procedures using ADS-B only)	1999
		4.1.1 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B only)	1999
		3.1.2 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B only)	2000
		3.1.3 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B)	2000
		4.1.2 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B)	2000
		4.3.1 Conflict Situational Awareness	2000
		3.2 Final Approach Spacing	2001
		4.2 Traffic Situational Awareness in Domestic Airspace	2001
		6.1.1 Runway and Final Approach Occupancy Awareness (using ADS-B only)	2001
		6.2 Airport Surface Situational Awareness	2001
		7.1 Enhanced Presentation of Surface Targets to Controller	2001
	2.2 Quantitative Costs and Benefits		
		3.1.1 Enhanced Visual Approaches (Visual Acquisition w/o Positive ID procedures using ADS-B only)	1999
		4.1.1 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B only)	1999
		3.1.2 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B only)	2000
		3.1.3 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B)	2000
		4.1.2 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B)	2000
		4.3.1 Conflict Situational Awareness	2000
	2.3 Cumulative Implementation Cases		
		3.1.1 Enhanced Visual Approaches (Visual Acquisition w/o Positive ID procedures using ADS-B only)	1999
		4.1.1 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B only)	1999
Maturity of Concepts & Technology			
	3.1 Looks Feasible and Worth Developing?		
		3.1.1 Enhanced Visual Approaches (Visual Acquisition w/o Positive ID procedures using ADS-B only)	1999
		4.1.1 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B only)	1999

3.1.2	Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B only)	2000
3.1.3	Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B)	2000
4.1.2	Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B)	2000
4.3.1	Conflict Situational Awareness	2000
3.2	Final Approach Spacing	2001
4.2	Traffic Situational Awareness in Domestic Airspace	2001
6.1.1	Runway and Final Approach Occupancy Awareness (using ADS-B only)	2001
6.2	Airport Surface Situational Awareness	2001
7.1	Enhanced Presentation of Surface Targets to Controller	2001
Operational Procedures		
4.1	**Initial Definition of Procedures**	
3.1.1	Enhanced Visual Approaches (Visual Acquisition w/o Positive ID procedures using ADS-B only)	1999
4.1.1	Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B only)	1999
3.1.2	Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B only)	2000
3.1.3	Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B)	2000
4.1.2	Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B)	2000
4.3.1	Conflict Situational Awareness	2000
3.2	Final Approach Spacing	2001
4.2	Traffic Situational Awareness in Domestic Airspace	2001
6.1.1	Runway and Final Approach Occupancy Awareness (using ADS-B only)	2001
6.2	Airport Surface Situational Awareness	2001
7.1	Enhanced Presentation of Surface Targets to Controller	2001
4.2	**Cockpit Simulation**	
3.1.1	Enhanced Visual Approaches (Visual Acquisition w/o Positive ID procedures using ADS-B only)	1999
4.1.1	Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B only)	1999
3.1.2	Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B only)	2000
3.1.3	Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B)	2000
4.1.2	Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B)	2000
4.3.1	Conflict Situational Awareness	2000
3.2	Final Approach Spacing	2001
4.2	Traffic Situational Awareness in Domestic Airspace	2001
6.1.1	Runway and Final Approach Occupancy Awareness (using ADS-B only)	2001
6.2	Airport Surface Situational Awareness	2001
4.3	**Controller Simulations**	
3.1.1	Enhanced Visual Approaches (Visual Acquisition w/o Positive ID procedures using ADS-B only)	1999
3.1.2	Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B only)	2000
3.1.3	Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B)	2000
3.2	Final Approach Spacing	2001
4.2	Traffic Situational Awareness in Domestic Airspace	2001
6.1.1	Runway and Final Approach Occupancy Awareness (using ADS-B only)	2001
6.2	Airport Surface Situational Awareness	2001
7.1	Enhanced Presentation of Surface Targets to Controller	2001
4.4	**Procedure Parameters**	
3.1.1	Enhanced Visual Approaches (Visual Acquisition w/o Positive ID procedures using ADS-B only)	1999
4.1.1	Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B only)	1999
3.1.2	Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B only)	2000
3.1.3	Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B)	2000
4.1.2	Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B)	2000
4.3.1	Conflict Situational Awareness	2000
4.5	**Procedures Training**	
3.1.1	Enhanced Visual Approaches (Visual Acquisition w/o Positive ID procedures using ADS-B only)	1999
4.1.1	Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B only)	1999
3.1.2	Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B only)	2000
3.1.3	Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B)	2000
4.1.2	Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B)	2000
4.3.1	Conflict Situational Awareness	2000
4.6	**Procedures Post-Full-Sim**	
3.1.1	Enhanced Visual Approaches (Visual Acquisition w/o Positive ID procedures using ADS-B only)	1999
4.1.1	Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B only)	1999
4.7	**Procedure Post-OpEval**	
3.1.1	Enhanced Visual Approaches (Visual Acquisition w/o Positive ID procedures using ADS-B only)	1999

4.1.1 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B only) 1999

Human Factors Issues (Pilot, Controller, Other)

5.1 Task Analysis

3.1.1 Enhanced Visual Approaches (Visual Acquisition w/o Positive ID procedures using ADS-B only) 1999
4.1.1 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B only) 1999
3.1.2 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B only) 2000
3.1.3 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B) 2000
4.1.2 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B) 2000
4.3.1 Conflict Situational Awareness 2000
3.2 Final Approach Spacing 2001
4.2 Traffic Situational Awareness in Domestic Airspace 2001
6.1.1 Runway and Final Approach Occupancy Awareness (using ADS-B only) 2001
6.2 Airport Surface Situational Awareness 2001
7.1 Enhanced Presentation of Surface Targets to Controller 2001

5.2 Initial Cockpit Human Factors

3.1.1 Enhanced Visual Approaches (Visual Acquisition w/o Positive ID procedures using ADS-B only) 1999
4.1.1 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B only) 1999
3.1.2 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B only) 2000
3.1.3 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B) 2000
4.1.2 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B) 2000
4.3.1 Conflict Situational Awareness 2000
3.2 Final Approach Spacing 2001
4.2 Traffic Situational Awareness in Domestic Airspace 2001
6.1.1 Runway and Final Approach Occupancy Awareness (using ADS-B only) 2001
6.2 Airport Surface Situational Awareness 2001

5.3 Initial Controller Human Factors

3.1.1 Enhanced Visual Approaches (Visual Acquisition w/o Positive ID procedures using ADS-B only) 1999
4.1.1 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B only) 1999
3.1.2 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B only) 2000
3.1.3 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B) 2000
4.1.2 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B) 2000
4.3.1 Conflict Situational Awareness 2000
3.2 Final Approach Spacing 2001
4.2 Traffic Situational Awareness in Domestic Airspace 2001
6.1.1 Runway and Final Approach Occupancy Awareness (using ADS-B only) 2001
6.2 Airport Surface Situational Awareness 2001
7.1 Enhanced Presentation of Surface Targets to Controller 2001

5.4 Human Factors Post-Full-Sim

3.1.1 Enhanced Visual Approaches (Visual Acquisition w/o Positive ID procedures using ADS-B only) 1999
4.1.1 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B only) 1999

5.5 Human Factors Post-OpEval

3.1.1 Enhanced Visual Approaches (Visual Acquisition w/o Positive ID procedures using ADS-B only) 1999
4.1.1 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B only) 1999

End to End Performance &Tech Reqs

6.1 Initial Performance Estimates

3.1.1 Enhanced Visual Approaches (Visual Acquisition w/o Positive ID procedures using ADS-B only) 1999
4.1.1 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B only) 1999
3.1.2 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B only) 2000
3.1.3 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B) 2000
4.1.2 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B) 2000
4.3.1 Conflict Situational Awareness 2000
3.2 Final Approach Spacing 2001
4.2 Traffic Situational Awareness in Domestic Airspace 2001
6.1.1 Runway and Final Approach Occupancy Awareness (using ADS-B only) 2001
6.2 Airport Surface Situational Awareness 2001
7.1 Enhanced Presentation of Surface Targets to Controller 2001

6.4 Performance Validation

3.1.1 Enhanced Visual Approaches (Visual Acquisition w/o Positive ID procedures using ADS-B only) 1999
4.1.1 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B only) 1999

6.2 Performance Requirements

3.1.1 Enhanced Visual Approaches (Visual Acquisition w/o Positive ID procedures using ADS-B only) 1999

4.1.1 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B only) 1999
3.1.2 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B only) 2000
3.1.3 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B) 2000
4.1.2 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B) 2000
4.3.1 Conflict Situational Awareness 2000

6.3 Supportability Requirements

3.1.1 Enhanced Visual Approaches (Visual Acquisition w/o Positive ID procedures using ADS-B only) 1999
4.1.1 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B only) 1999
3.1.2 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B only) 2000
3.1.3 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B) 2000
4.1.2 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B) 2000
4.3.1 Conflict Situational Awareness 2000

Interoperability Reqs for Air and Ground Systems

7.1 Interoperability Analysis

3.1.3 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B) 2000
4.1.2 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B) 2000
4.3.1 Conflict Situational Awareness 2000
3.2 Final Approach Spacing 2001
4.2 Traffic Situational Awareness in Domestic Airspace 2001
6.1.1 Runway and Final Approach Occupancy Awareness (using ADS-B only) 2001
6.2 Airport Surface Situational Awareness 2001
7.1 Enhanced Presentation of Surface Targets to Controller 2001

