CNS

Computer Networks & Software, Inc.

NAS Infrastructure Assessment

to

NASA's Glenn Research Center

for the

Airborne Internet Development

Under the

Small Aircraft Transportation System Project

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Version 1.0

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1. GENERAL

1.1. Background

The National Aeronautics and Space Administration (NASA), in partnership with the Federal Aviation Administration (FAA) and State and local aviation development organizations, has initiated a research and development program focused on maturing Small Aircraft Transportation System (SATS) enabling technologies. The program will initially focus on intermodal transportation systems engineering to develop an overall design for SATS that is complimentary to existing air and ground transportation systems. The bulk of the program will focus on developing digital airspace infrastructure and vehicle technologies that enable the SATS concept.

Air traffic congestion at "Hub and Spoke" airports in the commercial passenger aircraft transportation system is approaching a critical juncture in the next few years.[1] Rural areas and communities not close to the major airports find economic development hindered by lack of easy air access to their community. Air travel capacity, safety, accessibility, and the expense of personal time are major concerns. Further advancements in personal transportation stopped in about 1950 at an average speed of about 60 mph with the completion of the Interstate Highway System. The information age has stimulated greater human interactivity, yet ground travel suffers from gridlock, air travel suffers from hublock, and travelers suffer from inefficient use of time.

NASA is taking the lead in developing technologies for the SATS that could play a major role in helping to relieve large airport congestion and provide reliable, convenient, safe environmentally compatible air transportation service to rural and outlining communities, as well as revolutionizing the national transportation system. The Advanced General Aviation Transport Experiments (AGATE) and General Aviation Propulsion (GAP) programs have taken a quantum step in this process through the development of affordable, easy to use, environmentally friendly aircraft and propulsion systems. This investment is already benefiting the flying public through much more affordable, informative and readable avionics systems and will soon cause a revolution in small aircraft with the introduction of a whole new class of aircraft - safe, comfortable, affordable small jet aircraft. To bring the SATS vision to its full potential of a personal transportation alternative, however, will require major technology enhancements to the National Airspace System (NAS), and another order of magnitude advancement in affordability, performance and environment impact for aircraft systems.

The initial 5-year objective (FY01-05), SATSLAB, will address the President and Congress' charge to NASA and the FAA to "prove that SATS works.." SATSLAB is focused on demonstrating technologies to enable the use of existing small community and neighborhood airports, without requiring control towers, radar, and more land use for added runway protection zones. The key to such a system is a robust extremely reliable automated communications system. Such a system must be capable of passing large amounts of data between aircraft and various ground systems as well as between neighboring aircraft in a reliable fashion.

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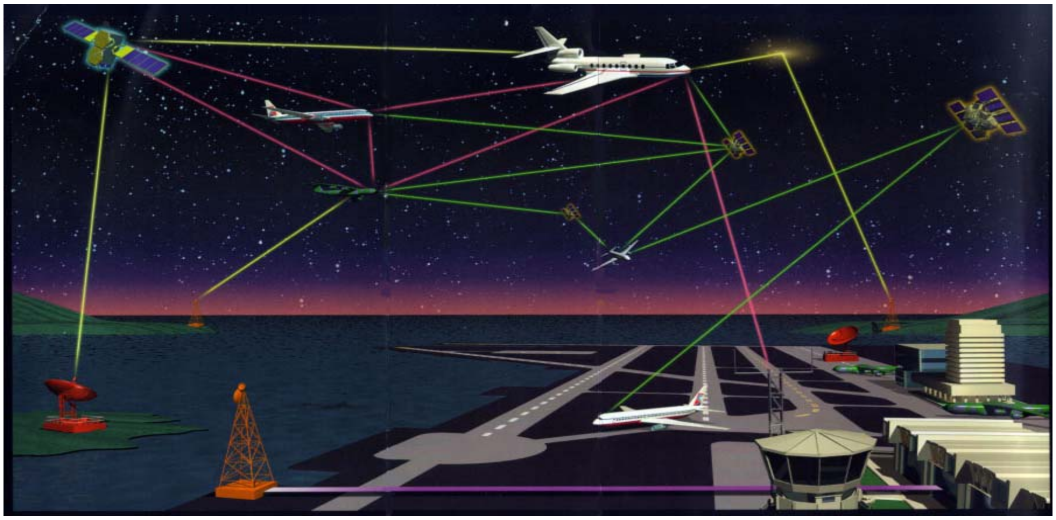
[1] The NAS Operational Evolution Plan, Version 3.0, Federal Aviation Administration, June 5, 2001

To this end, NASA Glenn Research Center, through its partnership with NASA Langley Research Center, is pursuing a key enabling technology area: *Airborne Internet*. (Figure 1)



Graphic Courtesy of Rockwell Collins

Figure 1. Airborne Internet - a Key Enabling Technology to Realize the SATS Vision

The Airborne Internet will leverage open standards and protocols for a client-server network system architecture (Figure 2) that are in development in the telecommunications industry for increased bandwidth for mobile applications. SATS research will leverage the developments in NASA and FAA Airspace System Capacity (ASC) research on Distributed Air Ground (DAG) collaborative decision-making. SATS research will focus on defining the functional allocations between clients and servers for all navigation, communications, and surveillance information necessary for aircraft operations including sequencing, separation, and conflict resolution.

Continued growth in air travel across all segments of aviation in the National Airspace System (NAS) is placing severe demands of the already constrained system and the underlying Communication-Navigation-Surveillance (CNS) infrastructure. Current NAS operations are primarily conducted via analog voice communications, radar surveillance, and ground-based navigation aides. Although a number of efforts are underway to modernize the NAS, the majority of these efforts are targeting the commercial air transport segment operating under the traditional hub-and-spoke model.

To meet the forecasted need, the consolidation and integration of communication, navigation, and surveillance technologies, systems, and services will have been initiated through a client-server internet-like model. A demonstration of integrated services via satellite-terrestrial hybrid communications architecture will benchmark the capability, efficiency, and safety of a digital airspace infrastructure. This infrastructure development will be the maturing of the Airborne Internet to enable the full SATS vision**.**

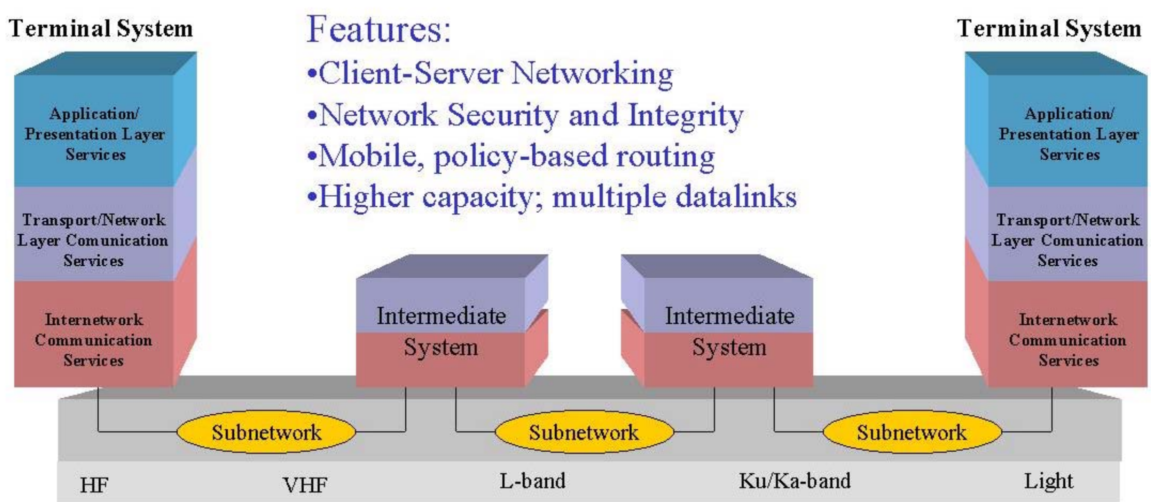


Figure 2. Airborne Internet Architecture

For public stakeholders in the states and airport communities, the SATS experiments and the data collected will be designed to demonstrate that SATS capabilities significantly increase affordable access to virtually all communities, including rural and remote areas. For the FAA, the SATS demonstration will illustrate airborne technology-based approaches for increasing NAS capacity, for lower costs for NAS expansion, and for greater NAS throughput. In addition, the SATS demonstration will show that the distributed nature of SATS augments air carrier hub and spoke operations by accessing untapped NAS capacity. Finally, for industry customers, the experiments will illustrate the role of human-aiding automation in creating single-crew mission safety and reliability comparable with two-crew operations. These results of the five-year proof of concept Program will establish the basis for decisions by industry, the FAA, NASA, and the state and community decision-makers.

Although SATSLAB will integrate key enabling technology areas to “prove that SATS works,” technology advancements for architectures, vehicles, and procedures will be limited. These initial advancements will need to be further developed while other technology elements for a complete SATS validation will need to be pursued and addressed in follow-on innovative transportation vehicle programs. As a result the CNS infrastructure needed to support the SATSLAB flight demonstrations will be built largely on commercially available systems having limited bandwidth and coverage area.

1.1.1. SATS Key Word Definitions

The following definitions help define the focus of the SATS Program.

- Small: The technologies targeted for development are aimed at smaller aircraft used for personal and business transportation missions within the infrastructure of smaller airports throughout the nation. These missions include travel by individuals, families, or groups of business associates. Consequently, the aircraft are of similar size to typical automobiles and vans used for non-commercial ground transportation - two to eight seats. They may be used for on demand, unscheduled air-taxi transportation of these same user types. Various forms of shared ownership and usage will likely be a most common means of use. While the aircraft are not specifically designed for air carrier use, the targeted technologies would provide benefits to commuter and major air carrier operations in the hub-and-spoke system as well. For FAA regulatory purposes, SATS technologies are targeted toward aircraft with a maximum take off weight (MTOW) less than 12,500 pounds (i.e., FAA small aircraft category).

- Aircraft: The strategy for development of airborne technologies focuses initially on fixed-wing airplane applications. However, the technologies created are also applicable to operational improvements for vertical take-off and landing aircraft. These technologies would enable near all-weather operations by new generations of such aircraft at virtually any landing facility in the nation. Near all-weather means operational reliability in instrument meteorological conditions except those classified as severe or hazardous (i.e., severe icing, severe turbulence, thunder storm activity, etc).

- Transportation: The technology investments are selected and prioritized for the purpose of transportation of people, goods, and services. Even so, the technologies would likely have favorable effects on safety, cost, and accessibility in recreational or other non-transportation commercial uses. The aircraft will have the altitude and speed performance, as well as the weather avoidance and toleration systems, to enable safe and reliable operations with high availability (similar to or better than today's air carrier reliability).

- System: In addition to technologies for the aircraft, SATS strategies are conceived to affect the nature of aviation operational capabilities for airports, airspace, and air traffic and commercial services. The SATS vision encompasses inter-modal connectivity between public and private, air and ground modes of travel. In concept, the SATS vision integrates the use of smaller landing facilities with the interstate highway system, intra-city rail transit systems, and hub-and-spoke airports. The strategy focuses on airborne technologies that expand the use of airports with excess capacity (those without precision instrument approaches) as well as underutilized, unmanaged airspace for transportation use (such as the low-altitude, non-radar airspace below 6,000 feet and the en route structure below 18,000 feet).

1.1.2. SATS Objective

The objective of the program is to conduct an integrated flight demonstration of four new operating capabilities that are currently not possible today. These operating capabilities are:

- Higher Volume Operations at Non-Towered/Non-Radar Airports. Simultaneous operations by multiple aircraft in non-radar airspace at and around small non-towered airports in near all-weather conditions through the use of vehicle-to-vehicle collaborative sequencing and self separation algorithms and automated air traffic management systems. Meeting this objective has the potential to safely expand the capacity of the NAS.

- Lower Landing Minimums at Minimally Equipped Landing Facilities. Precision approach and landing guidance, through the use of graphical flight path guidance and artificial vision, to any touchdown zone at any landing facility while avoiding land acquisition and approach lighting costs, as well as ground-based precision guidance systems such as an Instrumented Landing System (ILS). Meeting this objective has the potential to safely reduce the cost to increase accessibility to small airports.

- Increase Single Crew Safety & Mission Reliability to Two-Crew Levels. Increased safety and mission completion through the use of human-centered automation, intuitive and easy to follow flight path guidance superimposed on a depiction of the outside world, software enabled flight controls, and onboard flight planning/management systems. Meeting this objective has the potential to safely increase the throughput of the NAS.

- En Route Procedures & Systems for Integrated Fleet Operations. Integration of SATS equipped aircraft into the higher en route air traffic flows and controlled terminal airspace through the use of automated air traffic management systems designed to facilitate operations at non-towered airports and in non-radar airspace. Meeting this objective has the potential to safely reduce the need for ground holds.

1.1.3. Airborne Internet Subobjective

A program subobjective is to define and develop the Airborne Internet (AI) as an enabling technology for SATS. The AI should consolidate and integrate the exchange of communication, navigation, and surveillance data. Consolidation of CNS data exchange implies minimizing the number of radios and antennas on an aircraft. Full consolidation would be accomplished if all CNS data exchange functions could be performed via one radio.

1.2. Purpose

This report describes the activities performed to identify, assess and trade off the various issues and concepts involved in the Small Aircraft Transportation System (SATS) relationship with the National Airspace System (NAS) infrastructure.

1.3. Report Organization

This report is organized into 14 sections supported by two appendixes:

- Section 1 provides an introduction and overview.

- Section 2 contains a summary of the tasks performed to assess the NAS infrastructure.

- Section 3 identifies and characterizes SATS aircraft operational airspace.

- Section 4 describes and categorizes potential SATS airfields.
- Section 5 presents the results of the spectrum analysis.
- Section 6 describes existing and planned NAS communications, navigation and surveillance systems.
- Section 7 defines the operational services that will be available to SATS users.
- Section 8 describes the information exchanges objects that support the operational services. It also shows the relationships between the SATS operational services and information exchange objects.
- Section 9 identifies the NAS services that will be available to SATS users.
- Section 10 provides a comparison of the SATS information exchange objects and NAS systems.
- Section 11 describes the generic interface approaches and NAS issues.
- Section 12 describes the interactions of Non-SATS and SATS aircraft with the NAS.
- Section 13 provides an assessment of the SATS/NAS interface.
- Appendix A is a list of acronyms.
- Appendix B contains a list of references.

2. TASK METHODOLOGY

2.1. Airborne Internet Project Workflow

Figure 3 presents the overall task plan and relationships for the activities associated with the definition of the Airborne Internet. In Fiscal Year (FY) 2001 there are basically five major task flows indicted in the figure:

- NAS Infrastructure Assessment
- AI Requirements
- Technology Evaluation
- AI Architecture Development
- AI Architecture Evaluation (Testbed)

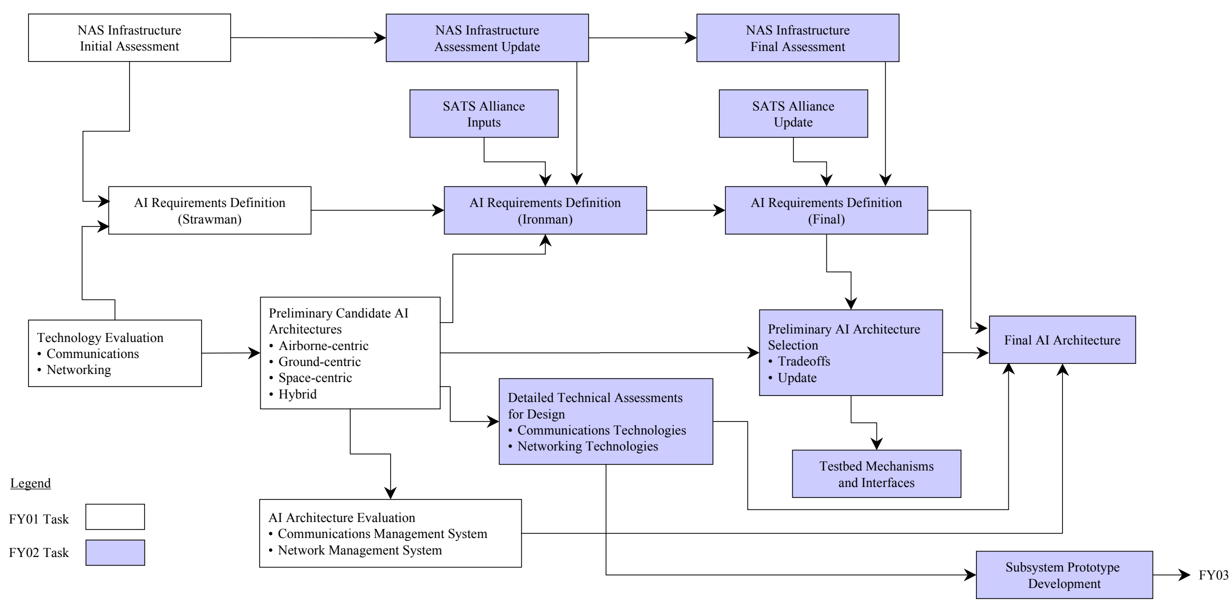


Figure 3. Task Flow Diagram

2.2. NAS Infrastructure Assessment

This document describes the activities performed to identify, assess and tradeoff the various issues and concepts involved in the SATS relationship with the NAS Infrastructure. Computer Networks & Software, Inc. gathered information about the programmatic and technical aspects of the NAS infrastructure as they relate to communications, navigation and surveillance functions. They evaluated both the technical and practical impacts of implementing the AI on the

NAS infrastructure and the methods for interfacing each of the communications and networking technologies with the NAS infrastructure. Obstacles to implementing a technology were also identified.

Figure 4 shows the Subtasks of work activity to accomplish the NAS Infrastructure Assessment.

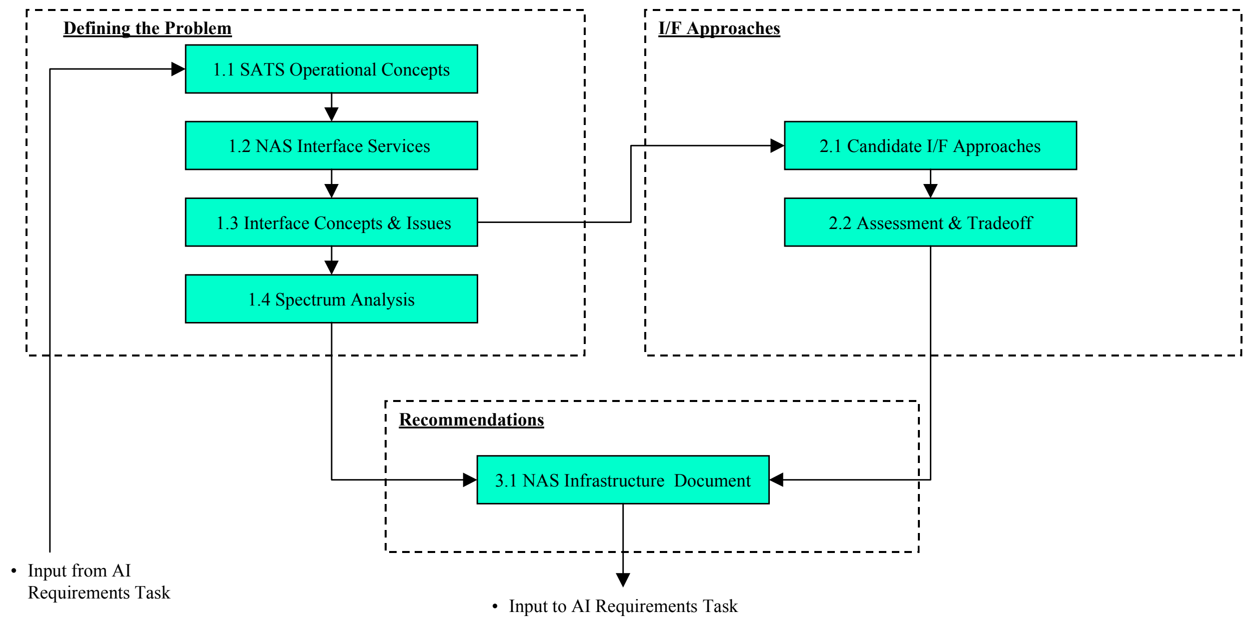


Figure 4. NAS Infrastructure Assessment Workflow Diagram - Initial Phase

Activities performed in this task included:

- Assessing today's NAS for its ability to accommodate the SATS objectives in context of the Airborne Internet development and implementation.
- Identification of NAS interface services
- Assessing the modernization plans of the NAS for their ability to accommodate the SATS objectives in context of the Airborne Internet development and implementation.
- Identification of Interface Concepts and Issues
- Identification of candidate interfaces
- Performance of an assessment and trade-off analysis of the candidate interfaces
- Identification of communications spectrum utilization as it relates to airborne operations

3. SATS AIRCRAFT OPERATIONAL AIRSPACE

3.1. SATS Operations

SATS aircraft use of NAS airspace will include operations in virtually all classes of airspace. Some SATS flights will originate in uncontrolled airspace, then transition into controlled airspace at flight plan coordinated fixes and times. SATS aircraft may transit the NAS at virtually any altitude, but will likely operate at altitudes between the Minimum En Route Altitude and Flight Level (FL) 220. SATS flights in controlled airspace will comply with the operational requirements of the airspace in use. Arrival and landing operations will be conducted at all levels of control, from TRACON airspace to uncontrolled approaches and landings at non-towered airfields. SATS operational airspace is shown in Figure 5.

