17 COMMUNICATIONS

The NAS communications architecture provides a plan for achieving reliable, timely, efficient, and cost-effective transfer of information among NAS users and between NAS users and the external environment. It addresses communications technology and standards, telecommunications system integration and partitioning, network operations and management, and transition. The architecture meets the concept of operations (CONOPS) requirement for seamless communications across domains and information sharing among all NAS users. It also provides for the subnetworks needed to support NAS resectorization in the future.

In order to facilitate the NAS architecture planning process, the communications system is divided into three elements: Interfacility Communications, Intrafacility Communications, and Mobile Communications.

- *Interfacility Communications:* Consist of the networks that transmit voice, data, and video information among FAA facilities and that connect to external facilities. Interfacility communications connect with intrafacility communications and mobile communications.
- *Intrafacility Communications:* Consist of the networks that transmit voice, data, and video to users within a facility. Intrafacility networks interface with interfacility networks to connect users within a given facility to users in other facilities or to mobile users.
- *Mobile Communications:* Consist of networks that transmit voice and data among mobile users. These networks interface with interfacility networks to provide communications paths between mobile users and users within a facility. Two types of mobile communications networks are used in the NAS: air-ground communications networks that support air traffic control and ground-ground networks that support maintenance and administrative activities.

Information exchange among NAS users involves one or more of these elements. Air-ground communications, for example, use all three elements of the communication system. Various applications of the communications system are further described in Section 21, En Route; Section 22, Oceanic and Offshore; Section 23, Terminal; and Section 24, Tower and Airport Surface. The data link system and services are described in Section 17.1.4, Data Link Service.

17.1 Communications System Evolution

The FAA has traditionally considered communications networks in terms of air-ground voice communications, ground-ground operational voice and data communications, and agency (administrative) voice and data communications. The communications architecture proposes to integrate these networks to improve interoperability, quality of service, network security, and survivability while reducing the cost per unit of service.

Most ground-ground transmission systems will be consolidated within a common network infrastructure that will integrate administrative and operational communications systems for interfacility transmission of voice, data, and video.

The NAS will migrate to a digital telecommunications infrastructure to take advantage of new technology and the growing number of digital services. The telecommunications infrastructure will also support current analog voice switches and legacy protocols.

The domestic air-ground system will migrate to digital technology for both voice and data communications. Oceanic communications will migrate to International Civil Aviation Organization (ICAO)-compliant aeronautical telecommunication network (ATN) data link applications using high frequency (HF) and satellite-based links.

17.1.1 Interfacility Communications System Evolution

The NAS interfacility system is expected to lower communications costs while providing qualitative service improvements and future growth capacity. A decisive change at this time is critical for two reasons. First, new data communications requirements will greatly increase recurring costs unless a significant communications redesign occurs now. Second, the upcoming expiration of the Federal Telecommunications System 2000 (FTS 2000) and Leased Interfacility NAS Communications System (LINCS) transmission facilities and service contracts are likely to provide the timing window for significant improvements that the FAA must be prepared to take advantage of.[1] When completed, the NAS interfacility communications system will consist of several logical networks supported by a predominantly leased physical infrastructure. This logical and physical network architecture is essential to NAS modernization.

Logical Network

Design. The interfacility communications system will provide a set of software-defined networks that are logically partitioned to provide connectivity between facilities. Each logical partition will support independent virtual private networks (VPNs) that share common telecommunications resources. VPNs have most of the features of a private network while providing very reliable communications at a lower unit cost.

The interfacility communications system will consolidate networks in order to transport operational and administrative traffic over the same physical links. However, traffic will be logically partitioned into four (or more) virtual private networks—two for voice and two for data and video (see Figure 17-1). Other VPNs may be added to meet special needs (e.g., security requirements may require a separate VPN for Internet communications).

Common Physical Network Infrastructure. The common physical network infrastructure is a shared physical networking environment that includes transmission, switching, multiplexing, and routing facilities. The common physical network infrastructure uses VPN technology to meet different administrative and operational performance requirements. It will also use a mix of transmission services and service providers to achieve the desired level of reliability and path diversity at the lowest cost.

The current physical communication networks consist of transmission systems (e.g., LINCS, radio communications link (RCL), and television microwave link (TML)); switching systems (e.g., National Airspace Data Interchange Network packet switch network (NADIN PSN)); and mul-

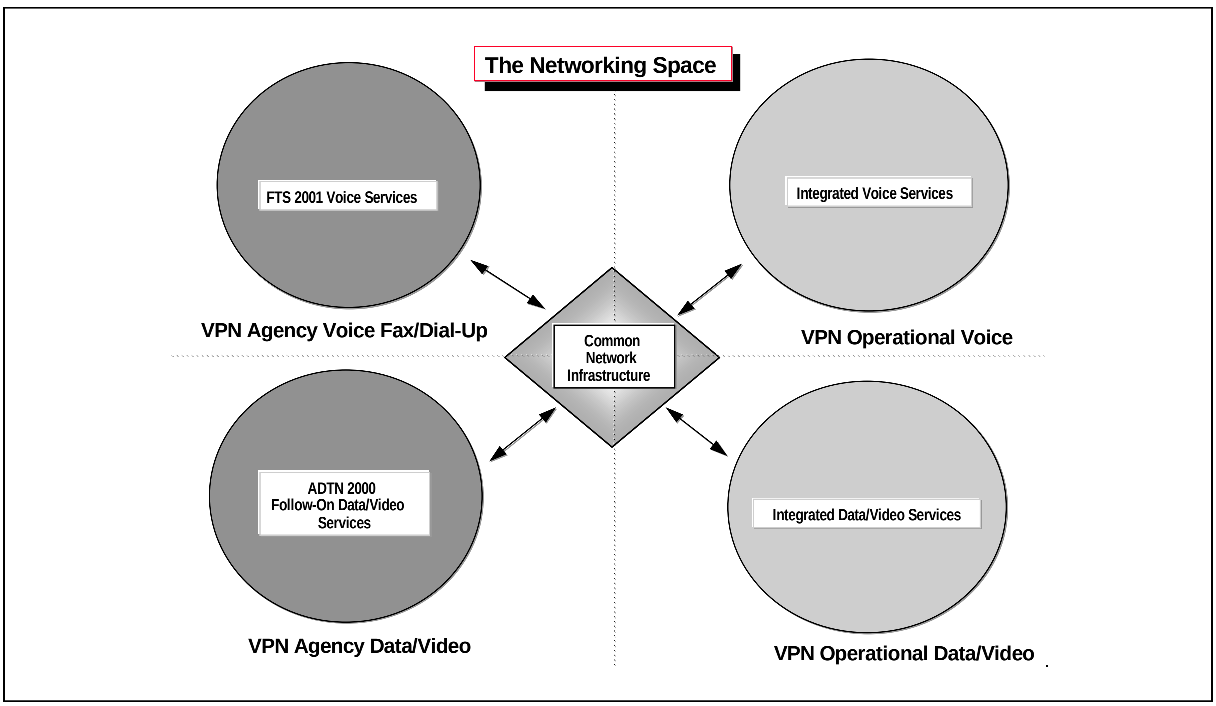

Figure 17-1. Logical Network Architecture

1. Note that the integrated communications system procurement does not include the following: air traffic control voice switches, the Alaskan NAS Interfacility Communications System (ANICS) ground infrastructure, digital airport telecommunications, administrative dial switches, or air-ground and mobile communications equipment and services.

tiplexing systems (e.g., data multiplexing network (DMN)). In the future, digital switches or routers at each ARTCC will replace existing multiplexer equipment. These various networks will be integrated by using a single transmission technology, such as asynchronous transfer mode.

Asynchronous transfer mode technology allows the replacement of dedicated physical trunks with virtual private trunks for operational traffic (currently the largest communications expenditure). It also provides a number of bandwidth-saving efficiencies, including channel release during moments of audible silence and compression of administrative voice (currently the largest traffic category). This technology can also provide multicasting, dynamic bandwidth allocation, quality of service guarantees, priority and preemption for critical and essential services, and survivability for operational-critical and essential services.