7.2 Interface Requirements Documents

3.1.3 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B) 2000
4.1.2 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B) 2000
4.3.1 Conflict Situational Awareness 2000

Operational Safety Assessment

8.1 Rationale/Prelim Model

3.1.1 Enhanced Visual Approaches (Visual Acquisition w/o Positive ID procedures using ADS-B only) 1999
4.1.1 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B only) 1999
3.1.2 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B only) 2000
3.1.3 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B) 2000
4.1.2 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B) 2000
4.3.1 Conflict Situational Awareness 2000

8.2 Validate Rationale/Preliminary Model

3.1.1 Enhanced Visual Approaches (Visual Acquisition w/o Positive ID procedures using ADS-B only) 1999
4.1.1 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B only) 1999

Avionics and Ground Systems

9.1 Systems and Avionics for OpEval

3.1.1 Enhanced Visual Approaches (Visual Acquisition w/o Positive ID procedures using ADS-B only) 1999
4.1.1 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B only) 1999

Operational Test and Evaluation

10.1 Limited Data Collection

3.1.1 Enhanced Visual Approaches (Visual Acquisition w/o Positive ID procedures using ADS-B only) 1999
4.1.1 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B only) 1999
3.1.2 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B only) 2000
3.1.3 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B) 2000
4.1.2 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B) 2000
4.3.1 Conflict Situational Awareness 2000

10.2 Full Mission Simulation

3.1.1 Enhanced Visual Approaches (Visual Acquisition w/o Positive ID procedures using ADS-B only) 1999
4.1.1 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B only) 1999

10.3 Plans for OpEval

3.1.1 Enhanced Visual Approaches (Visual Acquisition w/o Positive ID procedures using ADS-B only) 1999
4.1.1 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B only) 1999

10.4 Operational Test and Evaluation

3.1.1 Enhanced Visual Approaches (Visual Acquisition w/o Positive ID procedures using ADS-B only) 1999
4.1.1 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B only) 1999

Appendix D

Ohio Valley Tasks for 2000

Activity	Task	Application	OpEval Year
Operational Concept			
	1.1 Define Operational Concept		
		4.3.2 Flight-Path Deconfliction	2002
		5.2 Extended See and Avoid	2002
		6.1.2 Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)	2002
		6.3 Enhanced IMC Airport Surface Operations	2002
		9.2 ADS-B Enhancement of Terminal Radar	2002
	1.2 System Functionality		
		4.3.2 Flight-Path Deconfliction	2002
		5.2 Extended See and Avoid	2002
		6.1.2 Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)	2002
		6.3 Enhanced IMC Airport Surface Operations	2002
		9.2 ADS-B Enhancement of Terminal Radar	2002
Benefits & Constraints			
	2.1 Cost/Benefit Estimates and Parameters		
		4.3.2 Flight-Path Deconfliction	2002
		5.2 Extended See and Avoid	2002
		6.1.2 Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)	2002
		6.3 Enhanced IMC Airport Surface Operations	2002
		9.2 ADS-B Enhancement of Terminal Radar	2002
	2.2 Quantitative Costs and Benefits		
		3.2 Final Approach Spacing	2001
		4.2 Traffic Situational Awareness in Domestic Airspace	2001
		6.1.1 Runway and Final Approach Occupancy Awareness (using ADS-B only)	2001
		6.2 Airport Surface Situational Awareness	2001
		7.1 Enhanced Presentation of Surface Targets to Controller	2001
	2.3 Cumulative Implementation Cases		
		3.1.2 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B only)	2000
		3.1.3 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B)	2000
		4.1.2 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B)	2000
		4.3.1 Conflict Situational Awareness	2000
	2.4 Investment Decisions and Deployment Consensus		
		3.1.1 Enhanced Visual Approaches (Visual Acquisition w/o Positive ID procedures using ADS-B only)	1999
		4.1.1 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B only)	1999
Maturity of Concepts & Technology			
	3.1 Looks Feasible and Worth Developing?		
		4.3.2 Flight-Path Deconfliction	2002
		5.2 Extended See and Avoid	2002
		6.1.2 Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)	2002
		6.3 Enhanced IMC Airport Surface Operations	2002
		9.2 ADS-B Enhancement of Terminal Radar	2002
Operational Procedures			
	4.1 Initial Definition of Procedures		
		4.3.2 Flight-Path Deconfliction	2002
		5.2 Extended See and Avoid	2002
		6.1.2 Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)	2002
		6.3 Enhanced IMC Airport Surface Operations	2002
		9.2 ADS-B Enhancement of Terminal Radar	2002
	4.2 Cockpit Simulation		
		4.3.2 Flight-Path Deconfliction	2002
		5.2 Extended See and Avoid	2002
		6.1.2 Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)	2002

6.3 Enhanced IMC Airport Surface Operations	2002
9.2 ADS-B Enhancement of Terminal Radar	2002
4.3 Controller Simulations	
4.3.2 Flight-Path Deconfliction	2002
5.2 Extended See and Avoid	2002
6.1.2 Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)	2002
6.3 Enhanced IMC Airport Surface Operations	2002
9.2 ADS-B Enhancement of Terminal Radar	2002
4.4 Procedure Parameters	
3.2 Final Approach Spacing	2001
4.2 Traffic Situational Awareness in Domestic Airspace	2001
6.1.1 Runway and Final Approach Occupancy Awareness (using ADS-B only)	2001
6.2 Airport Surface Situational Awareness	2001
7.1 Enhanced Presentation of Surface Targets to Controller	2001
4.5 Procedures Training	
3.2 Final Approach Spacing	2001
4.2 Traffic Situational Awareness in Domestic Airspace	2001
6.1.1 Runway and Final Approach Occupancy Awareness (using ADS-B only)	2001
6.2 Airport Surface Situational Awareness	2001
7.1 Enhanced Presentation of Surface Targets to Controller	2001
4.6 Procedures Post-Full-Sim	
3.1.2 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B only)	2000
3.1.3 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B)	2000
4.1.2 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B)	2000
4.3.1 Conflict Situational Awareness	2000
4.7 Procedure Post-OpEval	
3.1.2 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B only)	2000
3.1.3 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B)	2000
4.1.2 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B)	2000
4.3.1 Conflict Situational Awareness	2000
Human Factors Issues (Pilot, Controller, Other)	
5.1 Task Analysis	
4.3.2 Flight-Path Deconfliction	2002
5.2 Extended See and Avoid	2002
6.1.2 Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)	2002
6.3 Enhanced IMC Airport Surface Operations	2002
9.2 ADS-B Enhancement of Terminal Radar	2002
5.2 Initial Cockpit Human Factors	
4.3.2 Flight-Path Deconfliction	2002
5.2 Extended See and Avoid	2002
6.1.2 Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)	2002
6.3 Enhanced IMC Airport Surface Operations	2002
9.2 ADS-B Enhancement of Terminal Radar	2002
5.3 Initial Controller Human Factors	
4.3.2 Flight-Path Deconfliction	2002
5.2 Extended See and Avoid	2002
6.1.2 Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)	2002
6.3 Enhanced IMC Airport Surface Operations	2002
9.2 ADS-B Enhancement of Terminal Radar	2002
5.4 Human Factors Post-Full-Sim	
3.1.2 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B only)	2000
3.1.3 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B)	2000
4.1.2 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B)	2000
4.3.1 Conflict Situational Awareness	2000
5.5 Human Factors Post-OpEval	
3.1.2 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B only)	2000
3.1.3 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B)	2000
4.1.2 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B)	2000
4.3.1 Conflict Situational Awareness	2000
End to End Performance &Tech Reqs	
6.1 Initial Performance Estimates	

	4.3.2 Flight-Path Deconfliction	2002
	5.2 Extended See and Avoid	2002
	6.1.2 Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)	2002
	6.3 Enhanced IMC Airport Surface Operations	2002
	9.2 ADS-B Enhancement of Terminal Radar	2002
6.4 Performance Validation		
	3.1.2 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B only)	2000
	3.1.3 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B)	2000
	4.1.2 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B)	2000
	4.3.1 Conflict Situational Awareness	2000
6.2 Performance Requirements		
	3.2 Final Approach Spacing	2001
	4.2 Traffic Situational Awareness in Domestic Airspace	2001
	6.1.1 Runway and Final Approach Occupancy Awareness (using ADS-B only)	2001
	6.2 Airport Surface Situational Awareness	2001
	7.1 Enhanced Presentation of Surface Targets to Controller	2001
6.3 Supportability Requirements		
	3.2 Final Approach Spacing	2001
	4.2 Traffic Situational Awareness in Domestic Airspace	2001
	6.1.1 Runway and Final Approach Occupancy Awareness (using ADS-B only)	2001
	6.2 Airport Surface Situational Awareness	2001
	7.1 Enhanced Presentation of Surface Targets to Controller	2001
Interoperability Reqs for Air and Ground Systems		
7.1 Interoperability Analysis		
	4.3.2 Flight-Path Deconfliction	2002
	6.1.2 Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)	2002
	6.3 Enhanced IMC Airport Surface Operations	2002
	9.2 ADS-B Enhancement of Terminal Radar	2002
7.2 Interface Requirements Documents		
	3.2 Final Approach Spacing	2001
	4.2 Traffic Situational Awareness in Domestic Airspace	2001
	6.1.1 Runway and Final Approach Occupancy Awareness (using ADS-B only)	2001
	6.2 Airport Surface Situational Awareness	2001
	7.1 Enhanced Presentation of Surface Targets to Controller	2001
7.3 Interoperable Prototypes		
	3.1.3 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B)	2000
	4.1.2 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B)	2000
	4.3.1 Conflict Situational Awareness	2000
7.4 Interoperability Post-OpEval		
	3.1.3 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B)	2000
	4.1.2 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B)	2000
	4.3.1 Conflict Situational Awareness	2000
Operational Safety Assessment		
8.1 Rationale/Prelim Model		
	3.2 Final Approach Spacing	2001
	4.2 Traffic Situational Awareness in Domestic Airspace	2001
	6.1.1 Runway and Final Approach Occupancy Awareness (using ADS-B only)	2001
	6.2 Airport Surface Situational Awareness	2001
	7.1 Enhanced Presentation of Surface Targets to Controller	2001
8.2 Validate Rationale/Preliminary Model		
	3.1.2 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B only)	2000
	3.1.3 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B)	2000
	4.1.2 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B)	2000
	4.3.1 Conflict Situational Awareness	2000
8.3 Full Collision Risk Model		
	3.1.1 Enhanced Visual Approaches (Visual Acquisition w/o Positive ID procedures using ADS-B only)	1999
	4.1.1 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B only)	1999
Avionics and Ground Systems		
9.1 Systems and Avionics for OpEval		
	3.1.2 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B only)	2000
	3.1.3 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B)	2000

