CNS

Computer Networks & Software, Inc.

Airborne Internet Testbed Demonstration Document (Build A)

to

NASA GRC

for the

Small Aircraft Transportation System (SATS) Project

NASA Contract No. NAS 3 99165, Task Order 11

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Airborne Internet Test Bed Demonstration Document (Build A)

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1. INTRODUCTION

This Demonstration Document provides a report of the Airborne Internet (AI) Testbed Demonstration (Build A) of the Small Aircraft Transportation System (SATS) AI Testbed facility as implemented at Computer Networks & Software, Inc. The SATS Testbed System Design Document formed the basis for this report and the Testbed implementation.

1.1. Identification

The Small Aircraft Transportation System (SATS) AI Testbed (Build A) Demonstration Document is a deliverable under Task Order 11 of NASA Contract No. NAS 3 99165.

1.2. Small Aircraft Transportation System Description

- 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 Federal Aviation Administration (FAA) regulatory purposes, SATS technologies are targeted toward aircraft with a maximum take off weight (MTOW) of 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 enroute structure below 18,000 feet).

1.3. SATS Objectives

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 National Airspace System (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 Instrument Landing System (ILS). Meeting this objective has the potential to safely reduce the cost to increase accessibility to small airports.

- **Increase Single Crew Safety and 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 and 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.

1.4. Airborne Internet (AI) Development Overview

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. 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 hub lock, and travelers suffer from inefficient use of time.

NASA is taking the lead in developing technologies for a Small Aircraft Transportation System 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 Program (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.*

To this end, NASA Glenn Research Center, through its partnership with NASA Langley Research Center, is pursuing a key enabling technology area: *Airborne Internet*. The *Airborne Internet* will leverage open standards and protocols for a client-server network system architecture 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 is placing severe demands of the already constrained system and the underlying Communications, 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 forecast need, the consolidation and integration of communication, navigation, and surveillance technologies, systems, and services will be initiated through a client-server internet-like model. A demonstration of integrated services via a 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.

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 would 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.

1.5. Document Overview

This report is organized into eight sections supported by four appendixes:

- Section 1 contains the scope and overall task plan.
- Section 2 presents an overview of the system design.
- Section 3 identifies the testbed objectives.
- Section 4 deals with the applications being demonstrated.
- Section 5 provides the application data flow.
- Section 6 outlines the hardware system.
- Section 7 outlines the software system.
- Section 8 contains the results of the Build A evaluations.
- Appendix A contains a list of acronyms.
- Appendix B contains sample log files.
- Appendix C displays screen capture shots.
- Appendix D shows a few SATSLAB pictures.

2. OVERVIEW OF SYSTEM DESIGN

2.1. System Overview

SATS can be thought of as an intermodal, personal, rapid transit air travel system. NASA is taking the lead in developing strategic technologies for 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.

This long-term undertaking has a goal to bring next-generation technologies and improve air access to small communities. Ultimately, SATS may permit more than tripling aviation system throughput capacity by tapping the under-utilized general aviation facilities to achieve the national goal of doorstep-to-destination travel at four times the speed of highways for the nation's suburban, rural, and remote communities.

A 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. To this end, NASA is pursuing a key enabling technology area: *Airborne Internet*. The *Airborne Internet* will leverage open standards and protocols for a client-server network system architecture that are in development in the telecommunications industry for increased bandwidth for mobile applications. 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.

Long before the envisioned SATS airplanes take to the skies, it is imperative to carry out the proof of concept. To this end, Computer Networks & Software, Inc. is building a partial implementation of the SATS Testbed. This Testbed will be used to test various technologies required to support the Airborne Internet. The CNS SATS conceptual architecture is shown in Figure 2-1.

In order to explore various subnetwork technologies that form the foundation for the AI concept, the SATS Testbed will be implemented as a sequence of Builds. Build A employs the VHF Data Link (VDL) Mode SATS subnetwork technology followed by Build B. Build B proposes to incorporate the Wireless 802.11b and Satellite Communications (SATCOM) subnetwork into the testbed.

2.2. CNS-SATS Conceptual Architecture

The CNS-SATS conceptual architecture consists of SATS aircraft operating in the NAS. It is assumed that there will information exchange between the SATS aircraft and the NAS. This information is conceptually exchanged through gateway functionality. The conceptual architecture illustrates multiple subnetwork technologies used to exchange information among the various entities. The applications to support SATS aircraft may be obtained from a number of sources including the Internet. Initially, VDL Mode SATS is proposed to be the enabling data link technology for testing the SATS Airborne Internet concept.

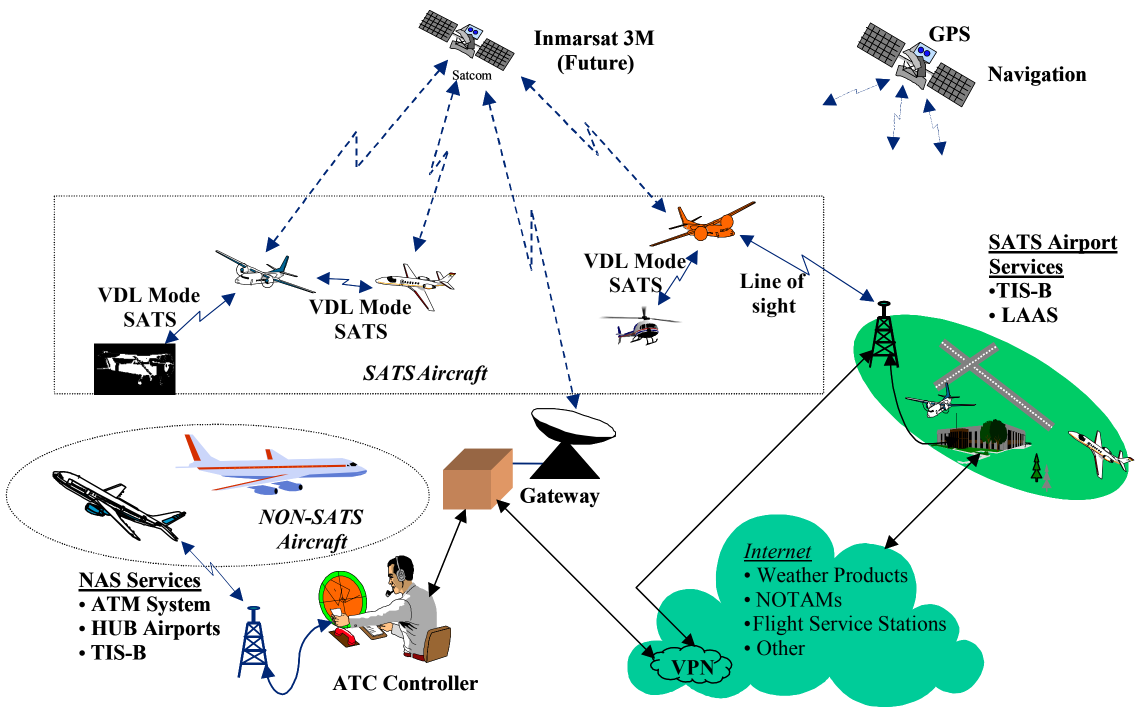


Figure 2-1. CNS-SATS Conceptual Architecture

2.3. SATS Testbed Topology

Figure 2-2 presents the SATS testbed topology. The testbed uses the VDL Mode SATS radio to support the AI and the testbed applications. The majority of testbed components are located in Computer Networks & Software's facility in Springfield, VA. The network control center is located in Bethesda, MD.

The testbed consists of five aircraft, a ground station and a controller station. Aircraft N382 and N384 have similar configurations. Aircraft N382 and N384 consists of a workstation running the Controller Pilot Data Link Communications (CPDLC) and peer-to-peer applications. Each aircraft's second workstation acts as the AI router as well as running the Automatic Dependent Surveillance - Broadcast (ADS-B), Flight Information Services - Broadcast (FIS-B) weather and e-mail applications. The AI router is connected to the VDL Mode SATS radio. The other three aircraft are emulated by a single workstation.

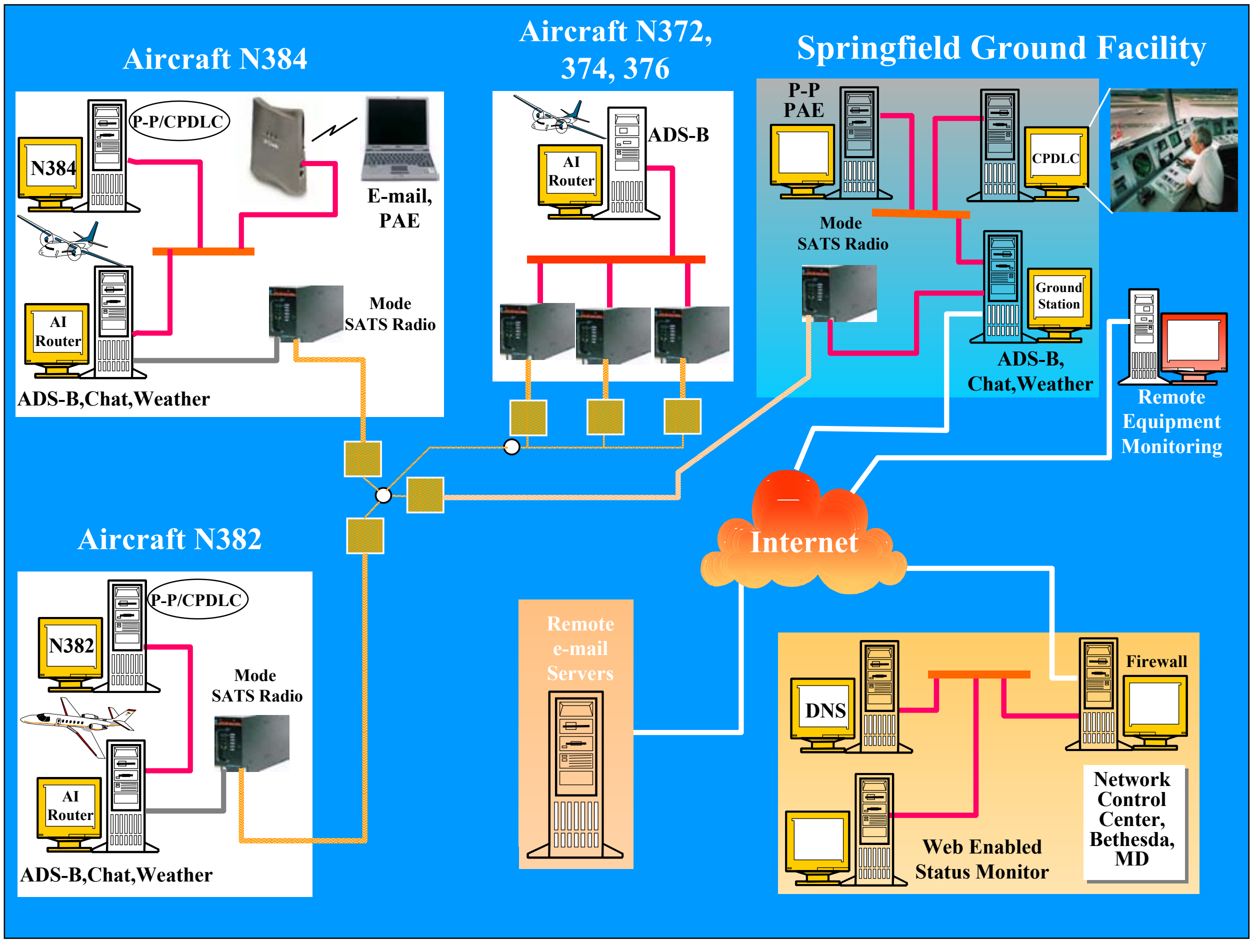


Figure 2-2. AI Testbed with VDL Mode SATS Subnet

The workstation acting as the ground station is the AI router in addition to running applications to support ADS-B, weather and e-mail. This router workstation is connected to the Internet as well as to a ground LAN and to the VDL Mode SATS radio. The CPDLC ground controller and the peer-to-peer workstations are connected to the ground LAN.

The web enabled status monitor (located at the Network Operations Center (NOC) in Bethesda, MD) remotely monitors the status of the routers and the radios. A workstation with web browser located in Computer Networks & Software's Springfield facility is used to get the monitor information from the Network Operations Center.

2.4. What is Mode SATS?

VDL Mode SATS employs a Self-organizing Time Division Multiple Access (STDMA) scheme where all operators use the same set of frequencies to transmit and receive position and state vector messages (often called *sync bursts*). Users transmit sync bursts in time slots that are defined relative to the Universal Time Coordinated (UTC) 1-second mark. There are 75 time slots per second.

"Self Organizing" means that each user, rather than a central controller, evaluates the network traffic and assigns itself time slots. As part of its sync burst, each mobile user transmits a time slot reservation for its subsequent transmissions. All users monitor the channel, track, and abide by this reservation information in order to prevent simultaneous use of the same time slot on a channel. When nearly all of the time slots are in use, there is a provision for two users to occupy the same time slot. A transmitter can select a time slot used by a distant transmitter, so users in the local areas of each transmitter will still receive the messages from the closer transmitter. In this way, reception range degrades gracefully as the number of users increase above the number of available time slots.

Each mobile user periodically transmits its state vector message on each of two assigned channels in the mobile VHF band (108 – 137 MHz is being considered; specific channels have not yet been assigned). Transmissions will be made on one channel once every 15 seconds, and on the other channel at an average rate of every 5 seconds. This scheme, which results in an effective overall update rate of one message per 3.75 seconds, serves to simultaneously maintain the maximum reception range for all users (albeit at a lower update rate) and maintain the required message update rate for those users in the same local area.

The signal modulation is Gaussian-filtered Frequency Shift Keying (GFSK) at a rate of 19.2 Kbps, with one bit per channel symbol. The modulation index of 0.25 (frequency deviation of ±2400 Hz) and time-bandwidth product (BT) of the modulation filter results in a compact transmit spectrum that fits in a single 25 KHz radio frequency (RF) channel.

The length of messages transmitted by mobile platforms is 168 bits, which includes a 16-bit Cyclic Redundancy Code (CRC) check word. This combined with other message overhead items (transmitter power-up and power-down times, signal synchronization) fits entirely within a single time slot with about 1.2 msec of guard time left over. Thus, messages transmitted from mobile users up to 200 nmi away will not overlap in time with messages transmitted from onboard the receiving aircraft.

Ground broadcast messages (for Flight Information and Traffic Information Services) are longer, but the exact length has not yet been determined. In order to accommodate the largest number of mobile users, two communication channels, different from the mobile channels, are proposed for ground broadcast use, probably located in the 108 – 137 MHz band (specific channels have not yet been assigned). Due to the signal-interference performance characteristic of the modulation and the localized applicability of the transmitted information, frequency reuse following a geographic scheme similar to that of cellular telephone is possible for these broadcasts.

2.5. What is Peer-to-Peer?

The emerging use of peer-to-peer networking and architectural approaches is not a single concept, but often defined as a wide array of technologies. The concept, when applied to supporting applications through the SATS AI, is very similar to the definition in a protocol architecture where the layer entities are paired with each other across the network. That is, the end system to end system internetworking takes place through a stacked set of services that can be said to be the peers of the similar stack (or layer) of the remote end system. This is the technique used both in the ATN and the TCP/IP communication architectures. The principle feature of the peer-to-peer approach is that there is no form of centralization required for user application execution, whether performed locally at the user's end system (PC) or between two geographically separated end systems. This is contrasted with the client-server approach in which the server is the centralizing component between two end systems. The centralizing concept would be extended to any internetworking that requires the use of a Domain Name Server (DNS) as defined in today's Internet sense. Thus, peer-to-peer is often defined by the use of something other than a DNS to specify the needed internetworking addressing that links the logical network interface address to the physical address of the end systems. Using this definition, the methods employed by the Napster service can be said to be peer-to-peer techniques.

Peer-to-peer applies to four general application activities:

- Collaboration systems
- Interaction between software applications
- Efficient use of network resources
- Supercomputing

The easiest to understand form of peer-to-peer techniques for collaboration (files, gaming, or workgroup communication) is called instant messaging (IM). However, IM often depends upon a "presence server" to assist in addressing and monitoring of exchanges.

The instant messaging concept is extended to a distributed system view to form the realm of collaboration between applications. The "interaction between applications" is seen as the support that the AI could provide to SATS applications. The interactions are likely to be hosted or provided as a platform that is similar to "middleware." Several firms developing the interactive application support tools are:

- Oculus Technologies
- Nextpage
- OpenDesign
- Tyberius Inc.

The efficient use of network resources (e.g., file storage) and the use of techniques covering the formulation of supercomputer equivalency by the use of parallel machines are not seen as the principle needs for the SATS Airborne Internet.

The placement of the peer-to-peer "middleware" software within the AI Testbed architecture is shown in Figure 2-2.

3. TESTBED OBJECTIVES

The objective of the SATS testbed is to demonstrate the Airborne Internet concept by emulating a real world SATS environment. The testbed provides an opportunity to test SATS applications and communication technologies.

The SATS testbed is designed to use multiple subnetwork technologies to support the AI architecture. Three types of subnetwork have been selected to support the SATS AI proof of concept. They include VDL Mode SATS, Wireless LAN 802.11b, and SATCOM.

VDL Mode SATS is the subnetwork employed to demonstrate the AI Testbed – Build A. The following objectives were sought to be accomplished:

- Demonstrate aircraft-to-aircraft communications. A broadcast capability can be achieved using Automatic Dependent Surveillance – Broadcast (ADS-B) and Trajectory Change Point (TCP).

- Ground broadcast Surveillance information service. Traffic Information Services – Broadcast (TIS-B) can be used for this purpose.

- Maneuver and Control can be demonstrated using Controller Pilot Data Link Communications (CPDLC)

- Applicability of external Internet for Flight Information Services – Broadcast (FIS-B) kind of services, like weather broadcast to aircraft from the ground. E-mail is another important service that can be provided.

- Prove the technology of VHF Digital Link Mode SATS, which uses Self-organizing Time Division Multiple Access (STDMA) as its media access mechanism. VDL Mode SATS permits data communication without the necessity of having a ground station to support the protocol.

- Peer-to-peer activity between two or more air nodes, and between air and ground nodes. Peer-to-peer communication enables real time collaboration between equal entities by sharing resources and information.

- Interoperability between applications residing on different platforms.

4. APPLICATION DEMONSTRATION

The following applications will be demonstrated using Build A of the SATS AI Testbed. It should be noted that the SATS AI concept would also support other applications, which are to be developed in the course of time.

- Airspace Situation - ADS-B will be used by pilots to "see" aircraft traffic in his vicinity. ADS-B broadcasts the position of all aircraft to all other devices.
- Maneuver and Control - CPDLC supports data link communications between the SATS aircraft and an ATC controller.
- FIS-B Weather Service - FIS-B can be used to provide near real time weather information to SATS pilots. One of the uses for VDL Mode SATS is a continuous broadcast by a ground station of local weather conditions.
- Peer-to-Peer - Pilot/Aircraft Exchange (PAE) service can be provided by the peer-to-peer tool Respondr.
- Public Information Exchange - This service can be demonstrated by the SATS pilots use of Internet e-mail.

4.1. Airspace Situation

4.1.1. Description

Automatic Dependant Surveillance – Broadcast (ADS-B) is a new technology that allows pilots in the cockpit and air traffic controllers on the ground to "see" aircraft traffic with much more precision than has been possible before. The FAA has identified more than 20 ways that ADS-B can make flying safer and can allow more efficient use of the airspace around our busiest airports.

Radar works by bouncing radio waves off of airborne targets and then "interpreting" the reflected signal. ADS-B doesn't need to interrogate targets to display them. Rather, it relies on the on-board navigation equipment (e.g., INS, GPS, DME-DME, etc.). Each ADS-B equipped aircraft broadcasts its precise position in space via a digital data link along with other data, including airspeed, altitude, and whether the aircraft is turning, climbing or descending. This provides anyone with ADS-B equipment a much more accurate depiction of air traffic than radar can provide. And, since the equipment is so small and light, it can be made a standard part of the equipment on board an aircraft, allowing pilots and controllers to see an accurate depiction of real-time air traffic. Figure 4-1 shows the ADS-B graphical user interface (GUI) traffic display.

Unlike conventional radar, ADS-B works at low altitudes and on the ground. Thus, it can be used to monitor traffic on the taxiways and runways of an airport. And it is effective in remote areas or in mountainous terrain where there is limited or no radar coverage. Power and data requirements are minimal, allowing easy remote management of ground stations.

ADS-B relies on the on-board three-dimensional (3-D) (or 4-D) navigation system to determine an aircraft's precise location in space. The system then converts the position into a digital code, which is combined with other information such as the type of aircraft, its speed, its flight number, and whether it's turning, climbing or descending. The digital code containing all of this information is updated several times a second and broadcast from the aircraft on a discreet frequency, called a data link.

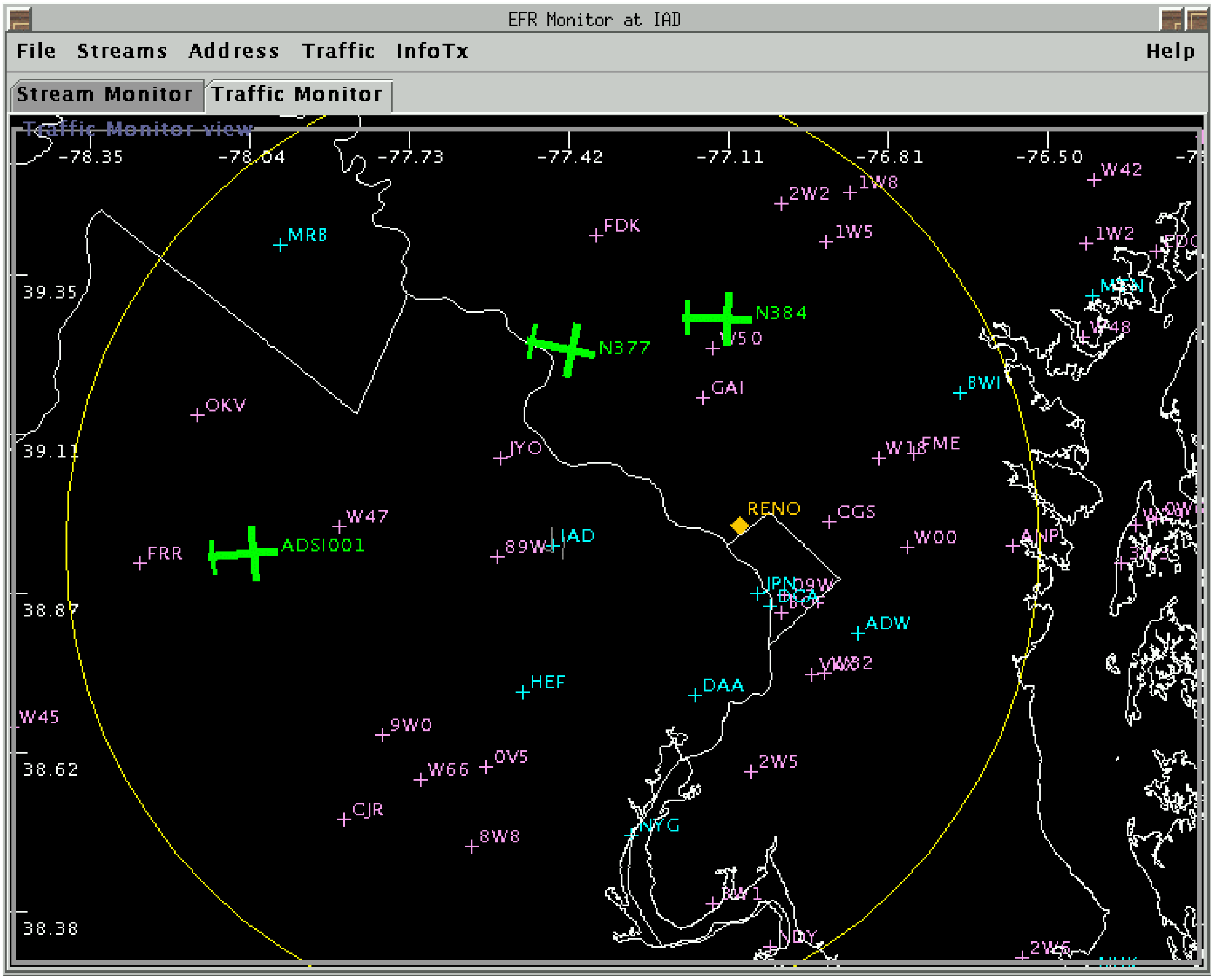


Figure 4-1. ADS-B Traffic Display

Other aircraft and ground stations within about 180 miles receive the data link broadcasts and display the information in a user-friendly format on a computer screen. Pilots in the cockpit see the traffic on a Cockpit Display of Traffic Information (CDTI). Controllers on the ground can see the ADS-B targets on their regular traffic display screen along with radar targets.