Each user application, whether operational or administrative, is assigned its own quality-of-service and priority. The highest priority would be used for critical operational traffic. Low-priority traffic would use the gaps between higher-priority traffic and any overflow capacity. Use of asynchronous transfer mode over satellite links, particularly over the FAA Telecommunications Satellite System (FAATSAT), could also provide better bandwidth utilization and better integration with terrestrial networks.

Frame-relay technology appears to be useful for data applications at sites where the total data requirement for network access is in the 64 Kbps to 1.544 Mbps range. This would require installing frame-relay access devices at small FAA sites. The frame-relay access devices can be connected to either a frame relay or an asynchronous transfer mode network.

Agency Voice VPN/Fax/Dial-Up. Voice services available through the Federal Telecommunications System (FTS 2000) contract will be replaced by an integrated telecommunications infrastructure that provides different classes of network connections and virtual circuits for all voice services needed to support FAA administrative functions. The classes of services implemented in the administrative voice VPN will depend on user needs. Those requiring high availability, for example, may receive dedicated bandwidth, while less critical voice services may receive a variable bit rate service that consumes less bandwidth and maintains low connect times.

Agency Data/Video VPN. VPN services provided by the integrated telecommunications infrastructure will be used for data networking, facsimile, dial-up, and video services needed for FAA business operations. Services will be assigned priorities according to business operations requirements. The integrated telecommunications infrastructure will also feature networking schemes to manage transmission control protocol/Internet protocol (TCP/IP)-based information and administrative data and video information.

Operations Voice VPN. VPN services provided by the integrated telecommunications infrastructure will be used for voice communications for NAS operations. This VPN will have the highest priority service in order to meet NAS voice operational requirements. Operational voice services requiring extremely high availability may be configured with a permanent virtual circuit class of service that provides dedicated connectivity. The operations voice VPN will include major air traffic facilities, such as air route traffic control centers (ARTCCs), terminal radar approach control (TRACON) facilities, and airport traffic control towers (ATCTs).

Operations Data/Video VPN. VPN data and video services available in the integrated telecommunications infrastructure will provide the data networking and video capability needed for NAS operations. The logical network design employed within the VPN framework will satisfy operational requirements for critical data and video services by using the appropriate class of service connections.

Physical Network Design

External Interfaces. Gateways and routers will provide external communications interfaces for the Department of Defense (DOD), aviation industry users, service providers, and international agencies. Access gateways or routers will be used between the appropriate FAA VPN and the airline operations center network (AOCNet). Aviation industry access will facilitate traffic flow management (TFM), collaborative decisionmaking (CDM), and other similar initiatives.

Network Management and Operation. The integrated telecommunications infrastructure will interface with the operations control centers and exchange both real-time and non-real-time information. The telecommunications infrastructure will provide the following network management services:

- Real-time information exchange
  - User help desk for service restoration and coordination
  - Network performance statistics
  - Hardware and software configuration
  - Remote equipment status
- Electronic security
- Non-real-time information sharing
  - Network statistics
  - Network planning
  - Billing and accounting data
  - Port utilization data.

17.1.1.1 Interfacility Communications System Evolution—Step 1 (Current–1998)

It is estimated that the FAA employs more than 25,000 interfacility point-to-point and multipoint circuits for air traffic services—of which roughly 60 percent are used for voice and 40 percent for data. FAA voice and data communications are often combined (multiplexed) over backbone transmission systems, although they are generally handled separately on the access networks.[2] Most voice and data circuits are leased on a monthly basis from communications service providers. Of the approximately $300M spent by the FAA on telecommunications in FY95, nearly 60 percent was for recurring circuit costs.

Today's interfacility operational voice communications are based on voice switches with analog voice output. Since the vast majority of interfacility voice trunks are digital (provided by LINCS), the analog voice signal must be digitized before it is transmitted. Operational voice circuits are usually configured as dedicated point-to-point and multipoint circuits and are used only a few minutes per hour.

Voice switches in the current system are not capable of switching calls through to another switch (tandem switching) and typically do not provide supervisory signaling. In cases where supervisory signaling is provided, it is typically provided inband, which forces switches to rely on dedicated point-to-point or multipoint circuits for connectivity to other switches. This results in a highly inefficient use of communications bandwidth, given the NAS voice traffic loading profile.

Today's interfacility data communications provide a variety of circuits and connection types between FAA sites. At the transmission level, RCL, TML, and low-density radio communications link (LDRCL) use analog and digital microwave circuits; FTS 2000 and LINCS use copper and optical fiber circuits; and Alaska NAS Interfacility Communications System (ANICS) and FAATSAT use satellite circuits. The FTS 2000 contract expired in 1998 and will be replaced by the FTS 2001 contract.

The data switching environment largely consists of separate, lightly loaded, low-bandwidth networks. The technologies used include a 1960's message switch network (i.e., NADIN message switch network (MSN)), several 1970's asynchronous systems used for weather data collection and distribution, a 1970's X.25 packet switch network (i.e., NADIN PSN), which is currently being upgraded to modern frame-relay capabilities, and a DMN that uses analog transmission circuits. Each network is administered, operated, and maintained separately and is generally unable to back up the other networks.

One way the FAA is improving network efficiency is through the use of bandwidth management systems that are capable of switching between independent transmission networks (e.g., RCL, LINCS, FAATSAT). Bandwidth management provides the ability to multiplex voice and data over higher-capacity trunks when it is cost-effective and simplifies transition to other service providers.

2. Low-speed data circuits are routinely combined on the FAA's DMN to achieve cost savings on interfacility circuits.

Except for high-end video conferencing, all agency data requirements are met by the Administrative Data Transmission Network 2000 (ADTN 2000). ADTN 2000 employs multiprotocol routers in conjunction with a frame-relay core to carry monthly traffic in excess of 300 gigabytes with an average delay under 200 milliseconds and availability of 0.999.

17.1.1.2 Interfacility Communications System Evolution—Step 2 (1999–2008)

To meet FAA communications growth in the next century, the interfacility communications system consolidates most of the transmission systems and voice and data networks within a single integrated communications infrastructure that offers integrated voice, data, and video services across the NAS. The new telecommunications infrastructure will provide improved performance at a lower unit cost.

The NAS ground-ground operations voice network will transition from a point-to-point network using dedicated trunks to a switched network that provides bandwidth on demand. The FAA will migrate from analog switch interfaces that use in-band signaling to digital interfaces and out-of-band signaling. Air traffic control (ATC) switches that currently use digital technology will have analog interfaces replaced with digital interfaces. Switches based on analog technology such as the small tower voice switch (STVS) will be provided, if cost-effective, with ear and mouth (E&M) signaling and connected to a channel bank or a network termination device in order to interface with the digital network. Future voice switches will not require legacy interfaces.

