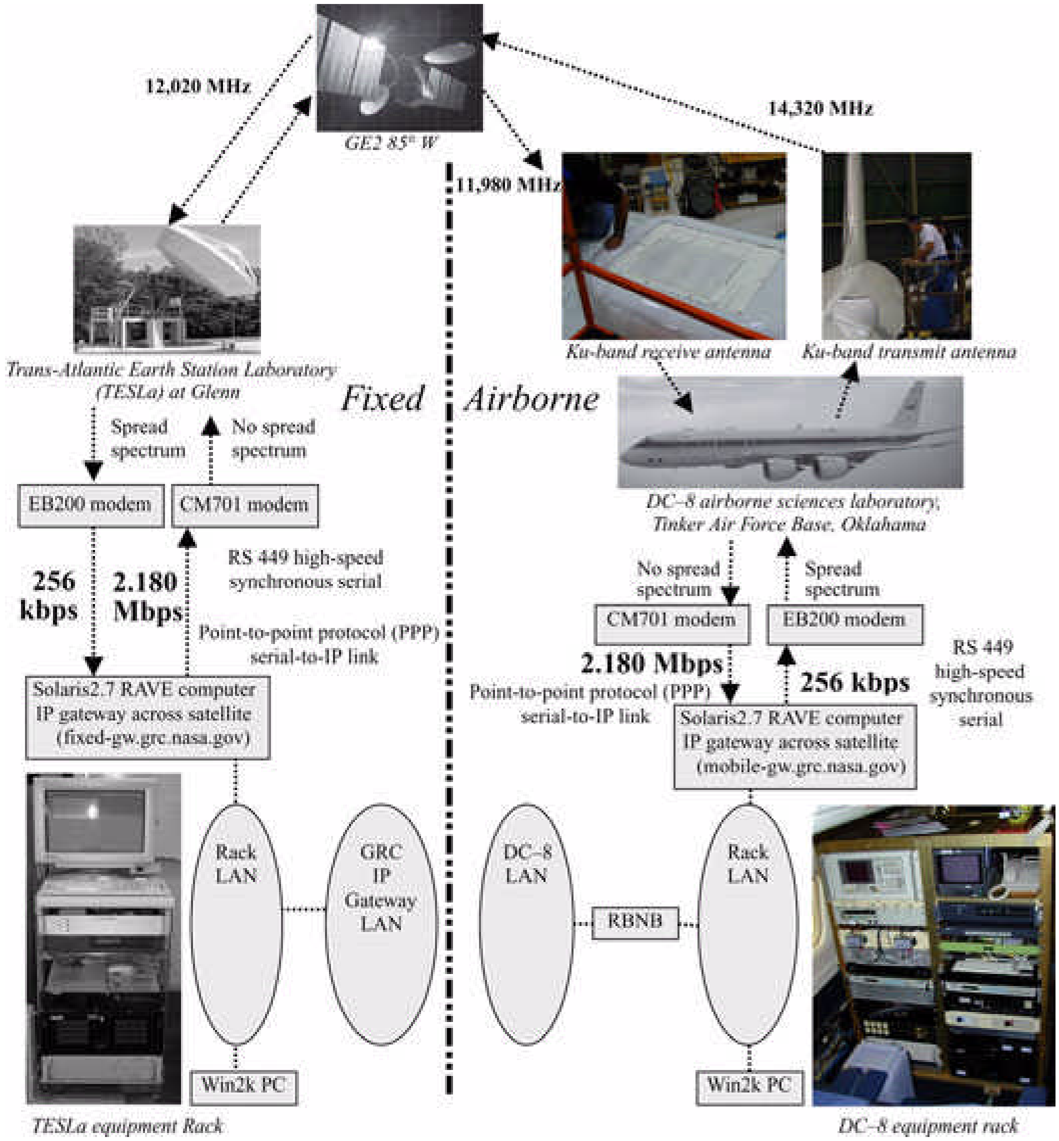
Aeronautical Satellite-Assisted Process for Information Exchange Through Network Technologies (Aero-SAPIENT) Conducted

Broadband satellite communications for aeronautics marries communication and network technologies to address NASA's goals in information technology base research and development, thereby serving the safety and capacity needs of the National Airspace System.

This marriage of technology increases the interactivity between airborne vehicles and ground systems. It improves decision-making and efficiency, reduces operation costs, and improves the safety and capacity of the National Airspace System.

To this end, a collaborative project called the Aeronautical Satellite Assisted Process for Information Exchange through Network Technologies, or Aero-SAPIENT, was conducted out of Tinker AFB, Oklahoma, during November and December 2000.



SAPIENT system overview.