SATS aircraft will be relatively unaffected by geography. Aircraft performance may be a factor in some environments and aircraft operating at lower altitudes may have trouble maintaining contact with ground-based CNS systems. This will be especially true for non-pressurized aircraft equipped with normally aspirated engines. These aircraft will normally operate at altitudes of 10,000 feet mean sea level (MSL) and below. Aircraft operating at these altitudes will likely encounter difficulty maintaining line-of-sight contact with ground-based CNS transmitters and may require the use of satellite systems to maintain communications.

Pressurized aircraft, especially those equipped with turbine engines, have operational service ceilings above 30,000 feet MSL and can operate freely in the NAS Low or High Altitude En route structure. Maintaining line-of-sight contact with ground-based systems should normally not be a problem for these aircraft.

3.2. Classes of Airspace

The FAA divides airspace into several classes depending on its characteristics and use. These classes are summarized in the following paragraphs, which are taken from the Pilot/Controller Glossary, an addendum to FAA Order 7110.65.[2]

3.2.1. Controlled Airspace

Controlled airspace is a generic term that covers Class A, Class B, Class C, Class D, and Class E airspace. It is airspace of defined dimensions within which air traffic control service is provided to Instrument Flight Rules (IFR) and Visual Flight Rules (VFR) flights in accordance with the airspace classification. Operating in controlled airspace mandates pilot qualifications, operating rules, and equipment requirements. For IFR operations in any class of controlled airspace, a pilot must file an IFR flight plan and receive an appropriate ATC clearance. Each Class B, Class C, and Class D airspace area designated for an airport contains at least one primary airport around

[2] FAA Order 7110.65, Air Traffic Control, Federal Aviation Administration, July 12, 2001

which the airspace is designated. Controlled airspace in the United States is designated as follows:

Class A airspace is generally that airspace from 18,000 feet MSL up to and including Flight Level (FL) 600, including the airspace overlying the waters within 12 nautical miles of the coast of the 48 contiguous States and Alaska. Unless otherwise authorized, all aircraft must operate under IFR.

Class B airspace is generally that airspace from the surface to 10,000 feet MSL surrounding the busiest airports in terms of IFR operations or passenger enplanements. The configuration of each Class B airspace area is individually tailored and consists of a surface area and two or more layers, and is designed to contain all published instrument procedures once an aircraft enters the airspace. An ATC clearance is required for all aircraft to operate in the area, and all aircraft that are so cleared receive separation services within the airspace. The cloud clearance requirement for VFR operations is "clear of clouds."

Class C airspace is generally that airspace from the surface to 4,000 feet above the airport elevation surrounding airports that have an operational control tower, are serviced by a radar approach control, and have a certain number of IFR operations or passenger enplanements. Although the configuration of each Class C airspace area is individually tailored, the airspace usually consists of a surface area with a 5 nautical mile (NM) radius, and an outer circle with a 1 NM radius that extends from 1,200 feet to 4,000 feet above the airport elevation. Each person must establish two-way radio communications with the ATC facility providing air traffic services prior to entering the airspace and thereafter maintain those communications while within the airspace. VFR aircraft are only separated from IFR aircraft within the airspace.

Class D airspace is generally that airspace from the surface to 2,500 feet above the airport elevation surrounding airports that have an operational control tower. The configuration of each Class D airspace area is individually tailored and when instrument procedures are published, the airspace will normally be designed to contain the procedures. Unless otherwise authorized, each person must establish two-way radio communications with the ATC facility providing air traffic services prior to entering the airspace and thereafter maintain those communications while in the airspace. No separation services are provided to VFR aircraft.

Class E airspace is controlled airspace that is not otherwise classified as Class A, Class B, Class C, or Class D. Class E airspace extends upward from either the surface or a designated altitude to the overlying or adjacent controlled airspace. The airspace is configured to contain all instrument procedures. Also in this class are Federal airways, airspace beginning at either 700 or 1,200 feet above ground level (AGL) used to transition to or from the terminal or en route environment, en route domestic, and offshore airspace areas designated below 18,000 feet MSL. Unless designated at a lower altitude, Class E airspace begins at 14,500 MSL over the United States, including that airspace overlying the waters within 12 nautical miles of the coast of the 48 contiguous States and Alaska. Class E airspace does not include the airspace 18,000 MSL or above.

3.2.2. Uncontrolled Airspace

Uncontrolled airspace is generally all airspace that is not classified as Class A, B, C, D, or E. Uncontrolled airspace is designated as Class G airspace.

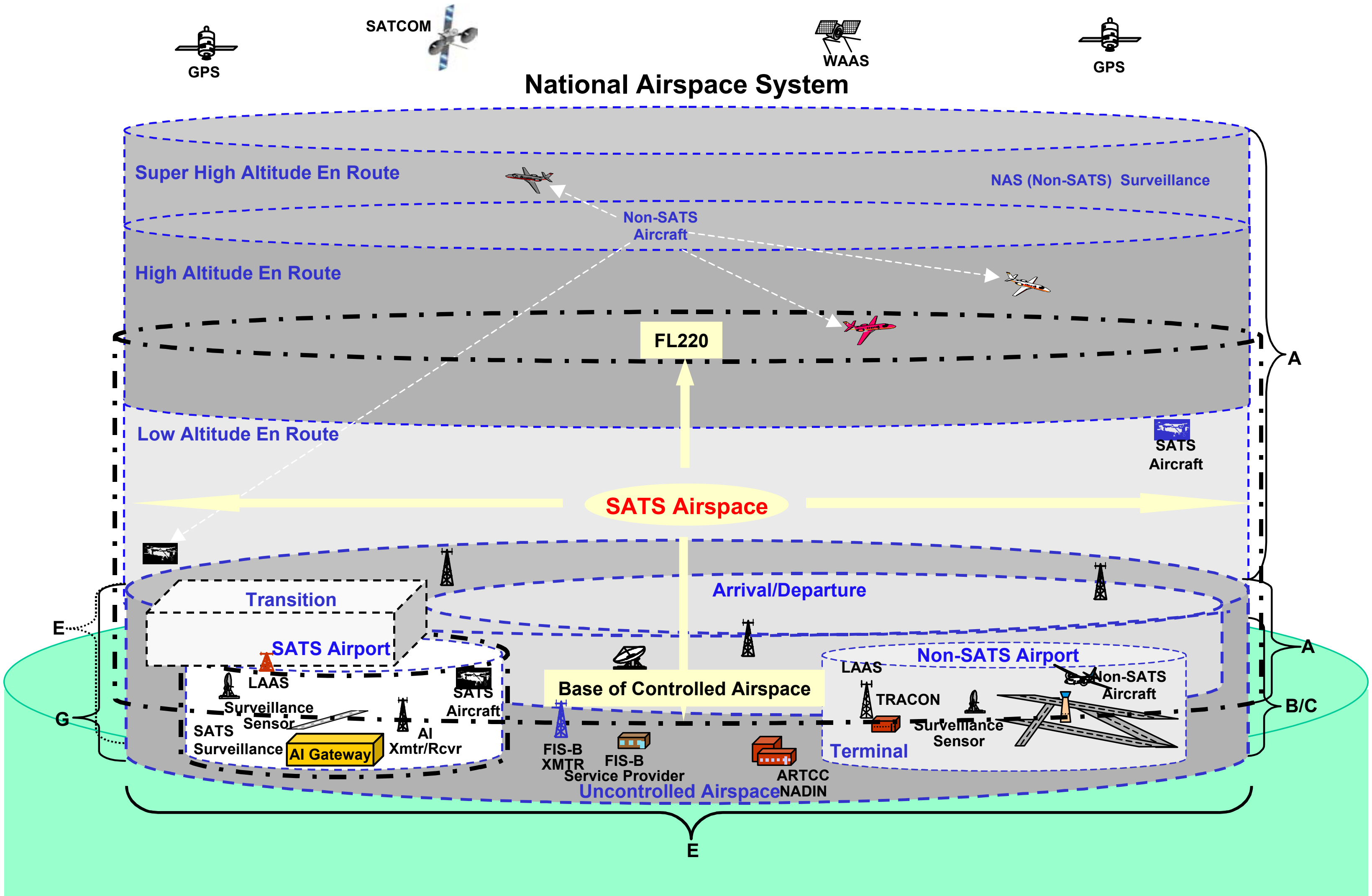


Figure 5. SATS Operational Airspace

4. PUBLIC AIRFIELDS

4.1. Airports in the United States

There are over 19,000 airports in the United States, of which more than 5,000 are open to the public. Of this number, the FAA considers only 3,367 to be significant to the capacity of the NAS.[3] The airports are included in the National Plan of Integrated Airport Systems (NPIAS)[4] and are divided into two major categories: commercial service airports and general aviation airports.

4.2. Commercial Service Airports

Commercial service (CS) airports are public airports that receive scheduled passenger service and account for 2,500 or more passengers per year on scheduled or unscheduled commercial flights. There are 546 commercial service airports in the U.S. Table 1 shows the breakout of the commercial service airports in the United States and the percentages of passengers for each airport type. Airports handling more than 10,000 passengers annually are classified as primary airports. Those with 2,500 to 10,000 passengers annually are classified as "other" commercial service airports.

Table 1. Commercial Service Airports

Type of Airport	Number of Airports	Definition of Airport Type	Percentage of Enplanements
Large Hub	31	At least 1% of passengers	69.6%
Medium Hub	37	0.25% to 1% of passengers	19.3%
Small Hub	72	0.05% to 0.25% of passengers	7.7%
All Hub Airports	140	More than 0.05% of passengers	96.6%
Non-Hubs	282	Less than 0.05% of passengers	3.2%
All Primary Airports	**422**	**More than 10,000 passengers**	**99.8%**
Other CS Airports	124	2,500 to 10,000 passengers	0.01%
All CS Airports	**546**	**More than 2,500 passengers**	**99.9%**

Within the primary airport classification, the term "hub" is used to identify very busy airports. The primary airports are divided into large-hub, medium-hub, small-hub, and non-hub airports, based on the number of annual passengers. Large-hub airports account for at least one percent of total U.S. passengers, medium hubs account for between 0.25 percent and one percent of total

3 2000 Aviation Capacity Enhancement Plan, Federal Aviation Administration, Office of System Capacity, December 2000.

4 National Plan of Integrated Airport Systems (1998 - 2002), Secretary of Transportation, March 1999.

passenger and small hubs from 0.05 percent to 0.25 percent of total passengers. Commercial service airports with less than 0.05 percent of total passengers but more than 10,000 annually are called non-hub primary airports. As shown in Table 1, traffic in the United States is concentrated at the largest airports. In 1999, the 31 large-hub airports accounted for 69.6 percent of total passengers, the 37 medium-hub airports for 19.3 percent, and the small hubs for another 7.7 percent (96.6 percent of total passengers). The remaining 282 primary airports had only 3.2 percent of passengers. The 128 non-primary commercial service airports carried only 0.1 percent of all passengers.

4.3. General Aviation Airports

Airports with less than 2,500 passengers annually or without scheduled commercial service are considered general aviation airports. Table 2 shows the types and numbers of general aviation airports and the percentage of total aircraft based at each.

Table 2. NPIAS General Aviation Airports

Type of Airport	Number of Airports	Percentage of Based Aircraft
Relievers	315	33%
GA > 50 Based Aircraft	438	22%
GA > 25 Based Aircraft	584	11%
GA > 10 Based Aircraft	777	7%
GA < 10 Based Aircraft	707	2%
All GA Airports	2,821	75%

The general aviation airports are divided into two airport categories: reliever and general aviation. Relievers are high capacity GA airports in major metropolitan areas that provide general aviation pilots and aircraft with attractive alternatives to using congested commercial service airports. The other general aviation airports usually serve rural areas, and have very little, if any, commercial service. In 1999, there were 2,821 general aviation airports, of which 315 were reliever airports and 2,506 general aviation airports.

Although relievers and other general aviation airports have little commercial service, they do carry a small number of passengers, primarily provided by air taxi operators. These airports account for only 0.1 percent of total passengers.

5. SPECTRUM ANALYSIS

5.1. Aviation Related Frequencies

The Federal Government depends heavily on the private sector to provide telecommunications service for its own use. This means that all functions normally associated with providing the service is performed by the private sector. These functions include design, engineering, system management and operation, maintenance, and logistical support.

The future applications of commercial wireless will be used by not only Federal civil agencies, but also by the military. Mobile-satellite services (MSS), as well as government-owned personal communications service (PCS) and wireless local area networks will be deployable with military warfighting units. Table 3 below describes current and projected Federal spectrum requirements.

Table 3. Future Federal Spectrum Requirements

Requirement	Frequency	Primary Users	Plans
Mobile			
Land Mobile	162-174 & 406–420 MHz bands, 12.5 spacing	Federal Civil Agencies & Military Departments	Narrowband operation 2005 162-174 MHz and 2008 406-420 MHz.
DoD Mobile	30-88 MHz, 138-144 MHz, 225-400 MHz	Aeronautical maritime & land tactical.	Additional 115 MHz by 2015
Aeronautical Mobile	2-23 MHz, 118-137 MHz, & 225-400 MHz	Federal Agencies	Need 108 kHz for Aero Mobile (R), 30 kHz for Aero Mobile (OR) 100 kHz for Aero Operations.
Flight Test Telemetry	1435-1535 MHz, 2200-2290 MHz, & 2310-2390 MHz	Military & commercial aircraft flight-testing. NASA, DoD & Commercial manufacturers.	Estimated an additional 300 MHz will be needed. Possible allocations in the 25.25-27.0 GHz band.
Paging	162-174 MHz & 406-420 MHz.	Federal Agencies	Moving the paging operations out of the land mobile. After Jan 1, 2005 all Federal systems (162-174) must operate within a 12.5 kHz channel.
Maritime Mobile			36-60 kHz of additional spectrum was required.
Fixed	37-38.5 GHz, 42.5-43.5 GHz	Exclusive Federal Allocations	All near-term requirements are met. Additional 630 MHz required for DoD by 2015.

Requirement	Frequency	Primary Users	Plans
Radio Astronomy	Radio astronomy allocations were revised in 50 GHz band.		Most can be satisfied. Study showed additional 9.6 MHz was required.
Radiolocation			Adequate in the near-term
Radionavigation			
GPS	A second civil signal at 1227.60 MHz beginning 2003	Civil, commercial, and scientific	A third civil signal at 1176.45 for safety-of-life application beginning 2005
Space Services			
Space Operations	2200-2290 MHz	DOD and Commercial	Additional spectrum is required, not identified yet.
Space Sciences			Adequate for the present
Fixed-Mobile Satellite	40.5-41 GHz, 42.5-43.5 GHz, 40- 41 GHz will be available FSS & MSS operations.	Federal, DOD	Increase from 123 to 215 MHz for protected SATCOM, & a many fold increase in wideband SATCOM.

5.2. Experimental Frequencies

Many different Federal agencies use the portions of the spectrum for experimental test of new technologies and hardware. The Long-Range Spectrum Plan[5] identifies the experimental frequencies listed in Table 4 below.

Table 4. Experimental Frequencies

Frequency	Government Usage
1990 - 2025 MHz	Numerous experimental antenna test stations checkout frequency response of transmit and receive antennas.
2120 - 2150 MHz	Experimental antenna test station evaluating antenna patterns is done in this band.
2150 - 2160 MHz	Experimental ground testing of transmitters.
2170 - 2200 MHz	Various Federal experimental test stations operate in this test band.
2300 - 2310 MHz	Various experimental test stations operate in this band as well as other systems that are not in conformance with the National Table of Frequency Allocations.
2310 - 2320 MHz	Various experimental test stations perform RDT&E activities in this band.

[5] Federal Long-Range Spectrum Plan, Department of Commerce, September 2000

Frequency	Government Usage
2320 - 2345 MHz	Various experimental test stations perform RDT&E activities in this band.
2345 - 2360 MHz	Various experimental test stations perform RDT&E activities in this band.
2360 - 2390 MHz	Various experimental test stations perform RDT&E activities in this band.
2390 - 2400 MHz	Various experimental test stations perform RDT&E activities in this band.
2400 - 2483.5 MHz	Various experimental test stations perform RDT&E activities in this band.
2485.5 - 2520 MHz	NASA conducts experimental testing of satellite transmitters supporting NASA Commercial Experimental Transporter (COMET)
2520 - 2640 MHz	Experimental testing of communications equipment is conducted.
3700 - 4200 MHz	Various Federal agencies operate test stations of radiolocation systems on an NIB basis.
5640 - 5600 MHz	Experimental RDT&E testing of radars occurs in this band.
6425 - 7075 MHz	RDT&E of radio communications equipment is performed on national and military test ranges as well as contractors facilities.
7075 - 7125 MHz	Some RDT&E of radio communications equipment is performed in this band.
7125 - 7145 MHz	Some experimental test stations operate at national and military test ranges. Also, NASA is conducting development testing at the DSN 26m antenna in support of Mars Global Surveyor.
7145 - 7155 MHz	Some experimental test stations operate at national and military test ranges.
10.7 - 11.7 GHz	Experimental testing is performed in this band for such studies as millimeter wave propagation studies, etc.
12.2 - 13.25 GHz	Experimental test stations on national and military test ranges operate in this band.
13.75 - 14 GHz	The military service performs RDT&E of new radar systems, techniques, tactics, etc., in this band.
14 - 14.2 GHz	Experimental RDT&E of radar systems are done in this band.
14.7145 - 15.1365 GHz	RDT&E of various systems and millimeter wave technology is performed in this band.
16.6 - 17.1 GHz	This band supports RDT&E of experimental radars, test ranges missile guidance radars, and target tracking radars.
17.1 - 17.2 GHz	Various radars are supported in the band.
17.2 - 17.3 GHz	Experimental testing and calibrations of sensors and navigational systems is performed in this band.
17.7 - 17.8 GHz	Experimental testing and calibrations of sensors and navigational systems is performed in this band. Also, this band supports RDT&E of experimental radars.
24.25 - 24.45 GHz	Experimental testing and calibrations of sensors and navigational systems is performed in this band.
24.45 - 24.65 GHz	Experimental testing of radio communication systems is conducted in this band.