		4.1.2 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B)	2000
		4.3.1 Conflict Situational Awareness	2000
	9.2 Systems and Avionics for Certification and Approval		
		3.1.1 Enhanced Visual Approaches (Visual Acquisition w/o Positive ID procedures using ADS-B only)	1999
		4.1.1 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B only)	1999
Operational Test and Evaluation			
	10.1 Limited Data Collection		
		3.2 Final Approach Spacing	2001
		4.2 Traffic Situational Awareness in Domestic Airspace	2001
		6.1.1 Runway and Final Approach Occupancy Awareness (using ADS-B only)	2001
		6.2 Airport Surface Situational Awareness	2001
		7.1 Enhanced Presentation of Surface Targets to Controller	2001
	10.2 Full Mission Simulation		
		3.1.2 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B only)	2000
		3.1.3 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B)	2000
		4.1.2 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B)	2000
		4.3.1 Conflict Situational Awareness	2000
	10.3 Plans for OpEval		
		3.1.2 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B only)	2000
		3.1.3 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B)	2000
		4.1.2 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B)	2000
		4.3.1 Conflict Situational Awareness	2000
	10.4 Operational Test and Evaluation		
		3.1.2 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B only)	2000
		3.1.3 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B)	2000
		4.1.2 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B)	2000
		4.3.1 Conflict Situational Awareness	2000

Appendix E

Ohio Valley Tasks for 2001

Activity	Task	Application	OpEval Year
Benefits & Constraints			
	2.2 Quantitative Costs and Benefits		
		4.3.2 Flight-Path Deconfliction	2002
		5.2 Extended See and Avoid	2002
		6.1.2 Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)	2002
		6.3 Enhanced IMC Airport Surface Operations	2002
		9.2 ADS-B Enhancement of Terminal Radar	2002
	2.3 Cumulative Implementation Cases		
		3.2 Final Approach Spacing	2001
		4.2 Traffic Situational Awareness in Domestic Airspace	2001
		6.1.1 Runway and Final Approach Occupancy Awareness (using ADS-B only)	2001
		6.2 Airport Surface Situational Awareness	2001
		7.1 Enhanced Presentation of Surface Targets to Controller	2001
	2.4 Investment Decisions and Deployment Consensus		
		3.1.2 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B only)	2000
		3.1.3 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B)	2000
		4.1.2 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B)	2000
		4.3.1 Conflict Situational Awareness	2000
Operational Procedures			
	4.4 Procedure Parameters		
		4.3.2 Flight-Path Deconfliction	2002
		5.2 Extended See and Avoid	2002
		6.1.2 Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)	2002
		6.3 Enhanced IMC Airport Surface Operations	2002
		9.2 ADS-B Enhancement of Terminal Radar	2002
	4.5 Procedures Training		
		4.3.2 Flight-Path Deconfliction	2002
		5.2 Extended See and Avoid	2002
		6.1.2 Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)	2002
		6.3 Enhanced IMC Airport Surface Operations	2002
		9.2 ADS-B Enhancement of Terminal Radar	2002
	4.6 Procedures Post-Full-Sim		
		3.2 Final Approach Spacing	2001
		4.2 Traffic Situational Awareness in Domestic Airspace	2001
		6.1.1 Runway and Final Approach Occupancy Awareness (using ADS-B only)	2001
		6.2 Airport Surface Situational Awareness	2001
		7.1 Enhanced Presentation of Surface Targets to Controller	2001
	4.7 Procedure Post-OpEval		
		3.2 Final Approach Spacing	2001
		4.2 Traffic Situational Awareness in Domestic Airspace	2001
		6.1.1 Runway and Final Approach Occupancy Awareness (using ADS-B only)	2001
		6.2 Airport Surface Situational Awareness	2001
		7.1 Enhanced Presentation of Surface Targets to Controller	2001
Human Factors Issues (Pilot, Controller, Other)			
	5.4 Human Factors Post-Full-Sim		
		3.2 Final Approach Spacing	2001
		4.2 Traffic Situational Awareness in Domestic Airspace	2001
		6.1.1 Runway and Final Approach Occupancy Awareness (using ADS-B only)	2001
		6.2 Airport Surface Situational Awareness	2001
		7.1 Enhanced Presentation of Surface Targets to Controller	2001
	5.5 Human Factors Post-OpEval		
		3.2 Final Approach Spacing	2001
		4.2 Traffic Situational Awareness in Domestic Airspace	2001
		6.1.1 Runway and Final Approach Occupancy Awareness (using ADS-B only)	2001

6.2 Airport Surface Situational Awareness	2001
7.1 Enhanced Presentation of Surface Targets to Controller	2001
End to End Performance &Tech Reqs	
6.4 Performance Validation	
3.2 Final Approach Spacing	2001
4.2 Traffic Situational Awareness in Domestic Airspace	2001
6.1.1 Runway and Final Approach Occupancy Awareness (using ADS-B only)	2001
6.2 Airport Surface Situational Awareness	2001
7.1 Enhanced Presentation of Surface Targets to Controller	2001
6.2 Performance Requirements	
4.3.2 Flight-Path Deconfliction	2002
5.2 Extended See and Avoid	2002
6.1.2 Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)	2002
6.3 Enhanced IMC Airport Surface Operations	2002
9.2 ADS-B Enhancement of Terminal Radar	2002
6.3 Supportability Requirements	
4.3.2 Flight-Path Deconfliction	2002
5.2 Extended See and Avoid	2002
6.1.2 Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)	2002
6.3 Enhanced IMC Airport Surface Operations	2002
9.2 ADS-B Enhancement of Terminal Radar	2002
Interoperability Reqs for Air and Ground Systems	
7.2 Interface Requirements Documents	
4.3.2 Flight-Path Deconfliction	2002
6.1.2 Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)	2002
6.3 Enhanced IMC Airport Surface Operations	2002
9.2 ADS-B Enhancement of Terminal Radar	2002
7.3 Interoperable Prototypes	
3.2 Final Approach Spacing	2001
4.2 Traffic Situational Awareness in Domestic Airspace	2001
6.1.1 Runway and Final Approach Occupancy Awareness (using ADS-B only)	2001
6.2 Airport Surface Situational Awareness	2001
7.1 Enhanced Presentation of Surface Targets to Controller	2001
7.4 Interoperability Post-OpEval	
3.2 Final Approach Spacing	2001
4.2 Traffic Situational Awareness in Domestic Airspace	2001
6.1.1 Runway and Final Approach Occupancy Awareness (using ADS-B only)	2001
6.2 Airport Surface Situational Awareness	2001
7.1 Enhanced Presentation of Surface Targets to Controller	2001
Operational Safety Assessment	
8.1 Rationale/Prelim Model	
4.3.2 Flight-Path Deconfliction	2002
5.2 Extended See and Avoid	2002
6.1.2 Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)	2002
6.3 Enhanced IMC Airport Surface Operations	2002
9.2 ADS-B Enhancement of Terminal Radar	2002
8.2 Validate Rationale/Preliminary Model	
3.2 Final Approach Spacing	2001
4.2 Traffic Situational Awareness in Domestic Airspace	2001
6.1.1 Runway and Final Approach Occupancy Awareness (using ADS-B only)	2001
6.2 Airport Surface Situational Awareness	2001
7.1 Enhanced Presentation of Surface Targets to Controller	2001
8.3 Full Collision Risk Model	
3.1.2 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B only)	2000
3.1.3 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B)	2000
4.1.2 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B)	2000
4.3.1 Conflict Situational Awareness	2000
Avionics and Ground Systems	
9.1 Systems and Avionics for OpEval	
3.2 Final Approach Spacing	2001
4.2 Traffic Situational Awareness in Domestic Airspace	2001

6.1.1 Runway and Final Approach Occupancy Awareness (using ADS-B only) 2001
6.2 Airport Surface Situational Awareness 2001
7.1 Enhanced Presentation of Surface Targets to Controller 2001