One of the greatest benefits of ADS-B is its ability to provide the same real-time information to pilots in aircraft cockpits and to ground controllers, so that for the first time they can both "see" the same data.

4.1.2. Applicability to SATS

SATS pilots can have information now available only to air traffic controllers – affordably, automatically and reliably. In terms of safety, one of the biggest advantages of ADS-B is scalability. This mitigates the problem of keeping up with increases in air traffic.

It is effective in remote areas or in mountainous terrain where there is limited or no radar coverage.

4.1.3. Demonstration Accomplishments

Aircraft-to-aircraft and aircraft-to-ground connectivity were established through broadcast links. ADS-B also provided a mechanism for the SATS pilot to safely maintain separation from other aircraft that it electronically "sees" via the traffic display.

4.2. Maneuver and Control

4.2.1. Description

The Controller Pilot Data Link Communications (CPDLC) application provides air-ground data communication between a pilot and a controller for ATC service. This includes a set of clearance/information/request message elements, which correspond to voice phraseology employed by Air Traffic Control procedures.

The controller is provided with the capability to issue level assignments, crossing constraints, lateral deviations, route changes and clearances, speed assignments, radio frequency assignments, and various requests for information. The pilot is provided with the capability to respond to messages, request clearances and information, report information, and declare or rescind an emergency. The pilot is provided with the Multifunction Control and Display Unit (MCDU) graphical user interface unit shown in Figure 4-2. A "free text" capability is also provided to exchange information not conforming to defined formats.

Controllers and pilots will use CPDLC in conjunction with the existing voice communications. CPDLC will be used for routine or frequent types of transactions. Although initial implementation is intended to conform to existing procedures, it is anticipated that future evolution of the system and procedures will result in the greater automation of functions for both aircraft and ground systems. The controller's interface is shown in Figure 4-3.

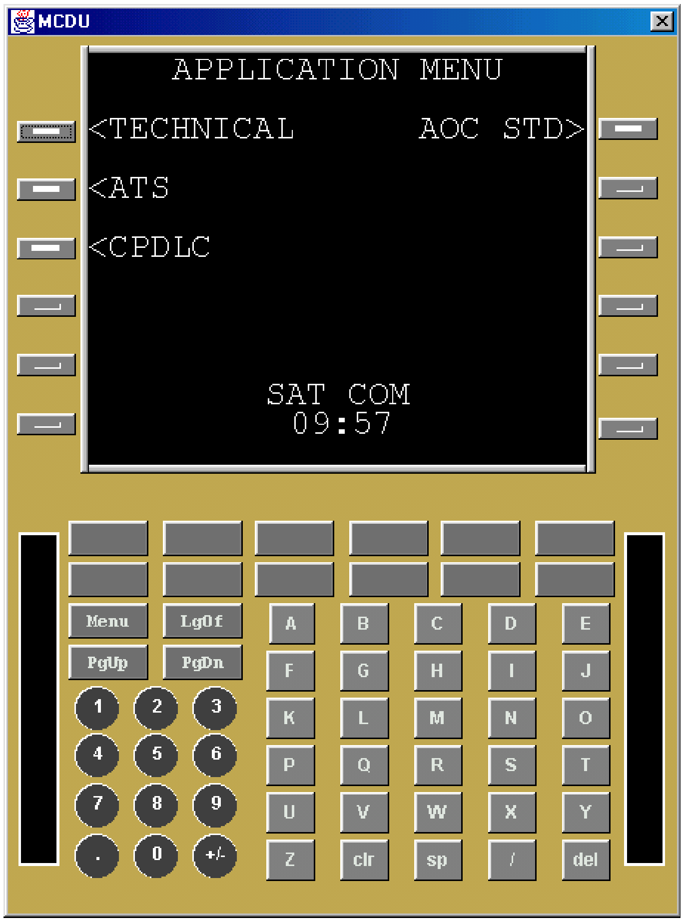


Figure 4-2. Multifunction Control and Display Unit

Sending a message by CPDLC consists of selecting the recipient, selecting the appropriate message from a displayed menu or by other means (which allow fast, and efficient message selection), and executing the transmission.

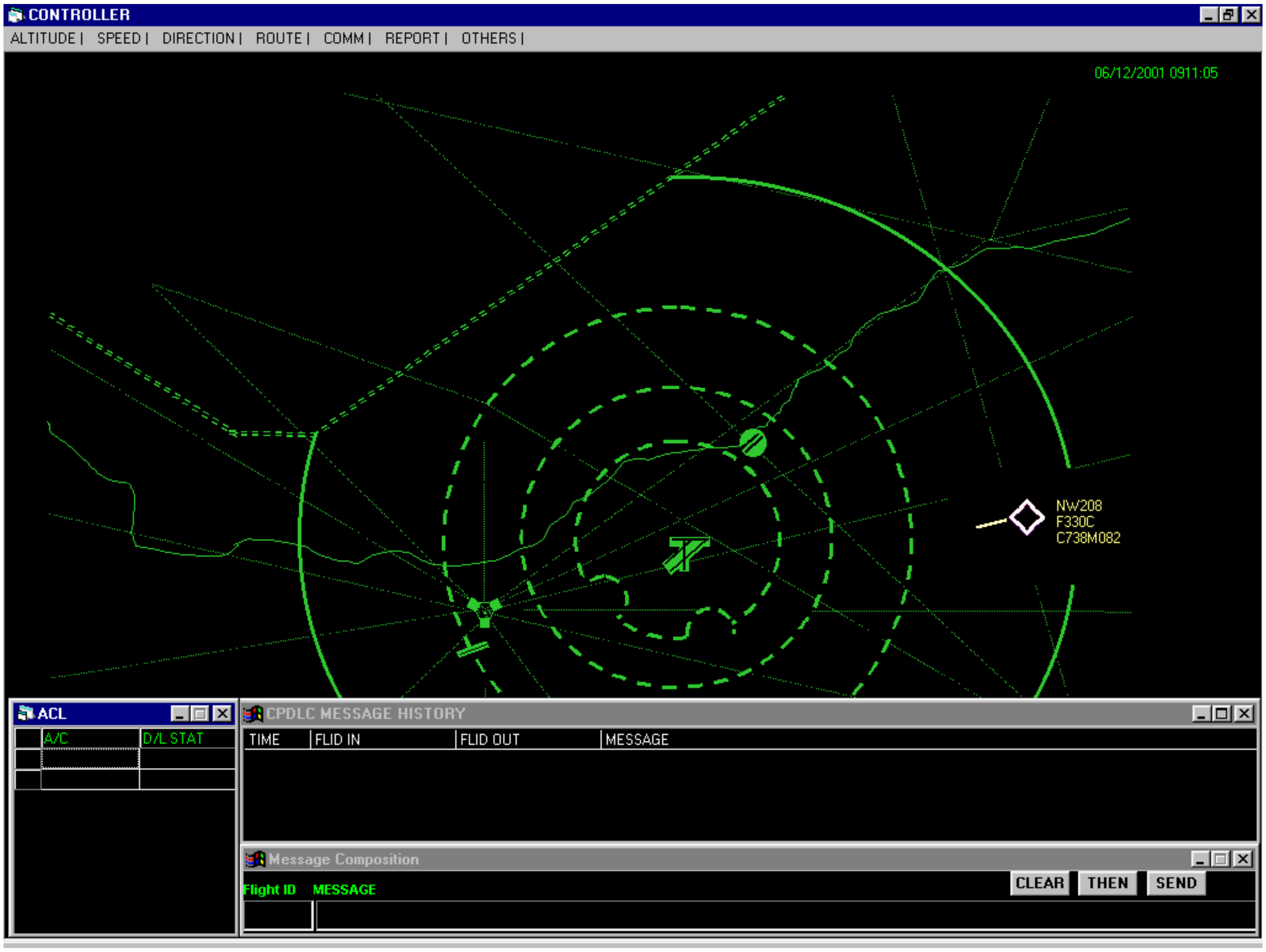


Figure 4-3. ATC Controller

4.2.2. Applicability to SATS

The CPDLC application is based on the International Civil Aviation Organization (ICAO) Aeronautical Telecommunications Network ATN Standards and Recommended Practices (SARPs). It emulates the future data link communication mechanism that an ATC controller would use to direct a SATS aircraft.

4.2.3. Demonstration Accomplishments

The demonstration showed that the AI could be used to support CPDLC communications between an ATC controller and a SATS aircraft pilot. Some gateway functionality would be needed at the Transport and Network layers. The gateway would handle the TP4/CLNP (ICAO standard) to TCP/IP conversions.

4.3. FIS-B Weather Service

4.3.1. Description

Detailed weather and forecast information can be obtained from any major weather service provider. The Computer Networks & Software SATS AI Testbed application uses the National Oceanic and Atmospheric Administration (NOAA) weather information. NOAA conducts research and gathers data about the global oceans, atmosphere, space, and sun, and applies this knowledge to science and services.

NOAA warns of dangerous weather, charts our seas and skies, guides the use and protection of ocean and coastal resources, and conducts research to improve the understanding and stewardship of the environment.

The FIS-B type of weather service provided by NOAA are through five major organizations: the National Weather Service, the National Ocean Service, the National Marine Fisheries Service, the National Environmental Satellite, Data and Information Service, and NOAA Research.

Figure 4-4 shows FIS-B graphical weather information that may be provided to SATS aircraft.

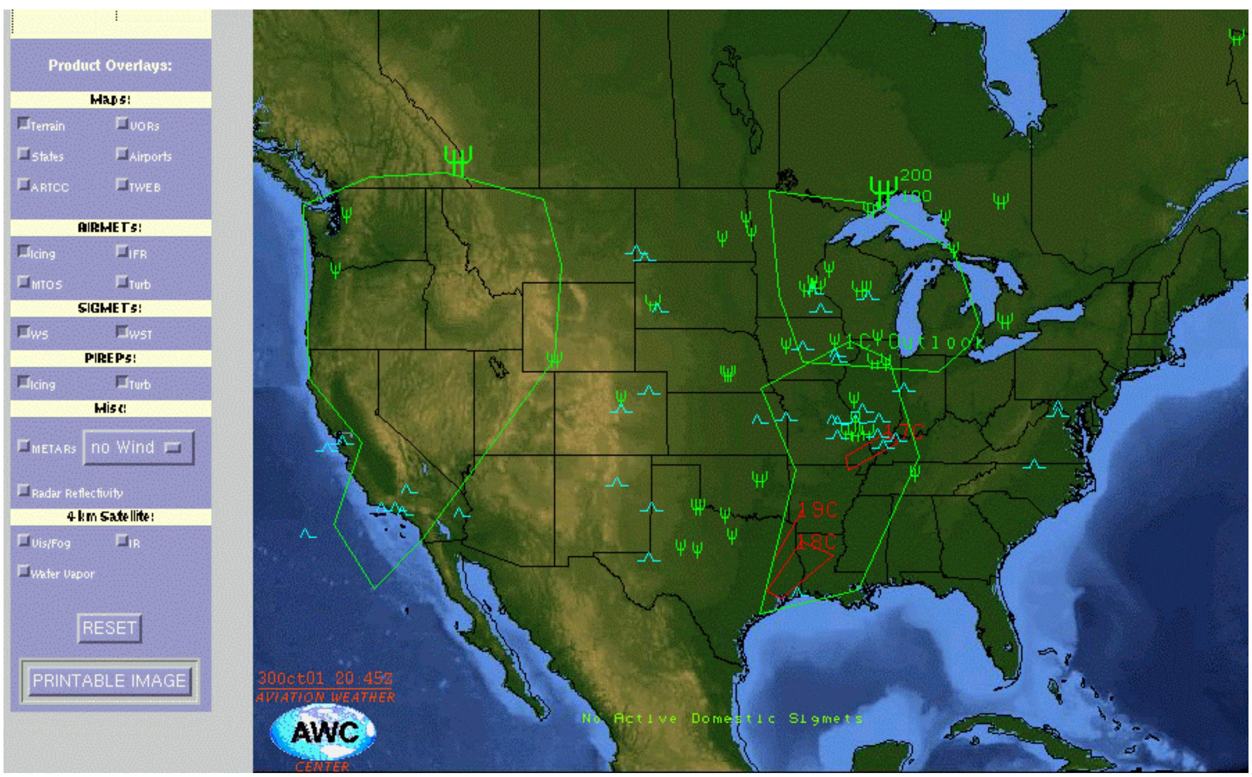


Figure 4-4. Graphical Weather Information Display

4.3.2. Applicability to SATS

Having access to FIS-B type weather data can enhance a safe flight by a SATS aircraft. Pilots can obtain near real-time weather information from weather service providers, thereby avoiding dangerous weather traps.

4.3.3. Demonstration Accomplishments

The capability for the ground station to access the external Internet for obtaining weather products from weather service providers was demonstrated. These products were broadcast periodically to all SATS aircraft and were accessible on-demand by the pilot.

4.4. Peer-to-Peer

4.4.1. Description

Convergence 2000 (C2K) is the peer-to-peer tool designed to provide process-to-process communication across various UNIX, UNIX like and Microsoft platforms.

The system consists of the C2K engine, components which attaches to that engine along with various configuration files that may be required. Each engine must operate with an IP address and port number that is like no other on the network where the engine resides. Engine (host) names and addresses, along with process names and identifications, appear in a table entitled “control.cfg”. Another table, “control.hst” provides a host name, which connects the engine to the proper portion of the configuration table during system start up and operation.

Peer-to-peer communication facilitates distribution of data and control that was previously difficult or impossible. These facilities might include interrogation of airborne device, control of airborne devices (automatic selection of transponder codes, altimeter settings, heading selections, etc.), control of ground device (runway lights, beacons, etc.), and data sharing (weather, position reports, Automated Terminal Information Service (ATIS), relays to and from ground control).

Various components that perform specific functions can attach to an engine. They are:

- UNICAST – This component is available on all engines and can be used to send a general text message to any other component. Along with being useful for general system testing, it also can be used to send requests to other components such as RESPONDR when a peer member requests specific data.

- RESPONDR – The responder, RESPONDR, generates random data simulating real data when requests are received for “temp”, “vapor”, “heading”, “altitude”, “speed”. These data items suggest that a ground controller could, without pilot interaction, capture data during climb out and descent useful for determining a comprehensive, low altitude weather pattern including moisture, lapse rates, etc.

- MONITOR – This component provides a viewable window, which can be created and erased, locally or remotely. It is used to record transmission to and from a selected aircraft or ground controller or a combination of these.

- COPYLIST – This component provides a modifiable list of receivers of data. This might include a list of controllers, to receive position reports, weather data, etc. It can also be used to propagate command instructions such as turn on devices, set transponder codes, altimeter settings, etc.

4.4.2. Applicability to SATS

The peer-to-peer tool provides Pilot/Aircraft Exchange (PAE) services. It is a mechanism for real time collaboration between SATS aircraft pilots.

4.4.3. Demonstration Accomplishments

Peer-to-peer activity between two or more air nodes was demonstrated. This enabled real time collaboration for distributed resource, application control and information.

4.5. Public Information Exchange

4.5.1. Description

Electronic mail (e-mail) allows people to communicate in a way that is faster and more economical than previous methods of communication. When you send someone an e-mail message, they often receive the message within seconds, and there is no postal charge for sending the message.

To send or receive e-mail, you must have an e-mail address, which one generally obtains from a business Internet service.

To send and receive e-mail, you also need an e-mail reader program. Netscape Navigator and Microsoft Internet Explorer have an e-mail reader included with the Web browser. You can also use a third-party e-mail reader program, such as Eudora. If you are using Netscape Navigator or Microsoft Internet Explorer as your web browser, you may start by using the e-mail reader included with the Web browser. After one becomes more comfortable with e-mail, you can always switch to a third-party e-mail reader program.

Some of the possible uses of e-mail in the SATS environment are presented below:

- E-mail notification of change of business appointments.
- Check on rental car status.
- Notify aircraft owner the maintenance status of aircraft.
- Pilots can exchange information with Fixed Base Operators (FBOs) via e-mail

4.5.2. Applicability to SATS

Public Information Exchange through Internet e-mail would support door-stop to destination planning and notification for SATS users.

4.5.3. Demonstration Accomplishments

The capability to send and receive e-mail with anyone having a connection to the external Internet was demonstrated. This included sending and receiving e-mail messages between aircraft.

5. APPLICATIONS OVERVIEW

5.1. ADS-B Application

The ADS-B application provides all units with position information of all other units. It works as follows (See Section 5.6):

1. An AI Router program (MCDU, umon, or circle.sh) sends commands over the Ethernet to the radio providing position (and other) information.

2. The radio encodes this information into a 21-byte frame and broadcasts this frame every 2 seconds.

3. All other radios receive the frames, decode the position information, and emit the data in an ASCII target sentence (User Datagram Protocol (UDP) over Ethernet).

4. On the ground AI Router (and any other AI Routers if desired), the syslog-ng logger and jmon program receives the UDP target sentence and jmon plots the position in an X-window display.

5.2. Datafeed Application

The Datafeed application broadcasts FIS-B weather information (similar to ATIS) from the ground station to all aircraft. It works as follows (See Section 5.7):

1. The wg.sh script on the ground AI Router retrieves various weather products from Internet sites and writes them to a local disk file.

2. The sequencer program reads these files, segments them into 430-byte portions and adds sequence numbers to the segments, and sends them (UDP port 8512) to the ground radio.

3. The ground radio receives these UDP frames and puts the frames into a queue.

4. The ground radio transmits the frames in the queue in the datafeed streams (15 slots (430 bytes) per transmission, four transmissions per minute).

5. All other radios receive the frames and transmit the data over Ethernet (UDP port 8152).

6. The collector program running on the air AI Routers listens for the UDP frames, reassembles the data, and writes the file to the local disk.

7. A text viewer or ".gif" viewer is used on the air AI Router to view the weather products.

5.3. E-mail Application

This is a description of e-mail sent from the air AI Router to an Internet site (See Section 5.8).

1. A user composes mail using a COTS MUA (mail user agent) mail program (Pine is used here) and sends it.
2. The mail composer program establishes a TCP connection to the localhost on port 25. This starts the from-client program running which accepts the TCP connection.
3. The from-client program accepts the data from the mailer program via the SMTP protocol, buffers the commands and mail text, and then closes the TCP connection to the mailer program.
4. After the SMTP conversation is completed, the from-client may compress the buffered data.
5. The from-client program segments the buffered data and transmits it to a ground station in UDP frames to port 8025.
6. The from-rf program on the ground AI Router starts and receives the data, and uncompresses it (if needed).
7. The from-rf program replays the SMTP commands and data to the local COTS MTA (mail transfer agent) program, and sends an ack over the RF to the sending from-client program.
8. The ground AI Router MTA uses normal SMTP delivery mechanisms to forward the mail to its destination.

This section describes the differences from the above for e-mail to the aircraft.

1. User composes e-mail on standard COTS MUA (mail user agent) and submits it to his standard COTS MTA (mail transfer agent) as normal.
2. User's MTA looks up MX record in its DNS cache.
3. User's MTA's DNS server follows the chain of DNS records and caches (for 24 hours) the fact that the DNS server on midway handles all MX records for aircraft.
4. User's MTA's DNS server then requests from the DNS server on midway (using the standard DNS protocol) for the server handling mail for the aircraft (*e.g.*, the MX record for the domain N384.cs.adsi-m4.com). The DNS server responds with the MX record (with a lifetime of 10 seconds).

5. The User's MTA's DNS server records that the aircraft can be reached from a particular ground station for 10 seconds and informs the MTA of the IP address of the ground station.[1]

6. The User's MTA forwards the mail to the designated ground station. The standard COTS MTA on the ground station then attempts to deliver the mail to the aircraft using the from-mailer program. (See the downlink mail delivery steps 5-7).

5.4. IP Transmission

The VDL Mode SATS radio can accept as input IP frames transmitted to it over the Ethernet. These frames can be forwarded/routed to other VDL Mode SATS radios and sent out their Ethernet ports. This allows various IP-based applications (either UDP or TCP) to obtain connectivity across the RF (See Section 5.9).

1. After one minute of radio operations, the Data Link Equipment (DLE) in the air-side radio establishes an HDLC link with the DLE in a ground-side radio. The data sent over this link is sequenced and acknowledged.

2. IP frames received by the radio via Ethernet that should be routed to another radio are sent over the HDLC link established to that radio.

3. IP frames received by the radio via the RF that do not have as the destination IP address the IP address of the radio itself are sent out the Ethernet port to the default router.

4. UDP port assignments are as follows:

   - 8025 port used by e-mail traffic
   - 8152 destination port for Datafeed messages
   - 8512 destination port for commands sent to the radio
   - 8517 port used by chat messages
   - 8777 source port of log messages
   - 8996 destination port for log messages

Data sent to the following UDP ports uses the routers network address translation feature. That is, traffic sent over the RF has the destination address of the radio, but the radio re-writes the IP header with the destination address of the AI Router, and forwards the traffic to the AI Router.

- 7 (echo) for testing
- 13 (daytime) for testing
- 19 (chargen) for testing
- 8025 (efrmail)

[1] If the aircraft is not currently connected, the DNS server on midway will reply that the mail is undeliverable and the User's MTA will bounce the mail back to the sender immediately.

- 8026 (spare)
- 8027 (spare)
- 8028 (spare)
- 8029 (spare)
- 8030 (spare)

5.4.1. CPDLC Application

Computer Networks & Software, Inc. has developed a CPDLC application that uses TCP connections between the endpoints of the communication. An X-window display of a controller workstation (on the groundside) and an X-window display of a Multifunction Control and Display Unit (MCDU) are used to enter and display data. Commands are selected on the displays and transmitted to the corresponding peer unit via the TCP connection (See Section 5.10).

1. The ground CPDLC controller workstation is started and listens for incoming TCP connections.

2. The air MCDU application is started and a login is requested. This causes TCP/IP frames to be sent over the RF using the IP transmission procedures described above. A TCP/IP association is established between the air MCDU and the ground CPDLC controller workstation.

3. The air MCDU and the ground CPDLC controller workstation exchange CPDLC-formatted messages over the TCP/IP connection using the IP transmission procedures described above.

4. The air MCDU application requests a logout and the TCP/IP connection is closed using the IP transmission procedures described above.

5.4.2. C2K Application

The Convergence 2000 (C2K) application from Tyberius provides an alternate means of neighbor discovery among the network nodes in the SATS AI Testbed. It works as follows:

1. C2K listeners are started on the applications processors.

2. The C2K engines poll each other using TCP/IP connects to find each other. This uses the IP transmission procedures described above.

3. When all C2K engines have established connections with each other, they exchange data over the TCP/IP connections.

5.5. Other Applications

Other ADSI applications that have been developed but were not shown in the NASA demo are described in the following subsections.

5.5.1. Chat

The chat application provides an instant messaging service between radios. It uses the connectionless data link mechanism of the VDL radios, so it does not need a DLE link to be established between the units (See Section 5.11). It works as follows.

1. A user at the transmitting AI router starts the chat program running.
2. A user at the receiving AI router starts the chat program running.
3. The user enters the call sign, tail number, or ICAO address of the peer station, and the text to be sent.
4. That data is sent over UDP to the radio to port 8517.
5. The radio queues the data as an addressed, connectionless (but acknowledged) message to the peer station. The frame is re-transmitted if an acknowledge is not received.
6. The receiving station transmits an acknowledge back to the sending station and transmits the data in a UDP frame over the Ethernet to the AI Router.
7. The chat program on the receiving station prints the message.

5.5.2. IP Access

If the air radio is configured to have a public IP address (*i.e.,* one that is valid for routing over the Internet), tunneling software in the NOC and ground station may be used to provide IP access directly to the aircraft. This allows any general TCP or UDP application on any Internet site (*e.g.,* a customer's host computer), to have access directly to the AI router applications (See Section 5.12). It works as follows:

1. The air radio establishes an Link Management Entity (LME) link to a ground radio.
2. The ground radio relays the connection information to the DNS in the NOC in Bethesda, which records the air radio <-> ground radio mapping.
3. An application at a customer site transmits an IP datagram with the destination address of the air radio.
4. The routing software in the Internet routes the IP datagram to the NOC in Bethesda.