Frequency	Government Usage
24.75 - 25.05 GHz	Experimental testing and calibrations of sensor and navigational systems is performed in this band.
25.25 - 25.5 GHz	Experimental testing and calibrations of sensor and navigational systems is performed in this band.
25.5 - 27 GHz	Experimental testing and calibrations of sensor and navigational systems is performed in this band.
27 - 27.5 GHz	Experimental testing of radio communication systems such as the demonstration of millimeter wave radio links.
27.5 - 29.5 GHz	Other Federal agencies are conducting experimental research on millimeter wave propagation.
33 - 33.4 GHz	DOD RDT&E is conducted in this band to evaluate millimeter wave systems as well as the accuracy of sensor and navigational systems.
33.4 - 34.2 GHz	DOD RDT&E is conducted in this band to evaluate millimeter wave systems as well as the accuracy of sensor and navigational systems.
34.7 - 35.5 GHz	Research is being conducted for airborne enhanced vision systems.
36 - 36.4 GHz	Experimental testing by some Federal agencies is conducted in this band towards improving the accuracy of sensor and navigational systems.
38 - 38.6 GHz	NASA conducts experimental research in this band for improving techniques for measuring rainfall.
38.6 - 39.5 GHz	Experimental testing is conducted in this band towards improving the accuracy of sensor and navigational systems.
50 - 55 GHz	RDT&E activities involving radar cross section measurements is performed in this band.
61.5 - 64 GHz	Experimental testing of millimeter wave radio systems is performed in this band.
68.5 - 71.5 GHz	RDT&E activities involving radar cross section measurements is performed in this band.
92 - 93.07 GHz	RDT&E of various millimeter wave radar technologies is done in this band.
93.07 - 93.27 GHz	RDT&E of various millimeter wave radar technologies is done in this band.
94.1 - 95 GHz	RDT&E of various millimeter wave radar technologies and antenna testing is done in this band.
95 - 97.88 GHz	Experimental research of atmospheric anomalies on millimeter wave frequencies is done in this band.

6. EXISTING AND PLANNED NAS SYSTEMS

In the current NAS, the focus is on sustaining essential air traffic control services and delivering early user benefits. Today Flight Service Stations (FSS) provide accurate and timely aviation weather, aeronautical information, and flight planning assistance to commercial and general aviation. This information is obtained directly from an FSS via telephone or by using a personal computer to access the FSS via the Internet. Current pre-flight and in-flight service functions include:

- Filing instrument flight rule (IFR) and visual flight rules (VFR) flight plans.
- Providing VFR flight following.
- Providing broadcast messages.
- Providing user access to weather briefings.
- Disseminating NOTAMs
- Processing and disseminating pilot reports (PIREPs)
- Providing emergency services.
- Providing other services as needed.

Computer Networks & Software, Inc. developed a SATS Operational Concepts document,[6] which identified a set of services that will be provided by the NAS and used by the SATS. This set of services is used to assess various interface approaches. For the purpose of this task, the NAS includes commercial sources and other aircraft. The FAA is deploying a number of technologies and systems to implement these NAS services. These systems are described in the following paragraphs.

6.1. Traffic Information Service (TIS)

The Traffic Information Service (TIS) data link provides automatic display of nearby traffic and warns the pilot of potentially threatening traffic conditions. Using the Mode-S data link, a TIS ground processor uplinks surveillance information generated by Mode S sensors to equipped aircraft. The aircraft TIS processor receives the data and displays the data on the TIS display, providing increased situational awareness and an enhanced "see-and-avoid" capability for pilots. TIS data is obtained from the ground Mode S sensor that acquires and maintains aircraft tracks within its coverage area.

TIS can only provide traffic information to aircraft equipped with Mode S, although the system acquires and maintains track information on all aircraft equipped with an ATC Radar Beacon

[6] SATS Operational Concepts, Version 1.6, Computer Networks & Software, Inc., October 10, 2001

System (ATCRBS). TIS can also integrate primary radar coverage to maintain tracks of non-transponder equipped aircraft. Because it is available to all Mode S transponders, TIS is inexpensive and its availability makes collision avoidance technology more accessible to the price-sensitive general aviation community.

TIS software and Mode S sensors are fielded at a number of terminals nationwide. Terminal Mode S installations (Figure 6) currently provide 60 nautical mile coverage, including a 5-mile buffer required for TIS coverage. Figure 7 is a TIS coverage map that shows the results of the 100 nautical mile terminal coverage project that is underway plus those of the proposed en route coverage project (currently unfunded).

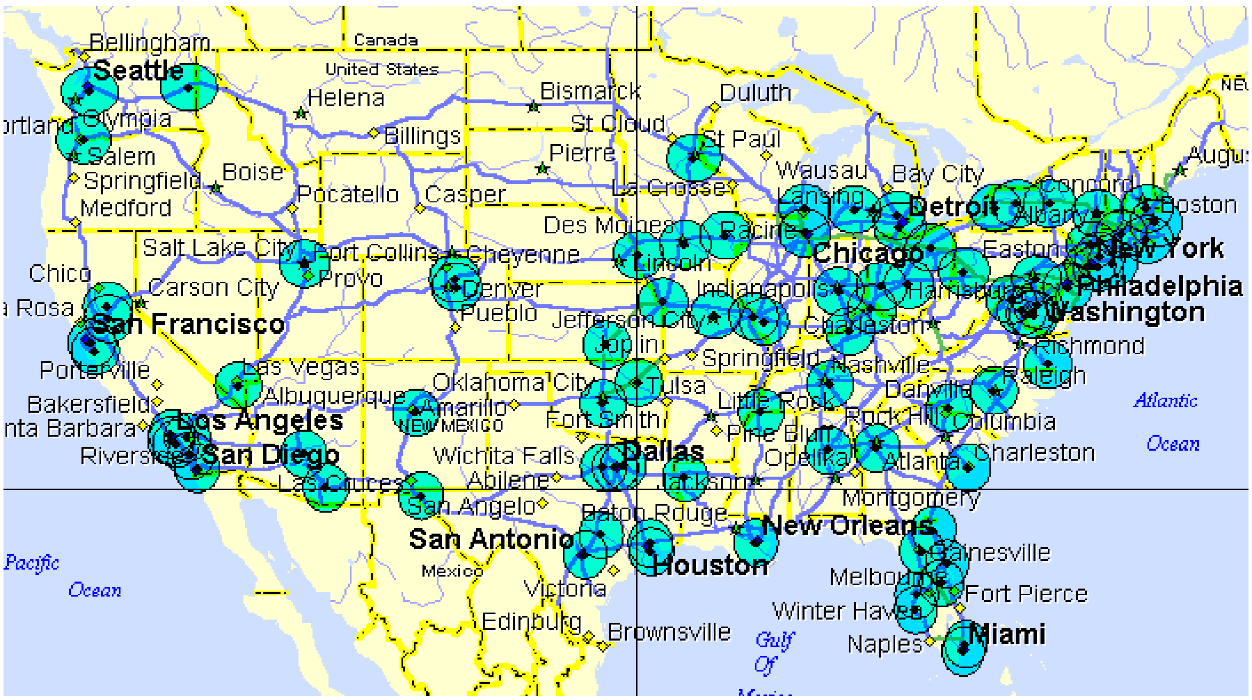


Figure 6. Terminal Mode S Coverage Area

A Mode S equipped aircraft requests TIS data via a downlink message at 1090 MHz. The ground station sends TIS data to the aircraft via a datalink that operates at 1030 MHz. Data formats for TIS are described in the Minimum Operational Performance Standards for Traffic Information Service (TIS) Data Link Communications.[7] The TIS cockpit display provides at least 5 miles of display range and TIS encoding provides values up to seven miles in 1/8-mile intervals. Relative altitudes from –3,000 to +3,500 feet are also accommodated.

[7] Minimum Operational Performance Standards for Traffic Information Service (TIS) Data Link Communications, DO-239, RTCA, April 2, 1997.

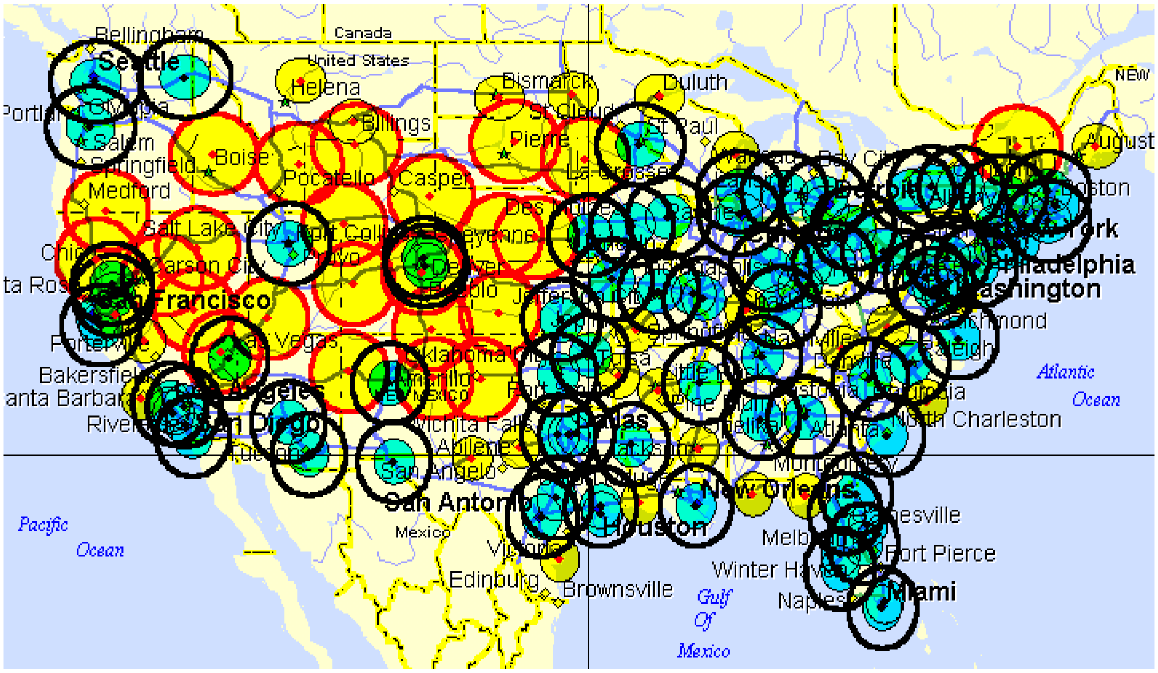


Figure 7. En Route and Extended Terminal TIS Coverage Area

6.2. Traffic Information Services - Broadcast (TIS-B)

The TIS-B service broadcasts traffic information obtained from ground surveillance sources to appropriately equipped aircraft. The principal sources of data for TIS-B are expected to be primary and secondary surveillance radar, although potential sources of TIS-B data include multilateration systems, ADS-B, and other future surveillance systems. TIS-B ground broadcasts contain all the traffic seen by the ground sensor and are displayed in terms of longitude and latitude, referenced to the World Geodetic System 1984 (WGS 84). TIS-B reports may be provided for aircraft, surface vehicles, and fixed obstacles. Several formats have been proposed for TIS-B data, but the final format has yet to be defined.

RTCA's Special Committee 186 (SC-186) is developing standards for TIS-B. One of the goals is to ensure that the avionics equipment that processes and displays Automatic Dependent Surveillance - Broadcast (ADS-B) reports will display TIS-B reports. Likewise, the ADS-B communications medium that is selected for use in the US will be the same medium that is used for TIS-B. The candidates that are being considered are UAT and Mode S. UAT does not have a permanently assigned frequency in the US. It is currently using 966 MHz. TIS-B transmissions via Mode S are at 1090 MHz. The FAA is expected to select the ADS-B medium by early 2002.

The TIS-B system architecture includes control facilities and ground stations. Surveillance processing and report generation and distribution are performed at the control facilities. TIS-B control facilities may be networked together to facilitate data exchange and coordination. Each facility may have multiple ground stations affiliated with it.

6.3. Flight Information Service - Broadcast (FIS-B)

FIS-B services are provided to the cockpit by data link. It is non-control advisory information needed by pilots to operate more safely and efficiently, including information necessary for flight planning, whether in the air or on the ground. FIS-B products include information on the NAS status, special use airspace (SUA), and meteorological information in text and graphical form. FIS-B data is currently available via commercial service providers.

The FAA has elected to provide this service through commercial suppliers. ARNAV and Honeywell won contracts from the FAA in 1999 to provide FIS-B services. They plan to use a VHF data link (employing the VDL Mode 2 protocol) to automatically and continuously broadcast weather and other FIS information to the cockpit. The FIS-B data rate used by ARNAV and Honeywell is 31,500 bits per second (31.5 Kbps). To assure adequate bandwidth, the FAA granted each company two 25-KHz VHF frequency channels - from 136.425 through 136.500 MHz. The firms are responsible for building the ground infrastructure, providing a data radio, and delivering the free weather information. They also will use the FIS-B datalink to offer aviators a menu of "fee-for-service" options.

The FAA's requirements document for the FIS data link[8] provided by ARNAV and Honeywell specifies that as a minimum, the data link will provide Aviation Routine Weather Reports (METAR), Terminal Area Forecasts (TAF), Significant Meteorological Information (SIGMET), Convective SIGMET, Airman's Meteorological Information (AIRMET), Pilot Reports (PIREPS) (urgent and routine), and Aviation Weather Watches (AWW) produced by the FAA or National Weather Service (NWS). These are to be provided to the user at no cost. In addition, ARNAV and Honeywell can charge a fee for other value-added products. All of their FIS-B products and services are to be based on government approved data sources. Approved aviation weather information includes information provided by the NWS, sources approved by the NWS, or those sources authorized by the FAA.

The FIS-B data link must be accessible from 5,000 feet above ground level (AGL) to 17,500 feet mean sea level (MSL). A desired goal is to be accessible from 5,000 feet AGL up to Flight Level (FL) 450. FIS-B products will be transmitted at least every 15 minutes. The FIS-B data link will operate using four 25-KHz VHF frequencies within the aeronautical mobile (route) service communications spectrum from 136.425 through 136.500 MHz. The FIS-B data link employs a one-way (broadcast) uplink communications infrastructure.

Honeywell plans to establish about 220 ground stations, comprised of a two-foot (0.61-meter)-square box containing NavRadio's VDL Mode 2 transmitter, a small satellite dish, and a satellite data link. The boxes will be placed at strategically selected locations. Honeywell is calling upon its nationwide network of distributors to host the ground station sites.

Roles and Responsibilities

[8] Requirements Document for Flight Information Services (FIS) Data Link, Federal Aviation Administration, January 19, 1999

The FAA is responsible for making NAS status and existing Federal meteorological data equally accessible to all aeronautical users, including service providers. They are working with other Government agencies, users, and industry to develop a common set of human factors guidelines and standards for the display and training associated with use of FIS-B products in the cockpit. The FAA has taken the lead to coordinate the establishment of national and international standards and operational procedures for delivery of FIS-B via data link, ensuring interoperability between various FIS-B capabilities and service providers. One result of this effort is the publishing by RTCA of DO-267, Minimum Aviation System Performance Standards (MASPS) for Flight Information Service Broadcast (FIS-B) Data Link.[9]

Other vendors may use different delivery media. ViGYAN plans to offer a SATCOM-based FIS-B Service that should be operational by the end of 2002. FIS-B services will be provided during Operational Evaluation (OpEval) 3 of SafeFlight 21 using Mode S (1090 MHz) and UAT as the transmission medium. In general, the transmission medium used will depend that used by the service provider to which the pilot chooses to subscribe.

Commercial service providers will provide the ground infrastructure (i.e., ground servers and data link transmitters) needed to get products to the aircraft. They may also provide avionics needed to process and display products in the cockpit. Users of the FIS-B services will be responsible for acquiring required avionics at their own cost.

The model for implementing the FAA's policy on FIS-B services is shown in Figure 8.

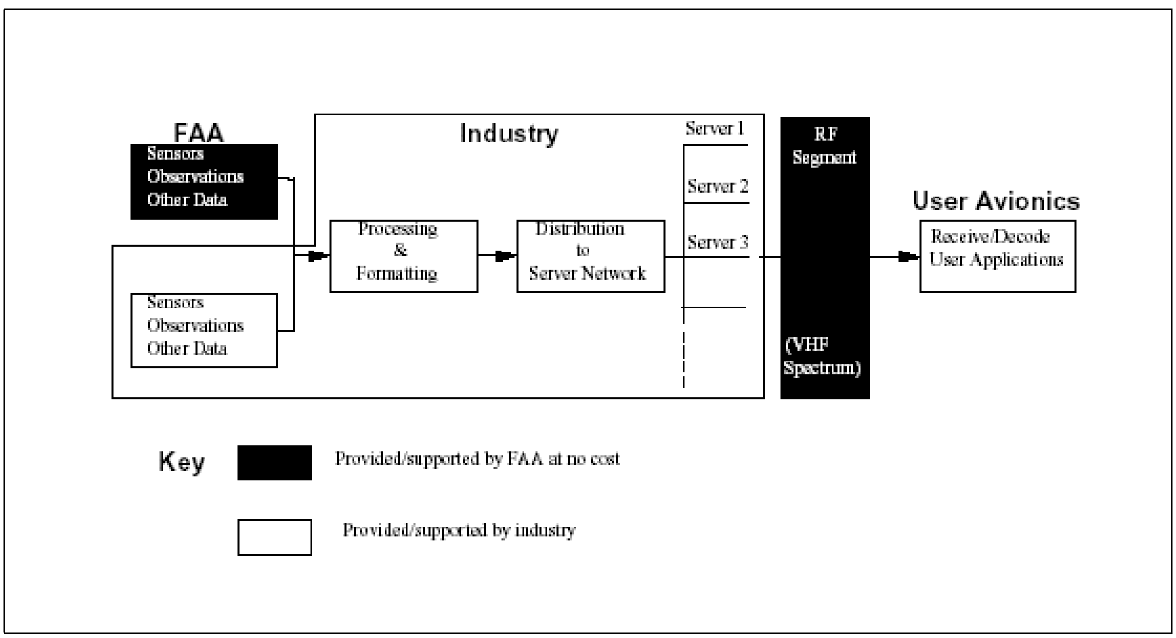


Figure 8. FAA FIS-B Services Model

9 Minimum Aviation System Performance Standards (MASPS) for Flight Information Service Broadcast (FIS-B) Data Link, RTCA, March 27, 2001

6.4. Controller Pilot Data Link Communication (CPDLC)

The Federal Aviation Administration (FAA), in conjunction with industry and foreign Civil Aviation Authority (CAA) participation, is developing a data link system to enhance air-ground communications. A part of this data link system is the Controller Pilot Data Link Communication (CPDLC) application, which will provide an additional communications means to complement the voice channels currently in use by controllers and pilots for the exchange of air traffic clearances and information.

CPDLC will be implemented in phases. The first phase of CPDLC (CPDLC Build I) implements a small subset of the messages defined in the ICAO Manual of Technical Provisions for the Aeronautical Telecommunication Network (ATN).[10] Successive phases of CPDLC implementation (CPDLC Builds IA, II, and III) will incorporate additional CPDLC messages. CPDLC Build I was originally scheduled for operational evaluation in the near future, but that was recently downgraded to a series of experiments. The schedule for CPDLC Build IA has also been delayed at least 2 years, from a scheduled initial operational capability in 2004 to 2006 or beyond.

CPDLC Builds I, IA and the initial spirals of Build II will use ARINC's VDL Mode 2 subnetwork for message delivery. The FAA hopes to deploy its own subnetwork around 2010. This subnetwork will use VDL Mode 3 as the data communications medium. The FAA's ground equipment for VDL Mode 3 will be developed under the Next Generation Communications (NEXCOM) program.

6.5. Local Area Augmentation System (LAAS)

The LAAS is being developed to support differential Global Navigation Satellite System (GNSS)-based precision approaches and landings. The LASS consists of three primary subsystems:[11]

- A satellite subsystem (GPS) that provides ranging signals.
- A ground subsystem that provides VHF data broadcasts containing differential corrections and other pertinent information. The LAAS ground subsystem operates on 25 KHz centers in the VHF navigation range. The lowest available frequency is centered on 108.000 MHz, the highest on 117.975 MHz.[12]
- An airborne subsystem, encompassing the aircraft equipment used to receive and process the LAAS and GPS signals in order to compute a position solution and deviations to a desired reference path.