9.2 Systems and Avionics for Certification and Approval

3.1.2 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B only) 2000
3.1.3 Enhanced Visual Approaches (w/ Positive ID procedures using ADS-B and TIS-B) 2000
4.1.2 Enhanced Visual Acquisition of Other Traffic for See-And-Avoid (using ADS-B and TIS-B) 2000
4.3.1 Conflict Situational Awareness 2000

Operational Test and Evaluation

10.1 Limited Data Collection

4.3.2 Flight-Path Deconfliction 2002
5.2 Extended See and Avoid 2002
6.1.2 Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B) 2002
6.3 Enhanced IMC Airport Surface Operations 2002
9.2 ADS-B Enhancement of Terminal Radar 2002

10.2 Full Mission Simulation

3.2 Final Approach Spacing 2001
4.2 Traffic Situational Awareness in Domestic Airspace 2001
6.1.1 Runway and Final Approach Occupancy Awareness (using ADS-B only) 2001
6.2 Airport Surface Situational Awareness 2001
7.1 Enhanced Presentation of Surface Targets to Controller 2001

10.3 Plans for OpEval

3.2 Final Approach Spacing 2001
4.2 Traffic Situational Awareness in Domestic Airspace 2001
6.1.1 Runway and Final Approach Occupancy Awareness (using ADS-B only) 2001
6.2 Airport Surface Situational Awareness 2001
7.1 Enhanced Presentation of Surface Targets to Controller 2001

10.4 Operational Test and Evaluation

3.2 Final Approach Spacing 2001
4.2 Traffic Situational Awareness in Domestic Airspace 2001
6.1.1 Runway and Final Approach Occupancy Awareness (using ADS-B only) 2001
6.2 Airport Surface Situational Awareness 2001
7.1 Enhanced Presentation of Surface Targets to Controller 2001

Appendix F

Ohio Valley Tasks for 2002

Activity	Task	Application	OpEval Year
Benefits & Constraints			
	2.3 Cumulative Implementation Cases		
		4.3.2 Flight-Path Deconfliction	2002
		5.2 Extended See and Avoid	2002
		6.1.2 Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)	2002
		6.3 Enhanced IMC Airport Surface Operations	2002
		9.2 ADS-B Enhancement of Terminal Radar	2002
	2.4 Investment Decisions and Deployment Consensus		
		3.2 Final Approach Spacing	2001
		4.2 Traffic Situational Awareness in Domestic Airspace	2001
		6.1.1 Runway and Final Approach Occupancy Awareness (using ADS-B only)	2001
		6.2 Airport Surface Situational Awareness	2001
		7.1 Enhanced Presentation of Surface Targets to Controller	2001
Operational Procedures			
	4.6 Procedures Post-Full-Sim		
		4.3.2 Flight-Path Deconfliction	2002
		5.2 Extended See and Avoid	2002
		6.1.2 Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)	2002
		6.3 Enhanced IMC Airport Surface Operations	2002
		9.2 ADS-B Enhancement of Terminal Radar	2002
	4.7 Procedure Post-OpEval		
		4.3.2 Flight-Path Deconfliction	2002
		5.2 Extended See and Avoid	2002
		6.1.2 Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)	2002
		6.3 Enhanced IMC Airport Surface Operations	2002
		9.2 ADS-B Enhancement of Terminal Radar	2002
Human Factors Issues (Pilot, Controller, Other)			
	5.4 Human Factors Post-Full-Sim		
		4.3.2 Flight-Path Deconfliction	2002
		5.2 Extended See and Avoid	2002
		6.1.2 Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)	2002
		6.3 Enhanced IMC Airport Surface Operations	2002
		9.2 ADS-B Enhancement of Terminal Radar	2002
	5.5 Human Factors Post-OpEval		
		4.3.2 Flight-Path Deconfliction	2002
		5.2 Extended See and Avoid	2002
		6.1.2 Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)	2002
		6.3 Enhanced IMC Airport Surface Operations	2002
		9.2 ADS-B Enhancement of Terminal Radar	2002
End to End Performance &Tech Reqs			
	6.4 Performance Validation		
		4.3.2 Flight-Path Deconfliction	2002
		5.2 Extended See and Avoid	2002
		6.1.2 Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)	2002
		6.3 Enhanced IMC Airport Surface Operations	2002
		9.2 ADS-B Enhancement of Terminal Radar	2002
Interoperability Reqs for Air and Ground Systems			
	7.3 Interoperable Prototypes		
		4.3.2 Flight-Path Deconfliction	2002
		6.1.2 Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)	2002
		6.3 Enhanced IMC Airport Surface Operations	2002
		9.2 ADS-B Enhancement of Terminal Radar	2002
	7.4 Interoperability Post-OpEval		
		4.3.2 Flight-Path Deconfliction	2002

6.1.2 Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)	2002
6.3 Enhanced IMC Airport Surface Operations	2002
9.2 ADS-B Enhancement of Terminal Radar	2002
Operational Safety Assessment	
8.2 Validate Rationale/Preliminary Model	
4.3.2 Flight-Path Deconfliction	2002
5.2 Extended See and Avoid	2002
6.1.2 Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)	2002
6.3 Enhanced IMC Airport Surface Operations	2002
9.2 ADS-B Enhancement of Terminal Radar	2002
8.3 Full Collision Risk Model	
3.2 Final Approach Spacing	2001
4.2 Traffic Situational Awareness in Domestic Airspace	2001
6.1.1 Runway and Final Approach Occupancy Awareness (using ADS-B only)	2001
6.2 Airport Surface Situational Awareness	2001
7.1 Enhanced Presentation of Surface Targets to Controller	2001
Avionics and Ground Systems	
9.1 Systems and Avionics for OpEval	
4.3.2 Flight-Path Deconfliction	2002
5.2 Extended See and Avoid	2002
6.1.2 Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)	2002
6.3 Enhanced IMC Airport Surface Operations	2002
9.2 ADS-B Enhancement of Terminal Radar	2002
9.2 Systems and Avionics for Certification and Approval	
3.2 Final Approach Spacing	2001
4.2 Traffic Situational Awareness in Domestic Airspace	2001
6.1.1 Runway and Final Approach Occupancy Awareness (using ADS-B only)	2001
6.2 Airport Surface Situational Awareness	2001
7.1 Enhanced Presentation of Surface Targets to Controller	2001
Operational Test and Evaluation	
10.2 Full Mission Simulation	
4.3.2 Flight-Path Deconfliction	2002
5.2 Extended See and Avoid	2002
6.1.2 Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)	2002
6.3 Enhanced IMC Airport Surface Operations	2002
9.2 ADS-B Enhancement of Terminal Radar	2002
10.3 Plans for OpEval	
4.3.2 Flight-Path Deconfliction	2002
5.2 Extended See and Avoid	2002
6.1.2 Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)	2002
6.3 Enhanced IMC Airport Surface Operations	2002
9.2 ADS-B Enhancement of Terminal Radar	2002
10.4 Operational Test and Evaluation	
4.3.2 Flight-Path Deconfliction	2002
5.2 Extended See and Avoid	2002
6.1.2 Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)	2002
6.3 Enhanced IMC Airport Surface Operations	2002
9.2 ADS-B Enhancement of Terminal Radar	2002

Appendix G

Ohio Valley Tasks for 2003

Activity	Task	Application	OpEval Year
Benefits & Constraints			
	2.4 Investment Decisions and Deployment Consensus		
		4.3.2 Flight-Path Deconfliction	2002
		5.2 Extended See and Avoid	2002
		6.1.2 Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)	2002
		6.3 Enhanced IMC Airport Surface Operations	2002
		9.2 ADS-B Enhancement of Terminal Radar	2002
Operational Safety Assessment			
	8.3 Full Collision Risk Model		
		4.3.2 Flight-Path Deconfliction	2002
		5.2 Extended See and Avoid	2002
		6.1.2 Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)	2002
		6.3 Enhanced IMC Airport Surface Operations	2002
		9.2 ADS-B Enhancement of Terminal Radar	2002
Avionics and Ground Systems			
	9.2 Systems and Avionics for Certification and Approval		
		4.3.2 Flight-Path Deconfliction	2002
		5.2 Extended See and Avoid	2002
		6.1.2 Runway and Final Approach Occupancy Awareness (using ADS-B and TIS-B)	2002
		6.3 Enhanced IMC Airport Surface Operations	2002
		9.2 ADS-B Enhancement of Terminal Radar	2002