5. The ha program in the NOC puts that IP datagram inside another IP datagram (*i.e.,* tunneling), and sends it to the ground AI router.

6. The fa program in the ground AI Router un-tunnels the inner IP datagram and forwards it to the ground radio.

7. The ground radio transmits the frame over the RF to the air radio.

8. The air radio forwards the IP frame to the air AI Router.

5.6. ADS-B Application Data Flow

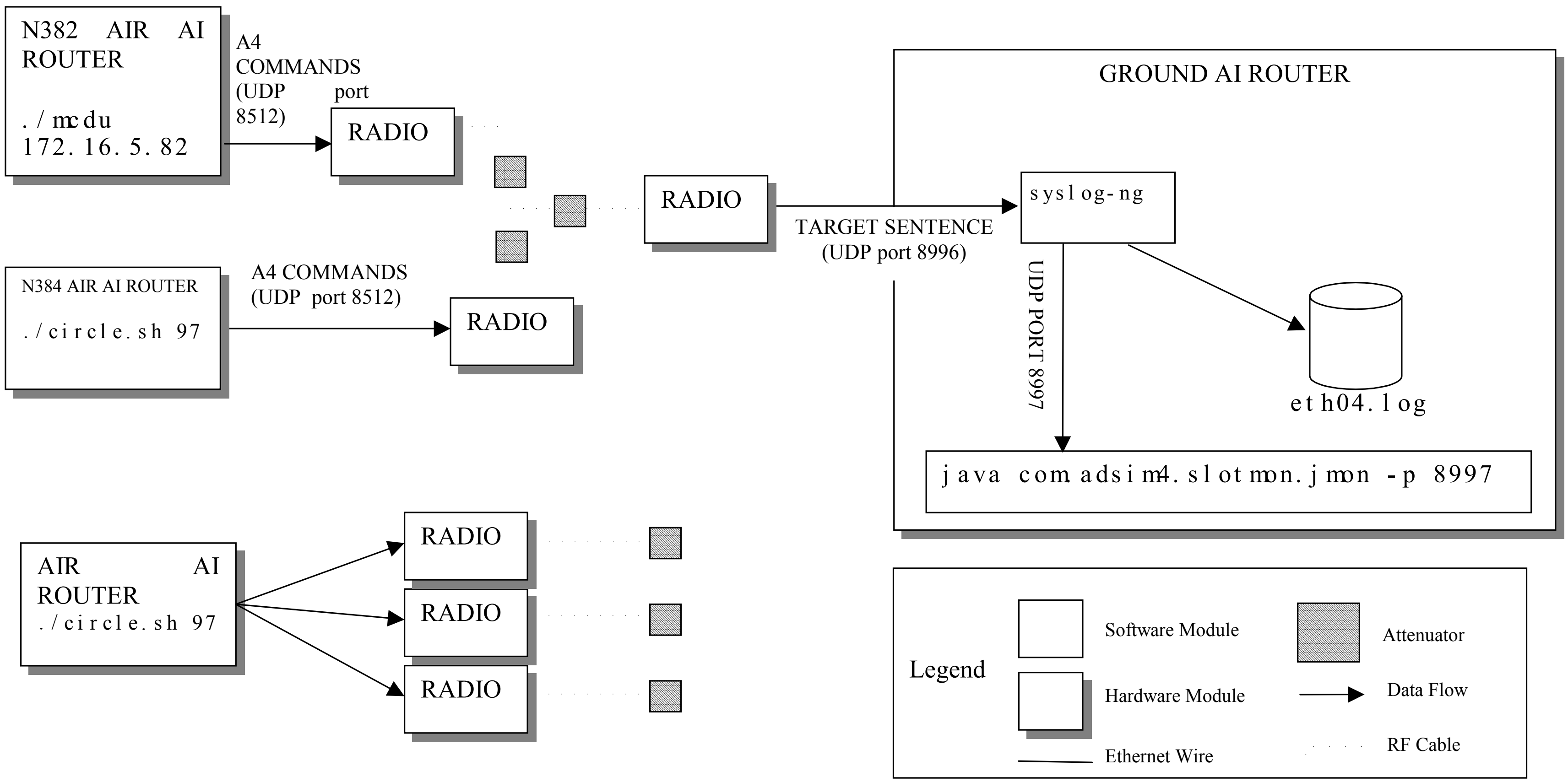


Figure 5-1. ADS-B Application Data Flow

5.7. Datafeed Application Data Flow

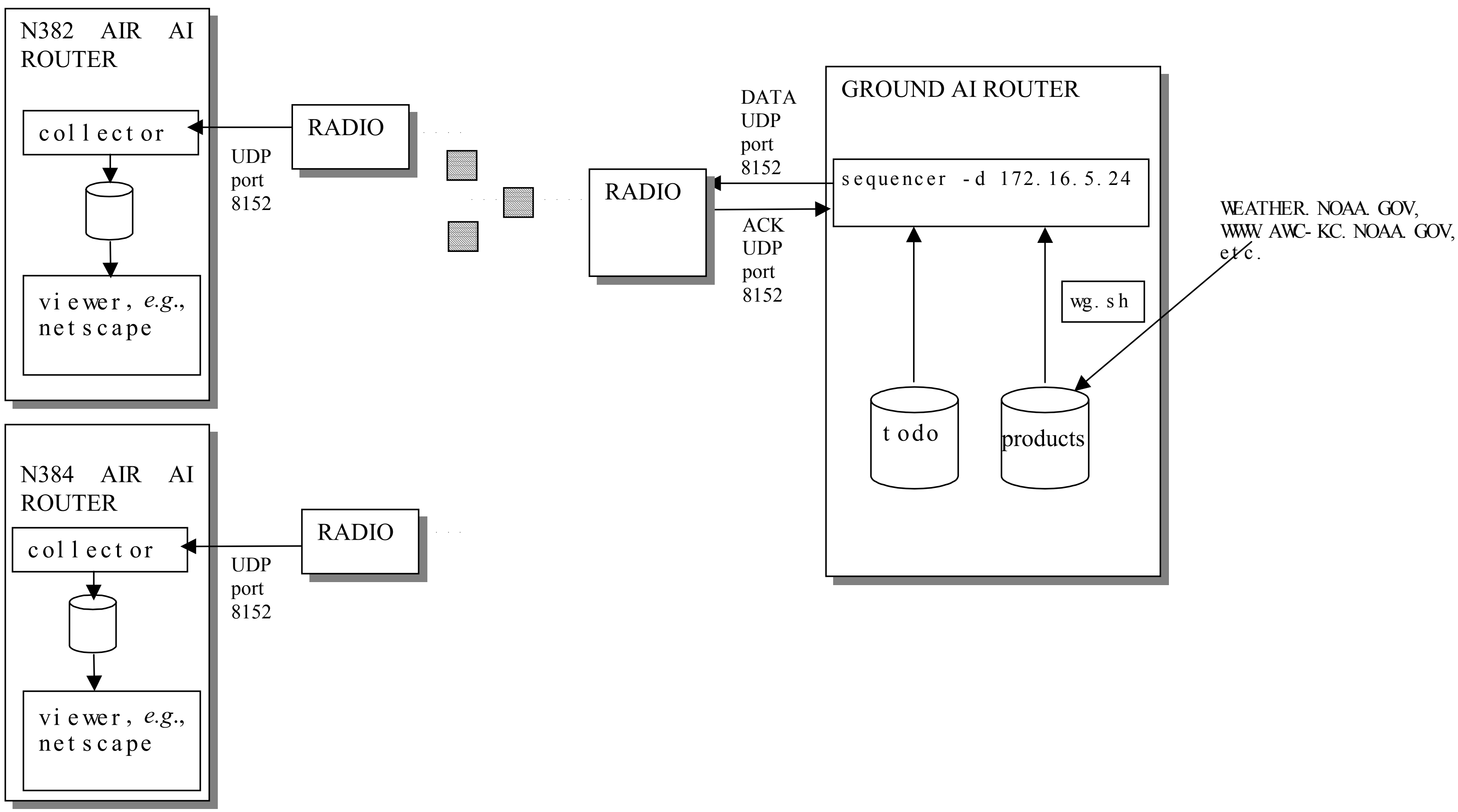


Figure 5-2. Datafeed Application Data Flow

5.8. E-mail Application Data Flow

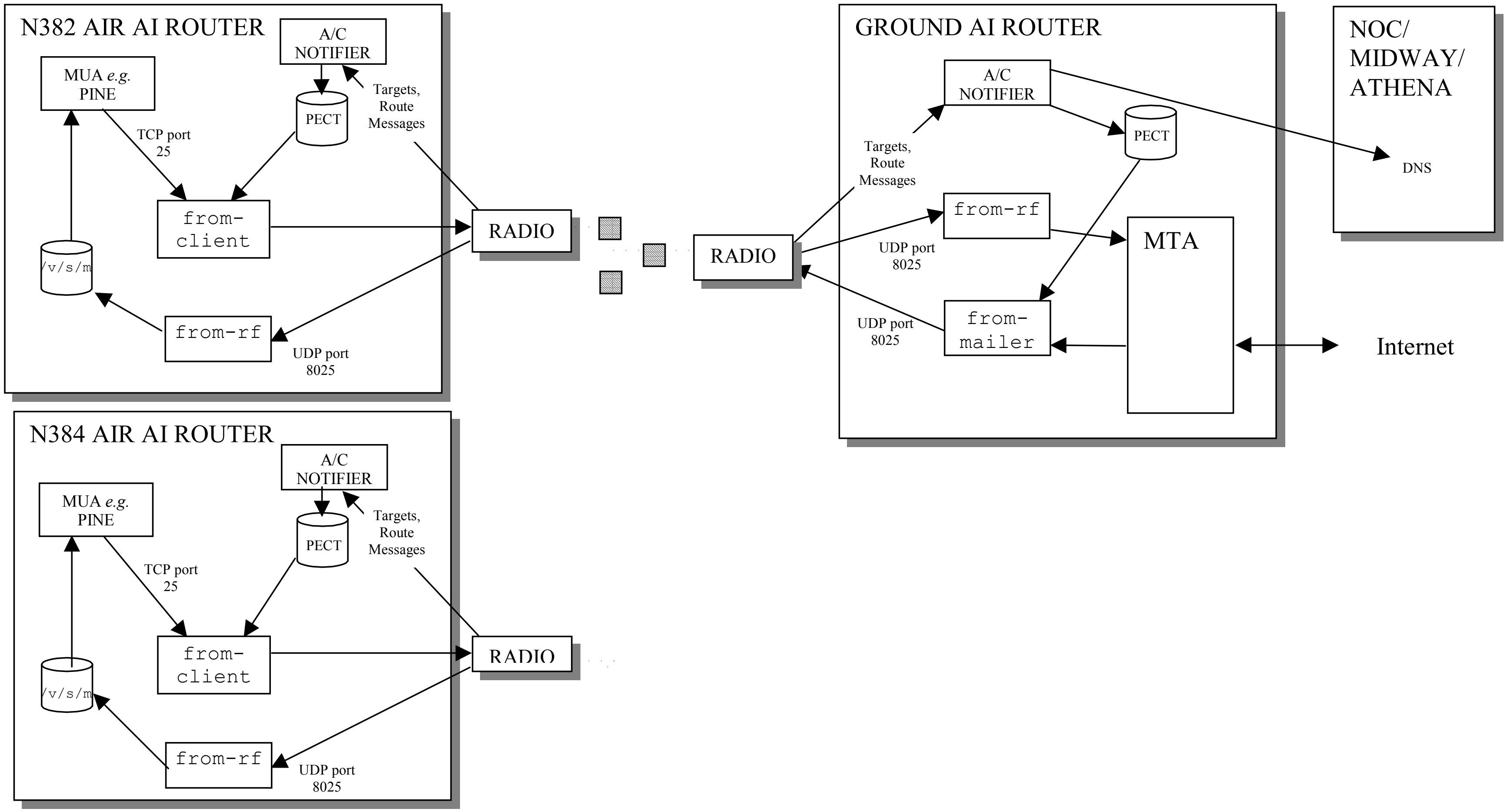


Figure 5-3. E-mail Application Data Flow

5.9. IP Transmission Data Flow

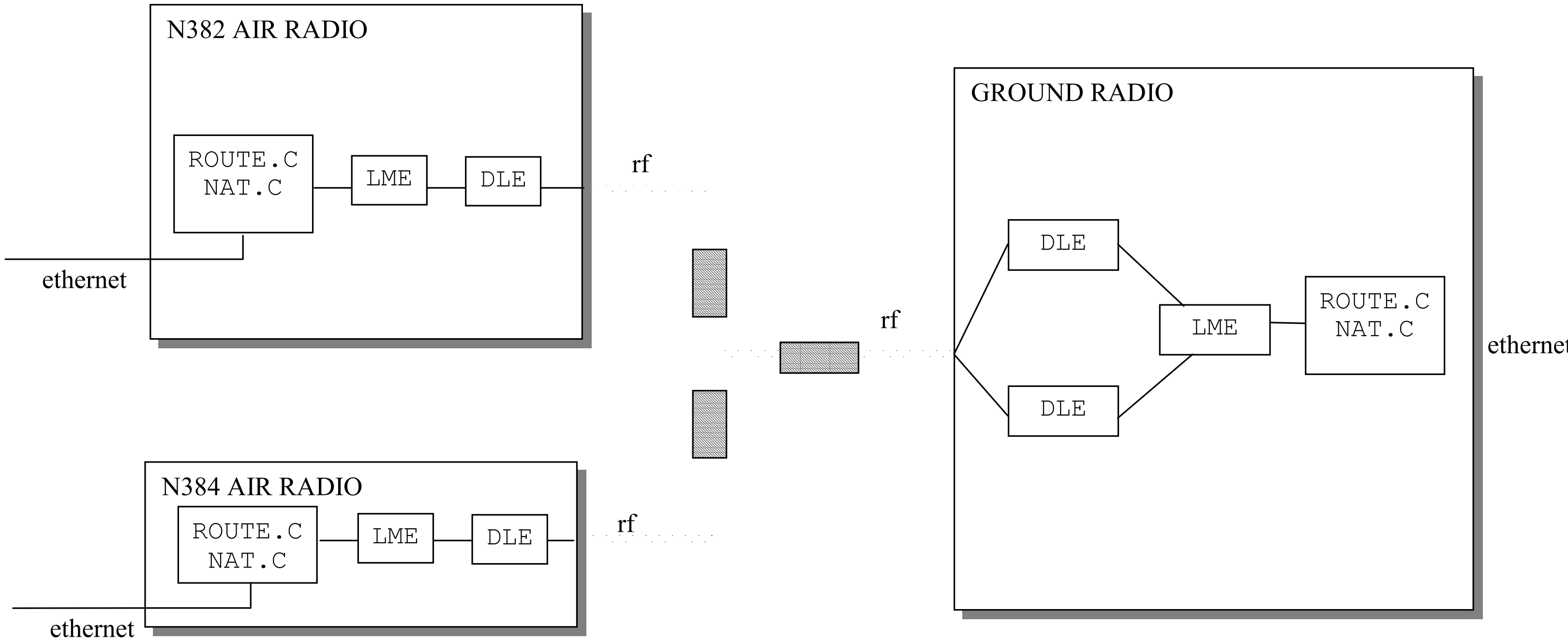


Figure 5-4. IP Transmission Data Flow

5.10. CPDLC Data Flow

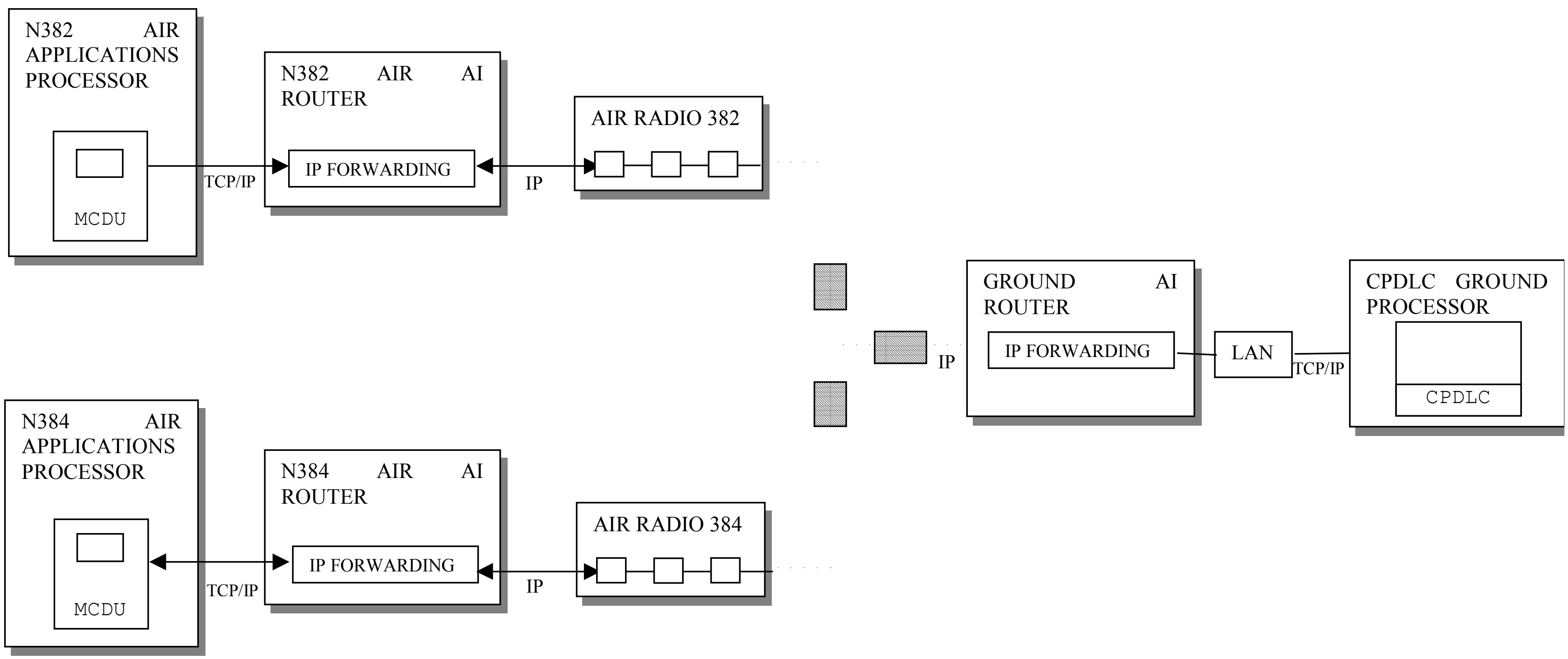


Figure 5-5. CPDLC Data Flow

5.11. Chat Data Flow

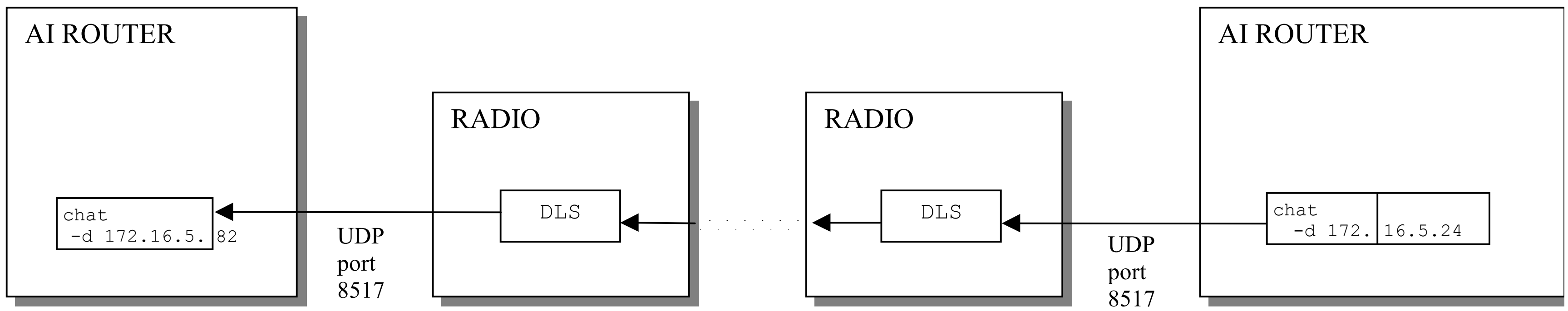


Figure 5-6. Chat Data Flow

5.12. IP Access Data Flow

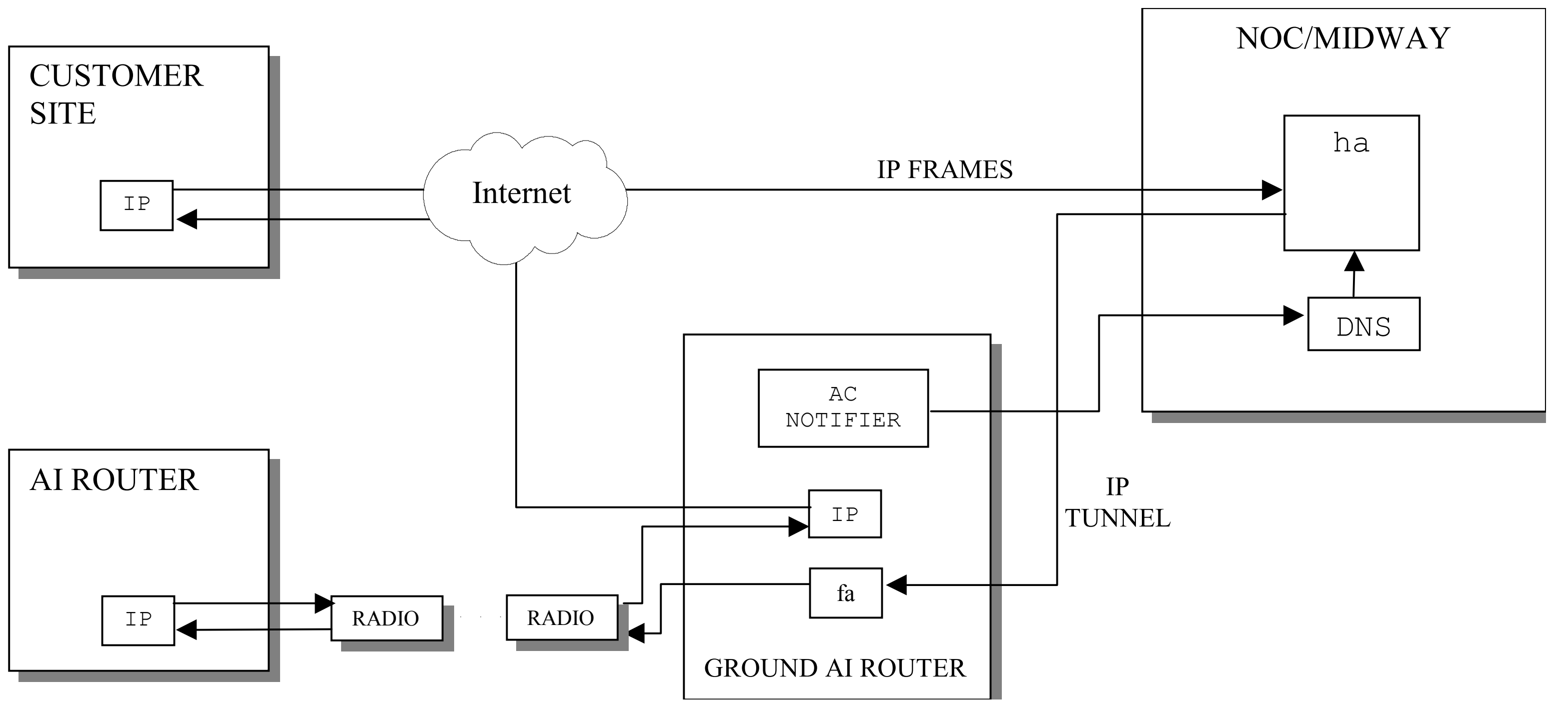


Figure 5-7. IP Access Data Flow

6. HARDWARE SYSTEMS

6.1. Springfield Ground Station - Addresses and Routes

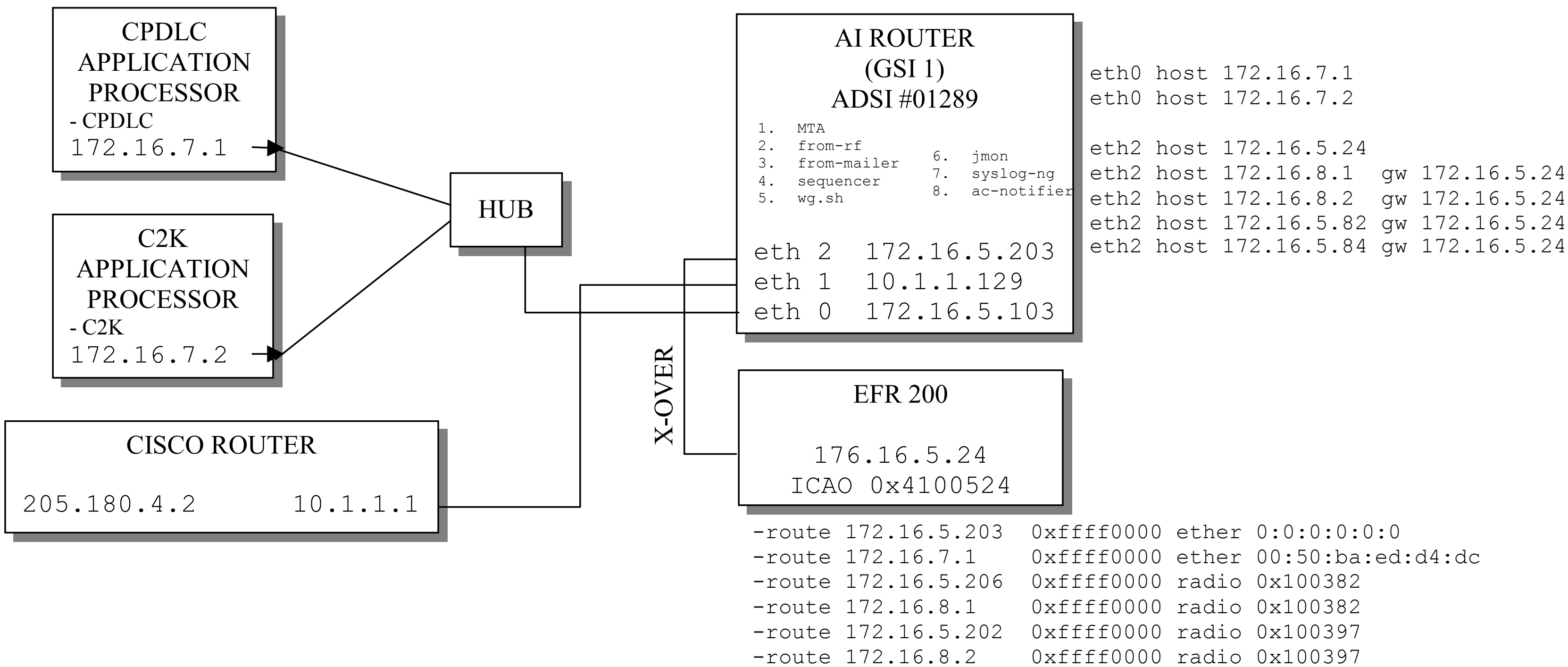


Figure 6-1. Springfield Ground Station - Addresses and Routes

6.2. Aircraft N382 - Addresses and Routes

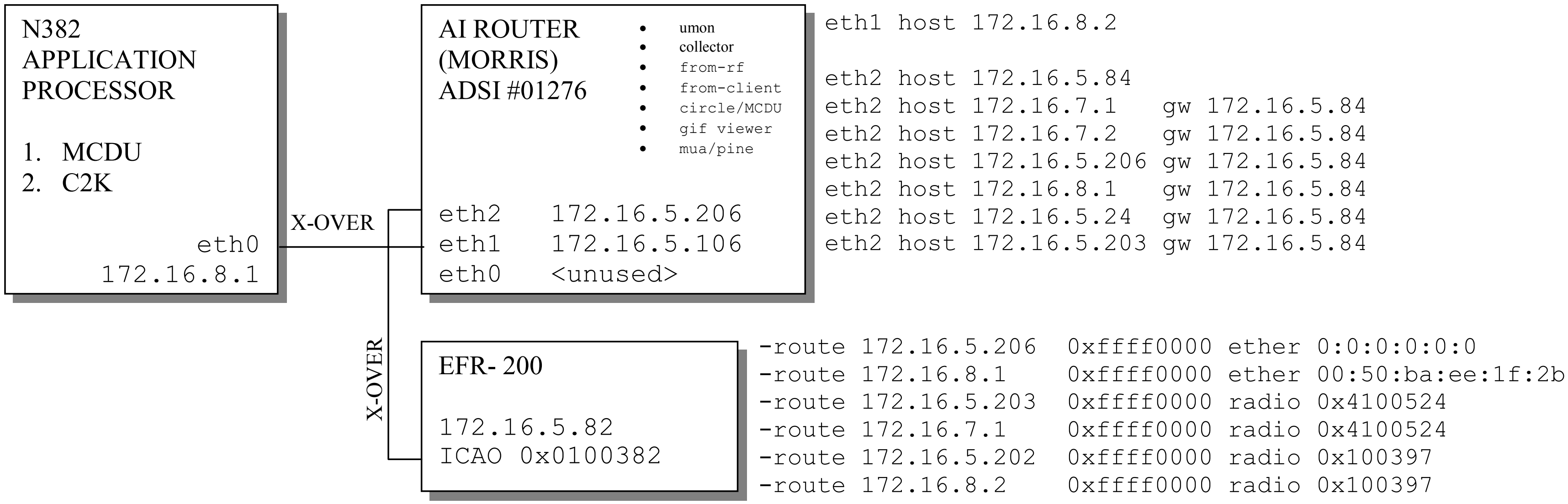


Figure 6-2. Aircraft N382 - Addresses and Routes

6.3. Aircraft N384 - Addresses and Routes

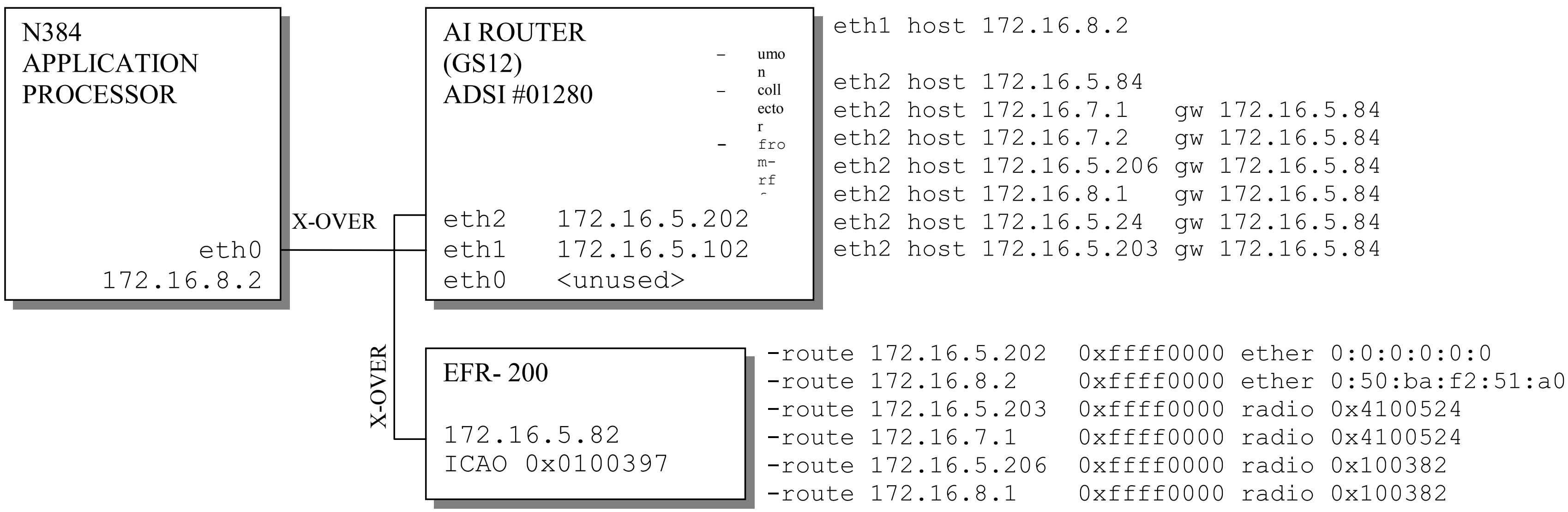


Figure 6-3. Aircraft N384 - Addresses and Routes

6.4. Aircraft Host

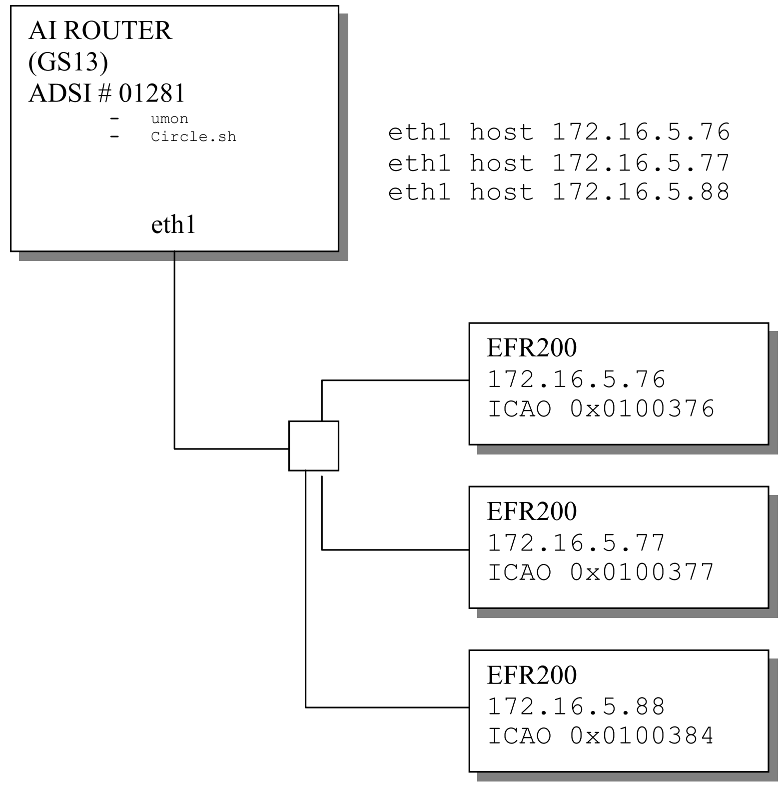


Figure 6-4. Aircraft Host

6.5. Network Operations Center

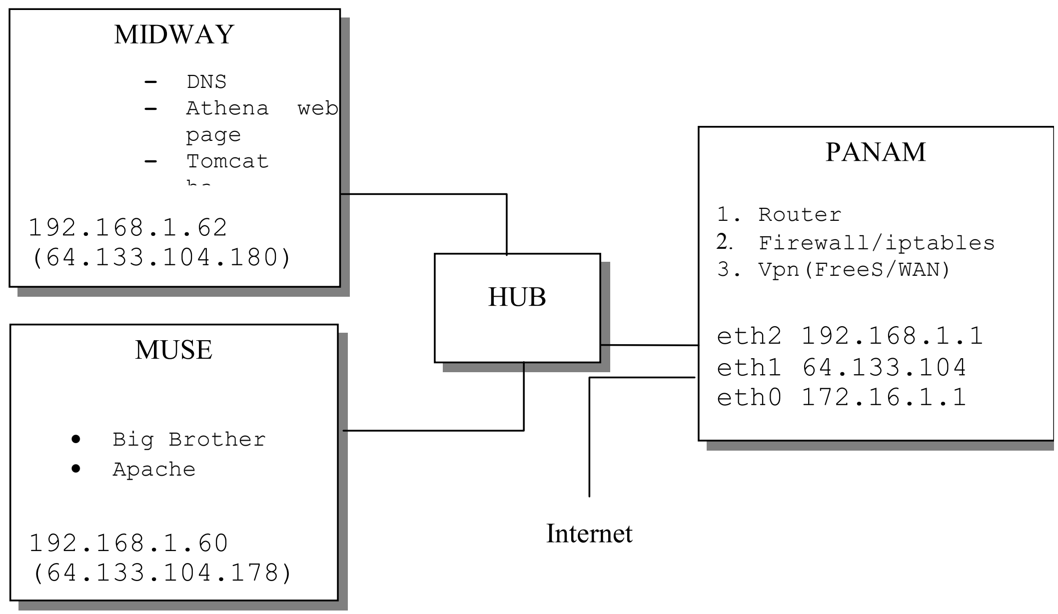


Figure 6-5. Network Operations Center

6.6. SATS Test Lab Equipment

6.6.1. Ground Station

- EFR-200-2 10018 Koramtec ADSI/DYIC Joint Venture (CPU 100524; n-connector backplate)
- HP Computer (GSI1 Nassau, ADSI01289)
- Keyboard
- Display
- 1 mouse pad
- Logitec model M-CAA43 mouse
- 1 n-connector RF cable
- 1 red banana jumper cable
- 1 black banana jumper cable
- Ethernet hub
- 3 Ethernet cables

6.6.2. Air Station N382

- EFR-CA-200-2 10015 Aviation Data System Innovations, LLC (CPU 100382; 429 connector backplate)
- HP Computer (Morris 172.16.6.106, ADSI01276)
- Keyboard
- Display
- Logitec model M-CAA43 mouse
- 429 plug w/RF and power wiring
- 2 Ethernet cross-over cables
- N382 Application Processor

6.6.3. Air Station N384

- <no label radio box> (CPU 100397; 429 connector backplate)
- HP Computer (GSI2, ADSI01280)
- Keyboard
- Display
- Logitec model M-CAA43 mouse
- 429 plug w/RF and power wiring
- 2 Ethernet cross-over cables
- N384 Application Processor

6.6.4. Air Host

- EFR-200-2 10017 Koramtec ADSI/DYIC Joint Venture (CPU 100376; n-connector backplate
- EFR-GRD-31x-2 10007 Koramtec ADSI/DYIC Joint Venture (CPU 100377; n-connector backplate)
- <no label radio box> (CPU 100384; 429 connector backplate)
- HP Computer (GSI3, ADSI01281)
- Keyboard
- Display
- HP mouse
- (2) N-connector antenna cable
- Antenna pin RF cable
- 1 DC power pin cable
- 2 red banana plug cables
- 2 black banana plug cables

6.6.5. RF Network

- (3) Bird Elec. Corp. model 25-A-MFN-30 25 Watts 30 dB attenuators
- 3 attenuators (model TBD)
- 1 RF elbow connector
- 1 RF tee connector
- 1 RF barrel connector

6.6.6. Power

- Power One DC Power Supply
- Leader 730-3D 30V 3A Regulated DC Power Supply
- 7 AC power cables

6.6.7. Furniture

- 4 desks with power strips
- 2 fans
- 11 large zip strips
- 4 small zip strips
- 2 clear tape

7. NETWORK OPERATIONS CENTER SUBSYSTEM COMPONENTS

The Network Operations Center (NOC) is located in the ADSI headquarters in Bethesda, Maryland. It consists of the following components:

Firewall. The firewall in the NOC (called 'panam') uses the following software:

- iptables - to perform firewall functions
- Free/SWAN - to establish a virtual private network among the ground stations

Home Agent. The home agent (called midway):

- tomcat - provides Java servlet run-time for athena
- athena - maintains dynamic table of ground station <-> aircraft logins; responds to DNS queries; provides web page for viewing system status
- ha - provides beginning endpoint of IP tunneling to the ground station/aircraft

Equipment Monitor. The equipment monitor computer (called muse) is the ADSI web server and uses the following software:

- Apache - serves web pages
- Big Brother - determines equipment status and generates web pages indicating status and historic availability reports

8. RESULTS

The following results were demonstrated in the Computer Networks & Software SATS AI Testbed:

- Connectivity. Point-to-point air-to-air and air-to-ground communication links were easily established. Broadcast air-to-air and air-to-ground communication links were also easily established. The connectivity to the external Internet (World Wide Web) as a source for FIS-B weather data to broadcast to SATS aircraft was successful demonstrated. Access to e-mail servers for transmission and retrieval was also demonstrated.

- Functionality

  – Airspace Situation. Aircraft surveillance data was provided through the ADS-B equipment aboard each aircraft.

  – Maneuver and Control. CPDLC was used to provide the maneuver and control data communications between two SATS aircraft and an ATC controller.

  – Weather Service. The ground station obtained FIS-B type weather products from weather service providers on the Internet and broadcast them to all SATS aircraft.

  – Peer-to-Peer. A Pilot/Aircraft Exchange (PAE) service was provided by the Respondr application.

  – Public Information Exchange. The Public Information Exchange service was demonstrated through an e-mail application that allowed the SATS aircraft to send and receive e-mail.