[10] Manual of Technical Provisions for the Aeronautical Telecommunication Network (ATN), ICAO DOC 9705/AN956, International Civil Aviation Organization, December 1999

[11] Minimum Operational Performance Standards for GPS Local Area Augmentation System Airborne Equipment, DO-253, RTCA, January 11, 2000

[12] GNSS Based Precision Approach Local Area Augmentation System (LAAS)-Signal-in-Space Interface Control Document (ICD), DO-246A, RTCA, January 11, 2000

6.6. Automated Flight Service Stations (AFSS)

Automated Flight Service Stations are a network of 61 facilities across the United States operated by the FAA. Currently 36 of these AFSSs are accessible through the Internet. These stations are a part of the FAA air traffic system and are staffed by uniquely trained air traffic control specialists. The primary role of an AFSS is to provide weather briefing and flight planning services to pilots. AFSSs also coordinate VFR search and rescue services, provide orientation service to lost aircraft, maintain continuous weather broadcasts on selected Navigational Aids (NAVAIDs), and issue and cancel Notices To Airmen (NOTAMs). The general aviation community makes up the lion's share of traffic at these facilities; however, military and commercial pilots are also frequent customers.

VHF voice radio is the current method of accessing an AFSS from an aircraft. The FAA does not provide a mechanism for an aircraft to access an AFSS via the Internet. However, it is possible for an aircraft to use a commercial ISP (e.g., DirectPC) to access an AFSS via the Internet using satellites as the connectivity means. The equipment today (e.g., antenna) is designed for home installation. An antenna system design for an aircraft is needed for this to be an effective option.

6.7. Direct User Access Terminal Service (DUATS)

DUATS is a computerized flight planning service provided by the FAA. DUATS makes available the very latest weather briefings, Notices to Airmen (NOTAM) and other data from the FAA’s Weather Message Switching Center Rehost (WMSCR) and the National Flight Data Center (NFDC). The service ensures that pilots have access to the most current and accurate data they need to fly in the NAS.

Pilots can file flight plans through DUATS. The program allows pilots to store commonly used information so that they don’t have to retype the same information every time they file a new flight plan. DUATS is provided by a number of commercial sources and is accessible through standard dial-in communication packages or the Internet.

Accessing DUATS from an aircraft requires Internet access. As mentioned previously, Internet access via a satellite connection through a commercial Internet Service Provider (ISP) such as DirectPC is feasible, but will not be an effective option until an appropriate antenna is designed for an aircraft.

6.8. Operational and Supportability Implementation System (OASIS)

OASIS provides integrated weather briefing and flight planning capabilities to the FAA and general aviation community at Automated Flight Service Stations. OASIS provides alphanumeric and graphical weather product acquisition and display, flight plan processing, NOTAMs, search and rescue services, administrative and supervisory capabilities, flight planning and regulatory information, and system maintenance functions. The weather graphic capabilities include the capability to acquire, display, and store near real-time weather radar images and products, weather satellite imagery and lightning detection data. OASIS will replace the existing FAA's Flight Service Automation System, and will be accessed through DUATS. A commercial service provider will provide OASIS service at no cost to pilots - similar to the current DUATS service. Accessing OASIS via DUATS from an aircraft requires Internet access via a satellite connection through a commercial ISP.

6.9. Digital Automated Terminal Information Service (D-ATIS)

D-ATIS provides ATIS text messages via data link to aircraft, airlines, and other users upon request; and computer synthesized ATIS voice messages over existing ATIS VHF transmitters at airports. Currently, the Digital ATIS information is generated in the Air Traffic Control Tower (ATCT) via the Tower Data Link System (TDLS). The TDLS system interfaces to and receives the weather information from the site weather input (e.g., Systems Atlanta Information Display System (SAIDS), Airport Weather Information System (AWIS), or Automated Surface Observing System (ASOS)). Using an editor, the controller can modify the weather information and add or modify airport information (e.g., runway, NOTAMS, etc.). The TDLS system then compiles the ATIS text message and the computer generated voice message. The text message is sent to the D-ATIS database through NADIN II, the FAA's X.25 service, and the ARINC Data Network Service (ADNS).

The flight crew of an Aircraft Communications Addressing and Reporting System (ACARS) equipped aircraft can request the ATIS message for any of the TDLS equipped ATCTs. Concurrently, the ATIS voice message will be broadcast over existing ATIS frequencies. The D-ATIS data is accessible by the airlines from the ARINC server via the ARINC Packet Network (APN)/ADNS.

The following airport specific information is available on D-ATIS.

- NOTAMS (specific to reporting airport): free text, taxiways and runways closed, SIGMETS, PIREPS, equipment outages, equipment obstacles, field conditions, ramps closed, airport closed, and other ARR/DEP NOTAMS.
- Advisories: free text, braking action, bird activity, wind shear/microburst alerts, other advisories.
- Runways: active arrival and departure runways, parallel runways, ILS runways, and approaches in use.
- Other/Weather: airport, time, measured wind, altimeter, weather remarks, meteorological aviation reports (METAR), ATC frequencies.

Although the communication means for providing D-ATIS data to an aircraft has historically been via ACARS, there is an evaluation in the planning stage that involves providing D-ATIS information to GA aircraft. D-ATIS will be a FIS-B product during OpEval 3 of SafeFlight 21. The communications means being evaluated are UAT and Mode S (1090 MHz).

6.10. Terminal Weather Information for Pilots (TWIP)

Recent weather-related programs sponsored by the FAA and the NWS will dramatically increase the quantity and quality of weather information available to ground-based users. However, there is an equally pressing need to provide improved weather information to flight crews. The Terminal Weather Information for Pilots (TWIP) program provides ground-based terminal weather information to pilots via data link. These products are intended to enhance pilot situational awareness of terminal weather phenomena such as micro bursts, gust fronts and heavy precipitation. The TWIP Data Processor (TDP) accepts weather data from the Terminal Doppler Weather Radar (TDWR) and generates TWIP products. Pilots can request these products via ACARS. At selected airports, text-only messages and character graphics maps will be generated based on the TDWR or the Integrated Terminal Weather System (ITWS).

TWIP products include information about terminal weather conditions with descriptions or depictions of present airport weather (micro burst alerts, wind shear alerts, or significant precipitation), the present convective activity within 15 NM of the terminal area, and expected weather that will impact airport operations (micro bursts, wind shear, and significant precipitation). The TWIP products are updated and stored in a database each minute. These products provide pilots strategic information to aid in flight planning prior to arriving in the terminal area.

Benefits of TWIP include:

- Improved situational awareness for safety
- Improved cockpit information management
- Reduced communications congestion
- Increased operational opportunities
- Reduced communication errors
- Better routes and altitudes
- Reduced delays and increased NAS capacity

Although the communication means for providing TWIP data to an aircraft has been via ACARS, OpEval 3 of SafeFlight 21 will evaluate providing TWIP information to GA aircraft as a FIS-B product. The communications means being evaluated are UAT and Mode S (1090 MHz).

6.11. Tropospheric Airborne Meteorological Data Reporting (TAMDAR)

TAMDAR uses aircraft systems to sense and report meteorological conditions, including moisture, temperature and winds. Forecast models, weather briefers, controllers, and other aircraft may use these reports. A team consisting of representatives of the FAA, NASA, National Oceanographic and Atmospheric Administration (NOAA), and NWS is developing a concept of operations for TAMDAR based on RTCA DO-252, Minimum Interoperability Standards (MIS) for Automated Meteorological Transmission (AUTOMET)[13].

TAMDAR is required to provide:

- Support for aircraft-to-aircraft communications.
- Ascent, descent and en route sensitive sampling rates.
- Immediate updates of HAZMET type reports (icing).
- No more than 5-minute latency from sample time to weather processing center.
- Data rate based on precision, sample rate, and update rate.

Several candidate communications means are being studied to provide TAMDAR data, including:

- ADS-B (UAT, Mode S, VDL Mode 4)
- VDL Mode 2 Broadcast
- 2-way VDL Mode 2 (ARINC, SITA)
- Satellite-based systems (Globalstar, Orbcomm/Echoflight, Generic Satellite Systems)

6.12. NAS Implementation Schedule

During the next few years, many of the systems described above will be deployed in the NAS. An implementation roadmap of the deployments is shown in Table 5. A key source for schedule information is the National Airspace System Architecture. [14]

13 Minimum Interoperability Standards (MIS) for Automated Meteorological Transmission (AUTOMET), RTCA, January 11,2000

14 National Airspace System Architecture, Version 4.0, Federal Aviation Administration, January 1999

Table 5. NAS Implementation Roadmap

NAS System	Description	System Dependencies	NAS Modernization Schedule Start	End
TIS	Radar and Mode S based traffic information provided to equipped aircraft on request; data is directly from Mode S radar site.	Mode-S radar FOC 10/00	Pre-199	2001
TIS-B	Radar and Mode-S traffic information broadcast to equipped aircraft; ADS reports added	Safe Flight 21 Evaluations during 2002 & Procedure development	Demo: 2002	2010
FIS-B	Weather products and flight information products broadcast to subscribers by FAA-contracted vendors	Contractor Infrastructure	2000	2003
CPDLC-ATN Build IA	Limited CPDLC message set to validate data link capability	VDL-2, DLAP, TDLS, ATN Routers	2005	2008
LAAS	Ground-based system to be installed at 112 airports to provide GPS correction accuracy to support CAT II/III approaches	LAAS Avionics	2006	2008
AFSS	AFSSs provide weather briefing and flight planning services to pilots and coordinate VFR search and rescue services, provide orientation service to lost aircraft, maintain continuous weather broadcasts on selected Navigational Aids (NAVAIDs), and issue and cancel Notices To Airmen (NOTAMs).		Currently 61 AFSSs in operation. Periodic upgrades planned.	
DUATS	Direct User Access Terminal - pilot interface to FAA/AFSS; receive weather and flight briefings; file flight plans.		Currently in use.	

NAS System	Description	System Dependencies	NAS Modernization Schedule Start	End
OASIS	Operational and Supportability Implementation System; AFSS capability provides improved graphics, weather data; modular design for system growth; self-brief and file flight plans.		2002	2007
D-ATIS	D-ATIS provides information about the conditions at an airport. D-ATIS information includes information about local air pressure, runway winds, runway conditions, visibility, etc.	TDLS	Pre-1999	2007
TWIP	Terminal Weather Information for Pilots products include information about terminal weather conditions with descriptions or depictions of present airport weather (micro burst alerts, wind shear alerts, or significant precipitation), the present convective activity within 15 NM of the terminal area, and expected weather that will impact airport operations (micro bursts, wind shear, and significant precipitation).	TWIP is to be transitioned/incorporated in ITWS in 2000 and ASR-WSP in 2001	Pre-1999	2015
TAMDAR	Tropospheric Airborne Meteorological Data Reporting (TAMDAR) uses aircraft systems to sense and report meteorological conditions, including moisture, temperature and winds.		Currently in R&D. Deployment decision has yet to be made.	

7. SATS OPERATIONAL SERVICES

A SATS aircraft will provide the means to use operational services provided by the FAA and commercial providers. The communications medium for accessing the services will be the AI. The operational services that might be used by a SATS pilot/aircraft and its passengers are shown in Table 6. The services are defined by the functional capabilities that the service provides. The first seven services are associated with the pilot. The eighth service (Public Information Exchange) is associated with the passengers.

Table 6. SATS Operational Services

Ref #	SATS User Services	Functional Capability
1	Flight Service	File flight plans and amendments. Process flight plans and amendments. Provide information for flight plans. Obtain in-flight or pre-flight weather and NAS status (NOTAMs) advisories. (*Near real time and forecast, tactical and strategic*) Obtain in-flight or pre-flight traffic advisories. (*Existing tactical and strategic*) Obtain in-flight NAS status advisories - current and scheduled.
2	Air Traffic Service	Provide separation of aircraft during ground operations. Provide separation of in-flight IFR aircraft. Avoid potential hazards and collisions. Maintain minimum distance from Special Use Airspace (SUA). Monitor flight progress. Enable in-flight sequencing, spacing, and flow management for SATS aircraft. Obtain pre-flight runway, taxi sequence, and movement restrictions. Project aircraft in-flight position and identify potential conflicts. Provide data to support managing use of SUA.
3	Emergency and Alerting Service	Provide emergency assistance and alerts. *(For downed or troubled aircraft)* Support search and rescue.
4	Self-Separation and Sequencing Service	Provide data to ensure proper separation to avoid potential hazards and collisions. Provide data to support VFR and IFR traffic separation. Provide data to monitor flight progress. Provide self-separation in NAS.

Ref #	SATS User Services	Functional Capability
5	Navigation Service	Provide airborne navigation guidance.
6	Pilot/Aircraft Information Service	Provide information concerning the flight. Enable separation of in-flight IFR aircraft. Enable in-flight sequencing and spacing for SATS aircraft. Provide aircraft in-flight position and identify potential conflicts.
7	Aircraft and Travel Service	Provide information about airport services. Notification to owner/operator about change in aircraft availability. Notification to owner/operator about aircraft maintenance issues. Provide other travel related information.
8	Public Information Exchange Service	Provide in-flight entertainment Provide public communications including email and web browsing.

8. SATS INFORMATION EXCHANGE OBJECTS

The operational services available to a SATS user require that information be exchanged between the user (pilot, aircraft, and passengers) and the external entities (other aircraft and ground-based systems). This is accomplished near and at hub airports via the various NAS systems identified above. Most of the NAS systems require their own communications means, which results in the need for many radios on an aircraft. Since the AI is intended to consolidate the data communications for SATS operational services, a different communications means may be implemented for accessing the services provided by NAS systems.

The AI Requirements Definition Document [15] used objects to model the information exchange that supports the SATS operational services. The objects "carry" the data between entities. Since the use of the AI by SATS may result in a "non-native" interface (i.e., use of a gateway) to the NAS systems, a mapping of objects with the NAS systems is needed. This will occur later in this document.

The SATS information exchange objects are shown in Table 7. The intent is that there not be overlapping functions performed by the objects.

Additional insight into the communications requirements associated with SATS services can be gained by matching the operational services with the information exchange objects that are involved. This comparison matrix is shown in Table 8.

[15] AI Requirements Definition Document, Computer Networks & Software, Inc., October 10, 2001.

Table 7. Information Exchange Objects

Ref #	SATS Information Exchange Object	Description of Process/Data
1	Flight Planning and Use (FPU)	Submission and processing of original or revised flight plans.
2	Weather (WX)	Collection and exchange of weather data both forecast and current (FIS-B like)
3	Airspace Situation (AS)	Information to enable a common situational awareness (ADS-B /TIS-B like).
4	Maneuver & Control (MC)	Near real time exchange of data to direct or implement the maneuvering of an aircraft (CPDLC like).
5	Navigation Information (NAV)	Information to provide airborne and surface navigation guidance.
6	Aviation System Information (ASI)	Information regarding the current status, use or readiness of the system entities.
7	Pilot/Aircraft Information Exchange (PAE)	Pilot-to-pilot or aircraft-to-aircraft exchange of flight information.
8	Aircraft & Travel (AT)	Exchange of aircraft status and other travel related information.
9	Public Information Exchanges (PIE)	Passengers use of email and other Internet-based services.

Table 8. SATS Operational Service/Information Object Matrix

Service	Purpose	Functions	FPU	WX	AS	MC	NAV	ASI	PAE	AT	PIE
Flight Service	Provide a lost comm separation plan. Provide SAR information.	File flight plans and amendments. Process flight plans and amendments. Provide information for flight plans. Obtain in-flight or pre-flight weather and NAS status (NOTAMs) advisories. (*Near real time and forecast, tactical and strategic*) Obtain in-flight or pre-flight traffic advisories. (*Existing tactical and strategic*) Obtain in-flight NAS status advisories - current and scheduled.	X	X	X			X			
Airspace Situation	Provide safe separation between SATS aircraft during surface operations. Provide safe separation between SATS aircraft and airspace.	Provide separation of aircraft during ground operations. Provide separation of in-flight IFR aircraft. Avoid potential hazards and collisions. Maintain minimum distance from Special Use Airspace (SUA). Monitor flight progress. Enable in-flight sequencing, spacing, and flow management for SATS aircraft. Obtain pre-flight runway, taxi sequence, and movement restrictions. Project aircraft in-flight position and identify potential conflicts. Provide data to support managing use of SUA.			X	X		X			

Service	Purpose	Functions	FPU	WX	AS	MC	NAV	ASI	PAE	AT	PIE
Emergency and Alerting Service	Minimize loss of life due to aircraft accidents and incidents.	Provide emergency assistance and alerts. *(For downed or troubled aircraft)* Support search and rescue.	X	X	X	X					
Self-Separation and Sequencing Service	Provide data for tracking aircraft on the ground. Provide data for tracking an aircraft en route Support safe separation between participating traffic and airspace.	Provide data to ensure proper separation to avoid potential hazards and collisions. Provide data to support VFR and IFR traffic separation. Provide data to monitor flight progress. Provide self-separation in NAS.			X				X		
Navigation Service	Enable aircraft to arrive at the planned destination via a predictable, planned, cleared route of flight.	Provide airborne navigation guidance.					X				
Pilot/Aircraft Information Service	Enable pilot-to-pilot or aircraft-to-aircraft exchange of flight information.	Provide information concerning the flight. Enable self-separation of in-flight IFR aircraft. Enable in-flight sequencing and spacing for SATS aircraft. Provide aircraft in-flight position and identify potential conflicts.		X	X				X		

Service	Purpose	Functions	FPU	WX	AS	MC	NAV	ASI	PAE	AT	PIE
Aircraft and Travel Service	Enable pilot exchange of non-flight information.	Provide information about airport services. Notification to owner/operator about change in aircraft availability. Notification to owner/operator about aircraft maintenance issues. Provide other travel-related information.								X	
Public Information Exchange Service	Provide passenger business, entertainment, and personal services.	Provide in-flight entertainment Provide public communications including voice and slow speed data.									X

9. NAS SERVICES FOR SATS USERS

There are efforts underway to deploy the next generation of communications, navigation, and surveillance equipment and the automation upgrades necessary to accommodate new CNS capabilities. Satellite-based navigation systems will be further augmented in local areas for more precise approaches. New digital radios that maximize the spectrum channels will be installed. As users equip, automatic dependent surveillance ground equipment will be installed to extend air traffic control surveillance services to non-radar areas. Equipment is upgraded as necessary to meet current and future requirements.

These efforts are focused on making NAS services available to pilots and aircrews. SATS pilots will want to take advantage of these services. Table 9 lists the services identified for SATS and identifies the NAS system that can provide that service.

Table 9. SATS Services

Ref #	SATS User Services	Functional Capability	NAS Systems
1	Flight Service	File flight plans and amendments. Process flight plans and amendments. Provide information for flight plans. Obtain in-flight or pre-flight weather and NAS status (NOTAMs) advisories. (*Near real time and forecast, tactical and strategic*) Obtain in-flight or pre-flight traffic advisories. (*Existing tactical and strategic*) Obtain in-flight NAS status advisories - current and scheduled.	FIS-B DUATS OASIS AFSS TWIP D-ATIS TAMDAR

Ref #	SATS User Services	Functional Capability	NAS Systems
2	Air Traffic Service	Provide separation of aircraft during ground operations. Provide separation of inflight IFR aircraft. Avoid potential hazards and collisions. Maintain minimum distance from Special Use Airspace (SUA). Monitor flight progress. Enable in-flight sequencing, spacing, and flow management for SATS aircraft. Obtain pre-flight runway, taxi sequence, and movement restrictions. Project aircraft in-flight position and identify potential conflicts. Provide data to support managing use of SUA.	TIS TIS-B
3	Emergency and Alerting Service	Provide emergency assistance and alerts. *(For downed or troubled aircraft)* Support search and rescue.	TIS-B
4	Self-Separation and Sequencing Service	Provide data to ensure proper separation to avoid potential hazards and collisions. Provide data to support VFR and IFR traffic separation. Provide data to monitor flight progress. Provide self-separation in NAS.	TIS TIS-B
5	Navigation Service	Provide airborne navigation guidance.	LAAS
6	Pilot/Aircraft Information Service	Provide information concerning the flight. Enable separation of inflight IFR aircraft. Enable in-flight sequencing and spacing for SATS aircraft. Provide aircraft in-flight position and identify potential conflicts.	Voice
7	Aircraft and Travel Service	Provide information about airport services. Notification to owner/operator about change in aircraft availability. Notification to owner/operator about aircraft maintenance issues. Provide other travel related information.	Voice

Ref #	SATS User Services	Functional Capability	NAS Systems
8	Public Information Exchange Service	Provide in-flight entertainment Provide public communications including email and web browsing.	None

10. INFORMATION EXCHANGE OBJECTS AND NAS SYSTEMS

A SATS aircraft will use the AI for accessing NAS operational services. Earlier, SATS information exchange objects were identified. Each object was associated with a type of data that a SATS aircraft will transmit or receive. To help analyze the interface(s) between the SATS equipment on the aircraft and the NAS systems, it is helpful to correlate the SATS information objects with the NAS systems. Table 10 shows these relationships.