Appendix H

Alaska Tasks for 1999

Activity	Task	Application	OpEval Year
Operational Concept			
	1.1 Define Operational Concept		
		1.1.1 FIS-B (with NEXRAD, Lightning, METAR/TAF, and SIGMET/AIRMET products)	2000
		2.1 Low cost terrain situational awareness	2000
		8.1 Expanded Surveillance Coverage in En Route Non-Radar Airspace	2000
		1.1.2 FIS-B (with Icing, Turbulence, SUA-status, and Volcanic Ash products)	2001
		2.2 Increased access to terrain-constrained low altitude airspace	2001
	1.2 System Functionality		
		1.1.1 FIS-B (with NEXRAD, Lightning, METAR/TAF, and SIGMET/AIRMET products)	2000
		2.1 Low cost terrain situational awareness	2000
		8.1 Expanded Surveillance Coverage in En Route Non-Radar Airspace	2000
		1.1.2 FIS-B (with Icing, Turbulence, SUA-status, and Volcanic Ash products)	2001
		2.2 Increased access to terrain-constrained low altitude airspace	2001
Benefits & Constraints			
	2.1 Cost/Benefit Estimates and Parameters		
		1.1.1 FIS-B (with NEXRAD, Lightning, METAR/TAF, and SIGMET/AIRMET products)	2000
		2.1 Low cost terrain situational awareness	2000
		8.1 Expanded Surveillance Coverage in En Route Non-Radar Airspace	2000
		1.1.2 FIS-B (with Icing, Turbulence, SUA-status, and Volcanic Ash products)	2001
		2.2 Increased access to terrain-constrained low altitude airspace	2001
	2.2 Quantitative Costs and Benefits		
		1.1.1 FIS-B (with NEXRAD, Lightning, METAR/TAF, and SIGMET/AIRMET products)	2000
		2.1 Low cost terrain situational awareness	2000
		8.1 Expanded Surveillance Coverage in En Route Non-Radar Airspace	2000
Maturity of Concepts & Technology			
	3.1 Looks Feasible and Worth Developing?		
		1.1.1 FIS-B (with NEXRAD, Lightning, METAR/TAF, and SIGMET/AIRMET products)	2000
		2.1 Low cost terrain situational awareness	2000
		8.1 Expanded Surveillance Coverage in En Route Non-Radar Airspace	2000
		1.1.2 FIS-B (with Icing, Turbulence, SUA-status, and Volcanic Ash products)	2001
		2.2 Increased access to terrain-constrained low altitude airspace	2001
Operational Procedures			
	4.1 Initial Definition of Procedures		
		2.1 Low cost terrain situational awareness	2000
		8.1 Expanded Surveillance Coverage in En Route Non-Radar Airspace	2000
		2.2 Increased access to terrain-constrained low altitude airspace	2001
	4.2 Cockpit Simulation		
		1.1.1 FIS-B (with NEXRAD, Lightning, METAR/TAF, and SIGMET/AIRMET products)	2000
		2.1 Low cost terrain situational awareness	2000
		1.1.2 FIS-B (with Icing, Turbulence, SUA-status, and Volcanic Ash products)	2001
		2.2 Increased access to terrain-constrained low altitude airspace	2001
	4.3 Controller Simulations		
		2.1 Low cost terrain situational awareness	2000
		8.1 Expanded Surveillance Coverage in En Route Non-Radar Airspace	2000
		2.2 Increased access to terrain-constrained low altitude airspace	2001
	4.4 Procedure Parameters		
		2.1 Low cost terrain situational awareness	2000
		8.1 Expanded Surveillance Coverage in En Route Non-Radar Airspace	2000
	4.5 Procedures Training		
		1.1.1 FIS-B (with NEXRAD, Lightning, METAR/TAF, and SIGMET/AIRMET products)	2000
		2.1 Low cost terrain situational awareness	2000
		8.1 Expanded Surveillance Coverage in En Route Non-Radar Airspace	2000

Human Factors Issues (Pilot, Controller, Other)		
5.1 Task Analysis		
1.1.1	FIS-B (with NEXRAD, Lightning, METAR/TAF, and SIGMET/AIRMET products)	2000
2.1	Low cost terrain situational awareness	2000
8.1	Expanded Surveillance Coverage in En Route Non-Radar Airspace	2000
1.1.2	FIS-B (with Icing, Turbulence, SUA-status, and Volcanic Ash products)	2001
2.2	Increased access to terrain-constrained low altitude airspace	2001
5.2 Initial Cockpit Human Factors		
1.1.1	FIS-B (with NEXRAD, Lightning, METAR/TAF, and SIGMET/AIRMET products)	2000
2.1	Low cost terrain situational awareness	2000
1.1.2	FIS-B (with Icing, Turbulence, SUA-status, and Volcanic Ash products)	2001
2.2	Increased access to terrain-constrained low altitude airspace	2001
5.3 Initial Controller Human Factors		
1.1.1	FIS-B (with NEXRAD, Lightning, METAR/TAF, and SIGMET/AIRMET products)	2000
2.1	Low cost terrain situational awareness	2000
8.1	Expanded Surveillance Coverage in En Route Non-Radar Airspace	2000
1.1.2	FIS-B (with Icing, Turbulence, SUA-status, and Volcanic Ash products)	2001
2.2	Increased access to terrain-constrained low altitude airspace	2001
End to End Performance &Tech Reqs		
6.1 Initial Performance Estimates		
1.1.1	FIS-B (with NEXRAD, Lightning, METAR/TAF, and SIGMET/AIRMET products)	2000
2.1	Low cost terrain situational awareness	2000
8.1	Expanded Surveillance Coverage in En Route Non-Radar Airspace	2000
1.1.2	FIS-B (with Icing, Turbulence, SUA-status, and Volcanic Ash products)	2001
2.2	Increased access to terrain-constrained low altitude airspace	2001
6.2 Performance Requirements		
1.1.1	FIS-B (with NEXRAD, Lightning, METAR/TAF, and SIGMET/AIRMET products)	2000
2.1	Low cost terrain situational awareness	2000
8.1	Expanded Surveillance Coverage in En Route Non-Radar Airspace	2000
6.3 Supportability Requirements		
1.1.1	FIS-B (with NEXRAD, Lightning, METAR/TAF, and SIGMET/AIRMET products)	2000
2.1	Low cost terrain situational awareness	2000
8.1	Expanded Surveillance Coverage in En Route Non-Radar Airspace	2000
Interoperability Reqs for Air and Ground Systems		
7.1 Interoperability Analysis		
1.1.1	FIS-B (with NEXRAD, Lightning, METAR/TAF, and SIGMET/AIRMET products)	2000
2.1	Low cost terrain situational awareness	2000
8.1	Expanded Surveillance Coverage in En Route Non-Radar Airspace	2000
1.1.2	FIS-B (with Icing, Turbulence, SUA-status, and Volcanic Ash products)	2001
2.2	Increased access to terrain-constrained low altitude airspace	2001
7.2 Interface Requirements Documents		
1.1.1	FIS-B (with NEXRAD, Lightning, METAR/TAF, and SIGMET/AIRMET products)	2000
2.1	Low cost terrain situational awareness	2000
8.1	Expanded Surveillance Coverage in En Route Non-Radar Airspace	2000
Operational Safety Assessment		
8.1 Rationale/Prelim Model		
1.1.1	FIS-B (with NEXRAD, Lightning, METAR/TAF, and SIGMET/AIRMET products)	2000
2.1	Low cost terrain situational awareness	2000
8.1	Expanded Surveillance Coverage in En Route Non-Radar Airspace	2000
Operational Test and Evaluation		
10.1 Limited Data Collection		
1.1.1	FIS-B (with NEXRAD, Lightning, METAR/TAF, and SIGMET/AIRMET products)	2000
2.1	Low cost terrain situational awareness	2000

8.1 Expanded Surveillance Coverage in En Route Non-Radar Airspace

Appendix I

Alaska Tasks for 2000

Activity	Task	Application	OpEval Year
Operational Concept			
	1.1 Define Operational Concept		
		8.2 Expanded Surveillance Coverage in Terminal Areas without Radar	2002
	1.2 System Functionality		
		8.2 Expanded Surveillance Coverage in Terminal Areas without Radar	2002
Benefits & Constraints			
	2.1 Cost/Benefit Estimates and Parameters		
		8.2 Expanded Surveillance Coverage in Terminal Areas without Radar	2002
	2.2 Quantitative Costs and Benefits		
		1.1.2 FIS-B (with Icing, Turbulence, SUA-status, and Volcanic Ash products)	2001
		2.2 Increased access to terrain-constrained low altitude airspace	2001
	2.3 Cumulative Implementation Cases		
		1.1.1 FIS-B (with NEXRAD, Lightning, METAR/TAF, and SIGMET/AIRMET products)	2000
		2.1 Low cost terrain situational awareness	2000
		8.1 Expanded Surveillance Coverage in En Route Non-Radar Airspace	2000
Maturity of Concepts & Technology			
	3.1 Looks Feasible and Worth Developing?		
		8.2 Expanded Surveillance Coverage in Terminal Areas without Radar	2002
Operational Procedures			
	4.1 Initial Definition of Procedures		
		8.2 Expanded Surveillance Coverage in Terminal Areas without Radar	2002
	4.3 Controller Simulations		
		8.2 Expanded Surveillance Coverage in Terminal Areas without Radar	2002
	4.4 Procedure Parameters		
		2.2 Increased access to terrain-constrained low altitude airspace	2001
	4.5 Procedures Training		
		1.1.2 FIS-B (with Icing, Turbulence, SUA-status, and Volcanic Ash products)	2001
		2.2 Increased access to terrain-constrained low altitude airspace	2001
	4.6 Procedures Post-Full-Sim		
		1.1.1 FIS-B (with NEXRAD, Lightning, METAR/TAF, and SIGMET/AIRMET products)	2000
		2.1 Low cost terrain situational awareness	2000
		8.1 Expanded Surveillance Coverage in En Route Non-Radar Airspace	2000
	4.7 Procedure Post-OpEval		
		1.1.1 FIS-B (with NEXRAD, Lightning, METAR/TAF, and SIGMET/AIRMET products)	2000
		2.1 Low cost terrain situational awareness	2000
		8.1 Expanded Surveillance Coverage in En Route Non-Radar Airspace	2000
Human Factors Issues (Pilot, Controller, Other)			
	5.1 Task Analysis		
		8.2 Expanded Surveillance Coverage in Terminal Areas without Radar	2002
	5.3 Initial Controller Human Factors		
		8.2 Expanded Surveillance Coverage in Terminal Areas without Radar	2002
	5.4 Human Factors Post-Full-Sim		
		1.1.1 FIS-B (with NEXRAD, Lightning, METAR/TAF, and SIGMET/AIRMET products)	2000
		2.1 Low cost terrain situational awareness	2000
		8.1 Expanded Surveillance Coverage in En Route Non-Radar Airspace	2000
	5.5 Human Factors Post-OpEval		
		1.1.1 FIS-B (with NEXRAD, Lightning, METAR/TAF, and SIGMET/AIRMET products)	2000
		2.1 Low cost terrain situational awareness	2000
		8.1 Expanded Surveillance Coverage in En Route Non-Radar Airspace	2000
End to End Performance &Tech Reqs			
	6.1 Initial Performance Estimates		
		8.2 Expanded Surveillance Coverage in Terminal Areas without Radar	2002
	6.4 Performance Validation		
		1.1.1 FIS-B (with NEXRAD, Lightning, METAR/TAF, and SIGMET/AIRMET products)	2000