Data communications to international air traffic services (ATS) facilities will evolve from the existing aeronautical fixed telecommunications network (AFTN) infrastructure to an ATN-based infrastructure. Most of the FAA's telecommunications systems (RCL, LINCS, FTS 2001, NADIN MSN, NADIN PSN, and the bandwidth manager) will be incorporated in the integrated telecommunications infrastructure.[3]

ANICS, FAATSAT, and the DMN will be integrated next. The LDRCL, however, will remain in service as a separate FAA-owned transmission system. Figure 17-2 provides an overview of the NAS interfacility environment as it will appear in this step. Edge devices (e.g., the edge/access device shown in Figure 17-2) will physically interconnect the integrated backbone network with legacy local area networks (LANs) and switches. These edge devices will initially route internetwork packets, but may evolve to provide both routing and switching functions. NADIN MSN

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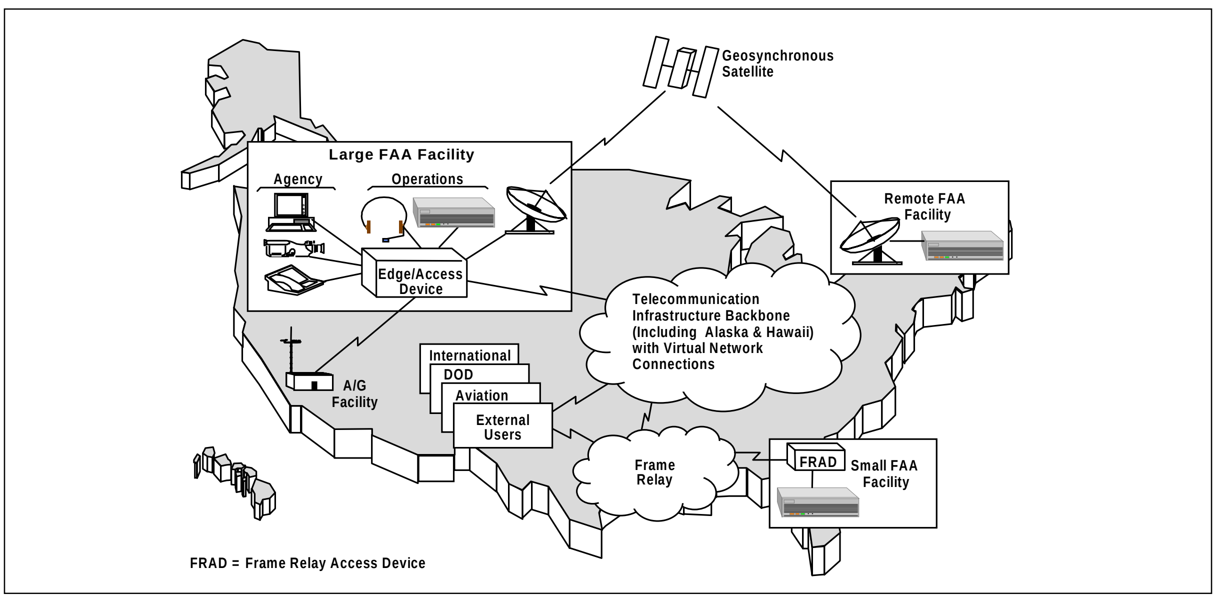

Figure 17-2. Interfacility Architecture in 2008

3. Mission Need Statement (MNS) *FAA Telecommunications Infrastructure* was approved in May 1998.

will be rehosted and will connect directly to an edge device.

17.1.1.3 Interfacility Communications System Evolution—Step 3 (2009–2015)

The interfacility communications system looks the same as the previous step, but undergoes technology refreshment, speed increases on access trunks, and a new generation of NAS voice switches with modern network interfaces is introduced. In addition to these qualitative improvements, cell-based multimedia networks are expected to become available at competitive prices from several vendors. In hard-to-service locations where access costs do not support diversity today, the FAA may employ switched access to low earth-orbiting (LEO) and medium earth-orbiting (MEO) satellite-based networks. Many LDRCLs will be phased out by competitively priced services available from communications carriers. Where such service is not available, LDRCL will remain.

17.1.1.4 Interfacility Communications Schedule

Transition of interfacility communications begins with replacement of the General Services Administration (GSA) FTS 2001 contract. This will be followed by implementing the integrated telecommunications infrastructure, which includes LINCS replacement. LINCS circuit cutover and network conversion schedules will be based on a 2-year transition period. These cutovers will be as expeditious as possible to reduce the time needed to support two networks. For safety, the old network service will be maintained after cutover until the new service has proven itself in a live environment. The communications transition schedule shown in Figure 17-3 assumes a multiyear conversion period that minimizes the impact on FAA staff and ensures a sufficient period of dual operation.

17.1.2 Intrafacility Communications System Evolution

Intrafacility data communications evolution will follow an approach similar to that used in the current administrative system (i.e., widespread use of commercial off-the-shelf (COTS) client-servers and LAN/IP-based networks connecting operational sites). This evolution is already in progress in a large number of major programs, (e.g., the display system replacement (DSR), Standard Terminal Automation Replacement System (STARS), weather and radar processor

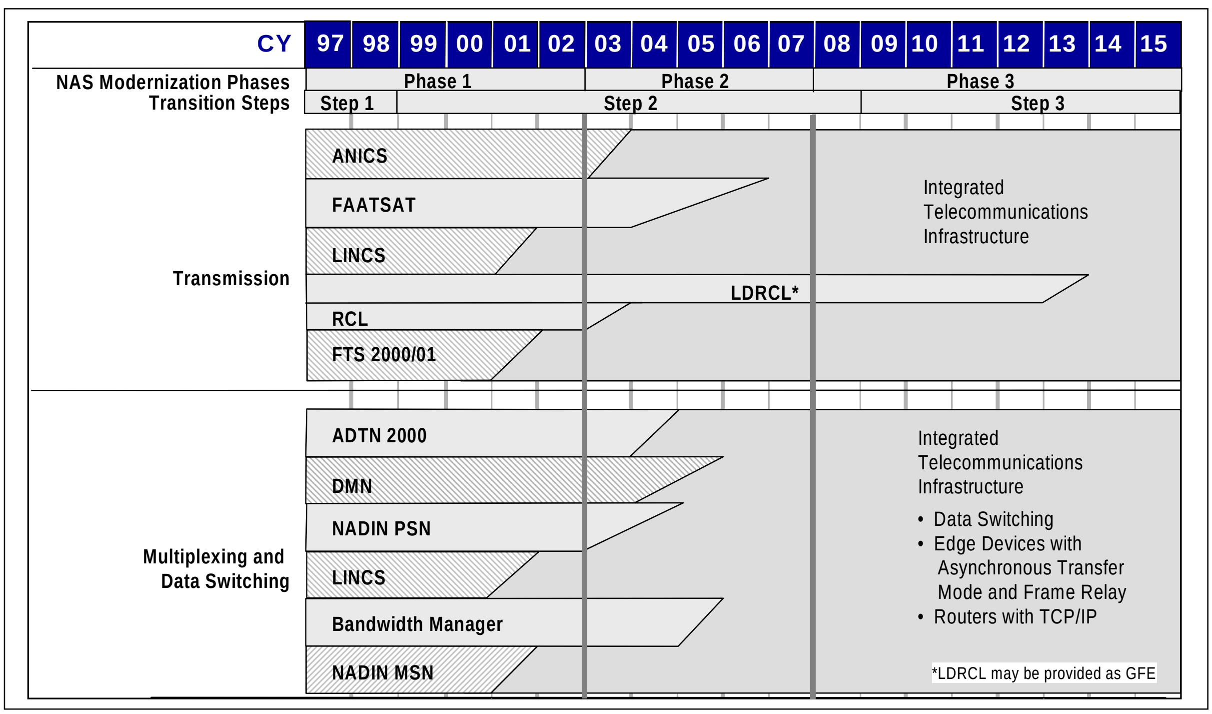

Figure 17-3. Interfacility Communications Transition

(WARP), center TRACON automation system (CTAS), enhanced traffic management system (ETMS), Operational and Supportability Implementation System (OASIS), and host interface device (HID)/NAS LAN). Like the interfacility network that connects operational sites, a number of special features are needed at ATC sites to ensure high availability (e.g., physical, electrical, and power diversities). The basic system components (i.e., LANs, routers, switches, and security access servers) are common to both the interfacility and intrafacility environments and will also provide support for low-speed video transmission.

Intrafacility ATC voice communications will continue to be provided by FAA-owned switches for the foreseeable future.

17.1.2.1 Intrafacility Communications System Evolution—Step 1 (Current–1999)

Today's intrafacility system carries all voice and data communications exchanges within facilities and provides services tailored to the largest ARTCCs and TRACONS as well as the smallest towers.