Table 10. Information Exchange Objects and NAS Systems Relationships

NAS Systems	SATS Information Exchange Objects								
	FPU	WX	AS	MC	NAV	ASI	PAE	AT	PIE
TIS			X						
TIS-B			X						
FIS-B		X				X			
CPDLC				X					
LAAS					X				
AFSS	X	X				X			
DUATS	X	X				X			
OASIS	X	X				X			
D-ATIS		X				X			
TWIP		X							
TAMDAR		X							

Table 11 looks at the information exchange object/NAS system relationships from a different perspective. It identifies the various mediums that have been defined or are being considered for the NAS system data links.

Table 11. NAS Systems Data Link Medium

Information Exchange Object	NAS System	Medium
FPU	AFSS	VHF to Internet SATCOM to Internet
FPU	DUATS	VHF to Internet SATCOM to Internet
FPU	OASIS	VHF to Internet SATCOM to Internet
WX	FIS-B	VDL M2 UAT Mode S (1090 MHz) SATCOM
WX	AFSS	VHF to Internet SATCOM to Internet
WX	DUATS	VHF to Internet SATCOM to Internet
WX	OASIS	VHF to Internet SATCOM to Internet
WX	D-ATIS	VDL M2 UAT Mode S (1090 MHz) SATCOM
WX	TAMDAR	VHF Broadcast VDL M2 VDL M4 UAT Mode S (1090 MHz) SATCOM
WX	TWIP	VDL M2 UAT Mode S (1090 MHz) SATCOM
AS	TIS	Mode S (1090 MHz)
AS	TIS-B	UAT Mode S (1090 MHz)
MC	CPDLC	VDL M2 VDL M3
NAV	LAAS	VHF
ASI	AFSS	VHF to Internet SATCOM to Internet
ASI	DUATS	VHF to Internet SATCOM to Internet

Information Exchange Object	NAS System	Medium
ASI	OASIS	VHF to Internet SATCOM to Internet
ASI	FIS-B	VDL M2 UAT Mode S (1090 MHz) SATCOM
ASI	D-ATIS	VDL M2 UAT Mode S (1090 MHz) SATCOM
PAE	None	VHF
AT	ISP	VHF to Internet SATCOM to Internet
PIE	ISP	VHF to Internet SATCOM to Internet

11. INTERFACE APPROACHES

11.1. Interface Concepts and Issues

There are a number of concepts that must be validated and a number of issues resolved in order for the SATS interface with the NAS to be finalized. They are listed below.

- What information will be provided by commercial service providers?
- Will information retrieved via the Internet be allowed because of lack of certification; e.g., NEXRAD weather from the NWS web site?
- What will be the source and communications mechanism for surveillance data?
- What CNS capability will have to be added to a non-radar, non-towered airfield?
- Will an aircraft on the ground have a data communications requirement with the NAS?
- Is there a requirement for additional equipment at an airport?
- What changes would be required at an unmanned airport?
- What impact will SATS have on airport operations?
- The FAA is testing in OpEval 3 of SafeFlight 21 UAT and Mode S (1090 MHz) as mechanism for ADS-B, TIS-B, and FIS-B. These services conceptually perform the broadcast functions of an AI. Can SATS develop its own TIS and FIS transmission technology while UAT or Mode S (1090 MHz) are deployed at major airports throughout the NAS?
- Is a SATS communications gateway to the NAS a viable approach?
- Would the FAA allow an Internet connection to NADIN?

11.2. Gateways

The AI objective of consolidating communications medium associated with CNS systems may require “non-native” interfaces to the NAS. This introduces the idea of implementing a gateway between the SATS systems and the NAS systems. A single interface (centralized) where all communications from SATS aircraft goes through a SATS/NAS gateway is shown in Figure 9.

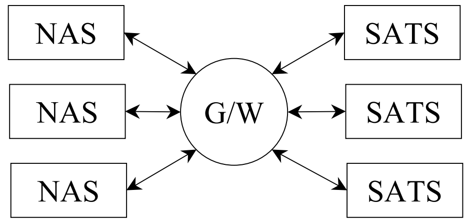


Figure 9. Centralized SATS/NAS Systems Interface

If it is not feasible to consolidate all of the SATS CNS data communications, some SATS systems will interface with NAS systems using the NAS "native" interface. Those systems can be characterized as having a decentralized interface. (Figure 10)

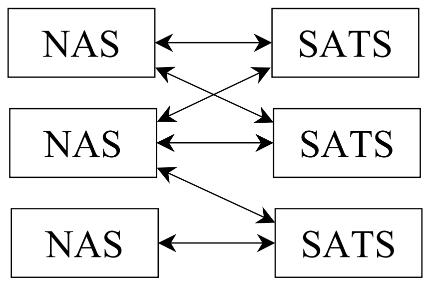


Figure 10. Decentralized SATS/NAS Systems Interface

If the SATS AI involves 'native" and 'non-native" interfaces to the NAS, the AI interface can be characterized as a hybrid. (Figure 11)

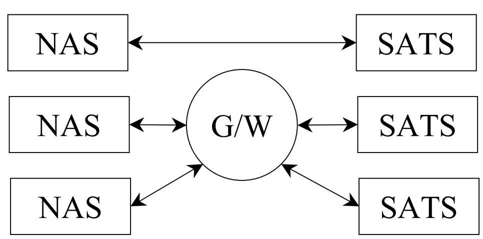


Figure 11. Hybrid SATS/NAS Systems Interface

12. SATS/NAS SYSTEMS INTERACTIONS

The following sections portray the exchange of information between non-SATS and SATS aircraft with NAS entities during different phases of flight. The focus is on how a SATS aircraft using the AI contrasts with a non-SATS aircraft using typical systems communicating in each environment. The environments are near a SATS airfield, en route, and near a hub airfield.

12.1. Flight Planning & Use (FPU)

DUATS (and later OASIS) is the NAS system that must be accessed for flight planning services via data link. DUATS provides a means to develop and file a flight plan with the AFSS, using a form-based interface. An aircraft will need an onboard computer to display the data.

The communications paths for Non-SATS and SATS aircraft access to DUATS/OASIS are shown in Figure 12. The Non-SATS aircraft communications path is shown as a dotted line while the SATS aircraft path is depicted with a solid line.

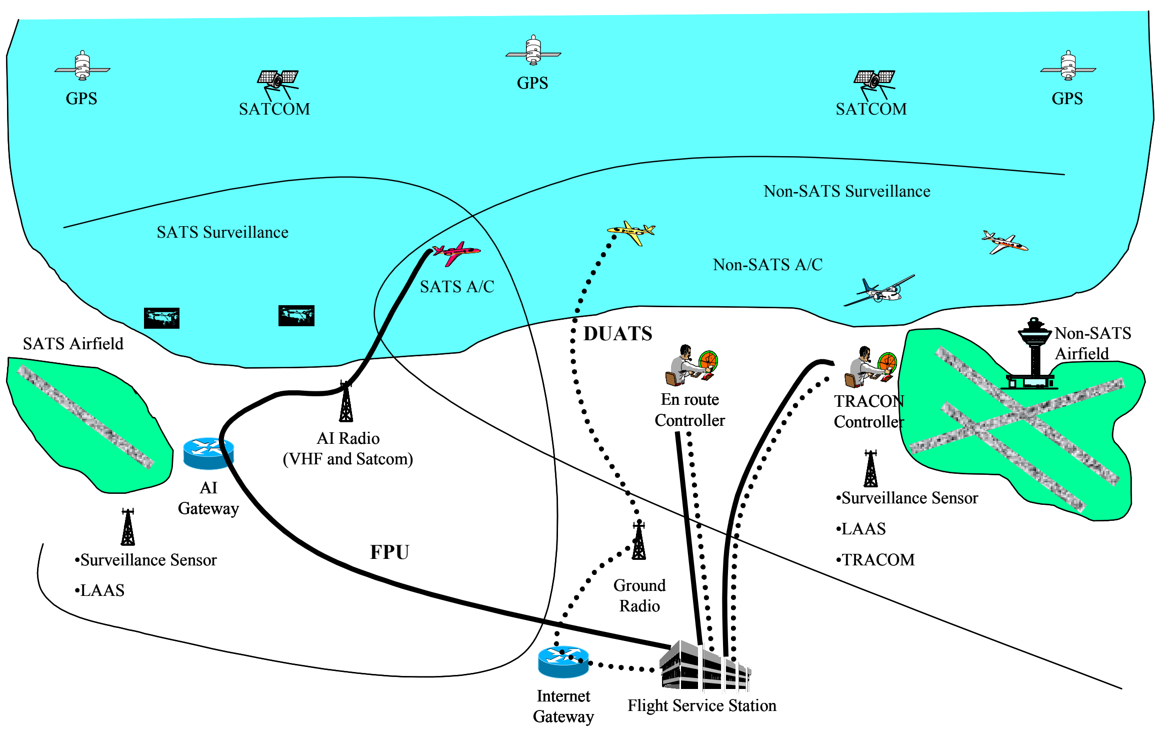


Figure 12. FPU/DUATS

12.1.1. Non-SATS Aircraft

DUATS Data Source and Destination

The pilot sends flight plans and changes to DUATS for distribution to controllers via the AFSS.

DUATS Interfaces

The aircraft must establish a connection with the Internet to access the DUATS. This involves establishing a connection via a radio with an Internet gateway on the ground. Then, a path to the commercial DUATS provider's web site must be established. The aircraft must establish a Transport Control Protocol (TCP) connection with the DUATS web site. The network protocol would be Internet Protocol (IP).

DUATS Communications Medium

The communications medium could be either VHF or SATCOM to a ground station. From there the connection would be a landline to an Internet gateway and then to the Internet. To use VHF, the aircraft must have line of sight access to a VHF radio that has a landline connection to an Internet gateway. Likewise for SATCOM, the ground station must have a connection to an Internet gateway.

Although a VHF radio connection to an ISP is possible, such a service is not available on a broad basis in CONUS. However, ISPs that use SATCOM as the access medium do exist and have a large coverage area.

DUATS Data Format

The Hyper Text Transport Protocol (HTTP) would be used to establish a connection between the aircraft and the DUATS web server. HTTP also supports the transfer of Hyper Text Markup Language (HTML) pages from DUATS to the aircraft's client browser. HTML would be the format used by the aircraft and DUATS for exchanging data.

DUATS Coverage Area

Since the FAA is not providing Internet access to aircraft, it is unlikely that an aircraft will be able to access the Internet via VHF radio. However, there are ISPs providing Internet access via SATCOM. Thus, it is likely that an aircraft could access DUATS from anywhere in the Continental United States (CONUS) if it used a SATCOM ISP.

12.1.2. SATS Aircraft

FPU Data Source and Destination

The FPU object is the same as the DUATS data object since the SATS aircraft will use the DUATS for flight planning. The pilot sends flight plans and changes to DUATS for distribution to controllers via the AFSS.

FPU Interface

A SATS AI-equipped aircraft could access the DUATS from the air by using the AI gateway's connection to the Internet. It is anticipated that TCP/IP will be the protocol used by the AI. If for some reason it is not, then the AI gateway will bridge the air/ground protocol with TCP/IP. The connection from the AI gateway to the DUATS web site will be via TCP/IP.

The AI gateway would combine the FPU data with other traffic and forward it to the AI radio. The AI radio can be a radio at the SATS airfield or a landline connection from the SATS airfield to the SATCOM ground station.

FPU Communications Medium

The communications medium could be either VHF or SATCOM to a ground station. From there the connection would be a landline through the AI gateway to an Internet gateway and then to the Internet. To use VHF, the aircraft must have line of sight access to a VHF radio that has a landline connection to an AI gateway. Likewise for SATCOM, the ground station must have a connection to an AI gateway.

FPU Data Format

The data format will be the same as for non-SATS aircraft. HTTP would be used to establish a connection between the aircraft and the DUATS web server. HTTP also supports the transfer of HTML pages from DUATS to the aircraft's client browser. HTML would be the format used by the aircraft and DUATS for exchanging data.

FPU Coverage Area

A SATS aircraft within line of sight of a SATS airfield would be able to exchange FPU data with an AI VHF radio at that airfield. Since the aircraft probably will not have VHF line of sight coverage throughout a long flight, a SATCOM communications means would be needed as the primary or alternate communications mechanism.

12.2. Weather (WX)

The communications paths for Non-SATS and SATS aircraft access to a weather service provider (labeled FIS-B Service Provider) and DUATS/OASIS/AFSS are shown in Figure 13. The Non-SATS aircraft communications path is shown as a dotted line while the SATS aircraft path is depicted with a solid line.

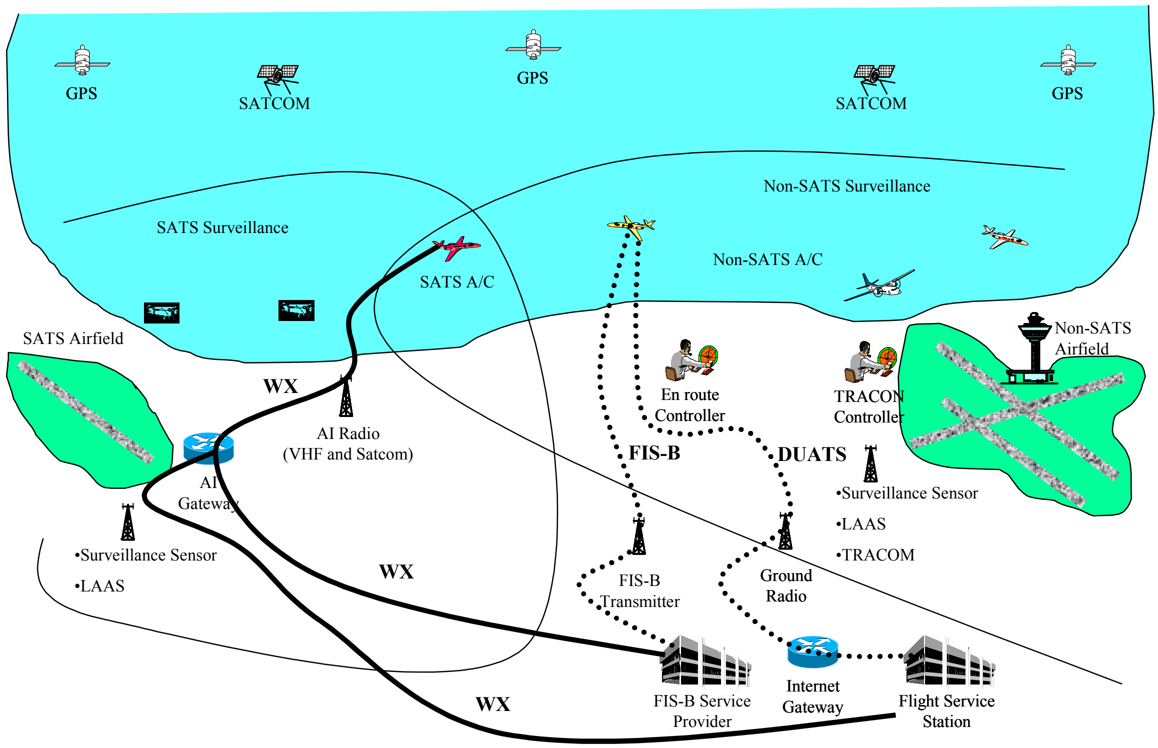


Figure 13. WX/FIS-B & DUATS/OASIS/AFSS

12.2.1. Non-SATS Aircraft

FIS-B Data Source and Destination

Data linked weather is available from multiple sources, most of which are external to the FAA. For example, a commercial FIS-B service provider will provide weather data. In fact, most sources are commercial service providers that supply weather data to aircraft on a subscription basis. The destination is the aircraft's avionics.

DUATS/OASIS/AFSS Data Source and Destination

The pilot requests and receives weather information from DUATS, OASIS and AFSS. All three are accessible through an Internet web site.

Weather Service Provider Interface

FIS-B data to non-SATS subscribers is a broadcast service through the providers' owned or leased equipment.

DUATS/OASIS/AFSS Interfaces

The aircraft must establish a connection with the Internet to access DUATS/OASIS/AFSS. This involves establishing a connection via a radio with an Internet gateway on the ground. Then, a path to the commercial DUATS provider's or the FAA's OASIS or AFSS web sites must be established. The aircraft must establish a TCP connection with the DUATS/OASIS/AFSS web site. The network protocol would be IP.

FIS-B Communications Medium

Weather data is usually provided via a broadcast medium as a component of the provider's FIS-B service. The weather service providers in the near term use or will use VDL Mode 2 and SATCOM as the medium for broadcasting to aircraft. The broadcasts are via the providers' network of radio communications equipment or via purchased time on communications satellites.

Experiments are underway in the SafeFlight 21 program to assess the viability of UAT and Mode S (1090 MHz) as the communications medium. If the tests are successful and a service provider decides to offer FIS-B via UAT or Mode S, it is unlikely that the service would be available before 2004.

DUATS/OASIS/AFSS Communications Medium

The communications medium could be either VHF or SATCOM to a ground station. From there the connection would be a landline to an Internet gateway and then to the Internet. To use VHF, the aircraft must have line of sight access to a VHF radio that has a landline connection to an Internet gateway. Likewise for SATCOM, the ground station must have a connection to an Internet gateway.

Although a VHF radio connection to an ISP is possible, such a service is not available on a broad basis in CONUS. However, ISPs that use SATCOM as the access medium do exist and have a large coverage area.

FIS-B Data Format

Aircraft receiving weather data will have to possess application software that will decode and display the data. The appropriate software will be available from the service provider.

DUATS/OASIS/AFSS Data Format

HTTP would be used to establish a connection between the aircraft and the DUATS/OASIS/AFSS web server. HTTP also supports the transfer of HTML pages from

DUATS/OASIS/AFSS to the aircraft's client browser. HTML would be the format used by the aircraft and DUATS/OASIS/AFSS for exchanging data.

FIS-B Coverage Area

The commercial service providers will offer FIS-B service that can be received anywhere in CONUS. Line of sight between the aircraft and the transmitter is a factor that greatly impacts communications coverage. The Honeywell and ARNAV FIS-B systems should provide FIS-B service to all aircraft that are at least 5,000 feet AGL.

An aircraft's capability to receive FIS-B reports via SATCOM will also be affected by line of sight restriction. The location of the satellite in relation to the horizon, terrain, and man-made obstacles may impact the aircraft's ability to receive FIS-B reports. ViGYAN has not announced which satellite will be used for its service so the impact of its location in relation to the horizon cannot be assessed.

DUATS/OASIS/AFSS Coverage Area

Since the FAA is not providing Internet access to aircraft, it is unlikely that an aircraft will be able to access the Internet via VHF radio. However, there are ISPs providing Internet access via SATCOM. Thus, it is likely that an aircraft could access DUATS/OASIS/AFSS from anywhere in the CONUS if it used a SATCOM ISP.

12.2.2. SATS Aircraft

WX Data Source and Destination

The source of data linked weather will be the same for SATS and Non-SATS aircraft; i.e., a commercial service provider or the DUATS/OASIS/AFSS systems. The destination is the aircraft's avionics.

WX Interface - Broadcast

The mechanism for providing broadcast weather service differs depending up whether the aircraft is AI equipped. FIS-B data to non-SATS subscribers is broadcast through the providers' owned or leased equipment. Weather data (WX) provided to a SATS aircraft via the AI would be sent via landline to the AI gateway at the various SATS airfields. An inexpensive mechanism for sending data from the FIS-B provider to the AI gateway is a Virtual Private Network (VPN) connection via the Internet.

The AI gateway will combine the WX data with other traffic and forward it to the AI radio for transmission to the aircraft.