- 2.1 Low cost terrain situational awareness — 2000
- 8.1 Expanded Surveillance Coverage in En Route Non-Radar Airspace — 2000

6.2 Performance Requirements
- 1.1.2 FIS-B (with Icing, Turbulence, SUA-status, and Volcanic Ash products) — 2001
- 2.2 Increased access to terrain-constrained low altitude airspace — 2001

6.3 Supportability Requirements
- 1.1.2 FIS-B (with Icing, Turbulence, SUA-status, and Volcanic Ash products) — 2001
- 2.2 Increased access to terrain-constrained low altitude airspace — 2001

Interoperability Reqs for Air and Ground Systems

7.1 Interoperability Analysis
- 8.2 Expanded Surveillance Coverage in Terminal Areas without Radar — 2002

7.2 Interface Requirements Documents
- 1.1.2 FIS-B (with Icing, Turbulence, SUA-status, and Volcanic Ash products) — 2001
- 2.2 Increased access to terrain-constrained low altitude airspace — 2001

7.3 Interoperable Prototypes
- 1.1.1 FIS-B (with NEXRAD, Lightning, METAR/TAF, and SIGMET/AIRMET products) — 2000
- 2.1 Low cost terrain situational awareness — 2000
- 8.1 Expanded Surveillance Coverage in En Route Non-Radar Airspace — 2000

7.4 Interoperability Post-OpEval
- 1.1.1 FIS-B (with NEXRAD, Lightning, METAR/TAF, and SIGMET/AIRMET products) — 2000
- 2.1 Low cost terrain situational awareness — 2000
- 8.1 Expanded Surveillance Coverage in En Route Non-Radar Airspace — 2000

Operational Safety Assessment

8.1 Rationale/Prelim Model
- 2.2 Increased access to terrain-constrained low altitude airspace — 2001

8.2 Validate Rationale/Preliminary Model
- 1.1.1 FIS-B (with NEXRAD, Lightning, METAR/TAF, and SIGMET/AIRMET products) — 2000
- 2.1 Low cost terrain situational awareness — 2000
- 8.1 Expanded Surveillance Coverage in En Route Non-Radar Airspace — 2000

Avionics and Ground Systems

9.1 Systems and Avionics for OpEval
- 1.1.1 FIS-B (with NEXRAD, Lightning, METAR/TAF, and SIGMET/AIRMET products) — 2000
- 2.1 Low cost terrain situational awareness — 2000
- 8.1 Expanded Surveillance Coverage in En Route Non-Radar Airspace — 2000

Operational Test and Evaluation

10.1 Limited Data Collection
- 1.1.2 FIS-B (with Icing, Turbulence, SUA-status, and Volcanic Ash products) — 2001
- 2.2 Increased access to terrain-constrained low altitude airspace — 2001

10.2 Full Mission Simulation
- 1.1.1 FIS-B (with NEXRAD, Lightning, METAR/TAF, and SIGMET/AIRMET products) — 2000
- 2.1 Low cost terrain situational awareness — 2000
- 8.1 Expanded Surveillance Coverage in En Route Non-Radar Airspace — 2000

10.3 Plans for OpEval
- 1.1.1 FIS-B (with NEXRAD, Lightning, METAR/TAF, and SIGMET/AIRMET products) — 2000
- 2.1 Low cost terrain situational awareness — 2000
- 8.1 Expanded Surveillance Coverage in En Route Non-Radar Airspace — 2000

10.4 Operational Test and Evaluation
- 1.1.1 FIS-B (with NEXRAD, Lightning, METAR/TAF, and SIGMET/AIRMET products) — 2000
- 2.1 Low cost terrain situational awareness — 2000
- 8.1 Expanded Surveillance Coverage in En Route Non-Radar Airspace — 2000

Appendix J

Alaska Tasks for 2001

Activity	Task	Application	OpEval Year
Benefits & Constraints			
	2.2 Quantitative Costs and Benefits		
		8.2 Expanded Surveillance Coverage in Terminal Areas without Radar	2002
	2.3 Cumulative Implementation Cases		
		1.1.2 FIS-B (with Icing, Turbulence, SUA-status, and Volcanic Ash products)	2001
		2.2 Increased access to terrain-constrained low altitude airspace	2001
	2.4 Investment Decisions and Deployment Consensus		
		1.1.1 FIS-B (with NEXRAD, Lightning, METAR/TAF, and SIGMET/AIRMET products)	2000
		2.1 Low cost terrain situational awareness	2000
		8.1 Expanded Surveillance Coverage in En Route Non-Radar Airspace	2000
Operational Procedures			
	4.4 Procedure Parameters		
		8.2 Expanded Surveillance Coverage in Terminal Areas without Radar	2002
	4.5 Procedures Training		
		8.2 Expanded Surveillance Coverage in Terminal Areas without Radar	2002
	4.6 Procedures Post-Full-Sim		
		1.1.2 FIS-B (with Icing, Turbulence, SUA-status, and Volcanic Ash products)	2001
		2.2 Increased access to terrain-constrained low altitude airspace	2001
	4.7 Procedure Post-OpEval		
		1.1.2 FIS-B (with Icing, Turbulence, SUA-status, and Volcanic Ash products)	2001
		2.2 Increased access to terrain-constrained low altitude airspace	2001
Human Factors Issues (Pilot, Controller, Other)			
	5.4 Human Factors Post-Full-Sim		
		1.1.2 FIS-B (with Icing, Turbulence, SUA-status, and Volcanic Ash products)	2001
		2.2 Increased access to terrain-constrained low altitude airspace	2001
	5.5 Human Factors Post-OpEval		
		1.1.2 FIS-B (with Icing, Turbulence, SUA-status, and Volcanic Ash products)	2001
		2.2 Increased access to terrain-constrained low altitude airspace	2001
End to End Performance &Tech Reqs			
	6.4 Performance Validation		
		1.1.2 FIS-B (with Icing, Turbulence, SUA-status, and Volcanic Ash products)	2001
		2.2 Increased access to terrain-constrained low altitude airspace	2001
	6.2 Performance Requirements		
		8.2 Expanded Surveillance Coverage in Terminal Areas without Radar	2002
	6.3 Supportability Requirements		
		8.2 Expanded Surveillance Coverage in Terminal Areas without Radar	2002
Interoperability Reqs for Air and Ground Systems			
	7.2 Interface Requirements Documents		
		8.2 Expanded Surveillance Coverage in Terminal Areas without Radar	2002
	7.3 Interoperable Prototypes		
		1.1.2 FIS-B (with Icing, Turbulence, SUA-status, and Volcanic Ash products)	2001
		2.2 Increased access to terrain-constrained low altitude airspace	2001
	7.4 Interoperability Post-OpEval		
		1.1.2 FIS-B (with Icing, Turbulence, SUA-status, and Volcanic Ash products)	2001
		2.2 Increased access to terrain-constrained low altitude airspace	2001
Operational Safety Assessment			
	8.1 Rationale/Prelim Model		
		8.2 Expanded Surveillance Coverage in Terminal Areas without Radar	2002
	8.2 Validate Rationale/Preliminary Model		
		2.2 Increased access to terrain-constrained low altitude airspace	2001
	8.3 Full Collision Risk Model		
		1.1.1 FIS-B (with NEXRAD, Lightning, METAR/TAF, and SIGMET/AIRMET products)	2000
		2.1 Low cost terrain situational awareness	2000
		8.1 Expanded Surveillance Coverage in En Route Non-Radar Airspace	2000

Avionics and Ground Systems

9.1 Systems and Avionics for OpEval		
1.1.2	FIS-B (with Icing, Turbulence, SUA-status, and Volcanic Ash products)	2001
2.2	Increased access to terrain-constrained low altitude airspace	2001
9.2 Systems and Avionics for Certification and Approval		
1.1.1	FIS-B (with NEXRAD, Lightning, METAR/TAF, and SIGMET/AIRMET products)	2000
2.1	Low cost terrain situational awareness	2000
8.1	Expanded Surveillance Coverage in En Route Non-Radar Airspace	2000