There are approximately 480 air traffic services voice switches consisting of eight different models from three vendors. These voice switches come in various sizes and configurations and include the STVS, rapid deployment voice switch (RDVS), integrated communications switching system (ICSS), traffic management voice switch, voice switching and control system (VSCS), emergency voice communications system (EVCS), and the soon-to-be-deployed enhanced terminal voice switch (ETVS). The intrafacility intercom services they provide are fundamentally the same in each.

Virtually all intrafacility data communications occur at speeds of 64 Kbps or slower. Although planned, there are no general-purpose LANs in the air traffic data environment today. The result is that each local system must be directly connected to another system it shares information with. The addition of new automation software and hardware combined with the large number of protocols and interfaces required thus results in a complex and hard-to-maintain system. The physical accumulation of wiring in many sites also poses severe restraints on access and upgrades.

The administrative data environment is supported by the Office Automation Technology Services (OATS) contract, which provides modern personal computers and Ethernet LANs for all of its office facilities.

17.1.2.2 Intrafacility Communications System Evolution—Step 2 (2000–2004)

Existing data communications (such as weather) will be transitioned to IP-based communications protocols. Surveillance data will be converted into a common format, the All Purpose Structural EUROCONTROL Radar Information Exchange (ASTERIX), for transmission of data from radars to ARTCCs and TRACONs. IP multicasting capabilities will route data collected for one application (e.g., surveillance, WARP, and integrated terminal weather system (ITWS)) to other applications (e.g., those for air traffic management).

Some agency LANs and facility cabling may be incorporated in the integrated communications infrastructure, leaving existing LANs (i.e., HID, STARS) in place. Figure 17-4 provides an overview of the NAS intrafacility environment in this step.

Voice switches in this step will continue to provide their current intrafacility functions.

17.1.2.3 Intrafacility Communications System Evolution—Step 3 (2005–2015)

Edge switches will be deployed, intrafacility communications speeds will increase, and protocol standardization will be established in the LAN domain. Deployment of fewer, more versatile protocol stacks will reduce maintenance support and troubleshooting and improve interfacility and application-to-application communications. The telephony environment is expected to be integrated via a cell-based protocol running over the LAN; this opens the possibility of higher levels of integration (i.e., data, video, and voice). Currently, gigabit LANs are being developed by industry, and standards are being redefined.

The FAA will acquire a new generation of ATC voice switches to replace its aging and hard-to-maintain inventory. The next generation of digital switches will likely come in several sizes and will meet the requirements of the future ATC voice network. Voice switches will provide the in-

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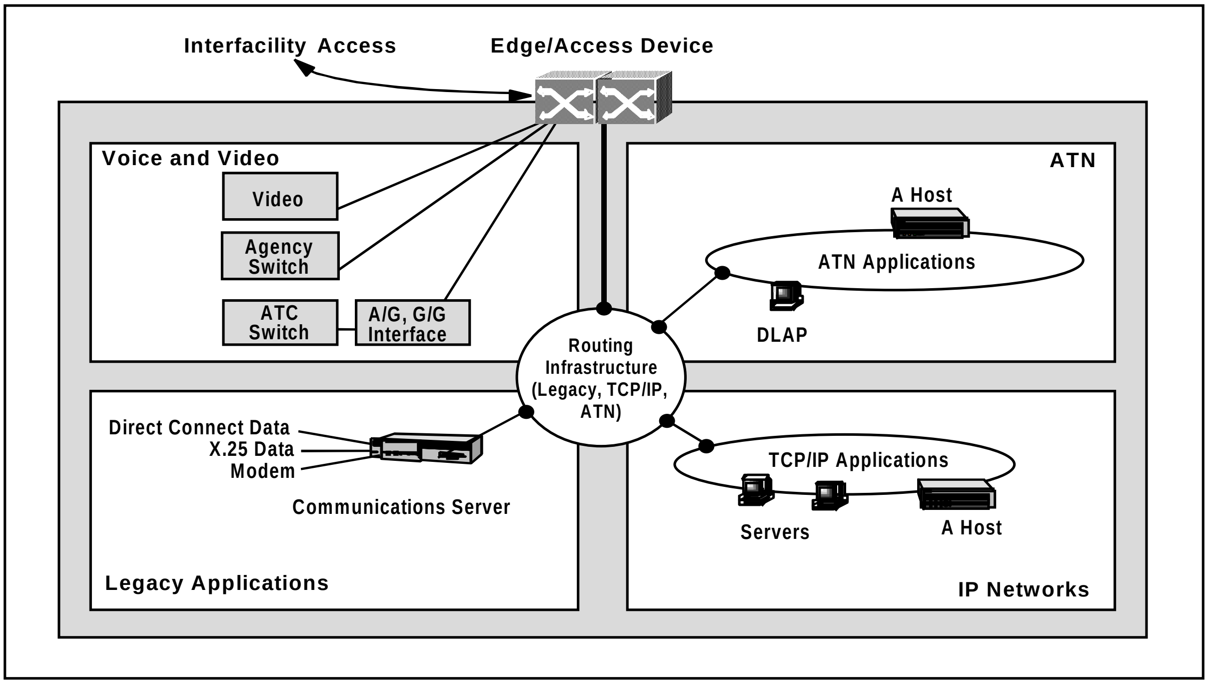

Figure 17-4. Intrafacility Architecture in 2004

trafacility functions required to support the new CONOPS.

Because of the high cost of customized switches, a number of smaller FAA facilities, both operational and administrative, might be economically served by off-site switching. Switches will be replaced as follows:

- ICSS, RDVS, and STVS will be replaced by the voice switch replacement system.
- ETVS will be gradually replaced by the voice switch replacement system.
- VSCS will be replaced after 10 years of service.

Figure 17-5 provides an overview of the NAS intrafacility environment in this step.

17.1.2.4 Intrafacility Communications Schedule

The transition to this new intrafacility environment is already in progress as evidenced by the deployment of the American National Standards Institute/Institute of Electrical and Electronics Engineers (ANSI/IEEE) 802.n-compliant HID NAS/LAN and the prototyping of various new IP/LAN-based applications. Figure 17-6 shows the intrafacility communications transition schedule. Under the current acquisition system, application development projects provide their own computer hardware and much of the required communications equipment. This has led to an array of communication equipment types, compounding facility infrastructure and maintenance problems. The new approach stipulates use of COTS equipment (clients, servers, LAN switches, network interface cards (NICs), routers, fax machines, etc.), and, in particular, protocol converters. The integrated telecommunications infrastructure will offer LAN equipment along with site installation and wiring assistance. EVCS will be decommissioned and incorporated into the follow-on integrated communications infrastructure.

17.1.3 Mobile Communications System

The mobile communications system consists of air-ground and ground-ground components. The air-ground component provides communications paths between controllers and pilots in both domestic and oceanic airspace. The ground-ground component (see Section 17.1.3.2) consists mainly of portable radios used by maintenance personnel.

17.1.3.1 Air-Ground Mobile Communications

Current NAS air-ground communications are provided by an analog system using HF, very high frequency (VHF), ultra high frequency (UHF), and satellite communications (SATCOM) radios.