- Software Development. CPDLC Build A was ported from the Sun OS to Red Hat's Linux. No significant issues were encountered during the development and setup of the testbed.

- Integration of Hardware and Software Components. Hardware from ADSI and Computer Networks & Software was successfully tested for interoperability. Software from ADSI, Computer Networks & Software, Tyberius, and various commercial off-the-shelf products were successfully integrated.

A sample of the data capture capabilities of the SATS Testbed is shown in Appendix B. The data can be used to analyze communications link performance.

Appendix A

Acronyms

Acronym	*Meaning*
3-D	Three-dimensional
4-D	Four-dimensional
ADS-B	Automatic Dependent Surveillance - Broadcast
AGATE	Advanced General Aviation Transport Experiments
AI	Airborne Internet
ARTCC	Air Route Traffic Control Center
ASC	Airspace System Capacity
ATC	Air Traffic Controller
ATIS	Automated Terminal Information Service
ATM	Air Traffic Management
ATN	Aeronautical Telecommunications Network
ATSU	Air Traffic Service Unit
BT	Time-Bandwidth Product
C2K	Convergence 2000
CDTI	Cockpit Display of Traffic Information
CNS	Communications, Navigation & Surveillance
COTS	Commercial Of The Shelf
CSMA-CA	Carrier Sense Multiple Access with Collision Avoidance
CPDLC	Controller Pilot Data Link Communications
CRC	Cyclic Redundancy Code
DAG	Distributed Air Ground
DME	Distance Measuring Equipment
DNS	Domain Name Server
DR	Data Radio
DSR	Digital SATS Radio
FAA	Federal Aviation Administration
FBOs	Fixed Base Operators
FIS-B	Flight Information Services - Broadcast
GAP	General Aviation Program
GFSK	Gaussian-filtered Frequency Shift Keying
GPS	Global Positioning System
GRC	Glenn Research Center
GUI	Graphical User Interface
HDLC	High level Data Link Control

Appendix A

Acronyms

Acronym	*Meaning*
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IM	Instant Messaging
INS	Inertial Navigation System
IP	Internet Protocol
Kbps	Kilo Bits Per Second
LAAS	Local Area Augmentation System
LAN	Local Area Network
LME	Link Management Entity
Mbps	Mega Bits Per Second
MCDU	Multifunction Control and Display Unit
METARs	French acronym for Aviation Routine Weather Report
MTA	Mail Transfer Agent
MTOW	Maximum Take Off Weight
MUA	Mail User Agent
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NIC	Network Interface Card
nmi	Nautical miles
NOAA	National Oceanic and Atmospheric Administration
NOC	Network Operations Center
NOTAMs	Notices to Airmen
P-P	Peer-to-Peer
PAE	Pilot/Aircraft Exchange
PC	Personal Computer
PPDLC	Pilot – Pilot Data Link Communications
RF	Radio Frequency
SATCOM	Satellite Communications
SATS	Small Aircraft Transportation System
SMTP	Simple Mail Transfer Protocol
STDMA	Self-organizing Time Division Multiple Access
TCP	Trajectory Change Point
TCP	Transport Control Protocol

Appendix A

Acronyms

Acronym	*Meaning*
TCP/IP	Transport Control Protocol/Internet Protocol
TIS-B	Traffic Information Services - Broadcast
TP4/CLNP	Transport Protocol Class 4/Connectionless Network Protocol
TWEB	Transcribed Weather Broadcast
UDP	User Datagram Protocol
UTC	Universal Time Coordinated
VHF	Very High Frequency
VDL	VHF Digital Link
VOR	VHF Omni-directional Radio
VPN	Virtual Private Network

Appendix B

Sample Log Files

Log files in /usr/local/efr/log.

e04.log:

Log file of general status messages sent from the radio; captured by syslog-ng.

```
Dec 4 14:02:52 172.16.5.24 res1 now=449716 then=449715 src=0x0100376 sqp=117 bl=1 len=19 msg=sync_burst_mid rtype=periodic pt=1 po=-1
Dec 4 14:02:52 172.16.5.24 tg1 now=449697 age=240 src=0x0100376 nucp=0 nucr=0 lat=39.209338 lng=-77.596602 qual=3 baro=45000 geo=? cat=31 cs=N376 gs=200 trk=61.87 barorate=10000
Dec 4 14:02:52 172.16.5.24 res1 now=449765 then=449762 src=0x0100397 sqp=115 bl=4 len=74 msg=compr_frm_mid rtype=unicast dst=0x0100382 offs=21 len=0
Dec 4 14:02:53 172.16.5.24 res1 now=449772 then=449770 src=0x0100382 sqp=116 bl=3 len=54 msg=compr_frm_mid rtype=unicast dst=0x0100397 offs=23 len=0
Dec 4 14:02:53 172.16.5.24 res1 now=449783 then=449783 src=0x0100382 sqp=116 bl=1 len=11 msg=compr_frm_mid rtype=response dst=0x0100397
Dec 4 14:02:53 172.16.5.24 res1 now=449793 then=449792 src=0x0100397 sqp=115 bl=2 len=11 msg=compr_frm_mid rtype=response dst=0x0100382
Dec 4 14:02:53 172.16.5.24 tx1 slot=448633 src=0x4100524 bl=1 rtype=response dst=0x0100382
Dec 4 14:02:53 172.16.5.24 note now=449818 lvl=5 info(5.1)
Dec 4 14:02:53 172.16.5.24 note now=449818 lvl=4 r-wfrr
Dec 4 14:02:53 172.16.5.24 print
Dec 4 14:02:53 172.16.5.24 msc: now=449818  info--->  (d82 ns5 nr1)
Dec 4 14:02:53 172.16.5.24 tx1 pid=b0003 slot=449820 src=0x4100524 bl=1 len=? rtype=unicast dst=0x0100382 offs=22 rlen=1 sfhr=1
Dec 4 14:02:53 172.16.5.24 res1 now=449829 then=449827 src=0x0100377 sqp=117 bl=2 len=19 msg=sync_burst_mid rtype=periodic pt=1 po=3
Dec 4 14:02:53 172.16.5.24 tg1 now=449794 age=440 src=0x0100377 nucp=0 nucr=0 lat=38.729041 lng=-76.759078 qual=3 baro=45000 geo=? cat=31 cs=N377 gs=200 trk=236.95 barorate=10000
Dec 4 14:02:53 172.16.5.24 res1 now=449833 then=449831 src=0x0100382 sqp=116 bl=3 len=54 msg=compr_frm_mid rtype=unicast dst=0x4100524 offs=23 len=0
Dec 4 14:02:53 172.16.5.24 upcall: now=449833 ft=info_p1 prio_len_e=0 pect: 0xb0003 dst: 0xb0003
Dec 4 14:02:53 172.16.5.24 msc: now=449833  <---info  (s82 ns1 nr6)
Dec 4 14:02:54 172.16.5.24 res1 now=449842 then=449842 src=0x0100382 sqp=116 bl=1 len=11 msg=compr_frm_mid rtype=response dst=0x4100524
Dec 4 14:02:54 172.16.5.24 upcall: now=449843 ft=rr_f1 prio_len_e=0 pect: 0xb0003 dst: 0xb0003
Dec 4 14:02:54 172.16.5.24 msc: now=449843  <---  rr  (s82 nr6)
Dec 4 14:02:54 172.16.5.24 encode_unicast: dst=0x0100382
Dec 4 14:02:54 172.16.5.24 note now=449834 lvl=5 info(1.6)
Dec 4 14:02:54 172.16.5.24 note now=449843 lvl=5 rr(6)
Dec 4 14:02:54 172.16.5.24 note now=449843 lvl=4 rr
Dec 4 14:02:54 172.16.5.24 print
```

beth.log:

Log file of messages sent between this ground station and the NOC; captured by syslog-ng.

```
Dec 4 16:00:54 172.16.5.24 route: status my_ip=172.16.5.24 my_cs=GSI1 number=2 icao_check=0x200719 cs_check=0x1d8
Dec 4 16:01:54 172.16.5.24 route: status my_ip=172.16.5.24 my_cs=GSI1 number=2 icao_check=0x200719 cs_check=0x1d8
Dec 4 16:02:54 172.16.5.24 route: status my_ip=172.16.5.24 my_cs=GSI1 number=2 icao_check=0x200719 cs_check=0x1d8
Dec 4 16:03:54 172.16.5.24 route: status my_ip=172.16.5.24 my_cs=GSI1 number=2 icao_check=0x200719 cs_check=0x1d8
Dec 4 16:04:54 172.16.5.24 route: status my_ip=172.16.5.24 my_cs=GSI1 number=2 icao_check=0x200719 cs_check=0x1d8
Dec 4 16:05:54 172.16.5.24 route: status my_ip=172.16.5.24 my_cs=GSI1 number=2 icao_check=0x200719 cs_check=0x1d8
```

```
Dec     4   16:06:54   172.16.5.24   route:   status   my_ip=172.16.5.24   my_cs=GSI1   number=2
icao_check=0x200719 cs_check=0x1d8
Dec     4   16:07:54   172.16.5.24   route:   status   my_ip=172.16.5.24   my_cs=GSI1   number=2
icao_check=0x200719 cs_check=0x1d8
Dec     4   16:08:54   172.16.5.24   route:   status   my_ip=172.16.5.24   my_cs=GSI1   number=2
icao_check=0x200719 cs_check=0x1d8
```

fa-tue1253.log:

Log file produced by fa program on ground station (de-tunnelling IP traffic between NOC and ground radio); written by fa program.

```
12:53:56 fa started by inetd
12:53:56 interface=eth2
12:53:56 radio_ip=172.16.5.24 (0xac100518)
12:53:56 packet_socket is 5
12:53:56 ioctl: r=0, index=8
12:53:56 ioctl: r=0, hw=0 50 ffffffba ffffffed ffffffd4 ffffffdc
12:53:56  our_hw 0:50:ba:ed:d4:dc
12:53:56  using argv ethernet addr
12:53:56  their_hw 0:50:c2:0:60:24
12:53:56 tunnel udp frame received from ip=64.133.104.180 len=35
12:53:56  payload=45 0 0 23 c2 84 0 0 26 11
12:53:56  payload=77 e4 40 85 68 b4 ac 10 5 18
12:53:56  payload: tos=0 len=35 id=49796 flags=0x0 offs=0 ttl=38 prot=17 UDP csum=0xe477 (good)
12:53:56  payload: ip_src=64.133.104.180 ip_dst=172.16.5.24
12:53:56  sendto: r=49
12:54:01 timeout, bye.
```

m-fc-tue1735.log:

Log file produced by from-client program.

```
starting
17:35:41 from-client starting
17:35:41 220 adsi-m4.com ESMTP
17:35:41 received: (len=16)
EHLO localhost
17:35:41 250 catalina
17:35:41 received: (len=6)
RSET
17:35:41 250 flushed
17:35:41 received: (len=47)
MAIL FROM:<wendell@x0100382.icao.adsi-m4.com>
17:35:41 250 ok
17:35:41 sending:250 ok

17:35:41 received: (len=33)
RCPT TO:<efr_testing@yahoo.com>
17:35:41 250 ok
17:35:41 received: (len=32)
RCPT TO:<mzernic@grc.nasa.gov>
17:35:41 250 ok
17:35:42 received: (len=6)
DATA
17:35:42 354 go ahead
17:35:42 received: (len=44)
Date: Tue, 4 Dec 2001 17:35:40 -0500 (EST)
17:35:42 received: (len=327)
From: Wendell Turner <wendell@x0100382.icao.adsi-m4.com>
```

```
X-X-Sender: <wendell@morris>
To: <efr_testing@yahoo.com>, <mzernic@grc.nasa.gov>
Subject: during the demo
Message-ID: <Pine.LNX.4.33.0112041735060.2094-100000@morris>
MIME-Version: 1.0
Content-Type: TEXT/PLAIN; charset=US-ASCII



hello from the demo


.
17:35:42 250 ok 956907809 qp 7027
17:35:42 data archived to /usr/local/efr/archive/m-fc-149C75CE-tue1735.log
17:35:42 sending to address 172.16.5.24 port 8025
17:35:42 cts=583
17:35:42 snd to efr: src=0x100382 msg=CE759C14 type=1 len=400 seq=1 >MAIL
FROM:<wendell@x0100382.icao.adsi-m4.com>\r\nRCPT TO:<efr_testing@yahoo.com>\r\nRCPT
TO:<mzernic@grc.nasa.gov>\r\n$$$\nReceived: by EFR200 x0100382 (39.022064,-77.745610,45000);\r\n
4 Dec 2001 17:35:42 -0500\r\nDate: Tue, 4 Dec 2001 17:35:40 -0500 (EST)\r\nFrom: Wendell Turner
<wendell@x0100382.icao.adsi-m4.com>\r\nX-X-Sender: <wendell@morris>\r\nTo:
<efr_testing@yahoo.com>, <mzernic@grc.nasa.gov>\r\n<
17:35:42 usleeping for 250000
17:35:42 cts=183
17:35:42 snd to efr: src=0x100382 msg=CE759C14 type=2 len=183 seq=2 >Subject: during the
demo\r\nMessage-ID: <Pine.LNX.4.33.0112041735060.2094-100000@morris>\r\nMIME-Version:
1.0\r\nContent-Type: TEXT/PLAIN; charset=US-ASCII\r\n\r\n\r\nhello from the
demo\r\n\r\n\r\n.\r\n<
17:35:42 usleeping for 250000
17:35:42 waiting for ack
17:35:46 ack from efr: src=0x0 msg=CE759C14 type=5 len=0 seq=0 ><
17:35:46 ack rcvd is: GOOD
```

m-fm-556CC13E-tue1728.log:

Log file produced by from-mailer program.

```
starting
17:28:03 data archived to /usr/local/efr/archive/m-fm-556CC13E-tue1728.log
17:28:03 SENDER=>efr_testing@yahoo.com<
17:28:03 RECIPIENT=>wendell@X0100382.icao.adsi-m4.com<
17:28:03 MAIL FROM:>efr_testing@yahoo.com<
17:28:03 RCPT TO:>wendell@X0100382.icao.adsi-m4.com<
17:28:03 using >172.16.5.82< as IP address
17:28:03 sending to address 172.16.5.82 port 8025
17:28:03 cts=1107
17:28:03 snd to efr: src=0x4100524 msg=3EC16C55 type=1 len=400 seq=1 >MAIL
FROM:<efr_testing@yahoo.com>\n\rRCPT TO:<wendell@X0100382.icao.adsi-m4.com>\n\r$$$\nReceived: by
EFR200 x4100524 (38.786110,-77.179726,280);\r\n 4 Dec 2001 17:28:03 -0500\nReceived: from
web13504.mail.yahoo.com (web13504.mail.yahoo.com [216.136.175.83])\n by gsi1.net.adsi-
m4.com (Postfix) with SMTP id B5A9727281\n for <wendell@X0100382.icao.adsi-m4.com>; Tue, 4 Dec
2001 17:28:01 -0500 (EST)\nMe<
17:28:03 usleeping for 250000
17:28:03 cts=707
17:28:03 snd to efr: src=0x4100524 msg=3EC16C55 type=1 len=400 seq=2 >ssage-ID:
<20011204224038.95105.qmail@web13504.mail.yahoo.com>\nReceived: from [208.185.12.1] by
web13504.mail.yahoo.com via HTTP; Tue, 04 Dec 2001 14:40:38 PST\nDate: Tue, 4 Dec 2001 14:40:38 -
0800 (PST)\nFrom: ADSI Testing <efr_testing@yahoo.com>\nSubject: Re: during the demo\nTo: Wendell
Turner <wendell@X0100382.icao.adsi-m4.com>\nIn-Reply-To: <Pine.LNX.4.33.0112041735060.2094-
100000@morris>\nMIME-Ver<
17:28:04 usleeping for 250000
17:28:04 cts=307
```

```
17:28:04 snd to efr: src=0x4100524 msg=3EC16C55 type=2 len=307 seq=3 >sion: 1.0\nContent-Type: text/plain; charset=us-ascii\n\n\nwwwwwwwwwwwwwwwwwwww\n--- Wendell Turner <wendell@X0100382.icao.adsi-m4.com>\nwrote:\n> \n> hello from the demo\n> \n> \n\n\n__________________________________________________\nDo You Yahoo!?\nMake a great connection at Yahoo! Personals.\nhttp://personals.yahoo.com\n<
17:28:04 usleeping for 250000
17:28:04 waiting for ack
17:28:07 ack from efr: src=0x0 msg=3EC16C55 type=5 len=0 seq=0 ><
17:28:07 ack rcvd is: GOOD
```

m-frtue1725.log:

Log file produced by from-rf program.

```
starting
17:25:26 from-rf starting
17:25:26 recvfrom: port=61099
17:25:26 rcvd from efr: src=0x82031000 msg=CE759C14 type=1 len=400 seq=1 >MAIL FROM:<wendell@x0100382.icao.adsi-m4.com>\r\nRCPT TO:<efr_testing@yahoo.com>\r\nRCPT TO:<mzernic@grc.nasa.gov>\r\n$$$\nReceived: by EFR200 x0100382 (39.022064,-77.745610,45000);\r\n 4 Dec 2001 17:35:42 -0500\r\nDate: Tue, 4 Dec 2001 17:35:40 -0500 (EST)\r\nFrom: Wendell Turner <wendell@x0100382.icao.adsi-m4.com>\r\nX-X-Sender: <wendell@morris>\r\nTo: <efr_testing@yahoo.com>, <mzernic@grc.nasa.gov>\r\n<
17:25:26 receipt of mail from 0x100382 beginning
17:25:26 duplicate: seen_seq=1, this_seq=1
17:25:26 rcvd from efr: src=0x82031000 msg=CE759C14 type=1 len=400 seq=1 >MAIL FROM:<wendell@x0100382.icao.adsi-m4.com>\r\nRCPT TO:<efr_testing@yahoo.com>\r\nRCPT TO:<mzernic@grc.nasa.gov>\r\n$$$\nReceived: by EFR200 x0100382 (39.022064,-77.745610,45000);\r\n 4 Dec 2001 17:35:42 -0500\r\nDate: Tue, 4 Dec 2001 17:35:40 -0500 (EST)\r\nFrom: Wendell Turner <wendell@x0100382.icao.adsi-m4.com>\r\nX-X-Sender: <wendell@morris>\r\nTo: <efr_testing@yahoo.com>, <mzernic@grc.nasa.gov>\r\n<
17:25:26 recvfrom: port=61099
17:25:26 rcvd from efr: src=0x82031000 msg=CE759C14 type=2 len=183 seq=2 >Subject: during the demo\r\nMessage-ID: <Pine.LNX.4.33.0112041735060.2094-100000@morris>\r\nMIME-Version: 1.0\r\nContent-Type: TEXT/PLAIN; charset=US-ASCII\r\n\r\n\r\nhello from the demo\r\n\r\n\r\n.\r\n<
17:25:26 EOF
17:25:26 domain is not local, will send to a real mailer
17:25:26 data archived to /usr/local/efr/archive/m-fr-CE759C14-tue1725.log
17:25:26 smtp connection to 127.0.0.1
17:25:26 SMTP sent >(tcp connect)< returned a code of 220, expected 220
17:25:26 HELO efrmail
17:25:26 SMTP sent >HELO efrmail< returned a code of 250, expected 250
17:25:26 sending: MAIL FROM:<wendell@x0100382.icao.adsi-m4.com>

17:25:26 MAIL FROM:<wendell@x0100382.icao.adsi-m4.com>
17:25:26 SMTP sent >MAIL FROM:<wendell@x0100382.icao.adsi-m4.com>< returned a code of 250, expected 250
17:25:26 sending: RCPT TO:<efr_testing@yahoo.com>

17:25:26 RCPT TO:<efr_testing@yahoo.com>
17:25:27 SMTP sent >RCPT TO:<efr_testing@yahoo.com>< returned a code of 250, expected 250
17:25:27 sending: RCPT TO:<mzernic@grc.nasa.gov>

17:25:27 RCPT TO:<mzernic@grc.nasa.gov>
17:25:27 SMTP sent >RCPT TO:<mzernic@grc.nasa.gov>< returned a code of 250, expected 250
17:25:27 DATA
17:25:27 SMTP sent >DATA< returned a code of 354, expected 354
17:25:27 Received: by EFR200 x4100524 (38.786110,-77.179726,280);
         4 Dec 2001 17:25:26 -0500
17:25:27 Received: by EFR200 x0100382 (39.022064,-77.745610,45000);
         4 Dec 2001 17:35:42 -0500
Date: Tue, 4 Dec 2001 17:35:40 -0500 (EST)
```

Appendix B

Sample Log Files

```
From: Wendell Turner <wendell@x0100382.icao.adsi-m4.com>
X-X-Sender:  <wendell@morris>
To:  <efr_testing@yahoo.com>,  <mzernic@grc.nasa.gov>
Subject: during the demo
Message-ID: <Pine.LNX.4.33.0112041735060.2094-100000@morris>
MIME-Version: 1.0
Content-Type: TEXT/PLAIN; charset=US-ASCII
```

ds-tue1432.log:

Log file produced by sequencer program.

```
14:33:07 read 2562 chars, pb.data now 2562
14:33:07 file st_mtime=1007493569, saved st_mtime=0
14:33:07 product metadata:name=mtos_WWWUS_current.gif type=0 subtype=0 asof=-1054798532 len=2562
encode=16777216 maxage=49245

14:33:07 sending vc=5 bip=6 ver=1 len=439 seq=1
14:33:07 waiting for ack
14:33:07 ackbuf.list_size=14
14:33:09 sending vc=5 bip=6 ver=1 len=439 seq=2
14:33:09 waiting for ack
14:33:09 ackbuf.list_size=15
14:33:11 sending vc=5 bip=6 ver=1 len=439 seq=3
14:33:11 waiting for ack
14:33:11 ackbuf.list_size=16
```

dc-wed0000.log:

Log file produced by collector program.

```
starting
14:43:02 rcvd: vc=0 bip=0 ver=0 len=0 seq=0
14:43:02 null frame
14:43:17 product metadata:name=fcst-KRIC.TXT type=0 subtype=0 asof=1213205820 len=139 encode=0
maxage=61440
14:43:17 rcvd: vc=0 bip=1 ver=1 len=195 seq=1
14:43:32 product metadata:name=fcst-KDAN.TXT type=0 subtype=0 asof=-2075128516 len=112 encode=0
maxage=61440
14:43:32 rcvd: vc=1 bip=1 ver=1 len=168 seq=1
14:43:47 product metadata:name=obs-KRIC.TXT type=0 subtype=0 asof=-1134359236 len=513 encode=0
maxage=61440
14:43:47 rcvd: vc=2 bip=2 ver=1 len=439 seq=1
14:44:02 rcvd: vc=2 bip=2 ver=1 len=130 seq=2
14:44:17 product metadata:name=obs-KDAN.TXT type=0 subtype=0 asof=-1134359236 len=494 encode=0
maxage=61440
14:44:17 rcvd: vc=3 bip=2 ver=1 len=439 seq=1
14:44:32 rcvd: vc=3 bip=2 ver=1 len=111 seq=2
14:44:47 product metadata:name=ifr_WWWUS_current.gif type=0 subtype=0 asof=-819917508 len=3334
encode=16777216 maxage=49245
14:44:47 rcvd: vc=4 bip=8 ver=1 len=439 seq=1
14:45:02 rcvd: vc=4 bip=8 ver=1 len=439 seq=2
14:45:17 rcvd: vc=4 bip=8 ver=1 len=439 seq=3
14:45:32 rcvd: vc=4 bip=8 ver=1 len=439 seq=4
14:45:47 rcvd: vc=4 bip=8 ver=1 len=439 seq=5
14:46:01 rcvd: vc=4 bip=8 ver=1 len=439 seq=6
14:46:17 rcvd: vc=4 bip=8 ver=1 len=439 seq=7
14:46:32 rcvd: vc=4 bip=8 ver=1 len=317 seq=8
```

```
14:46:47 product metadata:name=mtos_WWWUS_current.gif type=0 subtype=0 asof=-1054798532 len=2562
encode=16777216 maxage=49245
```

ac-tue1425.log:

Log file produced by ac-subs program.

```
09:47:19 0 station went away; removing file /usr/local/efr/pect/cs/N384
09:47:19 0 station went away; removing file /usr/local/efr/pect/icao/x0100397
10:13:55 0 station went away; removing file /usr/local/efr/pect/cs/N382
10:13:55 0 station went away; removing file /usr/local/efr/pect/icao/x0100382
```

Log files in /usr/local/efr/archive.

m-fm-556CC13E-tue1728.log:

Archive of actual e-mail message sent through the system; written by from-rf program.

```
starting
MAIL FROM:<wendell@x0100382.icao.adsi-m4.com>
RCPT TO:<efr_testing@yahoo.com>
RCPT TO:<mzernic@grc.nasa.gov>
$$$
Received: by EFR200 x0100382 (39.022064,-77.745610,45000);

         4 Dec 2001 17:35:42 -0500
Date: Tue, 4 Dec 2001 17:35:40 -0500 (EST)
From: Wendell Turner <wendell@x0100382.icao.adsi-m4.com>
X-X-Sender:  <wendell@morris>
To:  <efr_testing@yahoo.com>,  <mzernic@grc.nasa.gov>
Subject: during the demo
Message-ID: <Pine.LNX.4.33.0112041735060.2094-100000@morris>
MIME-Version: 1.0
Content-Type: TEXT/PLAIN; charset=US-ASCII


hello from the demo
```

Log files in local directory.

ethu1504.log:

Log file produced by 'umon -l' program:

```
14:41:21 24 tx1 slot=10365 src=0x4100524 bl=15 len=? rtype=periodic strmno=2 width=25
strm_ctr=1361 dist_off=-4 pt=0 po=-28 lncy=6
14:41:23 24 ow1 now=10490 age=0 src=0x4100524 nucp=0.0000 nucr=? lat=38.786110 lng=-77.179726
baro=280 geo=280
14:41:23 24 tx1 slot=10493 src=0x4100524 bl=1 len=? rtype=periodic strmno=4 width=25
strm_ctr=1497 dist_off=4 pt=3 po=0 lncy=6
14:41:23 24 res1 now=10512 then=10511 src=0x0100397 sqp=117 bl=1 len=19 msg=sync_burst_mid
rtype=periodic pt=3 po=0
```

Appendix B

Sample Log Files

```
14:41:23 24 tg1 now=10508 age=40 src=0x0100397 nucp=15 nucr=0 lat=? lng=? baro=? geo=? cat=31 cs=N384 gs=? trk=? arate=?
14:41:27 24 res1 now=10830 then=10828 src=0x0100397 sqp=117 bl=3 len=74 msg=compr_frm_mid rtype=unicast dst=0x4100524 offs=21 len=0
14:41:27 24 <175> upcall: now=10831 ft=info_p1 prio_len_e=0 pect: 0xb0003 dst: 0xb0003
14:41:27 24 <175> msc: now=10831  <---info  (s97 ns0 nr0)
```

Log files in /var/log.

Portion of **/var/log/messages:**

Written by syslog-ng.

```
Dec  4 17:20:35 gsi1 postfix/smtpd[11269]: connect from muse[64.133.104.178]
Dec  4 17:20:35 gsi1 postfix/smtpd[11269]: disconnect from muse[64.133.104.178]
Dec  4 17:25:25 gsi1 xinetd[889]: START: efrmail pid=11574 from=172.16.5.82
Dec  4 17:25:25 gsi1 xinetd[11574]: warning: /etc/hosts.allow, line 6: missing ":" separator
Dec  4 17:25:26 gsi1 from-rf[11574]: from-rf starting
Dec  4 17:25:26 gsi1 from-rf[11574]: recvfrom: port=61099
Dec  4 17:25:26 gsi1 from-rf[11574]: rcvd from efr: src=0x82031000 msg=CE759C14 type=1 len=400 seq=1 >MAIL FROM:<wendell@x0100382.icao.adsi-m4.com>\r\nRCPT TO:<efr_testing@yahoo.com>\r\nRCPT TO:<mzernic@grc.nasa.gov>\r\n$$$\nReceived: by EFR200 x0100382 (39.022064,-77.745610,45000);\r\n 4 Dec 2001 17:35:42 -0500\r\nDate: Tue, 4 Dec 2001 17:35:40 -0500 (EST)\r\nFrom: Wendell Turner <wendell@x0100382.icao.adsi-m4.com>\r\nX-X-Sender: <wendell@morris>\r\nTo: <efr_testing@yahoo.com>, <mzernic@grc.nasa.gov>\r\n<
Dec  4 17:25:26 gsi1 from-rf[11574]: receipt of mail from 0x100382 beginning
Dec  4 17:25:26 gsi1 from-rf[11574]: duplicate: seen_seq=1, this_seq=1
Dec  4 17:25:26 gsi1 from-rf[11574]: rcvd from efr: src=0x82031000 msg=CE759C14 type=1 len=400 seq=1 >MAIL FROM:<wendell@x0100382.icao.adsi-m4.com>\r\nRCPT TO:<efr_testing@yahoo.com>\r\nRCPT TO:<mzernic@grc.nasa.gov>\r\n$$$\nReceived: by EFR200 x0100382 (39.022064,-77.745610,45000);\r\n 4 Dec 2001 17:35:42 -0500\r\nDate: Tue, 4 Dec 2001 17:35:40 -0500 (EST)\r\nFrom: Wendell Turner <wendell@x0100382.icao.adsi-m4.com>\r\nX-X-Sender: <wendell@morris>\r\nTo: <efr_testing@yahoo.com>, <mzernic@grc.nasa.gov>\r\n<
Dec  4 17:25:26 gsi1 from-rf[11574]: recvfrom: port=61099
Dec  4 17:25:26 gsi1 from-rf[11574]: rcvd from efr: src=0x82031000 msg=CE759C14 type=2 len=183 seq=2 >Subject: during the demo\r\nMessage-ID: <Pine.LNX.4.33.0112041735060.2094-

100000@morris>\r\nMIME-Version: 1.0\r\nContent-Type: TEXT/PLAIN; charset=US-ASCII\r\n\r\n\r\nhello from the demo\r\n\r\n\r\n.\r\n<
Dec  4 17:25:26 gsi1 from-rf[11574]: EOF
Dec  4 17:25:26 gsi1 from-rf[11574]: domain is not local, will send to a real mailer
```

Portion of **/var/log/maillog:**

Written by postfix/syslog-ng.