WX Interface - Addressed

A SATS AI-equipped aircraft could access DUATS/OASIS/AFSS from the air by using the AI gateway's connection to the Internet. It is anticipated that TCP/IP will be the protocol used by the AI. If for some reason it is not, then the AI gateway will bridge the air/ground protocol with TCP/IP. The connection from the AI gateway to the DUATS/OASIS/AFSS web site will be via TCP/IP.

The AI gateway would combine the WX data with other traffic and forward it to the AI radio. The AI radio can be a radio at the SATS airfield or a landline connection from the SATS airfield to the SATCOM ground station.

WX Communications Medium

The AI radio can be a radio at the SATS airfield or a landline connection from the SATS airfield to the SATCOM ground station. Again, this landline could be a VPN over the Internet.

WX - FIS-B Data Format

Aircraft receiving weather data will have to possess application software that will decode and display the data. The appropriate software will be available from the service provider. The data formats at the application layer will be identical for SATS and non-SATS aircraft receiving the same service from a commercial provider. Thus, the AI weather object (WX) and the weather component of FIS-B are considered identical for this analysis.

WX - DUATS/OASIS/AFSS Data Format

The aircraft would use a web browser to access DUATS/OASIS/AFSS. HTTP would be used to establish a connection between the aircraft and the DUATS/OASIS/AFSS web server. HTTP also supports the transfer of HTML pages from DUATS/OASIS/AFSS to the aircraft's client browser. HTML would be the format used by the aircraft and DUATS/OASIS/AFSS for exchanging data.

WX Coverage Area

A SATS aircraft within line of sight of a SATS airfield will be able to receive WX reports from an AI VHF radio at that airfield. Since the aircraft may not always have VHF line of sight coverage, a SATCOM communications means would be needed as the primary or alternate communications mechanism.

12.3. Airspace Situation (AS)

The communications paths for Non-SATS and SATS aircraft access to airspace situation information are shown in Figure 14. The Non-SATS aircraft communications paths are shown as dotted lines while the SATS aircraft path is depicted with a solid line.

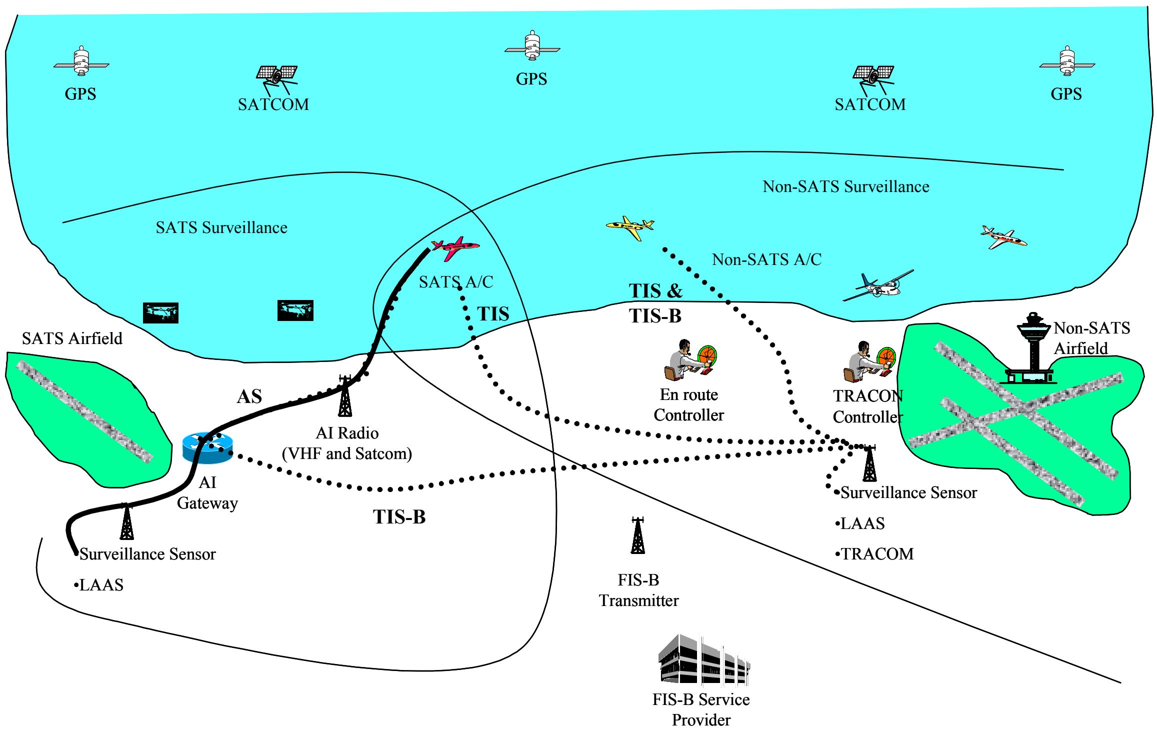


Figure 14. AS/TIS-B

12.3.1. Non-SATS Aircraft

TIS/TIS-B Data Source and Destination

Airspace situation (surveillance) information comes from multiple sources and is provided as TIS or TIS-B data to aircraft. TIS data is gathered from the Mode S data provided by aircraft in the vicinity. TIS-B uses the same data as well as radar and other sensor reports of aircraft in the area.

12.3.1.1. Traffic Information Service

TIS Interface

TIS data is an addressed transmission to an aircraft via the Mode S equipment on the ground and in the aircraft. TIS data is gathered from Mode S interrogations of aircraft. The data from each aircraft is integrated on the ground. The ground TIS system determines the aircraft in close proximity of each aircraft and transmits the nearby traffic to each aircraft via Mode S.

TIS Communications Medium

The communications medium for TIS is Mode S. An aircraft sends its Mode S data to the ground-based TIS system over its transponder tuned to 1030 MHz. The TIS system sends an addressed message containing TIS data to an aircraft on 1090 MHz.

TIS Data Format

The data format for TIS is specified in an RTCA document titled Minimum Operational Performance Standards for Traffic Information Service (TIS) Data Link Communications.[16] Aircraft receiving TIS data will have to possess application software that will decode and display the data.

TIS Coverage Area

The coverage area for TIS is the same as that for Mode S since TIS data is transmitted via the Mode S equipment. Mode S coverage is available throughout CONUS in Class A, B, and C airspace.

12.3.1.2. Traffic Information Service - Broadcast

TIS-B Interface

TIS-B integrates the Mode S data gathered from interrogations with radar data reports from the surveillance sensors. The resulting air situation (aircraft location "picture") is broadcast to all aircraft in the vicinity.

TIS-B Communications Medium

The official FAA transmission medium for broadcasting TIS-B data within the NAS has yet to be defined. The current philosophy is that TIS-B will use the same communications medium as ADS-B. The principal options are UAT and Mode S (1090 MHz). (VDL Mode 4 is an ADS-B candidate medium, but is unlikely to be selected.)

TIS-B Data Format

The official FAA data format for TIS-B has not been defined. RTCA's SC-186 is currently developing a standard for FAA/industry adoption. Aircraft receiving TIS-B data will have to possess application software that will decode and display the data. This may be a variation of an ADS-B application.

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16 Minimum Operational Performance Standards for Traffic Information Service (TIS) Data Link Communications, DO-239, RTCA, April 2, 1997.

TIS-B Coverage Area

The coverage area for reception of TIS-B reports depends upon the communications medium chosen and the associated equipment deployment. In general, line of sight communications is needed. The number of TIS-B sites has yet to be determined. It is reasonable to assume that a ground based communications system will be deployed with the equipment that integrated the surveillance data and develops the TIS-B reports.

12.3.2. SATS Aircraft

Data Source and Destination

A SATS aircraft may get airspace situation information from one or more three ground-based sources: a SATS AS system, a TIS system, or a TIS-B system. The SATS AS system would be located at a SATS airfield and would be similar in function to a TIS-B system. It is possible that a TIS-B system will be installed at a SATS airfield, but the cost of such an installation makes it unlikely.

The source of TIS data is the Mode S data provided by aircraft in the vicinity. The TIS system integrates all of the Mode S reports it receives and prepares and transmits individual addressed reports for each Mode S equipped aircraft. The reports indicate the location of other aircraft in the immediate vicinity of the recipient.

The TIS-B system integrates the TIS data with that gathered from radar and other sensors. The TIS-B reports are broadcast to all aircraft within communications range.

12.3.2.1. Airspace Situation - SATS

SATS AS Interface

The sensors at a SATS airfield will detect aircraft in the area and generate surveillance data. The AS data will be sent from the AS system to the AI gateway. The gateway will combine the AS reports with other SATS data and forward to an AI radio for transmission to the aircraft.

SATS AS Communications Medium

The AI radio can be a radio at the SATS airfield or a landline connection from the SATS airfield to the SATCOM ground station. The landline could be a VPN over the Internet.

SATS AS Data Format

The SATS AS data format has yet to be defined. It would be beneficial from an interoperability perspective if the data formats were the same as those chosen for TIS-B. Then, the same avionics equipment could process both AS and TIS-B data reports.

SATS AS Coverage Area

A SATS aircraft within line of sight of a SATS airfield will be able to receive AS reports from an AI VHF radio at that airfield. SATCOM could be used as the primary or alternate communications mechanism.

SATS AS Data Correlation

If the aircraft is within line of sight coverage of multiple SATS airfields that have overlapping surveillance coverage (service volumes), a means will be needed to correlate data reports. The data that needs to be correlated are the reports for the same aircraft that is detected in by both AS systems. Correlation of dual tracks for the same aircraft would also be an issue if SATCOM is the AI transmission means.

12.3.2.2. Traffic Information Service

The TIS system uses the Mode S communications equipment to transfer data between the aircraft and the ground. The mechanisms implemented in TIS restrict their use to Mode S communications equipment operating at 1030 and 1090 MHz. As a result, TIS cannot be consolidated with other services that will use the AI for their communications means.

A SATS aircraft will be able to use TIS if it is equipped to do so. The use and limitations of TIS is the same as discussed above for Non-SATS aircraft.

TIS Interface

The SATS aircraft must be equipped with a TIS enabled Mode S set. The aircraft must be within range of the TIS ground system. TIS data is an addressed transmission to an aircraft via the Mode S equipment on the ground and in the aircraft. TIS data is gathered from Mode S interrogations of aircraft. The data from each aircraft is integrated on the ground. The ground TIS system determines the aircraft in close proximity of each aircraft and transmits the nearby traffic to each aircraft via Mode S.

TIS Communications Medium

The communications medium for TIS is Mode S. An aircraft sends its Mode S data to the ground-based TIS system over its transponder tuned to 1030 MHz. The TIS system sends an addressed message containing TIS data to an aircraft on 1090 MHz.

TIS Data Format

The data format for TIS is specified in an RTCA document titled Minimum Operational Performance Standards for Traffic Information Service (TIS) Data Link Communications.[17]

[17] Minimum Operational Performance Standards for Traffic Information Service (TIS) Data Link Communications, DO-239, RTCA, April 2, 1997.

Aircraft receiving TIS data will have to possess application software that will decode and display the data.

TIS Coverage Area

The coverage area for TIS is the same as that for Mode S since TIS data is transmitted via the Mode S equipment. Mode S coverage is available throughout CONUS in Class A, B, and C airspace.

12.3.2.3. Traffic Information Service - Broadcast

The following discusses the mechanisms for providing TIS-B data to an aircraft. It also discusses the situation where a SATS aircraft receives both SATS AS and TIS-B data reports.

TIS-B Interface

TIS-B integrates the Mode S data gathered from interrogations with radar data reports from the surveillance sensors. The resulting air situation (aircraft location "picture") is normally broadcast to all aircraft in the vicinity. However, TIS-B data provided to a SATS aircraft within the service volume of the TIS-B system would be sent via the AI. The path would be via landline from the TIS-B system to the AI gateway at nearby SATS airfields. An inexpensive mechanism for sending data from the TIS-B system to the AI gateway is a VPN connection via the Internet.

The AI gateway will combine the TIS-B data with other traffic and forward it to the AI radio for transmission to the aircraft.

TIS-B Communications Medium

The AI radio can be a radio at the SATS airfield or a landline connection from the SATS airfield to the SATCOM ground station. Again, this landline could be a VPN over the Internet.

TIS-B Data Format

The official FAA data format for TIS-B has not been defined. RTCA's SC-186 is currently developing a standard for FAA/industry adoption. Aircraft receiving TIS-B data will have to possess application software that will decode and display the data.

If the SATS AS system data format is the same as the TIS-B format, the same avionics can interpret and display the data.

SATS AS/TIS-B Data Correlation

Two reports for the same aircraft may be received if a SATS aircraft is receiving positional information for other aircraft from both the SATS AS and TIS-B systems. A mechanism will be needed to correlate the reports and display only one track.

TIS-B Coverage Area

A SATS aircraft within line of sight of a SATS airfield will be able to receive TIS-B reports from an AI VHF radio at that airfield. SATCOM could be used as the primary or alternate communications mechanism.

12.4. Maneuver & Control (MC)

Maneuver and control information is exchanged between an aircraft and an FAA en route or terminal controller. Since a landing at a SATS airfield will not be under the direction of a controller, there will not be a SATS unique system that generates MC data. The FAA intends to use Controller Pilot Data Link Communications (CPDLC) as the data communications means for MC. The communications paths for Non-SATS and SATS aircraft access to maneuver and control information are shown in Figure 15. The communications paths for both are shown as dotted lines.

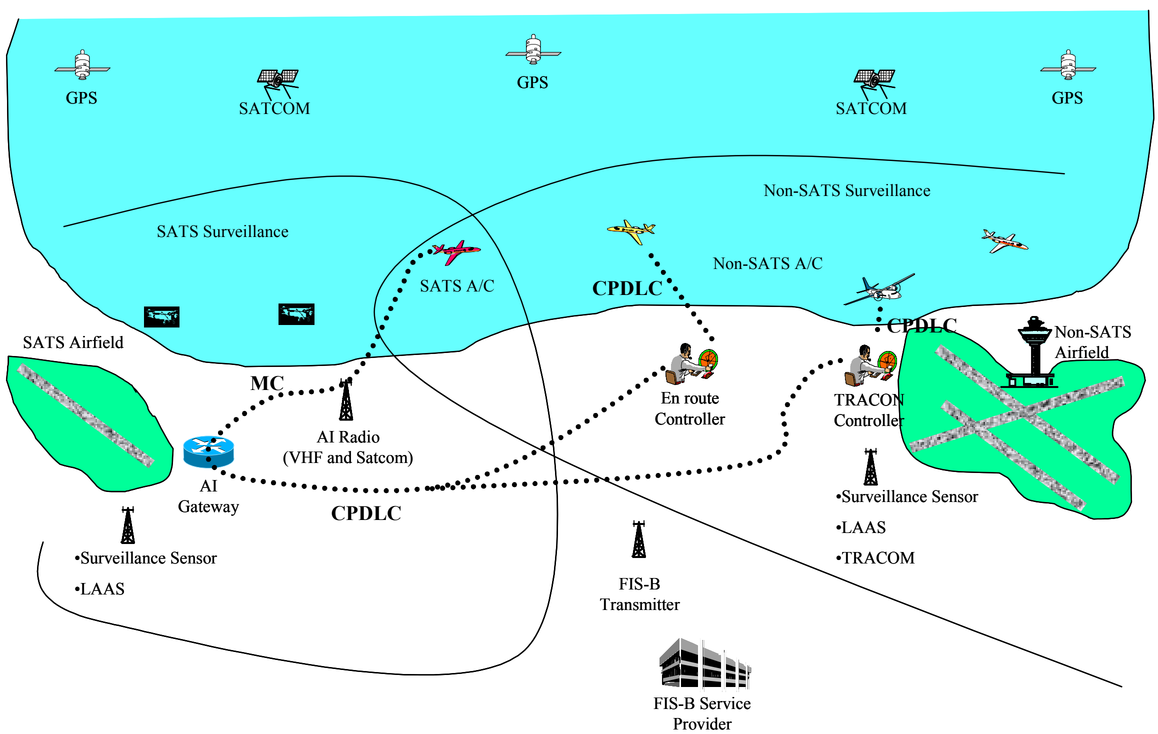

Figure 15. MC/CPDLC

12.4.1. Non-SATS Aircraft

CPDLC Data Source and Destination

Two-way data link communications exist between an aircraft and the en route or TRACON controller. The messages are addressed to the appropriate recipient.

CPDLC Interface

The FAA intends to use a commercial service provider (ARINC) for communicating with an aircraft. An aircraft will transmit a CPDLC message over VDL Mode 2 radio to an ARINC ground station. ARINC will route the message via landline to a National Airspace Data

Interchange Network (NADIN) access point. The message will flow over NADIN to the computer that services the controller. From there, the message is sent to the controller's display. Communications between the controller and the aircraft follow the same path in reverse. The avionics must support the generation and display of CPDLC messages.

CPDLC Communications Medium

The air-ground communications medium for CPDLC for the next 10 years will be VDL Mode 2.

CPDLC Data Format

ICAO specifies the format for CPDLC messages in its ATN Standards and Recommended Practices (SARPs). Build I of CPDLC complies with edition 2 of the SARPs.[18] Build IA and subsequent Builds will probably implement edition 3, which adds security to the data stream.

CPDLC Coverage Area

An aircraft will have to be in range of an ARINC VDL M2 ground radio to use CPDLC. ARINC intends to provide coverage throughout CONUS by deploying 175 ground stations. The deployment has started and ARINC will provide the ground stations as the FAA is ready to use them.

12.4.2. SATS Aircraft

MC Data Source and Destination

Maneuver and control information is exchanged between an aircraft and an FAA en route or terminal controller. CPDLC will be used as the data communications means for MC. Two-way data link communications using addressed messages will be implemented. Terminal control will not be available at SATS airfields.

MC Interface

The AI will replace ARINC's VDL M2 system for the air/ground link. A SATS aircraft will transmit a CPDLC message over its AI radio to an AI radio on the ground. The AI radio may be a VHF or SATCOM radio. The message will be sent from the ground radio to the AI gateway. From there the message will be routed to NADIN. This may be accomplished via a direct connection to NADIN or via an Internet connection. The message will flow over NADIN to the computer that services the controller. From there, the message is sent to the controller's display. Communications between the controller and the aircraft follow the same path in reverse. The avionics must support the generation and display of CPDLC messages.

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[18] Manual of Technical Provisions for the Aeronautical Telecommunication Network (ATN), ICAO DOC 9705/AN956, International Civil Aviation Organization, December 1999.

MC Communications Medium

The AI radio can be a radio at the SATS airfield or a landline connection from the SATS airfield to the SATCOM ground station. The landline could be a VPN over the Internet.

MC Data Format

The format will be the CPDLC format specified by ICAO in the ATN SARPs. Build I of CPDLC complies with edition 2 of the SARPs.[19] Build IA and subsequent Builds will probably implement edition 3, which adds security to the data stream.

MC Coverage Area

The coverage area for SATS aircraft will be limited if a VHF radio is used for the AI radio. The limitation will be that the SATS aircraft must be within range of the VHF radio, which will normally be deployed only at SATS airfields. Also, the AI gateways would have to be networked to provide coverage to SATS aircraft in the en route environment.

An alternative would be to use SATCOM as the transmission medium. Since each aircraft has an unique address, the CPDLC message would arrive at the correct aircraft. This would limit the number of AI gateways that would need to interface with NADIN.

Receiving CPDLC messages from a terminal controller via the AI will be dependent upon the coverage of the VHF AI radio. It will have to overlap the approach area for the Non-SATS airfield. There may be a safety issue involved if the overlap in coverage does not extend all the way to the surface of the Non-SATS airfield. Such coverage is unlikely in most situations due to line of sight issues. The safety issue would be that the terminal controller might lose communications with the SATS aircraft during a landing.

[19] Manual of Technical Provisions for the Aeronautical Telecommunication Network (ATN), ICAO DOC 9705/AN956, International Civil Aviation Organization, December 1999.

12.5. Navigation (NAV)

The primary means for navigation in the SATS aircraft will be GPS for both en route and terminal area guidance. In the terminal area, the Local Area Augmentation System (LAAS) will be used to enhance the GPS signal and provide support for precision approaches and landings. The LAAS ground subsystem provides VHF data broadcasts that contain differential corrections for the GPS signal.