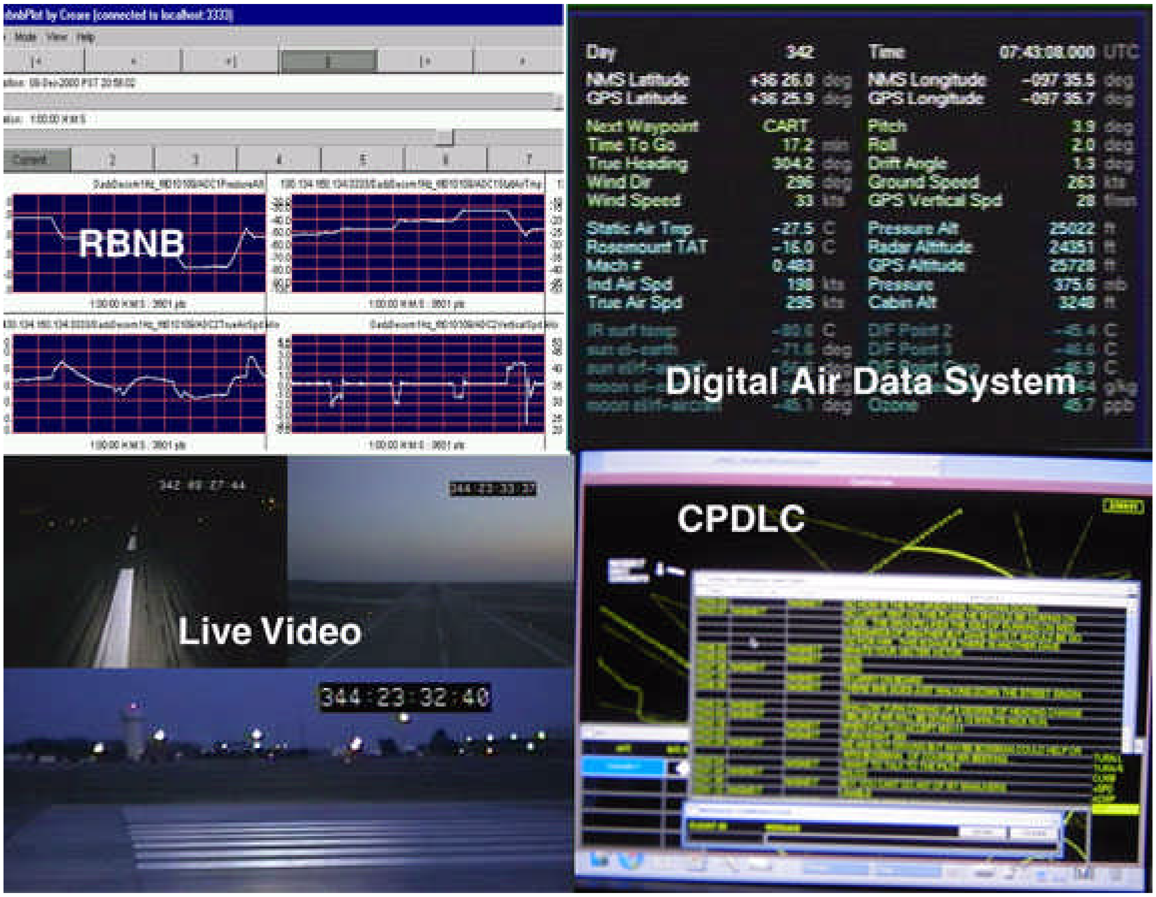
Long description Flow diagram showing SAPIENT system. (1) Fixed transmission from Glenn's IP gateway LAN and Win2k PC to rack local area network (LAN), to Solaris2.7 RAVE computer IP gateway across satellite (fixed-gw.grc.nasa.gov), through point-to-point protocol (PPP) serial-to-IP link and RS 449 high-speed synchronous serial at 2.180 Mbps to CM701 modem, transmission with no spread spectrum to Trans-Atlantic Earth Station Laboratory (TESLa) at Glenn, to GE2 85° west. (2) Fixed transmission from GE2 85° west at 12,020 MHz to TESLa at Glenn, spread spectrum transmission to EB200 modem, transmission at 256 kbps to Solaris2.7 RAVE computer, to rack LAN, and to Win2k PC and Glenn's IP gateway LAN. (3) Airborne transmission from Win2k PC to rack LAN and from DC-8 LAN through RBNB to rack LAN, to Solaris2.7 RAVE computer, through RS 449 at 256 kbps, to EB200 modem, transmission with spread spectrum to DC-8 airborne sciences laboratory at Tinker Air Force Base in Oklahoma, to Ku-band transmit antenna, and transmission at 14,320 MHz to GE2 85°. (4)Transmission from GE2 85° at 11,980 MHz, to Ku-band receive antenna, to DC-8 airborne sciences laboratory, transmission with no spread spectrum to CM701 modem, to PPP serial-to-IP link at 2.180 Mbps, to Solaris2.7 RAVE computer, to rack LAN, to Win2k PC and through RBNB to DC-8 LAN.