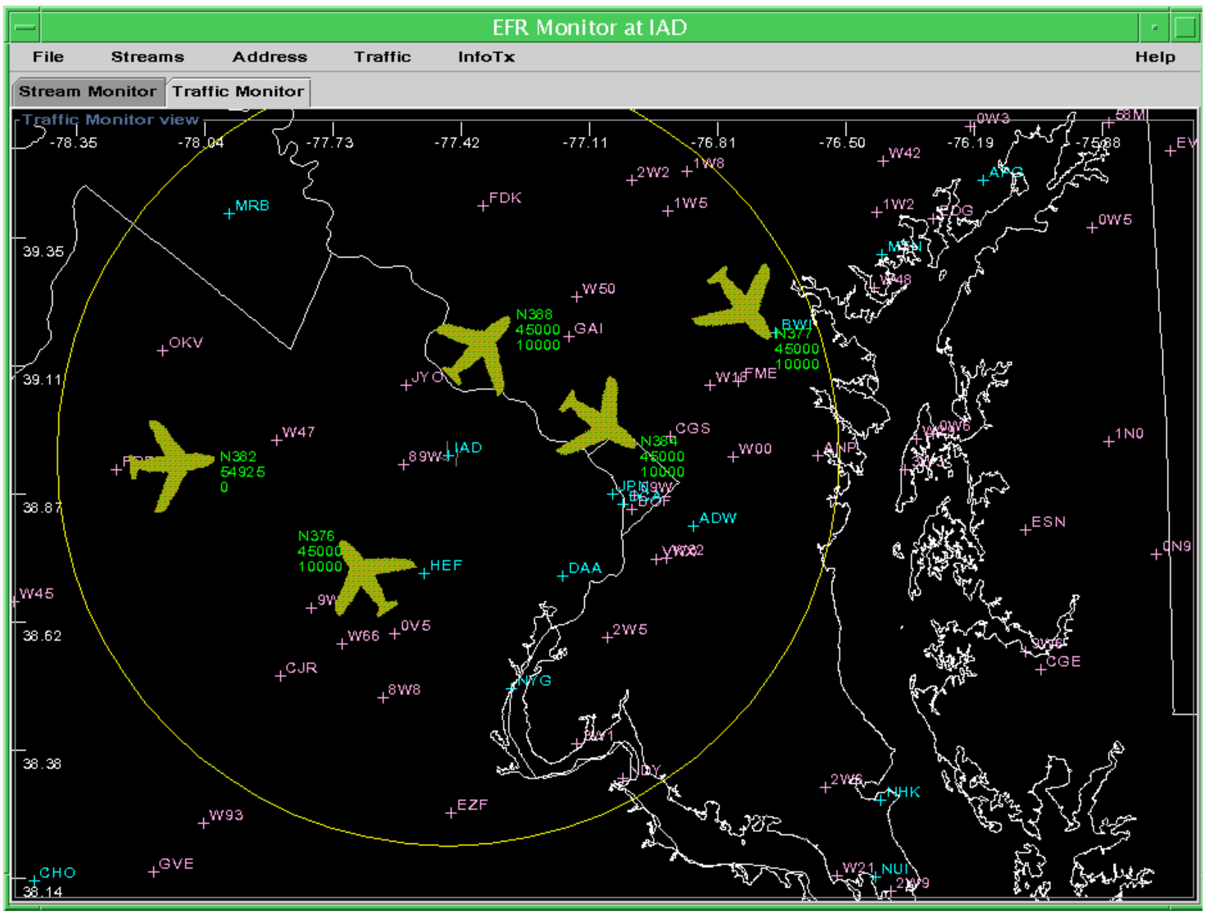
```
Dec  4 17:25:26 gsi1 postfix/smtpd[11575]: connect from localhost.localdomain[127.0.0.1]
Dec  4 17:25:26 gsi1 postfix/smtpd[11575]: DEABD27281: client=localhost.localdomain[127.0.0.1]
Dec  4 17:25:27 gsi1 postfix/cleanup[11576]: DEABD27281: message-id=<Pine.LNX.4.33.0112041735060.2094-100000@morris>
Dec  4 17:25:27 gsi1 postfix/smtpd[11575]: disconnect from localhost.localdomain[127.0.0.1]
Dec  4 17:25:32 gsi1 postfix/qmgr[961]: DEABD27281: from=<wendell@x0100382.icao.adsi-m4.com>, size=717, nrcpt=2 (queue active)
Dec  4 17:25:34 gsi1 postfix/smtp[11578]: DEABD27281: to=<mzernic@grc.nasa.gov>, relay=64.133.104.180[64.133.104.180], delay=8, status=sent (250 Ok: queued as AF054C545)
Dec  4 17:25:34 gsi1 postfix/smtp[11578]: DEABD27281: to=<efr_testing@yahoo.com>, relay=64.133.104.180[64.133.104.180], delay=8, status=sent (250 Ok: queued as AF054C545)
```

Appendix C

Screen Capture Shots

Ground AI Router Displays

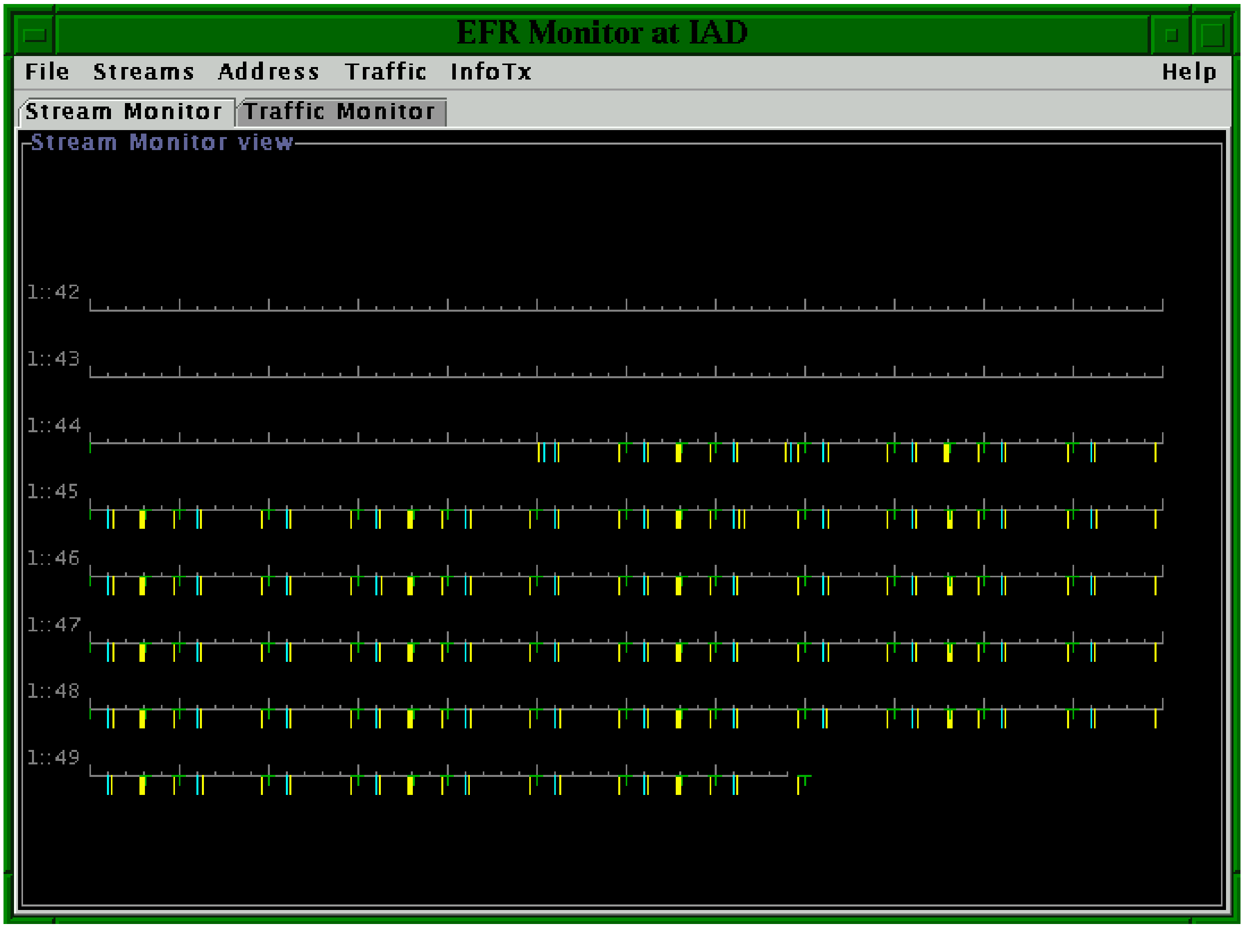
Screen capture of jmon program running on ground AI Router. This shows the ADS-B traffic monitor display with five aircraft and the (local) ground station.



Appendix C

Screen Capture Shots

Screen capture of jmon program running on ground AI Router. This shows the stream monitor display. The horizontal line represents one minute of operation. Each colored mark is an RF transmission.



Appendix C

Screen Capture Shots

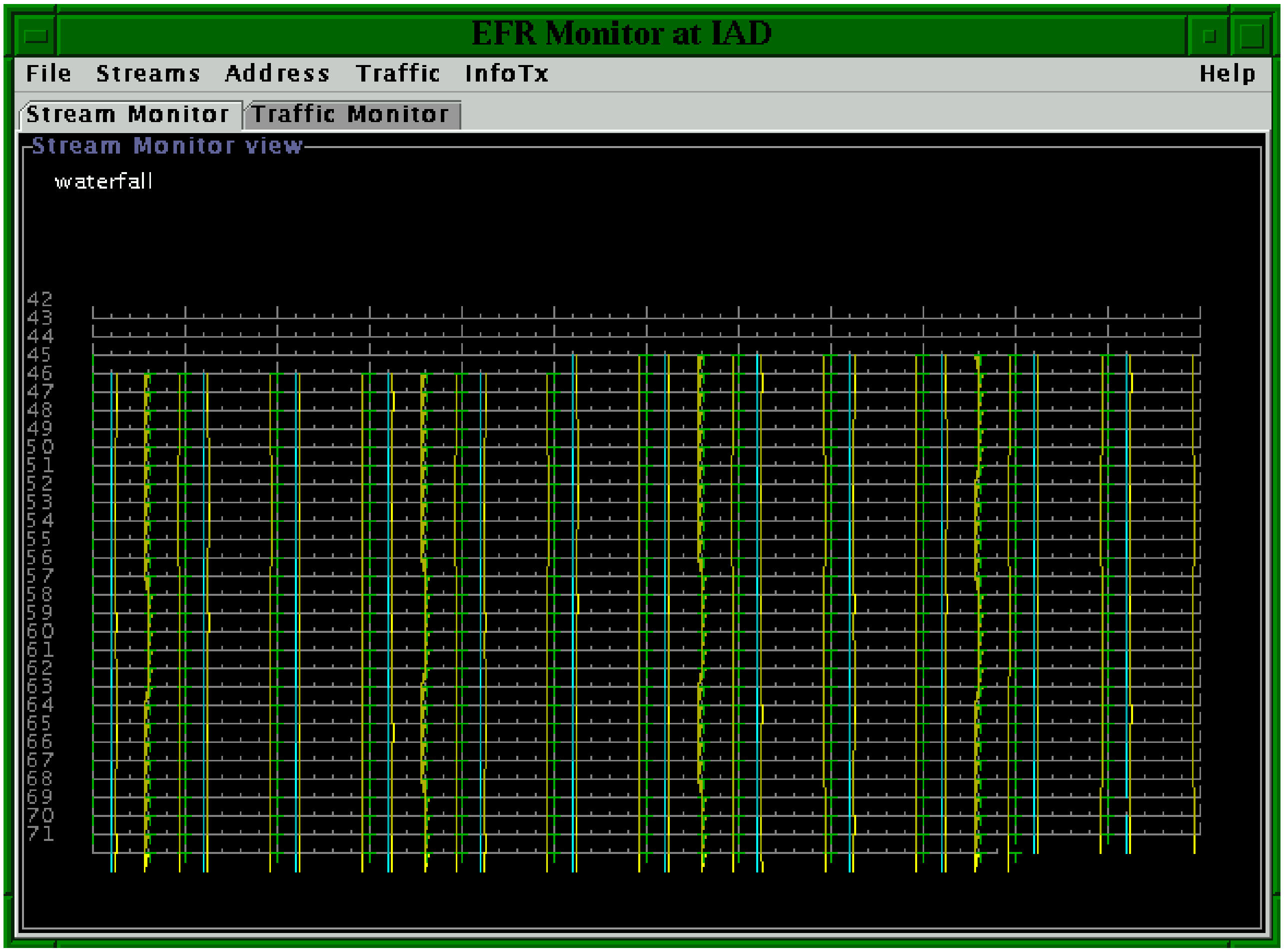
Screen capture of jmon program running on ground AI Router. This shows the waterfall display. The display program connects each RF "stream". This display shows the past 24 minutes of operation.

Appendix C

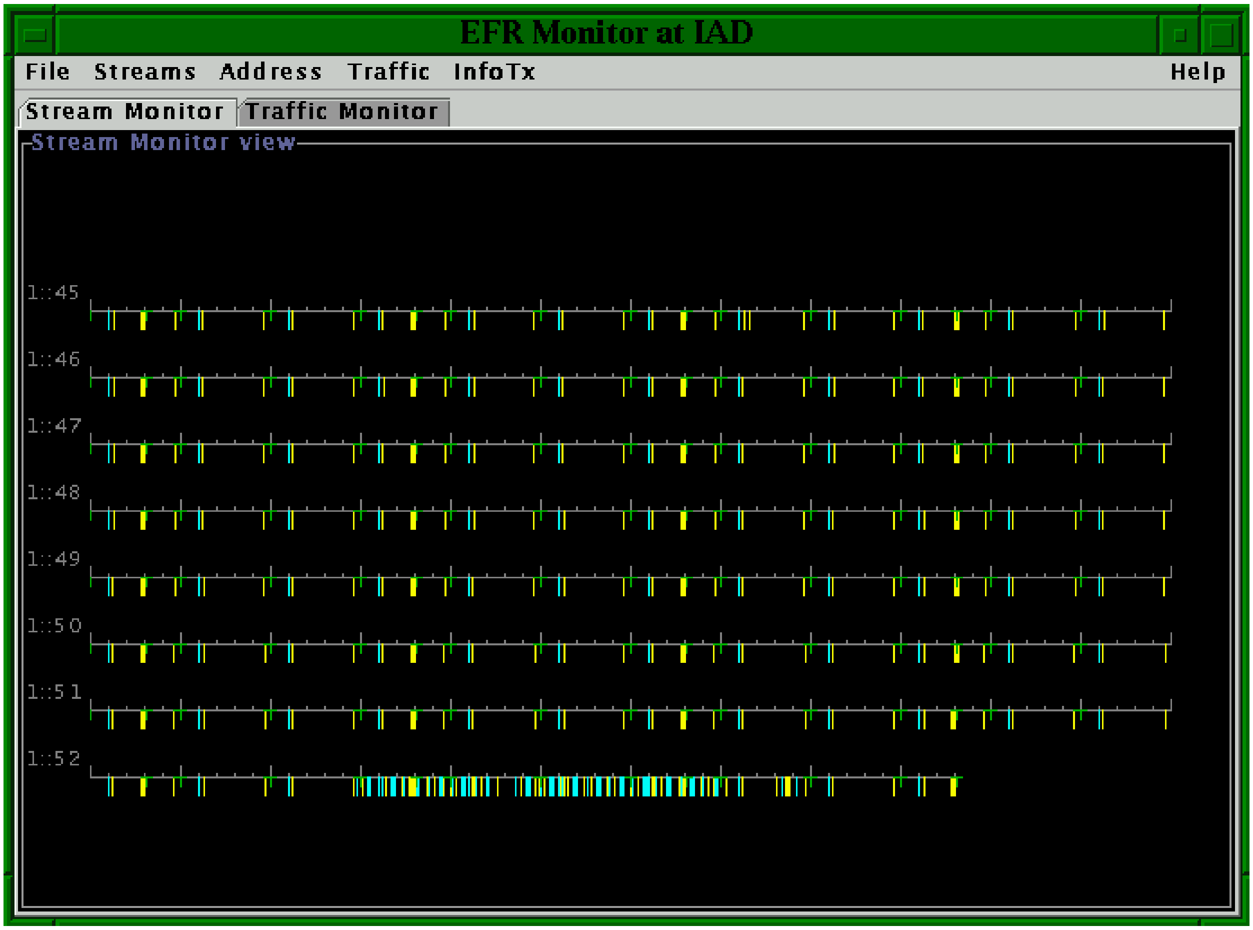
Screen Capture Shots

Appendix C

Screen Capture Shots



Jmon program running with slot map display. The last (most recent) minute of operation shows more RF activity due to large e-mail message sent from N382 to the ground station.

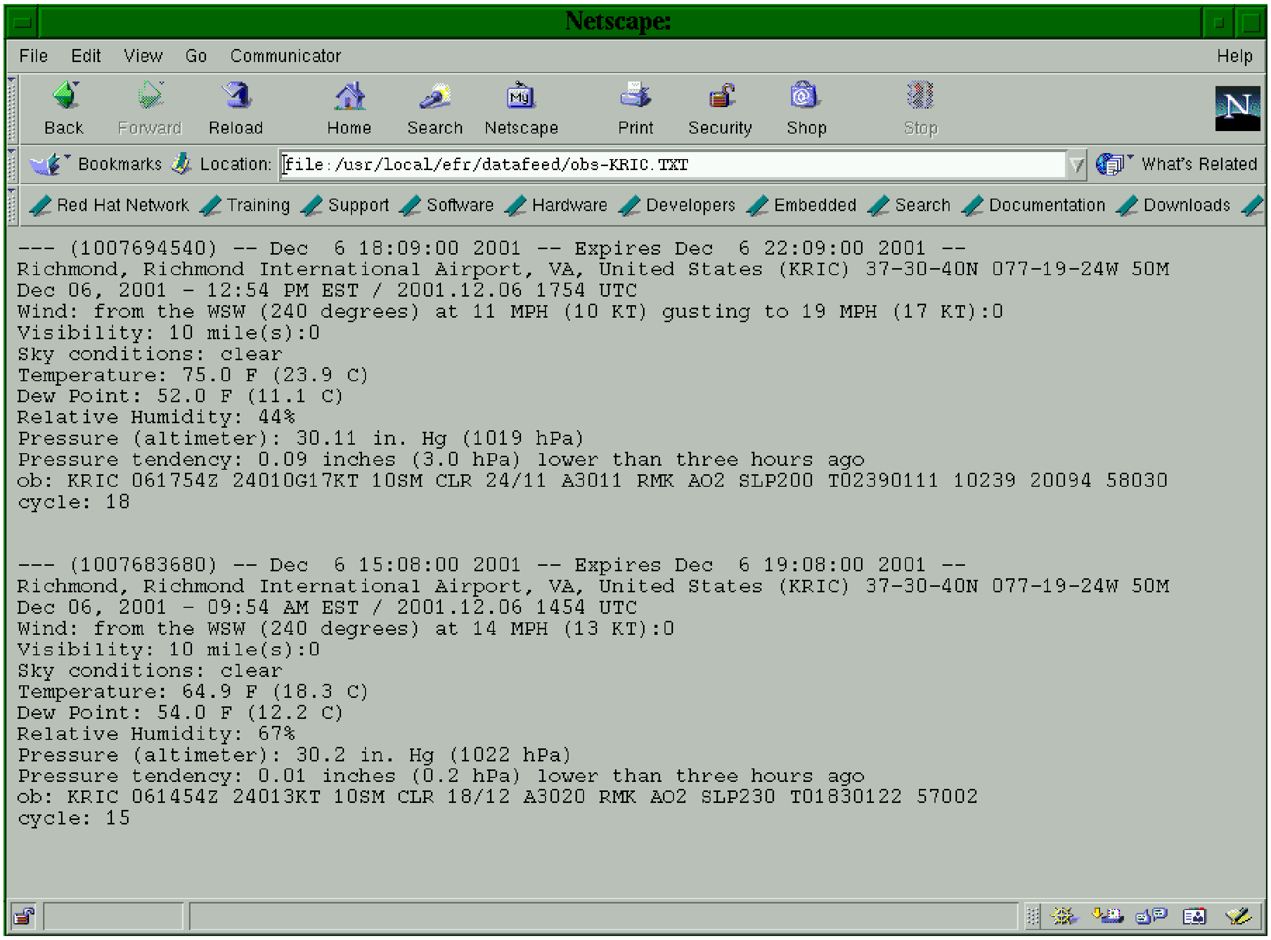


Air AI Router Displays

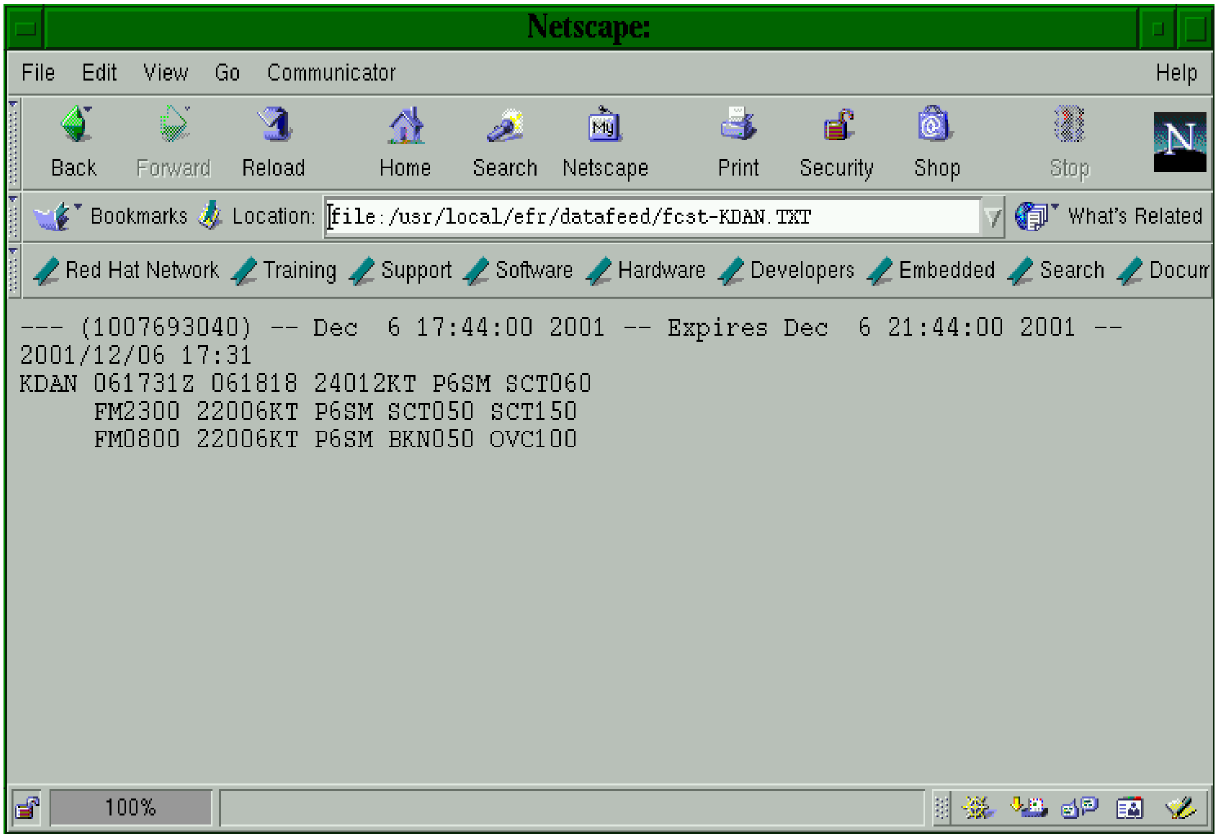
Netscape display of text weather products uplinked via the Datafeed application.

Appendix C

Screen Capture Shots



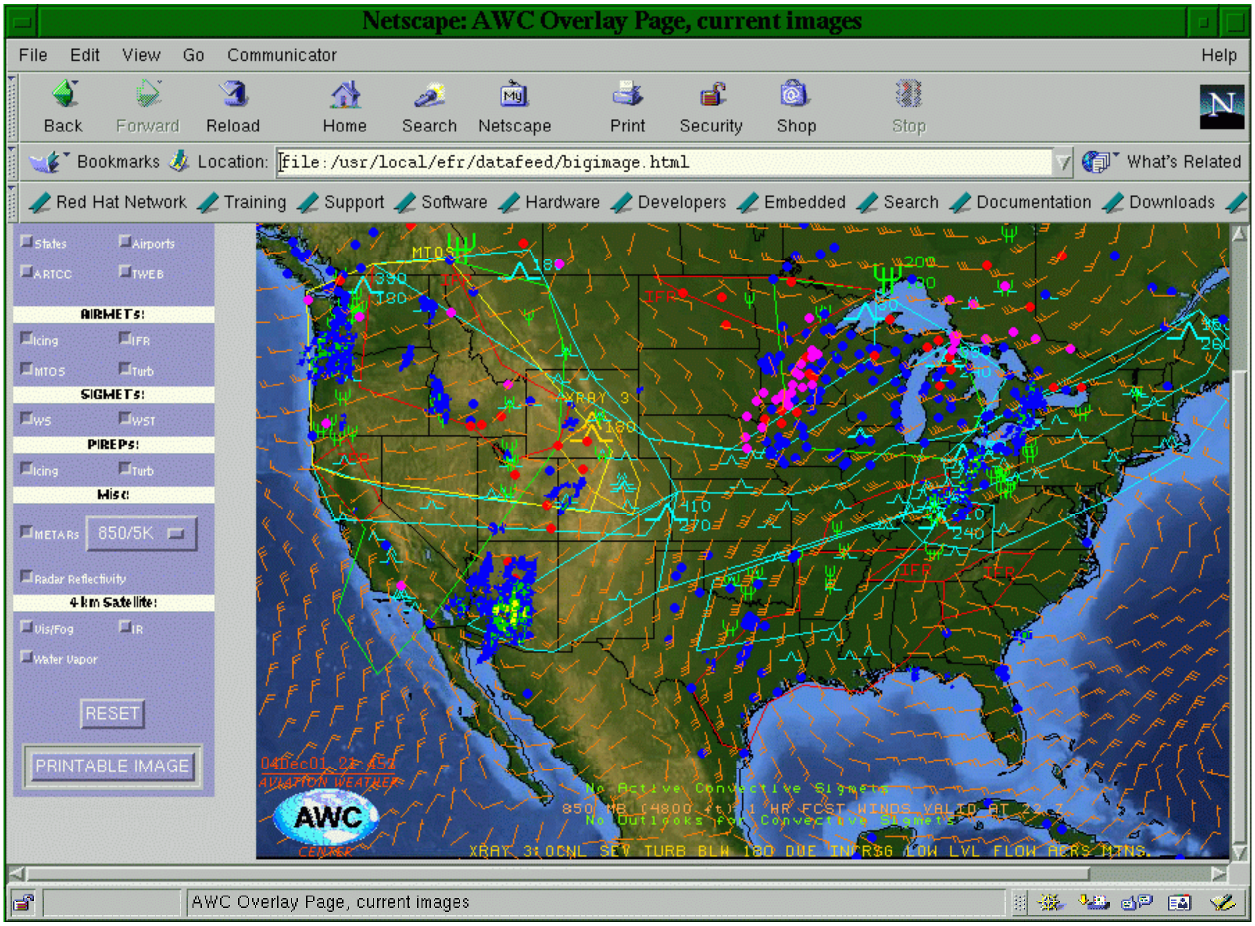
Netscape display of icing PIREP weather product uplinked via the Datafeed application.