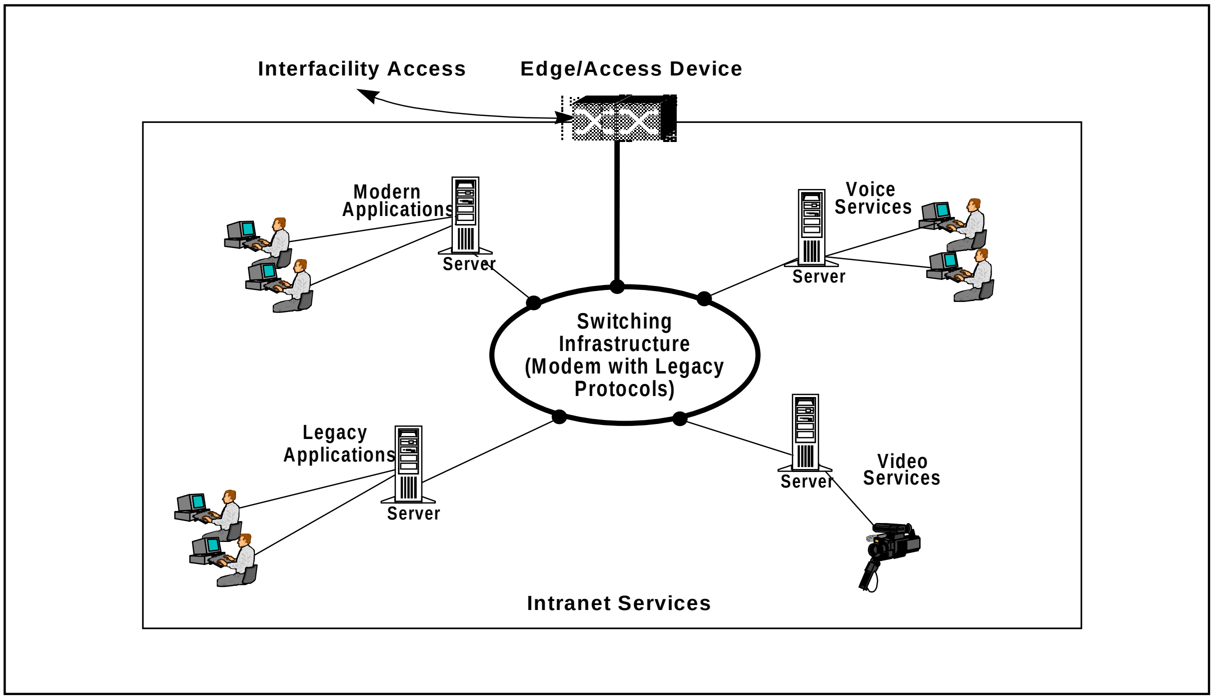

Figure 17-5. Intrafacility Architecture in 2010

Only limited data transmission capability exists in domestic airspace (predeparture clearance and digital air traffic information service) and in oceanic airspace (waypoint position reports via Future Air Navigation System (FANS)-1/A). As the NAS is modernized, however, this balance will shift toward ATN-compliant data communications and attention must be focused on the radios,

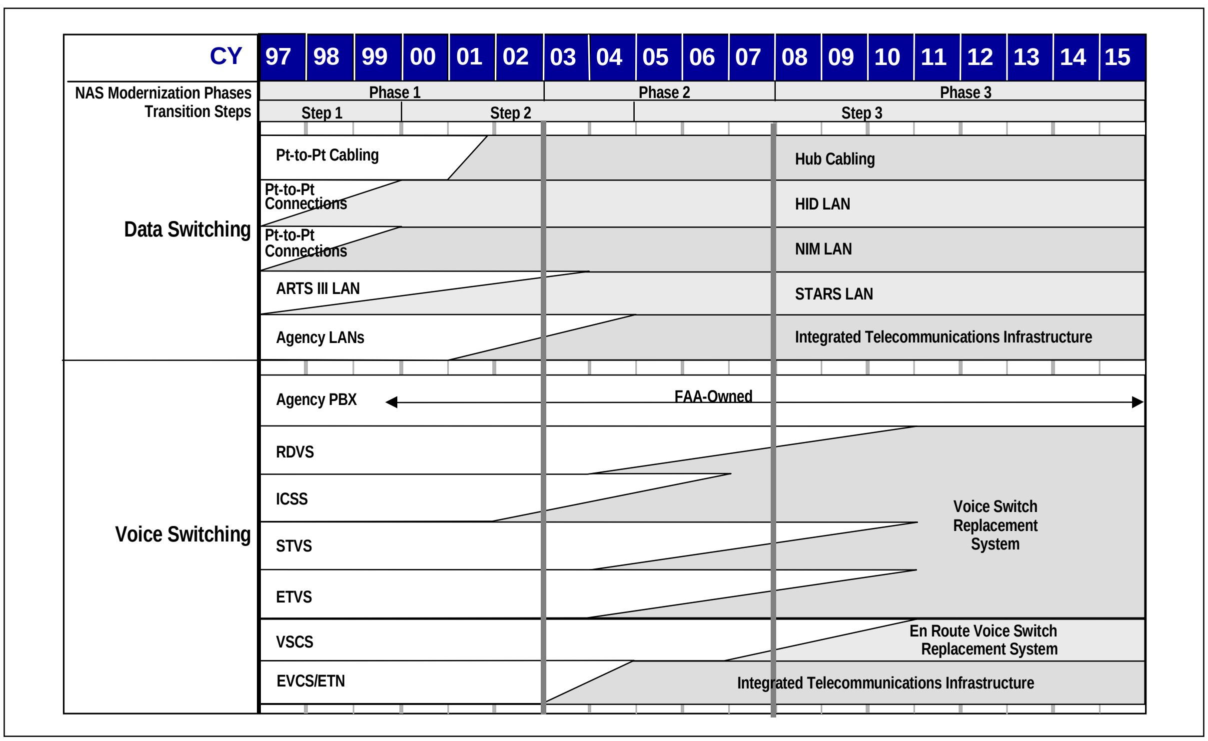

Figure 17-6. Intrafacility Communications Transition

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processors, and applications needed to support data transmission. A discussion of data link systems and services is found in Section 17.1.4. The various applications are covered in Section 21, En Route; Section 22, Oceanic and Offshore; Section 23, Terminal; and Section 24, Tower and Airport Surface.

In domestic airspace, voice communications for ATC operations are provided by VHF radios operating in the aeronautical mobile communications band (118-137 MHz) and UHF radios operating from 225 to 400 MHz. (UHF is used to communicate with military aircraft.) A 4-percent annual growth in VHF channel requirements over the past 20 years has used up most of the available channels. As a result, current requests for resectorization and new services are being denied in many cases, and certain services, such as weather advisories, are being limited in high-traffic density areas, such as Chicago.

For technical and economic reasons, a joint FAA and aviation industry decision was made to implement very high frequency digital link (VDL) Mode-3 domestically to solve these problems. As a result, the next-generation air-ground communications system (NEXCOM) will be an integrated voice and data system that uses the currently assigned 25 KHz VHF spectrum. This differs from the interim solution planned for European airspace, which subdivides the current 25 KHz spacing into 8.33 KHz channels.

In oceanic airspace, air traffic voice services are provided over HF radio using a communications service provider. The only currently available means by which to conduct oceanic data communications is SATCOM, but high frequency data link (HFDL) service is expected to provide a reliable, low-cost alternative.

Voice communications via HF radio are significantly influenced by atmospheric and solar disturbances. SATCOM voice communications are a reliable alternative but have high installation and transmission costs. Consequently, oceanic communications will evolve from relatively slow HF voice message contacts to short duration SATCOM data messages complemented by HFDL and HF voice. Voice will always be required for nonroutine oceanic communications. Satellite voice—currently being explored for emergency communications—may eventually play a larger role in other communications services.

17.1.3.1.1 Air-Ground Mobile Communications System Evolution—Step 1 (Current–1998)

At the center of air traffic communications is the VHF/UHF air-ground mobile voice communications system. This aging analog system has approximately 50,000 ground-based radios at nearly 4,000 sites. The radios operate in a simple push-to-talk mode, with the same frequency being used for both controller-to-pilot and pilot-to-controller transmissions. There is growing concern over the present VHF communications system because of increasing channel assignment requirements, low channel utilization, voice congestion on high-activity channels, moderate service availability, high failure rates (with older radios), susceptibility to channel blockage (“stuck mike” and “step-on”), increasing radio frequency interference, and lack of security.

In addition to VHF air-ground communications, other currently deployed systems include: Skylinks, which uses HF and satellite communications for oceanic voice and data; recovery communications used by site service technicians; tower data link services (TDLS); and the meteorological data collection and reporting system (MDCRS).