The NASA Glenn Research Center provided bidirectional broadband satellite communication technology and datalink, including an electronically scanned, low-profile phased-array antenna system developed through a NASA-Boeing partnership. Glenn also contributed multiprotocol network technology, the architecture, and a suite of applications to be tested. The system architecture is depicted in the preceding figure.

The experiment flew on NASA's DC-8 Airborne Sciences Laboratory operated by the NASA Dryden Flight Research Center. Dryden also tested a Java-based measurement network and data transport middleware concept called the Ring Buffered Network Bus, or RBNB. The RBNB provided simultaneous onboard data archival and online distribution of multiple flight data streams over the satellite link to a nationwide network of destinations on the ground. Some of these data streams were encrypted with public key infrastructure (PKI) technology.

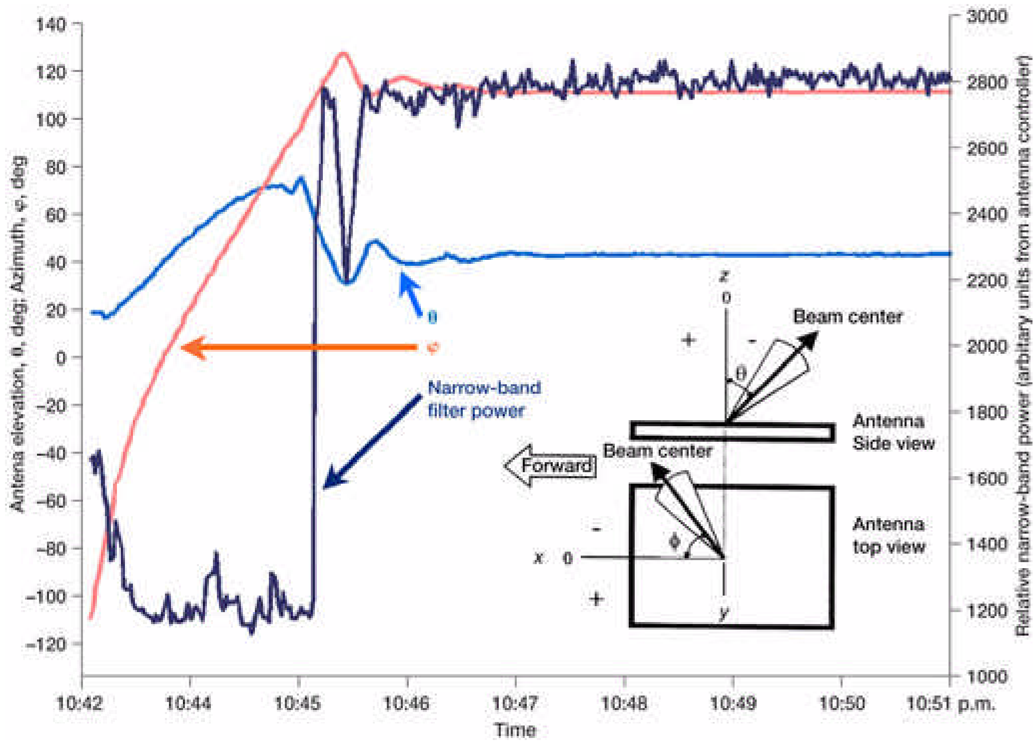
The mission successfully demonstrated real-time data link technology to move and distribute unique and distinct flight data to multiple sites in real time while addressing multilevel priorities in a secure, high-integrity data-sharing environment. Specific to the NASA Information Technology Program, the Aero-SAPIENT project achieved these level 1 milestones: flight-demonstrated technology to move and distribute unique and distinct flight data, addressed multilevel priorities, enabled real-time distribution to three NASA Centers (Glenn, Dryden, and the Ames Research Center), and developed a communications architecture for distinct, concurrent data streams of differing priority in a secure, authenticated high-integrity environment.

This mission was a collaborative effort that successfully pioneered in-flight network communications technology, enabling various simultaneous applications to be conducted at bidirectional rates 100 times greater than what is operational in today's National Airspace System. The applications employed various link, network, and transport protocols, which included VoIP (voice), FTP (file transfer), TTCP (capacity test tool), E-mail, HTTP (web browsing, weather access, web-server-provided DC-8 Digital Air Data System), Controller-Pilot Data Link Communication (using the Aeronautical Telecommunication Network, ATN, protocol), Sun Forum (duplex video, white boards, text), SSH (secured remote access), Ring Buffered Network Bus (Java middleware, cache management, stream proxy services), and authentication (PKI). Examples of some of these are shown in the following figure.