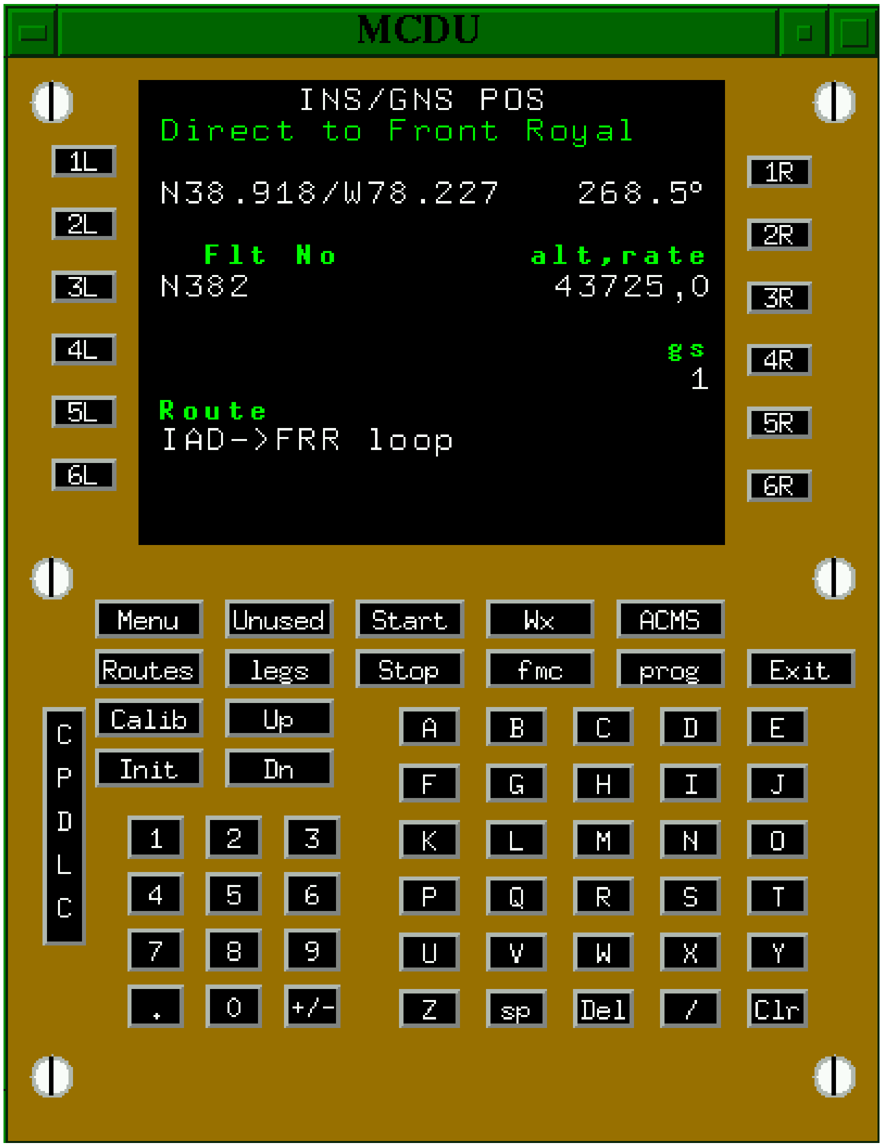
Netscape:
File Edit View Go Communicator Help
Back Forward Reload Home Search Netscape Print Security Shop Stop
Bookmarks Location: file:/usr/local/efr/datafeed/fcst-KDAN.TXT
What's Related
Red Hat Network Training Support Software Hardware Developers Embedded Search Docum
--- (1007693040) -- Dec 6 17:44:00 2001 -- Expires Dec 6 21:44:00 2001 --
2001/12/06 17:31
KDAN 061731Z 061818 24012KT P6SM SCT060
FM2300 22006KT P6SM SCT050 SCT150
FM0800 22006KT P6SM BKN050 OVC100
100%

Screen Capture Shots

Netscape display of all the graphic weather products uplinked via the Datafeed application.



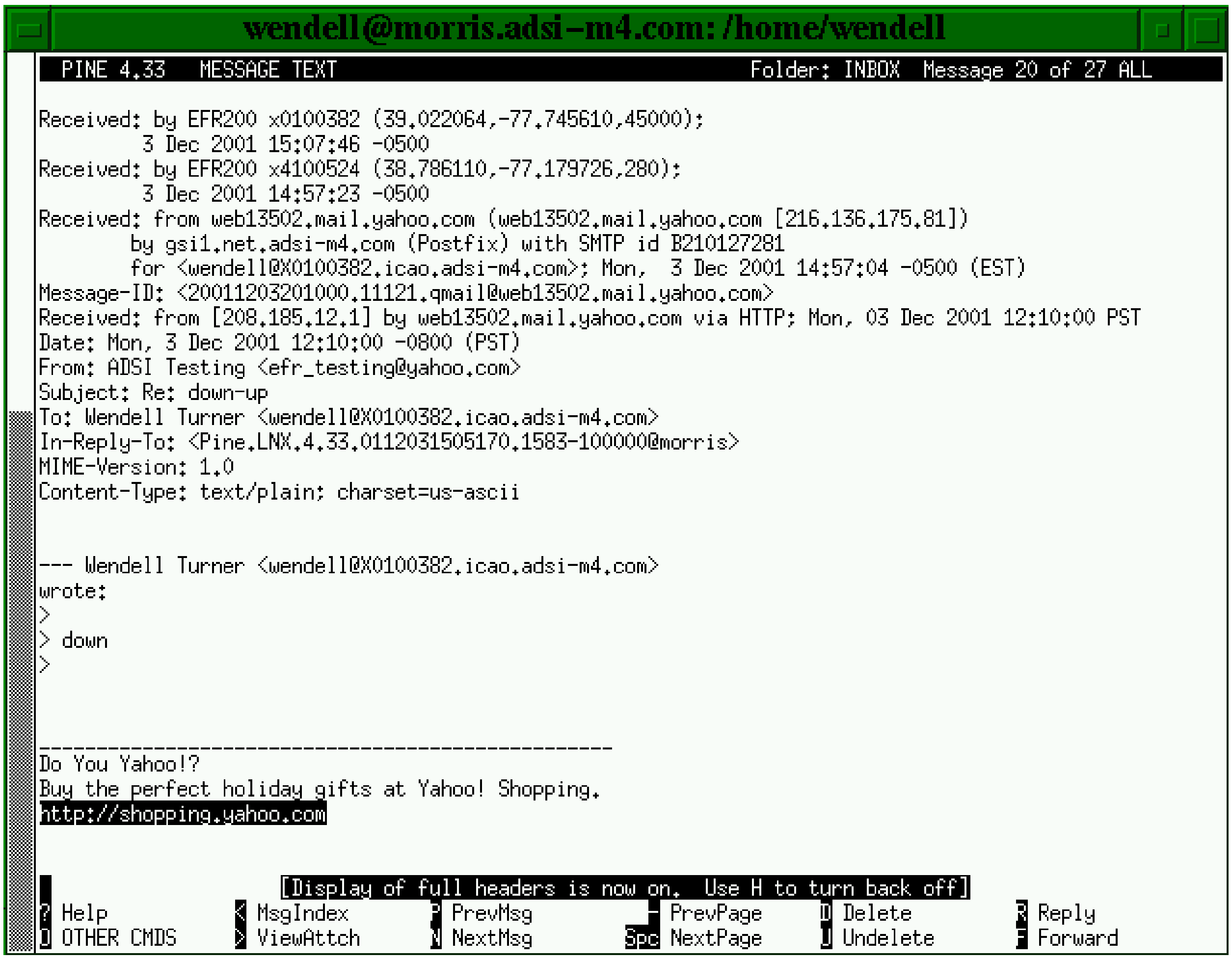
The MCDU program that is used to 'fly' a route (i.e., send ARINC 429 labels of latitude, longitude, altitude, etc. to the radio).



Appendix C

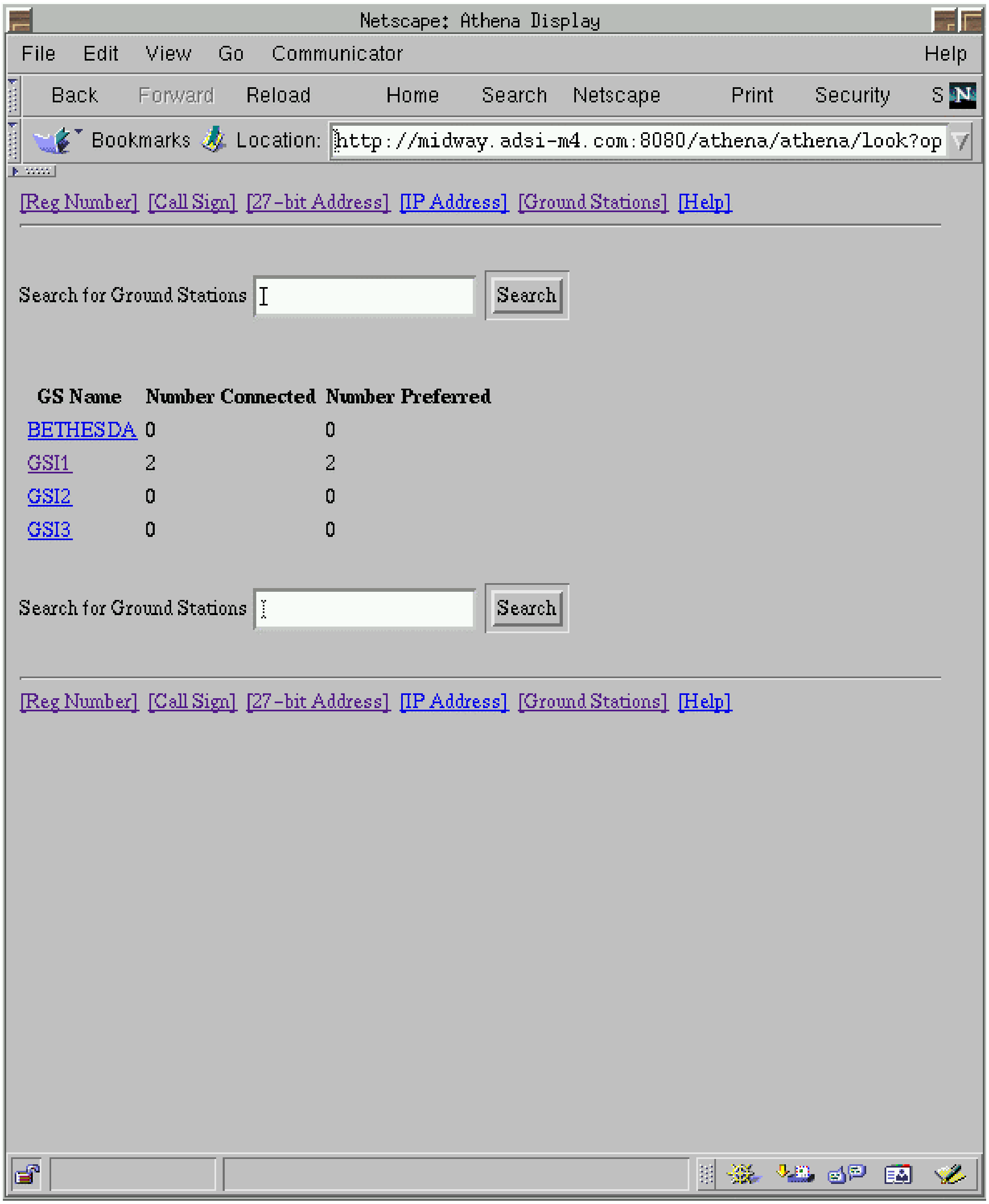
Screen Capture Shots

Pine mailer program running on N382 AI Router showing reception of e-mail from yahoo.com. Note in the first two 'Received' lines of the e-mail show that the two EFR200 AI Routers that processed and forwarded the mail put their position (lat, long, altitude) in the header of the message.

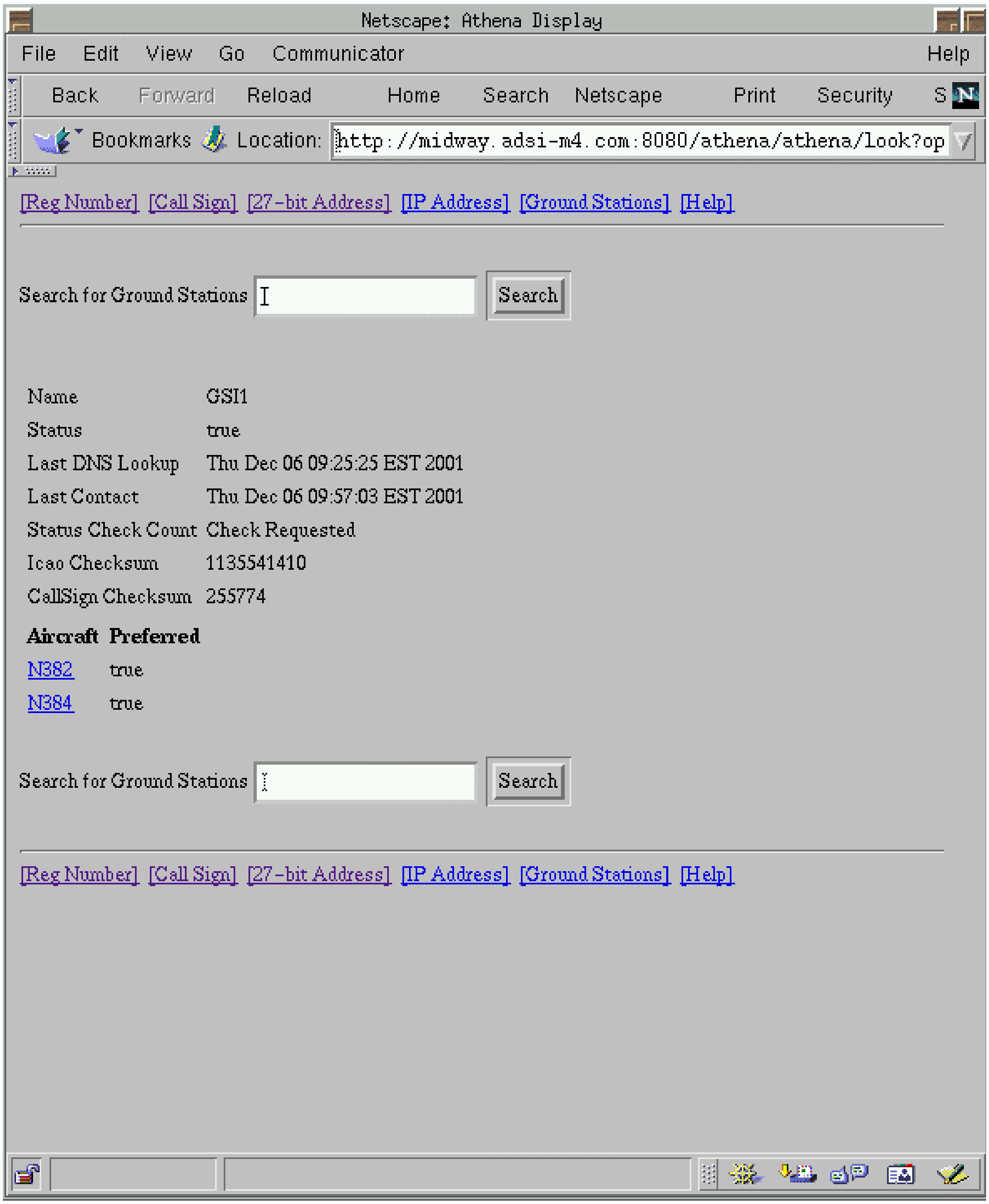


```
wendell@morris.adsi-m4.com: /home/wendell
 PINE 4.33   MESSAGE TEXT                              Folder: INBOX  Message 20 of 27 ALL

Received: by EFR200 x0100382 (39.022064,-77.745610,45000);
         3 Dec 2001 15:07:46 -0500
Received: by EFR200 x4100524 (38.786110,-77.179726,280);
         3 Dec 2001 14:57:23 -0500
Received: from web13502.mail.yahoo.com (web13502.mail.yahoo.com [216.136.175.81])
        by gsi1.net.adsi-m4.com (Postfix) with SMTP id B210127281
        for <wendell@X0100382.icao.adsi-m4.com>; Mon,  3 Dec 2001 14:57:04 -0500 (EST)
Message-ID: <20011203201000.11121.qmail@web13502.mail.yahoo.com>
Received: from [208.185.12.1] by web13502.mail.yahoo.com via HTTP; Mon, 03 Dec 2001 12:10:00 PST
Date: Mon, 3 Dec 2001 12:10:00 -0800 (PST)
From: ADSI Testing <efr_testing@yahoo.com>
Subject: Re: down-up
To: Wendell Turner <wendell@X0100382.icao.adsi-m4.com>
In-Reply-To: <Pine.LNX.4.33.0112031505170.1583-100000@morris>
MIME-Version: 1.0
Content-Type: text/plain; charset=us-ascii


--- Wendell Turner <wendell@X0100382.icao.adsi-m4.com>
wrote:
>
> down
>



__________________________________________________
Do You Yahoo!?
Buy the perfect holiday gifts at Yahoo! Shopping.
http://shopping.yahoo.com


                    [Display of full headers is now on.  Use H to turn back off]
? Help          < MsgIndex      P PrevMsg        - PrevPage   D Delete      R Reply
O OTHER CMDS    > ViewAttch     N NextMsg      Spc NextPage   U Undelete    F Forward
```

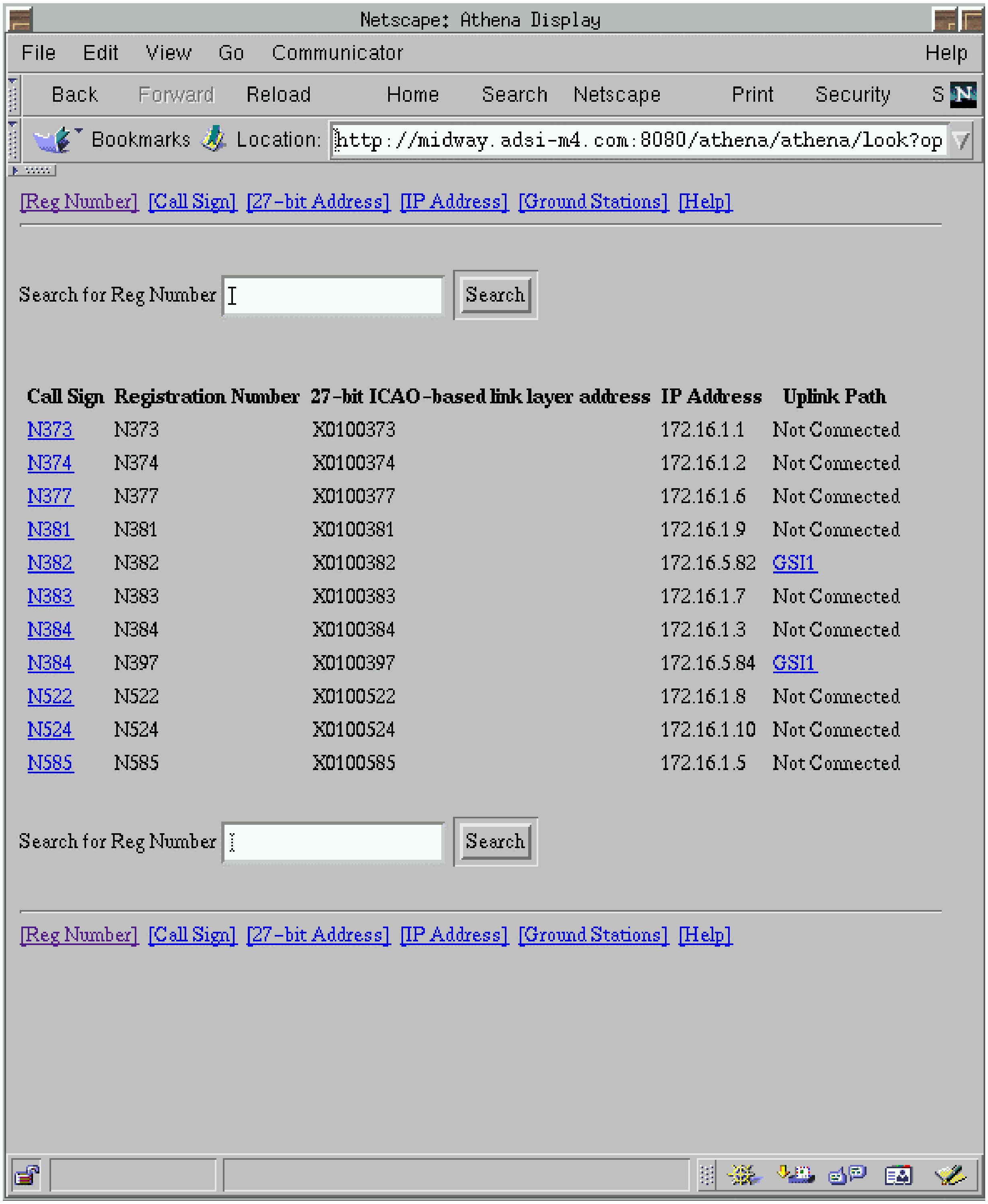
NOC Displays – Athena



List of all ground stations and basic information.

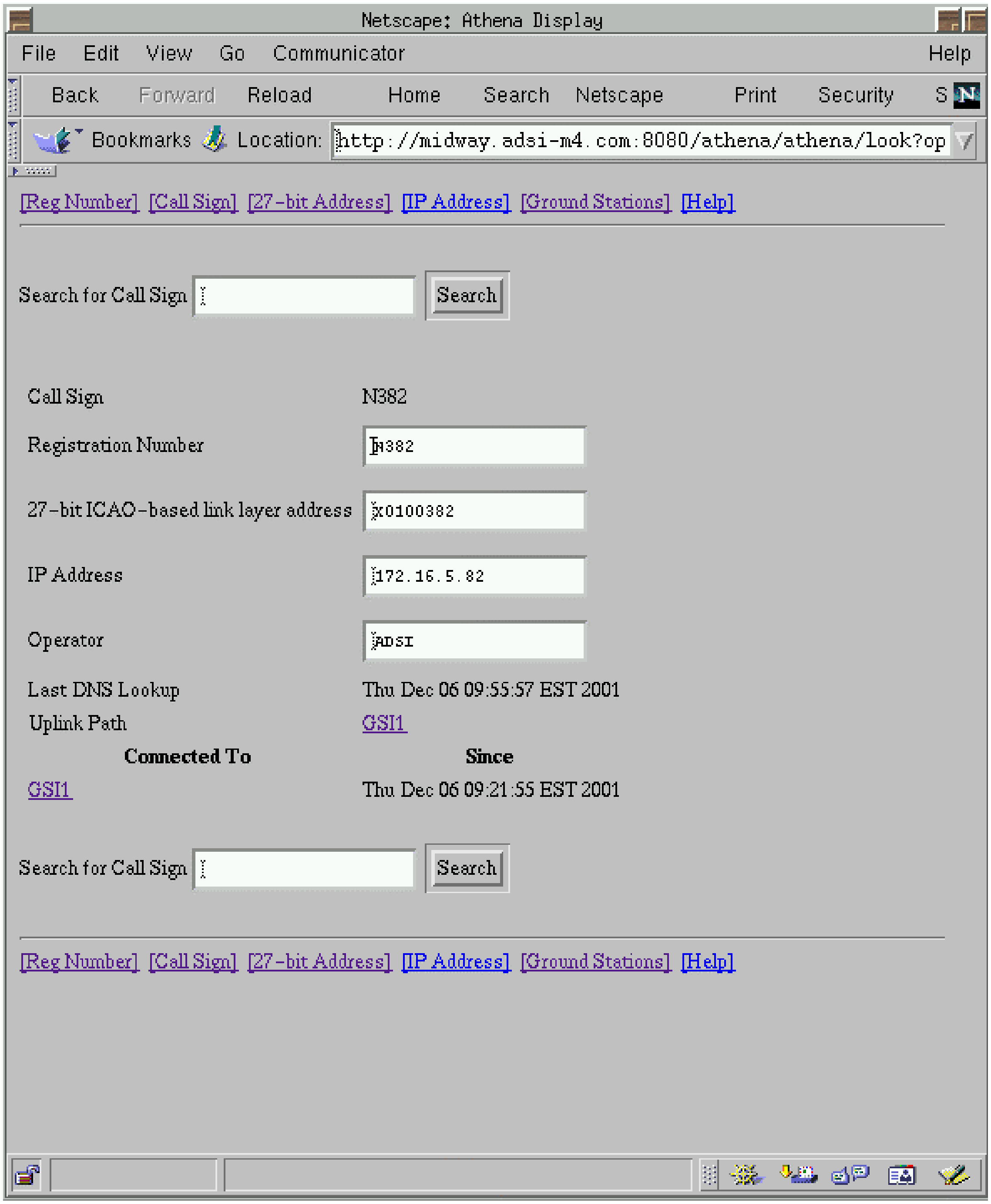


Drill down to view details of one particular ground station.