Aircraft will have to be equipped with a receiver and possess the application software to receive and process the LAAS and GPS data, to compute a positions solution, and to calculate deviations from the desired path.

The communications paths for Non-SATS and SATS aircraft access to LAAS data are shown in Figure 16. The Non-SATS aircraft communications paths are shown as dotted lines while the SATS aircraft path is depicted with a solid line.

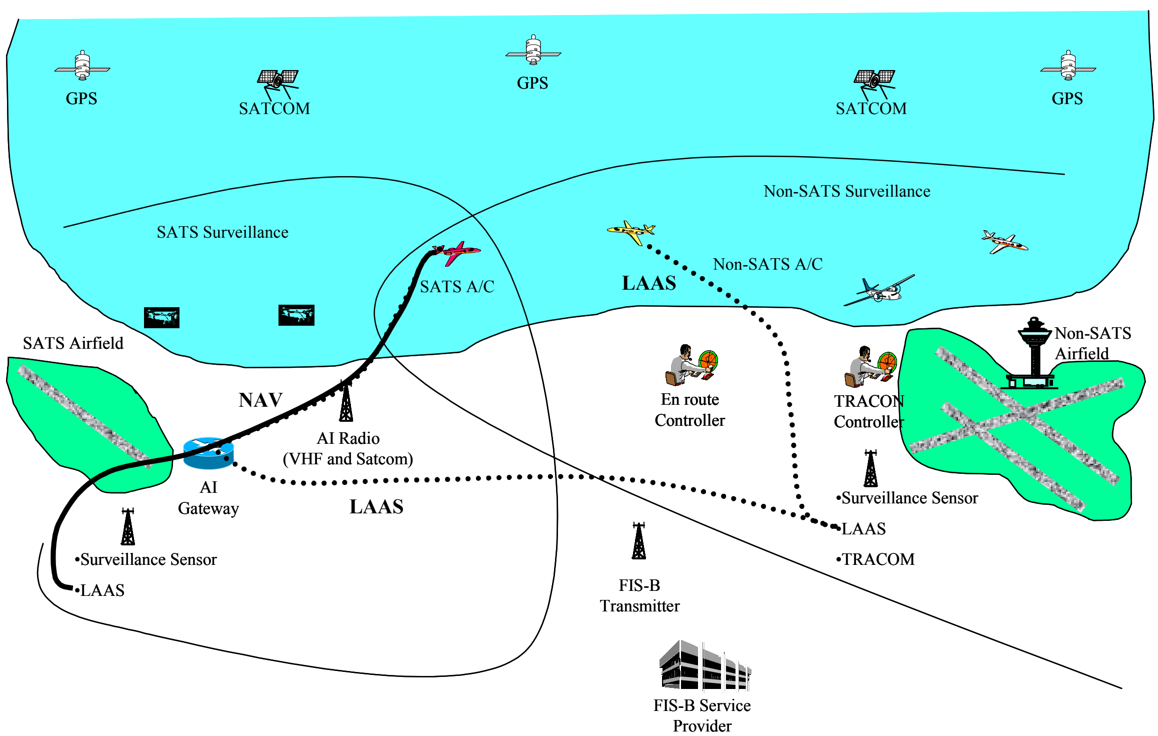

Figure 16. NAV/LAAS

12.5.1. Non-SATS Aircraft

LAAS Data Source and Destination

The LAAS data is broadcast by the LAAS to aircraft in vicinity of the airfield.

LAAS Interface

The interface is straightforward. The LAAS transmits its signal directly to the aircraft.

LAAS Communications Medium

LAAS data is broadcast via a VHF radio.

LAAS Data Format

The format for LAAS data is specified in RTCA DO-246A.[20]

LAAS Coverage Area

The LAAS system will be located at the airfield at which the aircraft is landing. Aircraft that are in the landing process should be able to receive the LAAS signal via VHF radio.

12.5.2. SATS Aircraft

LAAS is also the navigation system that will be used at SATS airfields. The method of getting LAAS data to a SATS aircraft will depend upon the type of airfield (SATS or Non-SATS) at which the landing is occurring.

NAV Data Source and Destination

The LAAS data is sent by the LAAS to aircraft in vicinity of the airfield.

NAV Interface - SATS Airfield Landing

The LAAS at the SATS airfield will send its data to the AI gateway to be combined with other traffic. The data will be forwarded to the AI Radio for transmission to the aircraft.

NAV Interface - Non-SATS Airfield Landing

A SATS aircraft landing at a Non-SATS airfield needs the LAAS data from that airfield. The data must be sent to the SATS aircraft via the AI. The LAAS at the Non-SATS airfield will send its data via landline to an IA gateway at a nearby SATS airfield. The gateway will combine the LAAS data with other traffic and forward it to the AI radio for transmission to the aircraft.

[20] GNSS Based Precision Approach Local Area Augmentation System (LAAS)-Signal-in-Space Interface Control Document (ICD), DO-246A, RTCA, January 11, 2000

NAV Communications Medium

The frequency of LAAS report updates may require that the landline between the Non-SATS LAAS and the AI gateway be a dedicated circuit. The time delay that could be experienced with an Internet VPN probably eliminates it as a communications means.

The AI radio will be a VHF radio. SATCOM is probably not a viable solution because of the delay involved.

NAV Data Format

The format for LAAS data is specified in RTCA DO-246A.[21]

NAV Coverage Area

Receiving LAAS data from a Non-SATS airfield via the AI will be dependent upon the coverage of the VHF AI radio. It will have to overlap the approach area for the Non-SATS airfield. There may be a safety issue involved if the overlap in coverage does not extend all the way to the surface of the Non-SATS airfield. Such coverage is unlikely in most situations due to line of sight issues. The safety concern would depend upon the type of landing the SATS aircraft was doing and the degree of reliance upon LAAS data.

[21] GNSS Based Precision Approach Local Area Augmentation System (LAAS)-Signal-in-Space Interface Control Document (ICD), DO-246A, RTCA, January 11, 2000

12.6. Aviation System Information (ASI)

Aviation system information, in the form of NAS status advisories (NOTAMs) and other information pertaining to system entities, will be available from multiple sources, both Government and commercial. This information will be broadcast as part of the subscription services provided by FIS-B vendors in the same manner as weather products. It will also be available from Flight Service Stations via the Internet.

The communications paths for Non-SATS and SATS aircraft access to a commercial service provider (labeled FIS-B Service Provider) and DUATS/OASIS/AFSS are shown in Figure 17. The Non-SATS aircraft communications path is shown as a dotted line while the SATS aircraft path is depicted with a solid line.

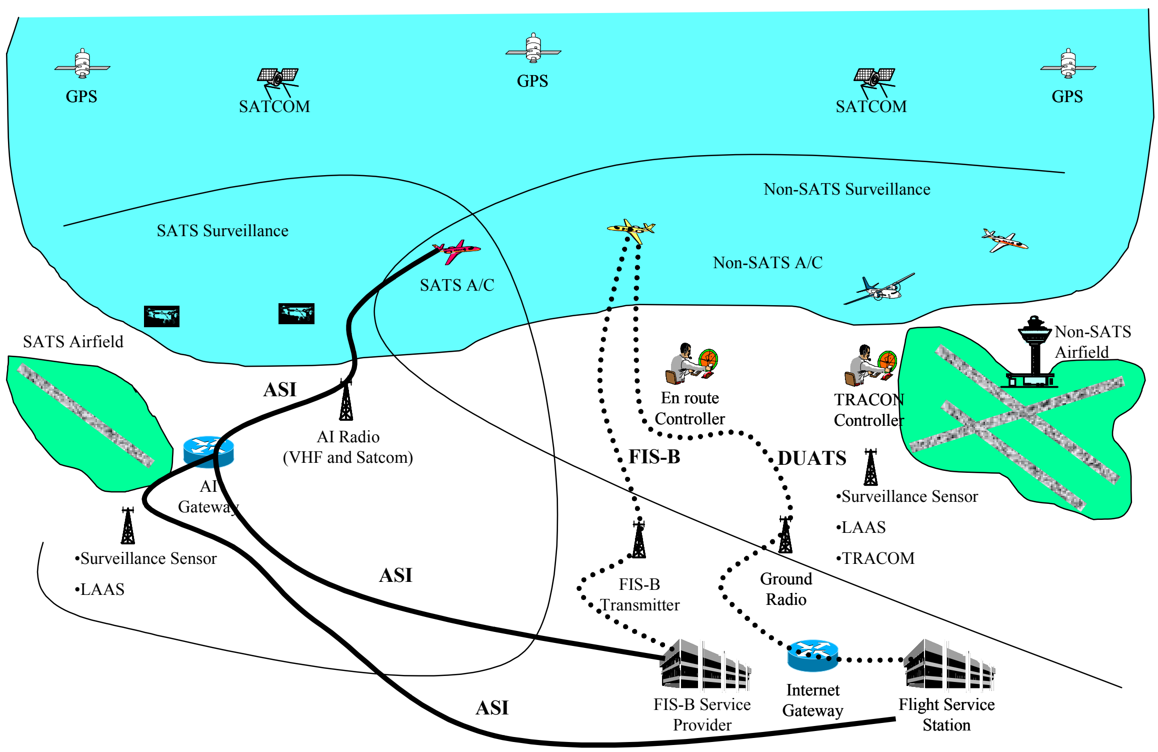

Figure 17. ASI/FIS-B & DUATS/OASIS/AFSS

12.6.1. Non-SATS Aircraft

FIS-B Data Source and Destination

System advisories are available from multiple sources, most of which are external to the FAA. Although most do not do it today, commercial FIS-B service provider will provide NOTAMs and D-ATIS data to an aircraft in the near future. Generally, the service will be provided on a subscription basis. The destination is the aircraft's avionics.

DUATS/OASIS/AFSS Data Source and Destination

The pilot requests and receives NOTAMs from DUATS, OASIS, or the AFSS's web site. All three are accessible through an Internet web site.

FIS-B Interface

FIS-B data to non-SATS subscribers is a broadcast service through the providers' owned or leased equipment.

DUATS/OASIS/AFSS Interfaces

The aircraft must establish a connection with the Internet to access DUATS/OASIS/AFSS. This involves establishing a connection via a radio with an Internet gateway on the ground. Then, a path to the commercial DUATS provider's or FAA's OASIS or AFSS web site must be established. The aircraft must establish a TCP connection with the DUATS/OASIS/AFSS web site. The network protocol would be IP.

FIS-B Communications Medium

NOTAMs will be provided via a broadcast medium as a component of the provider's FIS-B service. The weather service providers in the near term use or will use VDL Mode 2 and SATCOM as the medium for broadcasting to aircraft. The broadcasts are via the providers' network of radio communications equipment or via purchased time on communications satellites.

Experiments are underway in the SafeFlight 21 program to assess the viability of UAT and Mode S (1090 MHz) as the communications medium. If the tests are successful and a service provider decides to offer FIS-B via UAT or Mode S, it is unlikely that the service would be available before 2004.

DUATS/OASIS/AFSS Communications Medium

The communications medium could be either VHF or SATCOM to a ground station. From there the connection would be a landline to an Internet gateway and then to the Internet. To use VHF, the aircraft must have line of sight access to a VHF radio that has a landline connection to an Internet gateway. Likewise for SATCOM, the ground station must have a connection to an Internet gateway.

Although a VHF radio connection to an ISP is possible, such a service is not available on a broad basis in CONUS. However, ISPs that use SATCOM as the access medium do exist and have a large coverage area.

FIS-B Data Format

Aircraft receiving NOTAMs in textual or graphical format will have to possess application software that will decode and display the data. The appropriate software will be available from the service provider.

DUATS/OASIS/AFSS Data Format

The aircraft would use a web browser as its agent for accessing DUATS, OASIS, or an AFSS. HTTP would be used to establish a connection between the aircraft and the DUATS/OASIS/AFSS web server. HTTP also supports the transfer of HTML pages from DUATS/OASIS/AFSS to the aircraft's client browser. HTML would be the format used by the aircraft and DUATS/OASIS/AFSS for exchanging data.

FIS-B Coverage Area

The commercial service providers will offer FIS-B service that can be received anywhere in CONUS. Line of sight between the aircraft and the transmitter is a factor that greatly impacts communications coverage. The Honeywell and ARNAV FIS-B systems should provide FIS-B service to all aircraft that are at least 5,000 feet AGL.

An aircraft's capability to receive FIS-B reports via SATCOM will also be affected by line of sight restriction. The location of the satellite in relation to the horizon, terrain, and man-made obstacles may impact the aircraft's ability to receive FIS-B reports. ViGYAN has not announced which satellite will be used for its service so the impact of its location in relation to the horizon cannot be assessed.

DUATS/OASIS/AFSS Coverage Area

Since the FAA is not providing Internet access to aircraft, it is unlikely that an aircraft will be able to access the Internet via VHF radio. However, there are ISPs providing Internet access via SATCOM. Thus, it is likely that an aircraft could access DUATS/OASIS/AFSS from anywhere in the CONUS if it used a SATCOM ISP.

12.6.2. SATS Aircraft

ASI Data Source and Destination

The source of ASI data will be the same for SATS and Non-SATS aircraft; i.e., a commercial service provider or the DUATS/OASIS/AFSS systems. The destination is the aircraft's avionics.

ASI Interface - Broadcast

ASI data provided to a SATS aircraft via the AI would be sent via landline to the AI gateway at the various SATS airfields. An inexpensive mechanism for sending data from the FIS-B provider to the AI gateway is a VPN connection via the Internet. The AI gateway will combine the ASI data with other traffic and forward it to the AI radio for transmission to the aircraft.

ASI Interface - Addressed

A SATS AI-equipped aircraft could access the DUATS/OASIS/AFSS from the air by using the AI gateway's connection to the Internet. It is anticipated that TCP/IP will be the protocol used by the AI. If for some reason it is not, then the AI gateway will bridge the air/ground protocol with TCP/IP. The connection from the AI gateway to the DUATS/OASIS/AFSS web site will be via TCP/IP.

The AI gateway would combine the ASI data with other traffic and forward it to the AI radio. The AI radio can be a radio at the SATS airfield or a landline connection from the SATS airfield to the SATCOM ground station.

ASI Communications Medium

The AI radio can be a radio at the SATS airfield or a landline connection from the SATS airfield to the SATCOM ground station. Again, this landline could be a VPN over the Internet.

ASI - FIS-B Data Format

Aircraft receiving textual or graphical ASI data will have to possess application software that will decode and display the data. The appropriate software will be available from the service provider. The data formats at the application layer will be identical for SATS and non-SATS aircraft receiving the same service from a commercial provider.

ASI - DUATS/OASIS/AFSS Data Format

The aircraft would use an Internet web browser to access DUATS/OASIS/AFSS. HTTP would be used to establish a connection between the aircraft and the DUATS, OASIS or AFSS web server. HTTP also supports the transfer of HTML pages from DUATS/OASIS/AFSS to the aircraft's client browser. HTML would be the format used by the aircraft and DUATS/OASIS/AFSS for exchanging data.

ASI Coverage Area

A SATS aircraft within line of sight of a SATS airfield will be able to receive ASI reports from an AI VHF radio at that airfield. Since the aircraft may not always have VHF line of sight coverage, a SATCOM communications means would be needed as the primary or alternate communications mechanism.

12.7. Pilot/Aircraft Information Exchange (PAE)

The PAE object provides for pilot-to-pilot or aircraft-to-aircraft exchange of flight information. The mechanism for exchanging this information is not yet identified, but could be SATCOM-based using mobile IP, or could be provided via the AI. It applies to SATS aircraft only. There is not a Non-SATS counterpart data service. The heavy line in Figure 18 depicts the exchange between two SATS aircraft.

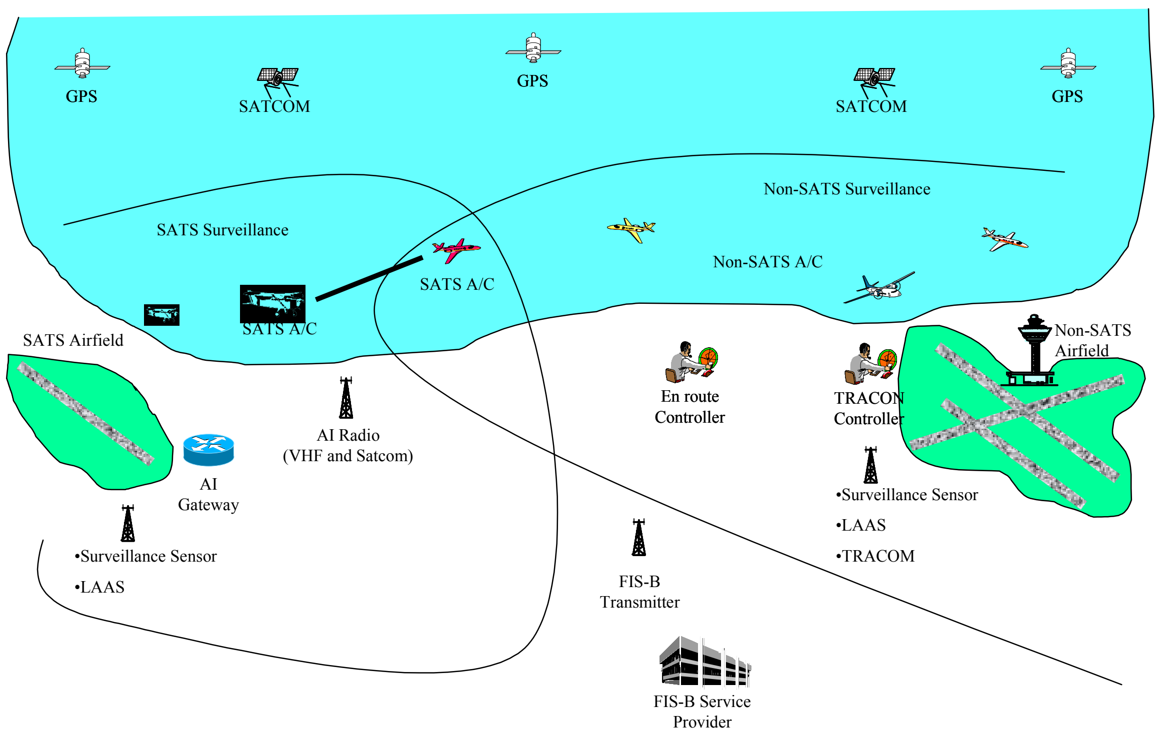

Figure 18. Pilot/Aircraft Information Exchange (PAE)

Data Source and Destination

The data source is one aircraft and the destination is another appropriately equipped aircraft.

Pilot/Aircraft Information Exchange Interface

The intent is that the AI will provide the interface between the aircraft. However, the interface has yet to be defined.

Communications Medium

The communications medium could be VHF radio or SATCOM.

Data Format

The data format has not been defined.

Coverage Area

Adequacy of coverage will depend on the mechanism chosen to transport PAE information. A SATCOM-based mechanism should provide adequate coverage. Likewise, a VHF solution should be adequate since the purpose of the link is focused on aircraft that are near one another and thus should be within VHF radio range.

12.8. Aircraft & Travel (AT)

The purpose of AT is to provide a means to communicate aircraft, passenger, or other pertinent travel information from the aircraft to another interested party, such as a fixed base operator or aircraft owner. The most likely medium would be the Internet using email or a forms-based web site. Access to the Internet must be through a commercial ISP account since the FAA does not provide this service.

The communications path for Non-SATS aircraft access to the Internet is via an ISP. The path for a SATS aircraft is via the AI. Both are shown in Figure 19. The Non-SATS aircraft communications path is shown as a dotted line while the SATS aircraft path is depicted with a solid line.