Operational Test and Evaluation

10.1 Limited Data Collection		
8.2	Expanded Surveillance Coverage in Terminal Areas without Radar	2002
10.2 Full Mission Simulation		
1.1.2	FIS-B (with Icing, Turbulence, SUA-status, and Volcanic Ash products)	2001
2.2	Increased access to terrain-constrained low altitude airspace	2001
10.3 Plans for OpEval		
1.1.2	FIS-B (with Icing, Turbulence, SUA-status, and Volcanic Ash products)	2001
2.2	Increased access to terrain-constrained low altitude airspace	2001
10.4 Operational Test and Evaluation		
1.1.2	FIS-B (with Icing, Turbulence, SUA-status, and Volcanic Ash products)	2001
2.2	Increased access to terrain-constrained low altitude airspace	2001

Appendix K

Alaska Tasks for 2002

Activity	Task	Application	OpEval Year
Benefits & Constraints			
	2.3 Cumulative Implementation Cases		
		8.2 Expanded Surveillance Coverage in Terminal Areas without Radar	2002
	2.4 Investment Decisions and Deployment Consensus		
		1.1.2 FIS-B (with Icing, Turbulence, SUA-status, and Volcanic Ash products)	2001
		2.2 Increased access to terrain-constrained low altitude airspace	2001
Operational Procedures			
	4.6 Procedures Post-Full-Sim		
		8.2 Expanded Surveillance Coverage in Terminal Areas without Radar	2002
	4.7 Procedure Post-OpEval		
		8.2 Expanded Surveillance Coverage in Terminal Areas without Radar	2002
Human Factors Issues (Pilot, Controller, Other)			
	5.4 Human Factors Post-Full-Sim		
		8.2 Expanded Surveillance Coverage in Terminal Areas without Radar	2002
	5.5 Human Factors Post-OpEval		
		8.2 Expanded Surveillance Coverage in Terminal Areas without Radar	2002
End to End Performance &Tech Reqs			
	6.4 Performance Validation		
		8.2 Expanded Surveillance Coverage in Terminal Areas without Radar	2002
Interoperability Reqs for Air and Ground Systems			
	7.3 Interoperable Prototypes		
		8.2 Expanded Surveillance Coverage in Terminal Areas without Radar	2002
	7.4 Interoperability Post-OpEval		
		8.2 Expanded Surveillance Coverage in Terminal Areas without Radar	2002
Operational Safety Assessment			
	8.2 Validate Rationale/Preliminary Model		
		8.2 Expanded Surveillance Coverage in Terminal Areas without Radar	2002
	8.3 Full Collision Risk Model		
		1.1.2 FIS-B (with Icing, Turbulence, SUA-status, and Volcanic Ash products)	2001
		2.2 Increased access to terrain-constrained low altitude airspace	2001
Avionics and Ground Systems			
	9.1 Systems and Avionics for OpEval		
		8.2 Expanded Surveillance Coverage in Terminal Areas without Radar	2002
	9.2 Systems and Avionics for Certification and Approval		
		1.1.2 FIS-B (with Icing, Turbulence, SUA-status, and Volcanic Ash products)	2001
		2.2 Increased access to terrain-constrained low altitude airspace	2001
Operational Test and Evaluation			
	10.2 Full Mission Simulation		
		8.2 Expanded Surveillance Coverage in Terminal Areas without Radar	2002
	10.3 Plans for OpEval		
		8.2 Expanded Surveillance Coverage in Terminal Areas without Radar	2002
	10.4 Operational Test and Evaluation		
		8.2 Expanded Surveillance Coverage in Terminal Areas without Radar	2002

Appendix L

Alaska Tasks for 2003

Activity	Task	Application	OpEval Year
Benefits & Constraints			
	2.4 Investment Decisions and Deployment Consensus		
		8.2 Expanded Surveillance Coverage in Terminal Areas without Radar	2002
Operational Safety Assessment			
	8.3 Full Collision Risk Model		
		8.2 Expanded Surveillance Coverage in Terminal Areas without Radar	2002
Avionics and Ground Systems			
	9.2 Systems and Avionics for Certification and Approval		
		8.2 Expanded Surveillance Coverage in Terminal Areas without Radar	2002

Appendix M

New Technology Adoption Model

There are several considerations for planning SafeFlight 21 operational enhancements. One of these is called the "New Technology Adoption Model" which prescribes characteristic consumer market behavior when new technologies are introduced to such markets. A desirable trait of this viewpoint is that it identifies the market forces that result in voluntary decisions to purchase equipment and use it in operations. These forces can be leveraged to accomplish a quick, efficient transition path to new, advanced operational capabilities, as has been demonstrated many times in high-tech industries.

Another consideration is the stated needs and preferences of the users and the FAA. These needs can be characterized in many ways, but one way of looking at them is the size of the problem the needs reflect, and how much relief or benefit could be realized by their resolution.

A third additional consideration at this point is the maturity of technologies and procedures. This is a very practical consideration of what is "do-able" given the nature of proposed procedural change, or operational use of new technology. It is consistent with the Evolutionary Spiral Process (ESP) model that endorses a step-at-a-time approach to technology and procedure development. It is also consistent with the likely ramp-up in numbers of users who become equipped and trained to perform new procedures.

As planning for SafeFlight 21 operational enhancements continues, it is probable that other factors may also be identified, and these can be readily incorporated. Therefore, it is useful to proceed with an analysis based on the factors identified above after a brief description is provided in the following pages.

The Technology Adoption Life Cycle (adapted from Moore[10]) provides useful insights on how new technologies and procedures are likely to be embraced by the NAS user community. Basically, if one plots the number of units of a "new technology" product purchased across a timeline, the result usually resembles a bell curve (see Figure M-1). This type of curve is applicable only to new technologies which require a substantial change in user behavior for benefits to be realized. Recent examples in consumer markets include palm-sized computer devices, cellular telephones, and VCR/camcorders - which all require, for example, that users invest time and money in equipment and training before they can see results. This is contrasted with other new introductions to the marketplace which represent

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[10] Moore, G. A., *Crossing the Chasm: Marketing and Selling High-Tech Products to Mainstream Customers*, 1991, HarperBusiness, New York

only a slight incremental improvement to an existing feature - such as a new film for standard 35mm cameras which requires virtually no change in behavior to reap the small incremental benefit. The general technology adoption life cycle, therefore, applies only to significant new technology that requires substantial change in user behavior.

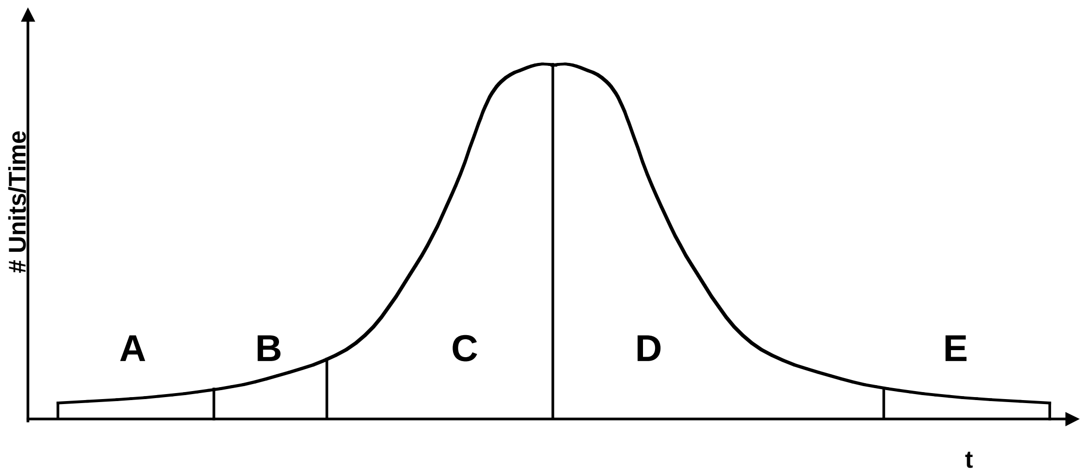

Figure M-1. New Products Purchased As a Function of Time

What high-tech market researchers have discovered is that, usually, a set common unique traits will accurately characterize consumers in various parts of the bell curve. The curve can be broken down under the loose general titles of (A) innovators, (B) early adopters, (C) early majority, (D) later majority, and (E) those who never consciously join. These groups will be described in the general sense first, and then modified slightly for application to the analysis of SafeFlight 21 operational enhancements.

Leading the introduction of new technologies is the market-segment called the "Innovators". This segment is generally comprised of individuals who tend to embrace technology for technology's sake, without necessarily having any beneficial application in mind. There are a host of motivations which may prompt such fascination, but return-on-investment is not usually a significant criteria.

Following innovators is a group called the "early adopters", who tend to see how specific applications of new technology may benefit their operation. They are willing to invest time and effort to develop such applications from scratch, and are not overly concerned by the lack of standards or maturity.

The early majority group is practically-minded, and tends to embrace new technology once it has taken hold in the market, and development effort and risks are down. Those in this group tend to modify and extend applications pioneered by the early adopters into more mainstream areas.

The later majority is comprised of those who join the bandwagon when the cost of entry is suitably small. As used here, "cost of entry" is a broad term to include not only cost of equipment, but also training, maintenance, and other aspects of procurement and operation. A high-tech product has truly reached consumer status when it appeals to the later majority.

The last group consists of those who never consciously join the new technology's market, either for practical or philosophical reasons.