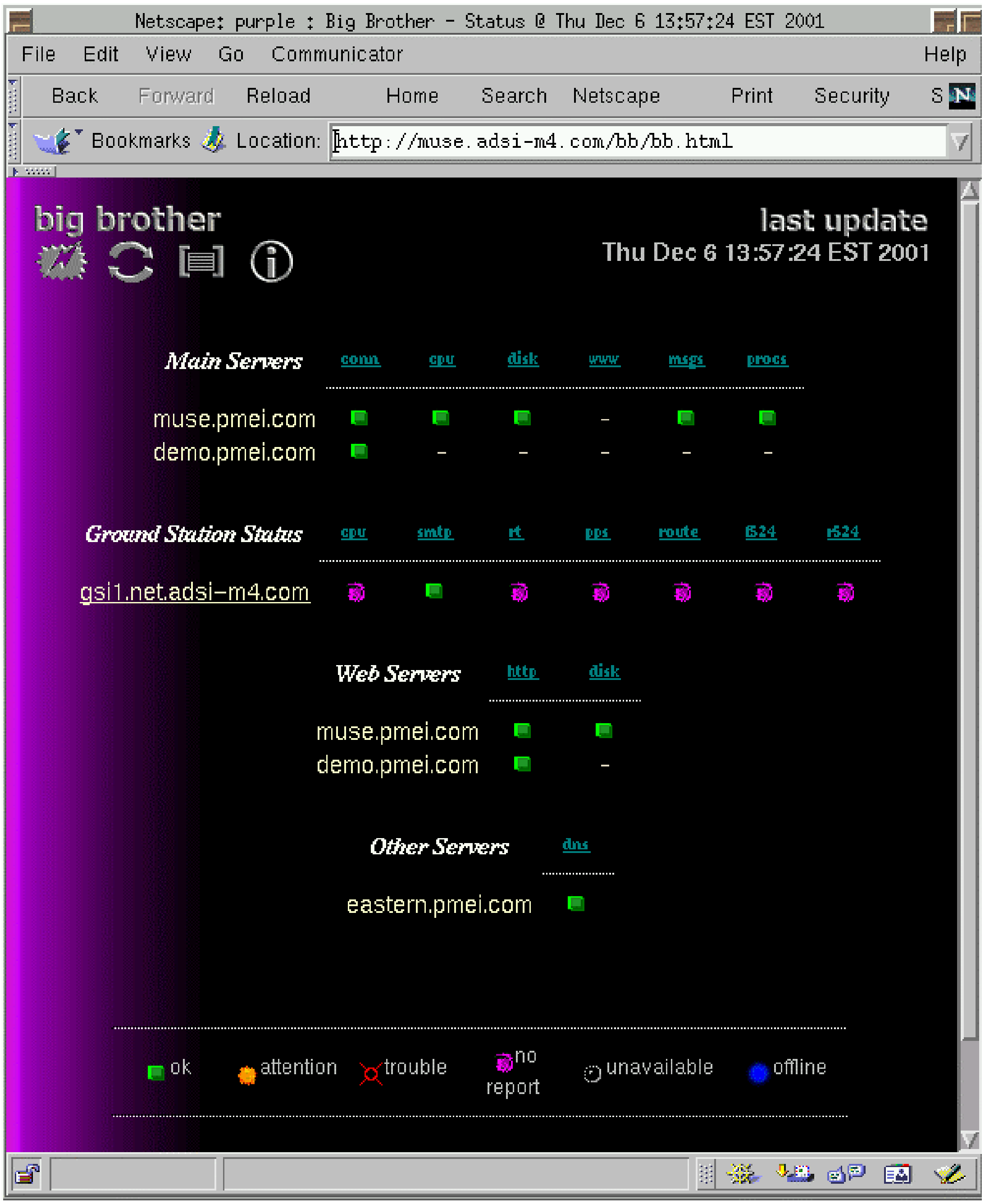
Call Sign	Registration Number	27-bit ICAO-based link layer address	IP Address	Uplink Path
N373	N373	X0100373	172.16.1.1	Not Connected
N374	N374	X0100374	172.16.1.2	Not Connected
N377	N377	X0100377	172.16.1.6	Not Connected
N381	N381	X0100381	172.16.1.9	Not Connected
N382	N382	X0100382	172.16.5.82	GSI1
N383	N383	X0100383	172.16.1.7	Not Connected
N384	N384	X0100384	172.16.1.3	Not Connected
N384	N397	X0100397	172.16.5.84	GSI1
N522	N522	X0100522	172.16.1.8	Not Connected
N524	N524	X0100524	172.16.1.10	Not Connected
N585	N585	X0100585	172.16.1.5	Not Connected

List of all aircraft by registration number and shows basic information (other views by call sign and ICAO id are also available) Drill down to view details of one particular aircraft. Provides text boxes for updating database (when attached to SQL database).

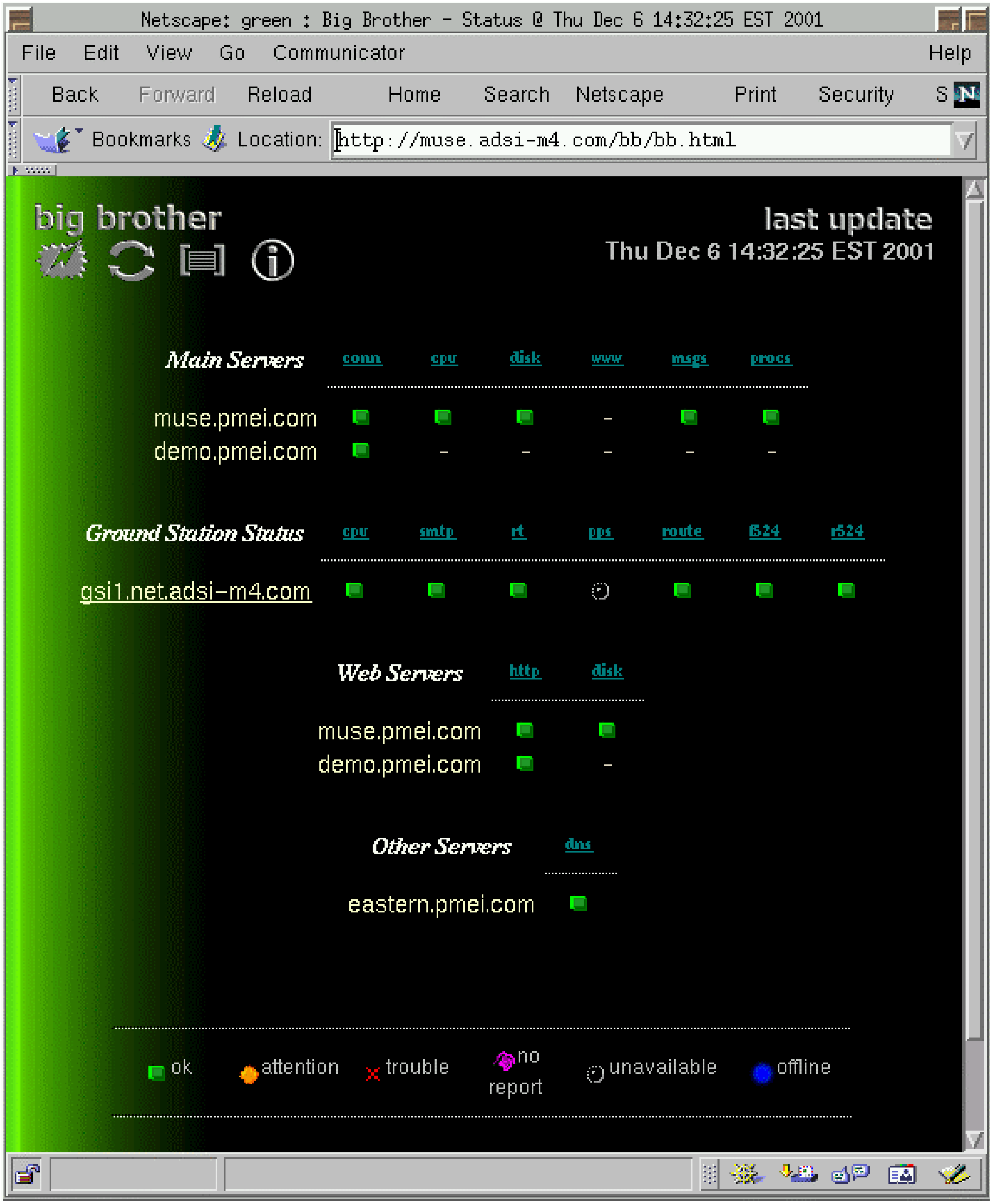


NOC Displays - Big Brother

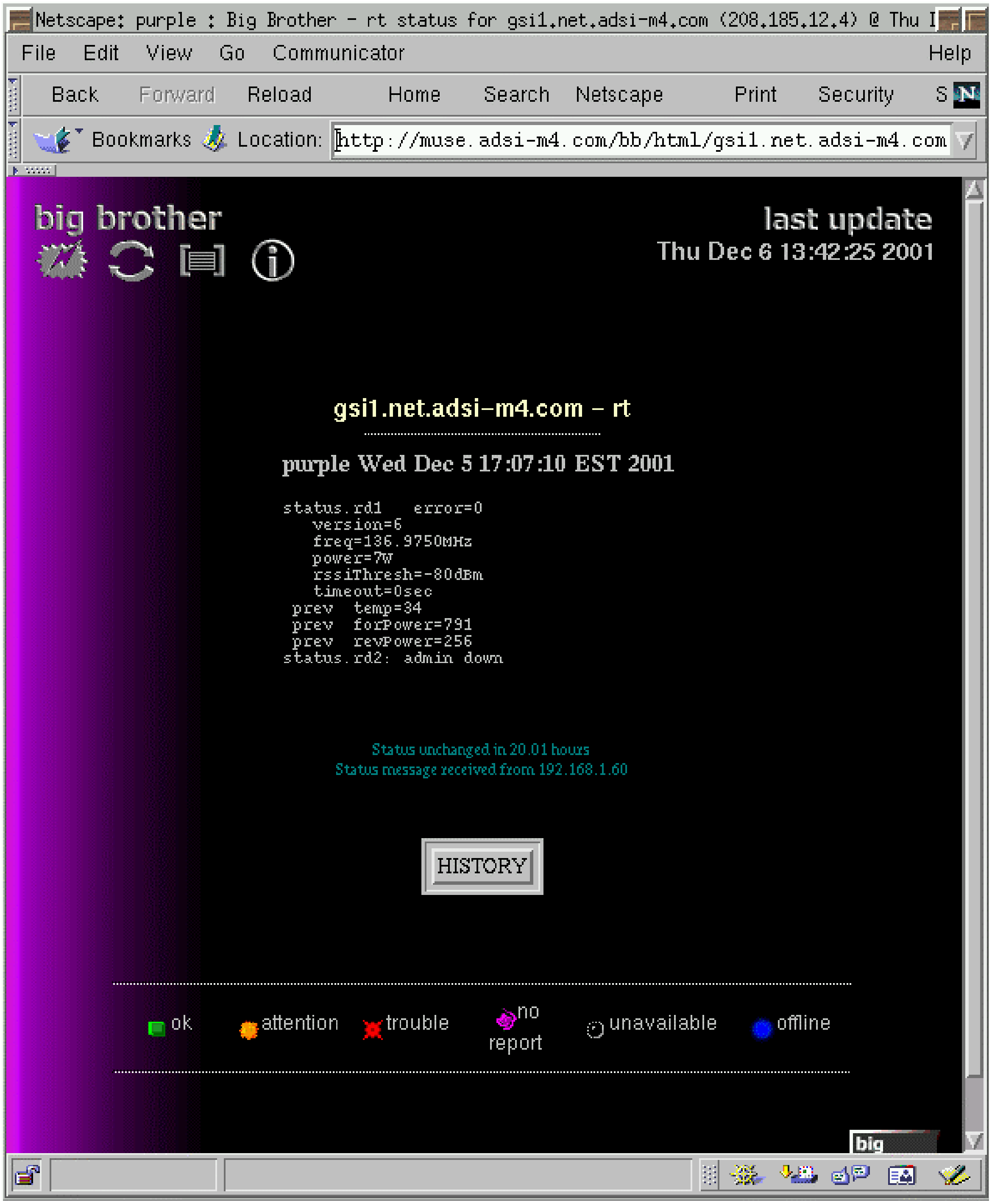
Top level view of big brother information regarding status of various nodes in Project Management Enterprises, Inc. and ADSI networks.



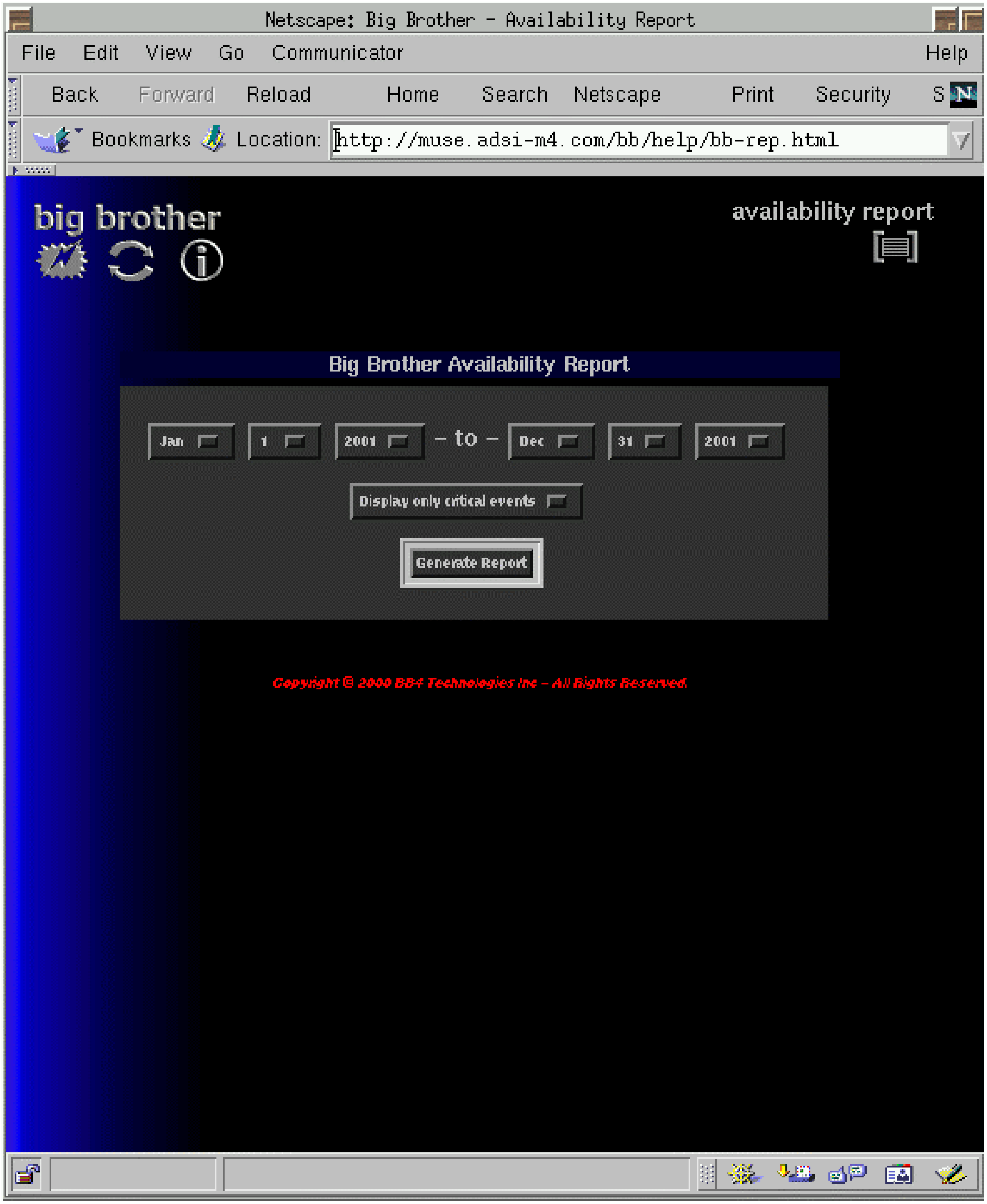
Like previous figure, but after radios were brought up so purple turned to green status.



Big brother results from querying ground station on radio status.



Big brother form to complete to determine ranges for use in computing availability statistics.

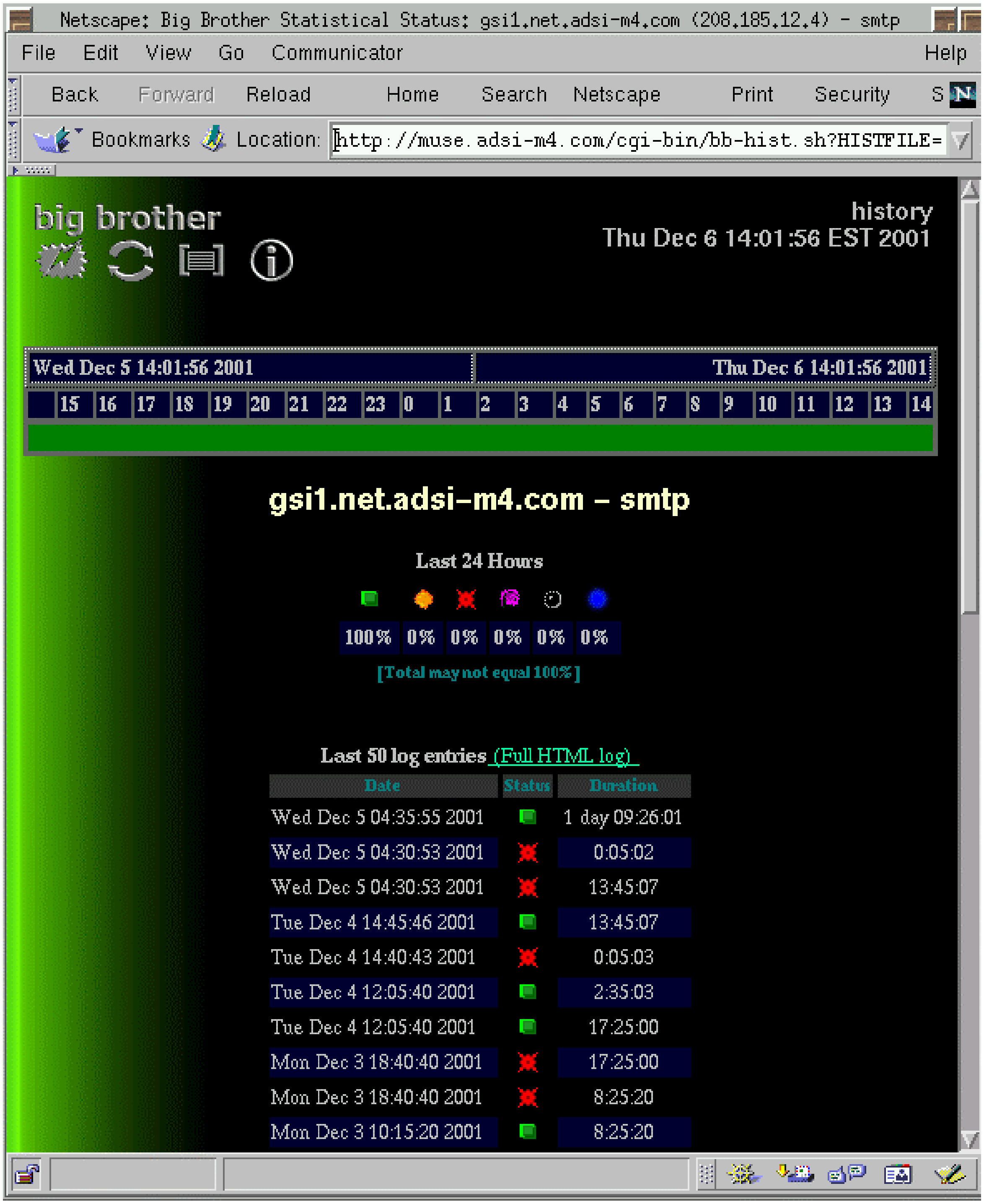


Appendix C

Screen Capture Shots

Big brother output of historic availability numbers for all nodes in network

Historical report of the status of one service on a machine.



Appendix D

SATS Lab Pictures

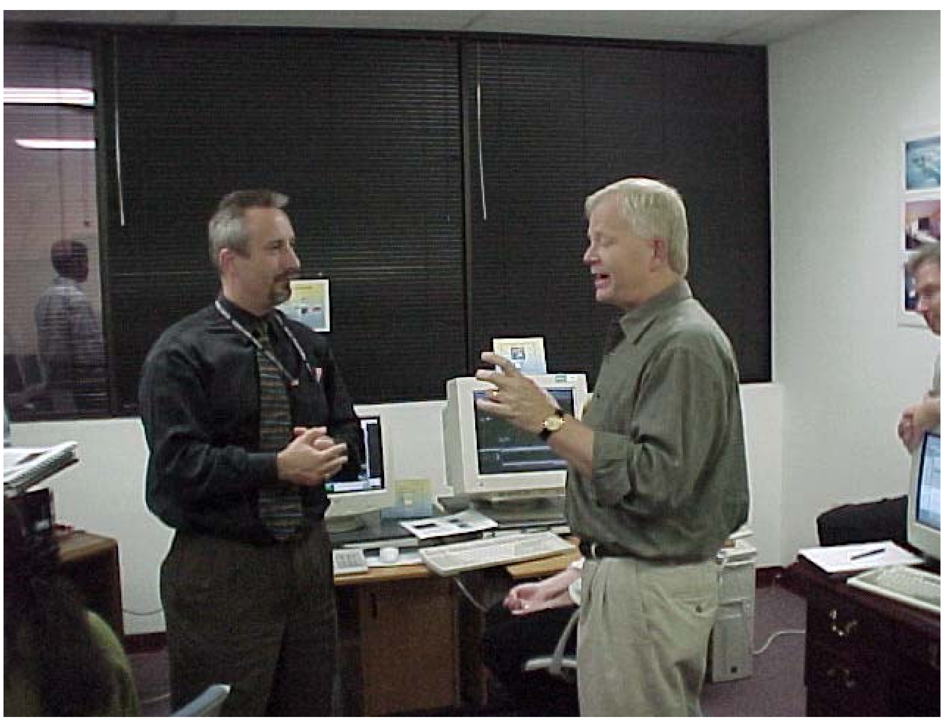
Photograph of SATS AI Testbed

Photograph of jmon display on Ground AI Router

Appendix D

SATS Lab Pictures

Photograph of CPDLC display on Ground CPDLC processor



Photograph of Chris Wargo explaining the SATS AI Testbed