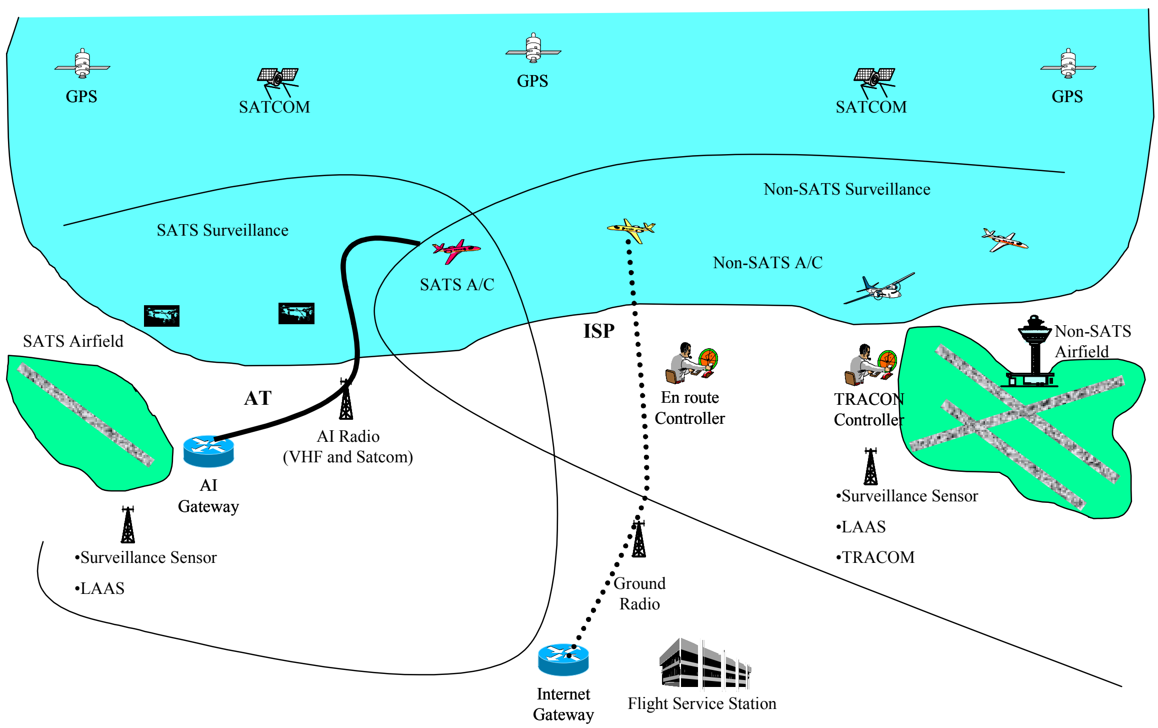

Figure 19. AT/ISP

12.8.1. Non-SATS Aircraft

ISP Data Source and Destination

The pilot engages in two-way communications with an Internet based email server or web server. All email and web servers that are accessible from a ground-based Internet connection are available to the pilot.

ISP Interfaces

The aircraft must establish a connection with the Internet to access email and web servers. This involves establishing a connection via a radio with an Internet gateway on the ground. Then, a path to the selected server must be established. The aircraft must establish a TCP connection with the selected web site. The network protocol will be IP.

ISP Communications Medium

The communications medium could be either VHF or SATCOM to a ground station. From there the connection would be a landline to an Internet gateway and then to the Internet. To use VHF, the aircraft must have line of sight access to a VHF radio that has a landline connection to an Internet gateway. Likewise for SATCOM, the ground station must have a connection to an Internet gateway.

Although a VHF radio connection to an ISP is possible, such a service is not available on a broad basis in CONUS. However, ISPs that use SATCOM as the access medium do exist and have a large coverage area.

ISP Data Format

Simple Mail Transport Protocol (SMTP) would be used to send email messages from the aircraft. Post Office Protocol 3 (POP 3) would be the protocol for retrieving messages from an Internet-based mail server. HTTP would be used to establish a connection between the aircraft and the web server. HTTP also supports the transfer of HTML pages from web sites to the aircraft's client browser. HTML would be the format used by the aircraft and the web site for exchanging data.

ISP Coverage Area

Since the FAA is not providing Internet access to aircraft, it is unlikely that an aircraft will be able to access the Internet via VHF radio. However, there are ISPs providing Internet access via SATCOM. Thus, it is likely that an aircraft could access the Internet from anywhere in the CONUS if it used a SATCOM ISP.

12.8.2. SATS Aircraft

AT Data Source and Destination

The pilot engages in two-way communications with an Internet based email server or web server. All email and web servers that are accessible from a ground-based Internet connection are available to the pilot.

AT Interface

A SATS AI-equipped aircraft could access email and web servers from the air by using the AI gateway's connection to the Internet. It is anticipated that TCP/IP will be the protocol used by the AI. If for some reason it is not, then the AI gateway will bridge the air/ground protocol with TCP/IP. The connection from the AI gateway to the email and web servers will be via TCP/IP.

The AI gateway would combine the AT data with other traffic and forward it to the AI radio. The AI radio can be a radio at the SATS airfield or a landline connection from the SATS airfield to the SATCOM ground station.

AT Communications Medium

The communications medium could be either VHF or SATCOM to a ground station. From there the connection would be a landline through the AI gateway to an Internet gateway and then to the Internet. To use VHF, the aircraft must have line of sight access to a VHF radio that has a landline connection to an AI gateway. Likewise for SATCOM, the ground station must have a connection to an AI gateway.

AT Data Format

SMTP would be the protocol used to send email messages from the aircraft. POP 3 would be the protocol for retrieving messages from an Internet-based mail server. HTTP would be used to establish a connection between the aircraft and the web server. HTTP also supports the transfer of HTML pages from web sites to the aircraft's client browser. HTML would be the format used by the aircraft and the web site for exchanging data.

AT Coverage Area

A SATS aircraft within line of sight of a SATS airfield would be able to exchange AT data with an AI VHF radio at that airfield. Since the aircraft probably will not have VHF line of sight coverage throughout a long flight, a SATCOM communications means would be needed as the primary or alternate communications mechanism.

12.9. Public Information Exchange (PIE)

The purpose of the PIE object is to provide a means for passengers or aircrew to access e-mail or other Internet-based services. Access to the Internet must be through a commercial ISP account since the FAA does not provide this service.

The communications path for Non-SATS aircraft access to the Internet is via an ISP. The path for a SATS aircraft is via the PIE. Both are shown in Figure 20. The Non-SATS aircraft communications path is shown as a dotted line while the SATS aircraft path is depicted with a solid line.

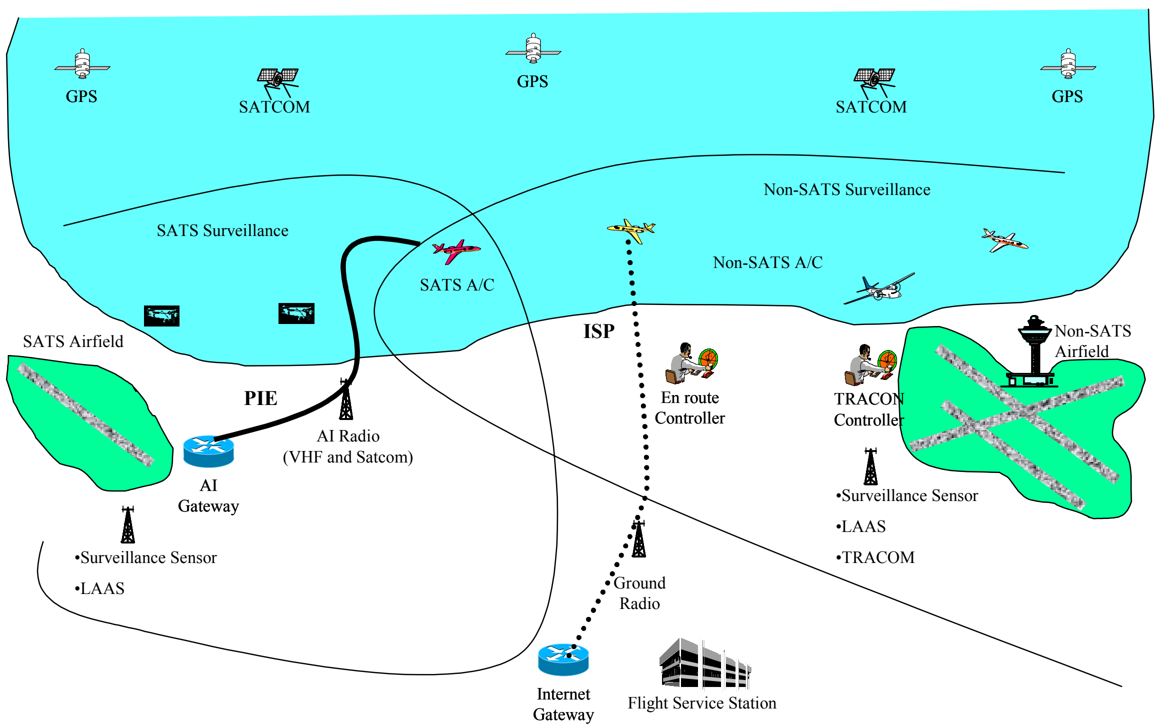

Figure 20. PIE/ISP

12.9.1. Non-SATS Aircraft

ISP Data Source and Destination

The passenger or aircrew engage in two-way communications with an Internet based email server or web server. All email and web servers that are accessible from a ground-based Internet connection are available to the aircraft.

ISP Interfaces

The aircraft must establish a connection with the Internet to access email and web servers. This involves establishing a connection via a radio with an Internet gateway on the ground. Then, a path to the selected server must be established. The aircraft must establish a TCP connection with the selected web site. The network protocol will be IP.

ISP Communications Medium

The communications medium could be either VHF or SATCOM to a ground station. From there the connection would be a landline to an Internet gateway and then to the Internet. To use VHF, the aircraft must have line of sight access to a VHF radio that has a landline connection to an Internet gateway. Likewise for SATCOM, the ground station must have a connection to an Internet gateway.

Although a VHF radio connection to an ISP is possible, such a service is not available on a broad basis in CONUS. However, ISPs that use SATCOM as the access medium do exist and have a large coverage area.

ISP Data Format

SMTP would be the protocol used to send email messages from the aircraft. POP 3 would be the protocol for retrieving messages from an Internet-based mail server. HTTP would be used to establish a connection between the aircraft and the web server. HTTP also supports the transfer of HTML pages from web sites to the aircraft's client browser. HTML would be the format used by the aircraft and the web site for exchanging data.

ISP Coverage Area

Since the FAA is not providing Internet access to aircraft, it is unlikely that an aircraft will be able to access the Internet via VHF radio. However, there are ISPs providing Internet access via SATCOM. Thus, it is likely that an aircraft could access the Internet from anywhere in the CONUS if it used a SATCOM ISP.

12.9.2. SATS Aircraft

PIE Data Source and Destination

The passengers and aircrew engage in two-way communications with an Internet based email server or web server. All email and web servers that are accessible from a ground-based Internet connection are available to the aircraft.

PIE Interface

A SATS AI-equipped aircraft could access email and web servers from the air by using the AI gateway's connection to the Internet. It is anticipated that TCP/IP will be the protocol used by the AI. If for some reason it is not, then the AI gateway will bridge the air/ground protocol with TCP/IP. The connection from the AI gateway to the email and web servers will be via TCP/IP.

The AI gateway would combine PIE data with other traffic and forward it to the AI radio. The AI radio can be a radio at the SATS airfield or a landline connection from the SATS airfield to the SATCOM ground station.

PIE Communications Medium

The communications medium could be either VHF or SATCOM to a ground station. From there the connection would be a landline through the AI gateway to an Internet gateway and then to the Internet. To use VHF, the aircraft must have line of sight access to a VHF radio that has a landline connection to an AI gateway. Likewise for SATCOM, the ground station must have a connection to an AI gateway.

PIE Data Format

SMTP would be the protocol used to send email messages from the aircraft. POP 3 would be the protocol for retrieving messages from an Internet-based mail server. HTTP would be used to establish a connection between the aircraft and the web server. HTTP also supports the transfer of HTML pages from web sites to the aircraft's client browser. HTML would be the format used by the aircraft and the web site for exchanging data.

PIE Coverage Area

A SATS aircraft within line of sight of a SATS airfield would be able to exchange PIE data with an AI VHF radio at that airfield. Since the aircraft probably will not have VHF line of sight coverage throughout a long flight, a SATCOM communications means would be needed as the primary or alternate communications mechanism.

13. ASSESSMENT

The key points from SATS/NAS systems interactions are shown in Table 12.

Table 12. SATS/NAS Systems Interactions - Key Points

SATS/NAS Service	Key Points
FPU	• Requires Internet access via AI gateway. • May be out of range of AI VHF radio. • AI SATCOM can be primary or alternate communications means.
WX	• Requires a landline between commercial service provider's FIS-B system and AI gateway. • Requires Internet access via AI gateway for DUATS/OASIS/AFSS web site access. • May be out of range of AI VHF radio. • AI SATCOM can be primary or alternate communications means.
AS/TIS/TIS-B	Sensors - SATS airfield • Will be able to receive reports via AI VHF radio. • Overlapping SATS airfield service volumes will require a dual track correlation method. • AS data generated by sensors at a SATS airfield should be transmitted using the TIS-B format for avionics compatibility. Sensor - Non-SATS airfield • TIS data cannot be consolidated for transmission over the AI. Requires a Mode S radio. • TIS-B requires a landline between sensor and AI gateway at nearby SATS airfield. • Aircraft will require TIS-B processing software if the format is not the same as that of the AS. An alternative would be to have the AI gateway convert the FIS-B data reports to AS format. • A dual track correlation mechanism will be needed if TIS-B and AS have overlapping service volumes. • SATS aircraft may be out of range of AI VHF radio when receiving TIS-B reports. • AI SATCOM can be primary or alternate communications means.
MC	• CPDLC is the protocol used by the controllers. • Requires a landline between NADIN and the AI gateway. • AI gateways would have to be networked to provide coverage in an enroute environment. Transmitting the messages via SATCOM would be an alternative. • May be out of range of all AI VHF radios. • Communication with a terminal controller at a Non-SATS airfield would lost if an AI VHF radios coverage pattern does not cover the entire airfield. • AI SATCOM can be primary or alternate communications means.

SATS/NAS Service	Key Points
NAV	LAAS - SATS airfield landing • Sent via AI VHF radio. • Some question as to whether the delay would permit the use of an AI SATCOM radio. LAAS - Non-SATS airfield landing • Requires a landline from the LAAS to the AI gateway at a nearby SATS airfield. Update frequency means that a dedicated circuit is needed. Could not tolerate Internet delays. • Sent via AI VHF radio. SATCOM is probably not a viable solution because of the delay involved. • May be out of range of all AI VHF radios. • Safety issue if AI VHF radios coverage pattern does not cover the entire airfield.
ASI	• Requires a landline between commercial service provider's FIS-B system and AI gateway. • Requires Internet access via AI gateway for DUATS/OASIS/AFSS web site access. • May be out of range of AI VHF radio. • AI SATCOM can be primary or alternate communications means.
PAE	• Probably use AI VHF radio. • Could use SATCOM. • Formats of messages yet to be defined.
AT	• Requires Internet access via AI gateway. • May be out of range of AI VHF radio. • AI SATCOM can be primary or alternate communications means.
PIE	• Requires Internet access via AI gateway. • May be out of range of AI VHF radio. • AI SATCOM can be primary or alternate communications means.

The points that can be synthesized from Table 12 are:

- The AI should not be used to transmit LAAS data to a SATS aircraft that is landing at a Non-SATS airfield. The delivery of the LAAS data is dependent upon the coverage pattern of the AI VHF radio at a nearby SATS airfield. It is reasonable to assume that all Non-SATS airfields with LAAS will not have a nearby SATS airfield with adequate VHF coverage. Thus, a SATS aircraft would not be able to use the LAAS at the Non-SATS airfield if its data were transmitted via the AI.

- A factor in the completeness of AI VHF radio coverage is the rapidity with which the radios are installed at individual SATS airfields. Since local governments control many of these airfields, the deployment of sufficient AI VHF radios to provide complete coverage in CONUS will take many years.

- Relying on the AI VHF radio for communicating with a SATS aircraft is problematic. Reception should not be a problem when the aircraft is near a SATS airfield. However, it will not be able to communicate via the AI when it is not within range of a SATS airfield. SATCOM looks to be a more reliable communications means.

- The AI gateway or another device at the SATS airfield should provide access to the Internet.

Appendix A. Acronyms

Acronym	Meaning
ACARS	Aircraft Communications Addressing and Reporting System
ADNS	ARINC Data Network Service
ADS-B	Automatic Dependent Surveillance - Broadcast
AFSS	Automated Flight Service Station
AGATE	Advanced General Aviation Transport Experiments
AGL	Above Ground Level
AI	Airborne Internet
AIRMET	Airman's Meteorological Information
APN	ARINC Packet Network
ARR	Arrival
AS	Airspace Situation
ASC	Airspace System Capacity
ASI	Aviation System Information
ASOS	Automated Surface Observing System
AT	Aircraft & Travel
ATC	Air Traffic Control
ATCRBS	ATC Radar Beacon System
ATCT	Air Traffic Control Tower
ATN	Aeronautical Telecommunications Network
AUTOMET	Automated Meteorological Transmission
AWIS	Airport Weather Information System
AWW	Aviation Weather Watches
CNS	Communication-Navigation-Surveillance
COMET	Commercial Experimental Transporter
CONUS	Continental United States
CPDLC	Controller Pilot Data Link Communication
CS	Commercial Service
DAG	Distributed Air Ground
D-ATIS	Digital Automated Terminal Information Service
DEP	Departure
DoD	Department of Defense
DSN	Deep Space Network
DUATS	Direct User Access Terminal Service
FAA	Federal Aviation Administration
FIS-B	Flight Information Service - Broadcast
FL	Flight Level
FOC	Full Operational Capability
FPU	Flight Planning & Use
FSS	Flight Service Station
FY	Fiscal Year

Acronym	Meaning
GA	General Aviation
GAP	General Aviation Propulsion
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
G/W	Gateway
HAZMET	Hazardous Meteorological Conditions Information
HF	High Frequency
HTML	Hyper Text Markup Language
HTTP	Hyper Text Transport Protocol
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IOC	Initial Operational Capability
IP	Internet Protocol
ISP	Internet Service Provider
LAAS	Local Area Augmentation System
MASPS	Minimum Aviation System Performance Standards
MC	Maneuver & Control
METAR	Aviation Routine Weather Reports
MIS	Minimum Interoperability Standards
MSL	Mean Sea Level
MSS	Mobile Satellite Services
MTOW	Maximum Take Off Weight
NADIN	National Airspace Data Interchange Network
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NAV	Navigation
NAVAID	Navigational Aid
NEXCOM	Next Generation Communications
NEXRAD	Next Generation Radar
NFDC	National Flight Data Center
NIB	Non-Interference Basis
NM	Nautical Mile
NOAA	National Oceanographic and Atmospheric Agency
NOTAM	Notice to Airmen
NPIAS	National Plan of Integrated Airport Systems
NWS	National Weather Service

Acronym	Meaning
OASIS	Operational and Supportability Implementation System
OpEval	Operational Evaluation
PAE	Pilot/Aircraft Information Exchange
PCS	Personal Communications Service
PDC	Pre-Departure Clearance
PIE	Public Information Exchange
PIREP	Pilot Report
POP 3	Post Office Protocol 3
RDT&E	Research, Development, Test & Evaluation
SAIDS	Systems Atlanta Information Display System
SARPs	Standards and Recommended Practices
SATCOM	Satellite Communications
SATS	Small Aircraft Transportation System
SC	Special Committee
SIGMET	Significant Meteorological Information
SMTP	Simple Mail Transport Protocol
SUA	Special Use Airspace
TAF	Terminal Area Forecast
TAMDAR	Tropospheric Airborne Meteorological Data Reporting
TCP	Transport Control Protocol
TCP/IP	Transport Control Protocol/Internet Protocol
TDLS	Tower Data Link System
TDP	TWIP Data Processor
TIS	Traffic Information Service
TIS-B	Traffic Information Service - Broadcast
TRACON	Terminal Radar Approach Control
TWIP	Terminal Weather Information for Pilots
TDWR	Terminal Doppler Weather Radar
UAT	Universal Access Transceiver
VDL	VHF Data Link
VDL-2	VHF Data Link Mode 2
VDL M2	VHF Data Link Mode 2
VFR	Visual Flight Rules
VHF	Very High Frequency
VPN	Virtual Private Network
WGS 84	World Geodetic System 1984

Acronym	Meaning
WMSCR	Weather Message Switching Center Rehost
WX	Weather

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