Simultaneous bidirectional applications included the Ring Buffered Network Bus (RBNB), onboard vehicle information via the Digital Air Data System, live video from several onboard cameras, and Controller-Pilot Data Link Communication (CPDLC).

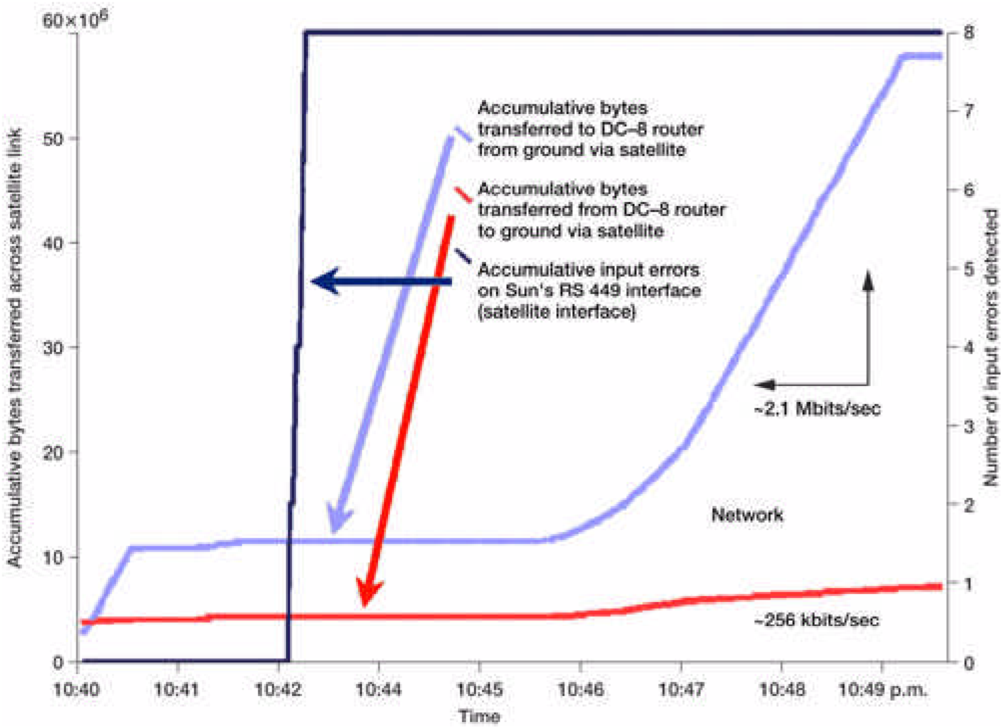
In addition to constructing a network architecture that included a mobile platform and simultaneous bidirectional applications, the evaluation of the physical electrical interconnect and the network performance was of particular interest in understanding a high-integrity communications environment. Because this mission was the first flight of the prototype Ku-band antenna system, the antennas were characterized in a variety of flight profiles that included different combinations of roll, pitch, and heading with regard to the geostationary satellite. The experimental link performed extremely well, yielding data transfers of approximately 2.1 Mbits/sec onto the aircraft, and 256 kbits/sec from the aircraft to the ground network that extended across the Nation. The data rates were limited by the installed firmware on the various modems used in the network, and could be increased by upgrading to the latest modem firmware revisions. Extreme flight profiles (e.g., a 45° change in roll coupled with a 50° change in heading) were purposely flown to determine the threshold of sustaining the communication link. This also provided the opportunity to understand the relationship between the antenna system performance (shown in the next graph) and the network recovery (shown in the final graph), during a particular flight profile or system event.



Antenna system performance conducted under a severe flight profile. December 8, 2000, Boeing antenna statistics.

Long description Graph shows narrow-band filter power, beam center, antenna side view, and antenna top view.

These NASA technology investments for airspace safety and capacity have resulted in commercialization opportunities. Two such examples are the forthcoming Connexion by Boeing service utilizing phased-array antenna technology and the available DataTurbine software server by Creare, Inc., which is based on the Ring Buffered Network Bus concept. As a testimony to this achievement, both Glenn and Dryden were given the NASA 2001 Turning Goals Into Reality award for Commercializing Technology.



Network recovery during an interrupted communications link caused by an extreme flight profile. December 8, 2000, DC-8 airborne router satellite link utilization.

Long description Graph shows accumulative bytes transferred to DC-8 router from ground via satellite and acculaulative input errors on Sun's RS 449 interface (satellite interface); transmission approximately 2.1 Mbps and 256 kbps

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