17.1.3.1.2 Air-Ground Mobile Communications System Evolution—Step 2 (1999–2005)

A new service provider network, VDL-2, will be used initially by one ARTCC to provide limited ATC data link service for en route airspace.

The existing domestic air-ground system (composed of VHF radios, backup emergency communications (BUECs), and radio control equipment (RCE)) will continue to provide voice communications during transition to the NEXCOM system. NEXCOM radios will be installed first in all high-altitude and super-high-altitude en route sectors. Initially, all multimode NEXCOM radios will operate in analog mode (i.e., emulate the current radios). En route sectors above Flight Level 240, however, will begin transition to digital voice mode operation near the end of this time period.

Oceanic communications will migrate from primary dependence on service provider HF voice to data link service via satellite and HFDL. HF voice and SATCOM voice will remain available for backup.

Figure 17-7 depicts the mobile communications system (including air-ground communications) as it will appear in this time period.

17.1.3.1.3 Air-Ground Mobile Communications System Evolution—Step 3 (2006–2010)

The ground network infrastructure needed to support data link services over NEXCOM, as appropriate, will be deployed for operation in the ARTCCs.

Most oceanic traffic will complete the transition to HFDL and satellite ATN-compliant data link communications in this time period. A dual protocol stack is planned to maintain compatibility with FANS-1/A-equipped aircraft in the ATN environment.

17.1.3.1.4 Air-Ground Mobile Communications System Evolution—Step 4 (2011–2015)

Selected high-density terminal airspace and the associated low en route sectors will transition to digital NEXCOM service in this period. Civilian aircraft flying instrument flight rules (IFR) in these areas will require NEXCOM radios. UHF radio service will continue until the DOD equips military aircraft with NEXCOM radios. As users equip with the avionics needed for data communications, data services will migrate from VDL Mode-2 to NEXCOM, and new data link services will be provided directly by the FAA. NEXCOM radios operating in analog voice mode will continue to replace legacy radios in order to sustain the overall air-ground system.

Service provider networks are expected to accommodate new data communications applications in domestic and oceanic airspace. For oceanic communications, satellites will be used increasingly for new applications as the cost of satellite services declines. A transition to domestic air-ground satellite service is dependent on performance, equipage, and competitive pricing for service.

Figure 17-8 depicts an overview of the mobile communications system as it will appear in this time period.

17.1.3.2 Ground-Ground Mobile Communications

Agency ground-ground mobile communications are modest but widespread. The FAA uses a large number of pagers, portable telephones, and modem-equipped laptop computers. The latter are

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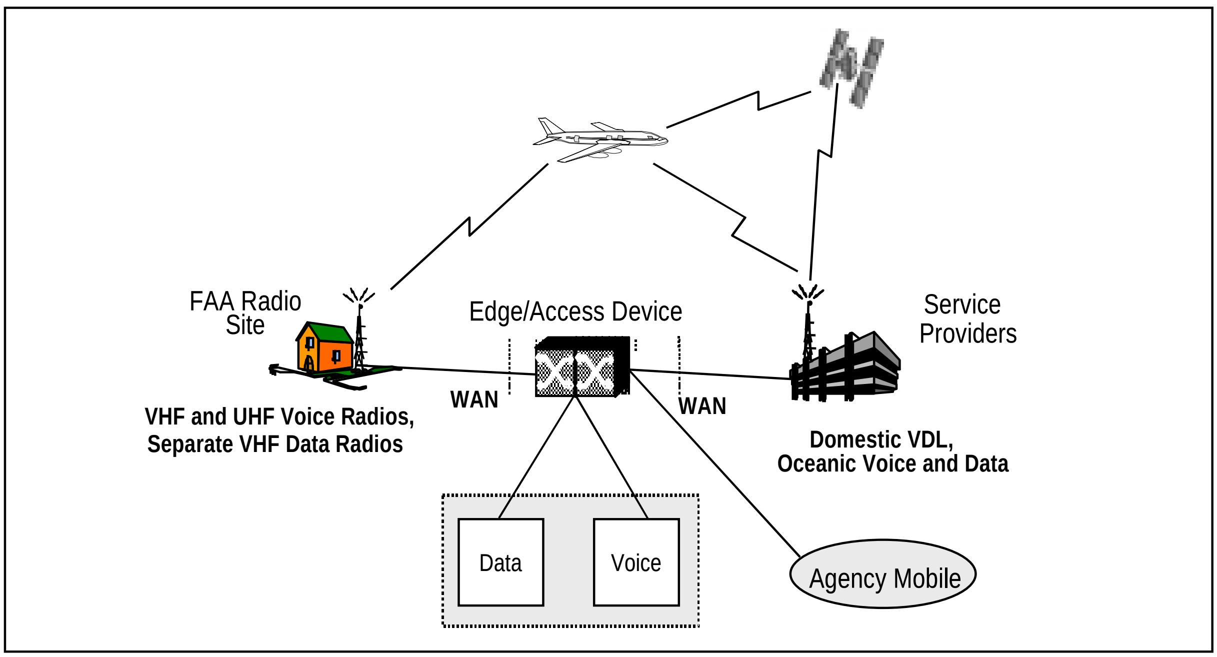

Figure 17-7. Mobile Communications Architecture in 2005

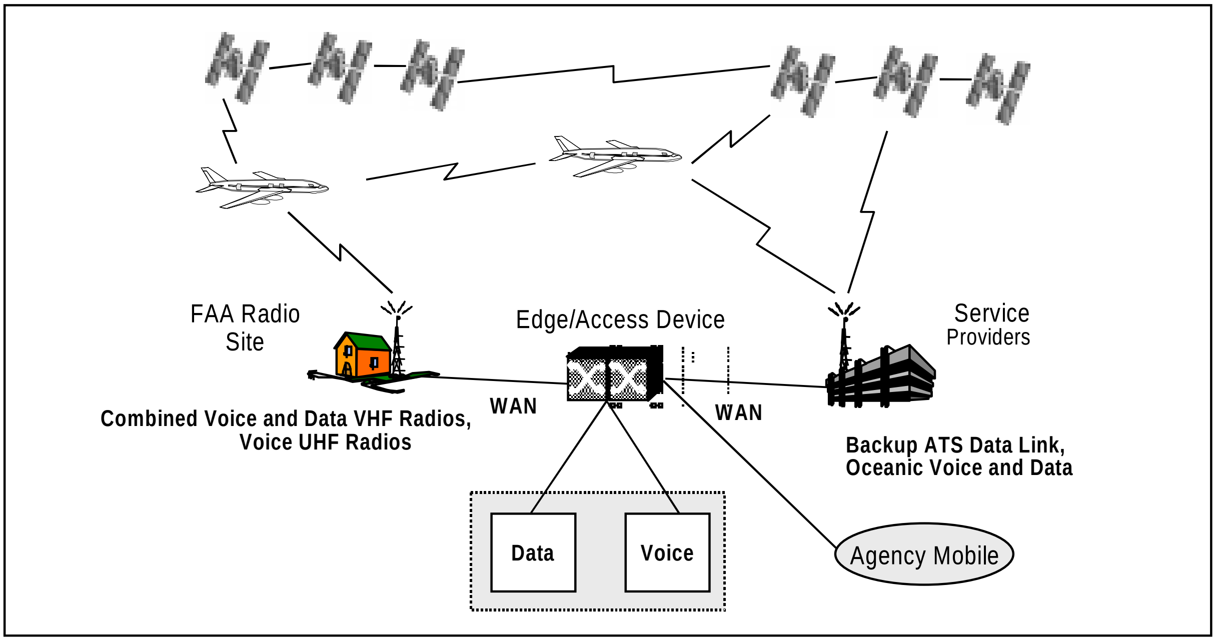

Figure 17-8. Mobile Communications Architecture in 2015

used to access data bases on departmental servers and to send and retrieve e-mail.

The present method of procuring mobile communications for maintenance and administrative use (e.g., pagers and mobile radios) is through the FTS 2000 contract. This same method will be used in the follow-on contract, FTS 2001.