Several key principles have emerged in high-tech marketing in recent years. One is that the technology adoption life cycle is not really a continuum, but rather has breaks between the sub markets as shown in Figure M-2. This is due to the fact that the motivations people have for acquiring and using a high-tech product are usually very distinct, lending to crisply-defined market segments.

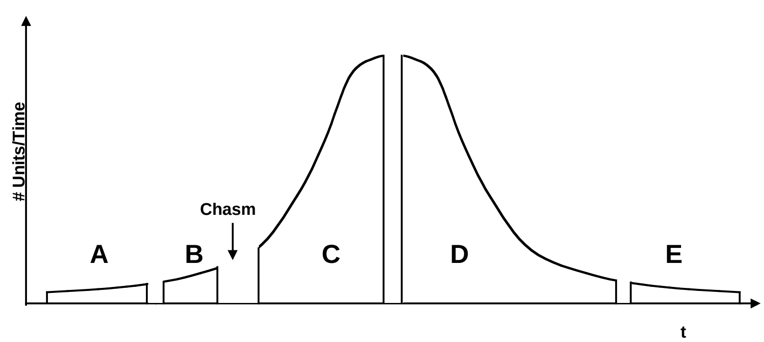

Figure M-2. The Chasm

A second key principle is that one needs a very specialized marketing plan tailored to the interests of each group. This is a natural consequence of the motivations and preferences unique to each group.

Finally, moving to the right, toward true "consumer status", requires that the new technology be effectively cultivated and marketed through all the segments to the left. The most common mistake in high-tech marketing is to attempt to jump into the majority regions of the curve, without a good foundation built by the experience and exposure provided by innovators and early adopters. A more effective strategy is to effectively market each of the identified groups (in sequence), and use the experience gained in one segment to serve as a launch point to the next.

A key focus of the work adapted for this discussion is that the most difficult marketing jump is from the early adopters to the early majority (the "chasm"). However, with proper treatment of the early adopter market, there are many ways in which this jump can be made more negotiable.

There are many ways in which this technology adoption model is applicable to the NAS and contemplated system upgrades - especially where user equipage is an issue.

First, when the cumulative number of units are expressed as a percentage of the total possible market, the equipage curve (on the right of Figure M-3) emerges. The two curves are directly linked, and the suggestion is that the desired, high user-equipage rates in the NAS will be best prompted by a well-considered, methodical "marketing strategy" that addresses each unique group. In addition, such a strategy will force resolution of the "chicken-egg" problems associated with such concepts as ADS-B (for which certain applications require high levels of equipage before benefits can be obtained). When considered in light of the model, it is possible to develop strategies for introducing ADS-B in ways that can effectively service the early adopters, thereby laying the foundation for jumping the chasm to more mainstream markets.

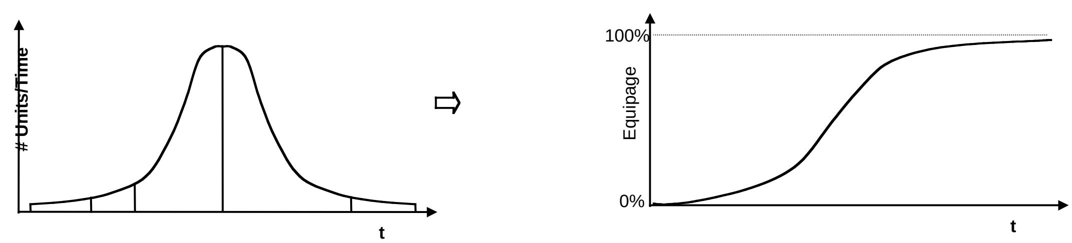

Figure M-3. Equipage

It also provides another valid basis for planning and sequencing SafeFlight 21 operational enhancements, and invites an ordered approach to gradually expanding the infrastructure and capabilities to support the market. It is not necessary to do everything at once, and such an approach is contrary to one of the most basic premises of effective high-tech marketing.

Finally, the model is consistent with other factors considered in the planning of SafeFlight 21 operational enhancements.

It should be noted that the user equipage curve drives many other curves reflecting the quality and effectiveness of future NAS operations. (See Figure M-4) The number of "advanced" operations, for example, is directly related to the percentage of users equipped to perform such operations.

Another dynamic related to the user equipage curve is the commensurate geographic region captured by gradually-increasing equipage levels. Innovators and early adopters in the NAS, for example, will likely equip for niche applications that are very local in nature. However, as more from the early majority join, the set of feasible operational enhancements grows toward regional and "universal" applications. (See Figure M-5)

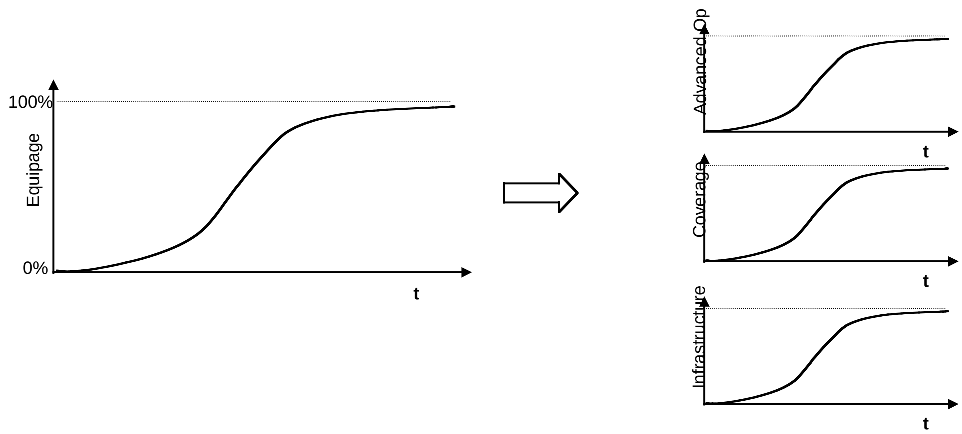

Figure M-4. Equipage Curve Feed Other Curves

Figure M-5. Geographic Implementation

For the sake of simplicity in applying the model to the SafeFlight 21 operational enhancement analysis, the five marketing regions have been conveniently gathered into three groups: "early" (consisting of A and B), "middle" (consisting of C and D), and "late" (E) as shown in Figure M-6.

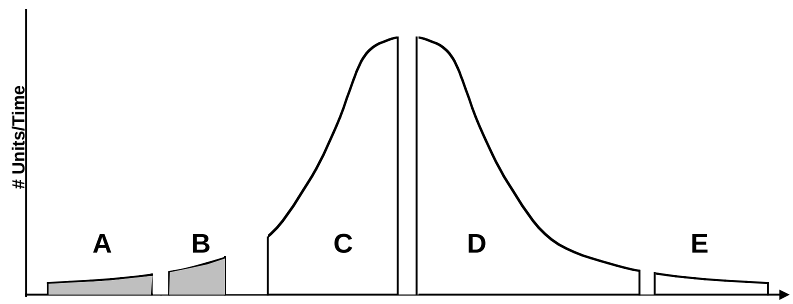

Figure M-6. Grouping the Regions

It is critically important that regions A and B be actively developed in order to make a successful jump to the majority regions, and many view this treatment of the early market to be the most important focus of the SafeFlight 21 effort.

As described earlier, participants in this market segment are drawn either by the novelty of the technology, or because it has the potential to provide benefits in focused applications. Participants are willing to invest resources necessary to get operational approval, and also to tolerate situations where standards may not exist and have to be developed. Generally, equipment purchases are made in quantities of ones or twos (or small lots) by individual or small fleet operators. The airlines participating in the Cargo Airline Association operational evaluation of ADS-B are characteristic examples.

The operational enhancements most appealing to the early segments are those which offer benefit on an individual basis (such as CFIT avoidance, FIS-B, and TIS-B) and do not require a high percentage of neighboring aircraft to be equipped. Another appeal would be to those fleet operators who could apply the technology (initially) where a high local concentration of "own" aircraft makes consideration of some ADS-B applications feasible.

Progression to the middle, majority regions of C and D can only happen if a good foundation has been laid in the earlier experiences of A and B. This is critically important for any NAS improvement.

Generally, applications in the majority markets are usually extensions of that which has been proven in the early markets. The early experience usually provides the basis for better and more comprehensive technical standards, and this gives the technology more credibility. This raises the comfort level for those in the mainstream who have been waiting to join. The comfort level is further raised as the technology gradually transforms into a stable consumer item, as evidenced by larger productions runs, simplified operation, and training. Far beyond a fad, technologies reaching the mature markets gain the status of being a "necessity".

Beyond the operational enhancements built up in the experiences of the early markets, the increasing equipage levels brought on by the majority regions enables more widespread use of advance air-to-air applications. This is because random pairings of aircraft over a large geographic region would likely produce two aircraft equipped to conduct such applications. Ultimately, at the very far right reaches of the majority portions, it might be safely concluded that, effectively, 100% of the NAS user-base is equipped. This would allow resource planners to consider scaling down redundant or back-up systems, depending on system availability and performance.

The final market group to consider consists of those who either do not want to join, or cannot join. There are many possible reasons but perhaps the most common are related to equipment limitations (e.g., no electrical system, or no weight/space allowance), or related to somewhat specialized missions to which the NAS “mass market” services are not usually responsive (e.g., crop dusting).

It may be that there will never be incentives for users in this region to equip. However, it is very helpful, even from the standpoint of better serving the majority markets, to closely examine this market segment. At the very least, methods of accommodation of this remnant should be examined.