17.1.3.3 Mobile Communications Schedule

The major events occurring during the mobile communications transition are shown in Figure 17-9.

17.1.4 Data Link Service

The purpose of data link applications is to facilitate exchange of ATC weather, flight service, and aeronautical information between aircraft and ground systems. Data link is expected to reduce congestion on voice channels; reduce misunderstanding of instructions and information; reduce the need for transcribing messages by air crews; reduce the workload of FAA ground personnel, such as air traffic controllers and flight service specialists; and facilitate CDM. The aviation user community—through forums such as RTCA Task Force 3 and the Free Flight Select Committee—has stated a firm need for data link in order to achieve operational benefits.

Data link includes the computer-human interface (CHI) for pilots and controllers, applications software in cockpit avionics and ground automation systems, the data link applications processor, and the communications infrastructure (air-ground, airborne, and ground communication systems). The previous section, 17.1.3, describes the air-ground transmission system that will be used for data link. This section, along with the automation sections, describes the applications software. See Section 19, NAS Information Architecture and Services for Collaboration and Information Sharing; Section 20, Traffic Flow Management; Section 21, En Route; Section 22, Oceanic and Offshore; Section 23, Terminal; Section 24, Tower and Airport Surface; Section 25, Flight Services; and Section 26, Aviation Weather.

A number of data link applications will use ATN to provide global, seamless, secure, and error-free communications between air- and ground-based systems. ATN will use multiple subnetworks (i.e., VDL, HFDL, and SATCOM) to provide this service.

17.1.4.1 Data Link Service Description

Data link services will be implemented in stages to facilitate phased delivery of user benefits. The stages also allow familiarization with the new technology and orderly integration with the NAS

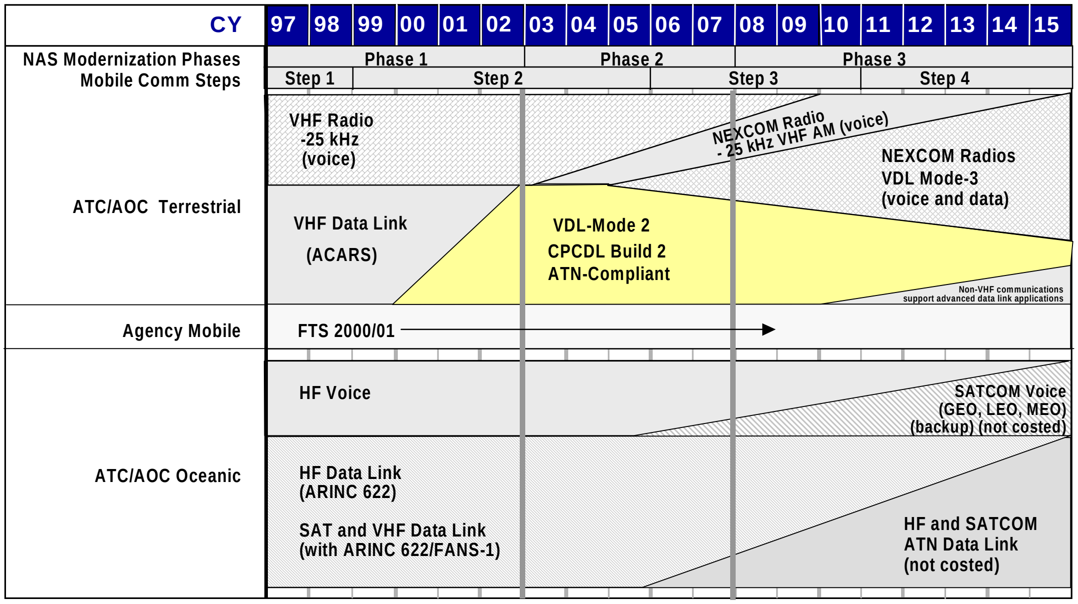

Figure 17-9. Mobile Communications Transition

telecommunications and automation infrastructures. Initial services will provide a foundation for more advanced services and will evolve from computer-to-human information transfer to include computer-to-computer information transfer.

Data link will provide three major evolutionary capabilities:

- Services that support communications between pilots and controllers
- Ground-based services that provide relevant information to pilots
- Decision support services that support coordination among flight decks, airline operations centers (AOCs), and air traffic management services for efficient flight management.

The data link section discusses services in the following order:

- Controller-Pilot Communications and Air Traffic Services:
  - – Tower Data Link Services (TDLS)
  - – Data Delivery of Taxi Clearance (DDTC)
  - – Controller-Pilot Data Link Communications (CPDLC)
  - – Oceanic Two-Way Data Link Communications (TWDL) Services
- Flight Information Services:
  - – Flight Information Service (FIS)
  - – Meteorological Data Collection and Reporting System (MDCRS)
  - – Terminal Weather Information for Pilots (TWIP)
  - – Traffic Information Service (TIS)
- Decision Support System (DSS) Services.

17.1.4.1.1 Controller-Pilot Communications and Air Traffic Service

CPDLC is a means to provide ATS data services, which are currently voice-oriented, and to transition some of these services to data link. The earliest stage of data link is currently in operation and supports communications such as predeparture clearances (PDCs) and digital automated terminal information services (D-ATIS). A data delivery of taxi clearance service is being tested as a prototype capability at the Detroit Tower. In oceanic airspace, FANS-1/A-equipped aircraft use data link service via SATCOM to exchange all types of ATC messages, including automatic dependent surveillance addressed (ADS-A).

Tower Data Link Service. The TDLS system automates tower-generated information for transmission to aircraft via data link. TDLS interfaces

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with sources of local weather data and flight data and provides PDC and D-ATIS. PDC helps tower clearance delivery specialists compose and deliver departure clearances. The clearances are then transmitted in text form via the Aircraft Communication and Reporting System (ACARS) to an ACARS-equipped aircraft for review and acknowledgment by the flight crew. The D-ATIS application also enables controllers to formulate D-ATIS text messages for delivery. The ATIS text messages are then delivered to flight crews via ACARS data link. An ATIS automatic voice-generation function produces spoken broadcasts using a synthesized voice to read the ATIS message.

Data Delivery of Taxi Clearance. DDTC is being implemented as a prototype capability at the Detroit Tower for operational assessment by the FAA. DDTC, like PDC, reduces both the delay in communicating the clearance information as well as any inaccuracies inherent in voice communications. The DDTC service will also use ACARS and, based on results, may be expanded to other TDLS locations.

Controller-Pilot Data Link Communication. CPDLC will be implemented first in the en route environment in a four-step process to introduce early benefits to NAS users while minimizing technical and procedural risks during development of the ATN-compliant system. Each of these steps is associated with specific automation software development and implementation activities (e.g., host computer software releases, DSR implementation and upgrades, and data link applications processor (DLAP) implementation).

Oceanic Two-Way Data Link Service. FANS-1/A avionics enables Boeing and Airbus aircraft to conduct TWDL. FANS-1/A-equipped aircraft will have automatic dependent surveillance (ADS) capability in FAA-controlled Pacific Ocean airspace. Oceanic data link services will evolve to ICAO-ATN-compliant communication services and applications over an extended transition period of accommodation for both FANS-1/A- and ATN-equipped users.

17.1.4.1.2 Flight Information Services

Flight Information Service. FIS will be provided to the cockpit by data link in the future. FIS information is defined as noncontrol advisory information needed by pilots to operate more safely and efficiently in both domestic and international airspace. FIS includes information necessary for continued safe flight and for flight planning, whether in the air or on the ground.

The rationale for providing FIS to the cockpit via data link is to improve safety, increase NAS utility, efficiency, and capacity and reduce costs to the user and the FAA. FIS is intended to complement, not replace, existing voice communications. Initial FIS products for delivery to the cockpit include information on NAS status (e.g., notices to airmen (NOTAMs) and special use airspace (SUA)) and meteorological information in text and graphic formats.

FIS depends on both public and private enterprise to provide affordable FIS products. To ensure services are developed and provided to the cockpit, the FAA will use private sector FIS wherever possible to bring services and products to the marketplace quickly and efficiently. The FAA will make NAS status and existing weather data available to private data link service providers for the development of FIS products. Commercial providers may make basic FIS products available, at no cost to the government or the user, and may make “value-added” products available for a fee. Such products are likely to include graphical/textual weather dissemination, first as a broadcast service, then as request-reply. Enhanced FIS, the final system, is likely to offer a mix of both government- and private sector-provided services.

Meteorological Data Collection and Reporting System. A number of today’s aircraft measure wind, temperature, humidity, and turbulence information in-flight and automatically relay the information to a commercial service provider. The service provider collects and reformats the information into MDCRS format and forwards it to the National Weather Service (NWS). The NWS uses this information and weather data from other sources to generate gridded weather forecasts. The forecasts are distributed to airlines and the FAA to help plan flight operations. The NWS gridded weather forecasts generated based on MDCRS will also be provided to WARP for use by meteorologists and to be forwarded to other automation systems and tools, such as the User Request Evaluation Tool (URET). ITWS will combine MDCRS with other terminal area weather information to create a high temporal, high horizontal resolution (5 minute/2 km) terminal area wind forecast.

Terminal Weather Information for Pilots. TWIP uses information from the terminal Doppler weather radar (TDWR) to provide near real-time aviation-tailored airport windshear and micro-burst information to pilots in the form of text and character graphic messages over ACARS. The future transition of TWIP to ITWS will improve the accuracy of weather information to the cockpit. TWIP functionality will be incorporated into the airport surveillance radar-weather system processor (ASR-WSP) system, thereby extending windshear coverage. By expanding the choices of delivery mechanisms, it may be possible to extend this capability to a broader community of users.

Traffic Information Service. The TIS application is being fielded currently at 119 sites nationwide. Using the Mode-S data link, a TIS ground processor uplinks surveillance information generated by a Mode-S sensor to properly equipped aircraft. The aircraft TIS processor receives the data and displays the data on the TIS display, providing increased situational awareness and an enhanced "see-and-avoid" capability for pilots.

17.1.4.1.3 Decision Support System Services

The most advanced set of capabilities will come from the interaction of air and ground DSSs. These expanded data link services are required to integrate flight deck systems, such as flight management systems (FMSs) with advanced ATM capabilities. The automated downlink of information, such as aircraft position, velocity, intent, and performance data from flight management systems to ground-based DSSs, will improve trajectory prediction and increase the accuracy of these systems.

17.1.4.2 Data Link Service Evolution (2000–2008 and Beyond)

Initial data link services only involve information to aircraft and require no reply from the flight deck. The next stage of evolution adds controller-pilot dialogue capability to communicate strategic and tactical air traffic services messages that are currently conveyed by voice. This will be augmented with request-reply functionality, which is initiated by the flight deck. In this case, a ground-based processor receives a downlinked request from the flight deck, compiles the requested information, and uplinks it to the aircraft for display. Next, data link will facilitate an automated downlink of weather and aircraft state-and-intent information to improve the prediction capabilities of decision support and weather systems. Finally, data link will facilitate a more extensive use of user-preferred trajectories through the negotiation of conflict-free trajectories between the flight deck and ATC service providers.

Data Link Architecture Evolution

Step 1 (1999-2002). CPDLC Build 1 will introduce an initial ATN-compliant CPDLC data link capability at one key site—the Miami ARTCC—for four selected messages over the VDL Mode-2 network. Four selected message types are potential candidates for this: transfer of communications (TOC), initial contact (IC), altimeter setting message (ASM), and predefined messages (PDM). The TOC will be the first message type to be tested. This leverages planned avionics upgrades by the airlines to equip with VDL Mode-2 for AOC communications and to participate in ATN data link trials in Europe. This approach should ensure a reasonable population of suitably equipped aircraft for initial operation and evaluation. This key site evaluation will determine operational utility and whether users benefits are sufficient to warrant further development. It will mitigate risks by deploying an operational tool to evaluate system performance, training procedures, and human factors requirements and solutions.

A multisector oceanic data link (ODL) that uses satellite communications is being installed to provide a reliable data communications link between pilots and controllers for FANS-1/A-equipped aircraft. This data communications consists of internationally standardized CPDLC messages for routine air traffic control and free text messages (see Section 22, Oceanic and Offshore).

Initial flight information services, such as weather to the cockpit, are currently available via a service provider. TIS, via Mode-S data link, are being fielded at selected sites nationwide.

Step 2 (2002-2004). CPDLC Build 1A expands the message set from 4 to 18 operational messages, including pilot-initiated downlink messages. This build will continue to use VDL Mode-2 technology. Minor changes to the en route automation system (i.e., Host/oceanic computer system replacement (HOCSR)) and DLAP are required, but no upgrades are needed for the avionics. Expansion will take place center by center to ensure an orderly transition to nationwide implementation. Throughout this process, the results of the U.S and EUROCONTROL projects will be used to refine the cockpit and controller human factors and refine the message set for CPDLC Build 2; this will provide a set of messages with the most value to pilots and controllers.

During this time frame, ADS-A will provide surveillance of intercontinental flights in oceanic airspace through satellite data link. ADS-A will allow automated position reports and intent information to be periodically sent from the aircraft FMS to ground controllers via data link. This represents a significant improvement over manual voice reporting. The ground controller establishes the frequency of reports with the FMS and sets the event threshold for conformance monitoring. The FMS automatically transmits any deviations from assigned altitude or course. Additional information is included in Section 22, Oceanic and Offshore.

Step 3 (2004-2006). CPDLC Build 2 via VDL Mode-2 expands the message set from 18 to more than 100 operational messages. DSR will require changes to make the CHI suitable for the expanded message set. En route automation changes will also be required.

Step 4 (2007–2015). CPDLC Build 2 will transition from VDL Mode-2 to the FAA-owned NEXCOM air-ground communication network that uses VDL Mode-3 technology. VDL Mode-2 will continue to be available via a service provider for AOC use. Later in the step, CPDLC Build 3 will be implemented over the NEXCOM air-ground communications network. Build 3 will provide the full ICAO-ATN-compliant message set for both the en route and the high-density terminal domains. Compared to VDL Mode-2, NEXCOM will have greater capacity and will provide message prioritization that meets operational requirements associated with the full ATN-compliant message set. NEXCOM will also satisfy communications performance requirements needed for decision support services.

NAS-wide data link services will be available from a combination of service providers and the FAA. It will include the full CPDLC message set and expanded FIS and TIS.

17.2 Summary of Capabilities

Today's air-ground radio system was designed for analog voice but has been adapted to provide limited data exchange capability. Currently, predeparture clearances and D-ATIS are being provided at 57 airports using ACARS, a VHF service provider system operating at 2400 bps. The meteorological data collection and reporting system services also use ACARS, which transmits in-flight weather observations to the NWS. Taxi clearances over ACARS were demonstrated in 1997, and a nationwide implementation of this system is planned.

Selected non-time-critical CPDLC messages for transfer of control using ATN-compliant protocols over VDL-2 will be implemented first at a key site. Coverage will be expanded nationwide using a larger message set. NEXCOM will be introduced in three steps beginning with digital voice for en route communications, followed by en route data link communications and then expanding NEXCOM service to the busiest terminal areas. All aircraft with the exception of military aircraft will require NEXCOM radios to operate in selected airspace at that time.

FANS-1/A TWDL will become operational in 1998. HF voice, HFDL, and satellite communications will all be available in the oceanic environment for many years.

Figure 17-10 shows data link evolution beginning with existing operational and prototype services.

17.3 Transition

The key communications transitions appear in Figures 17-3, 17-6, and 17-9.

17.4 Costs

The FAA estimates for research, engineering, and development (R,E&D); facilities and equipment

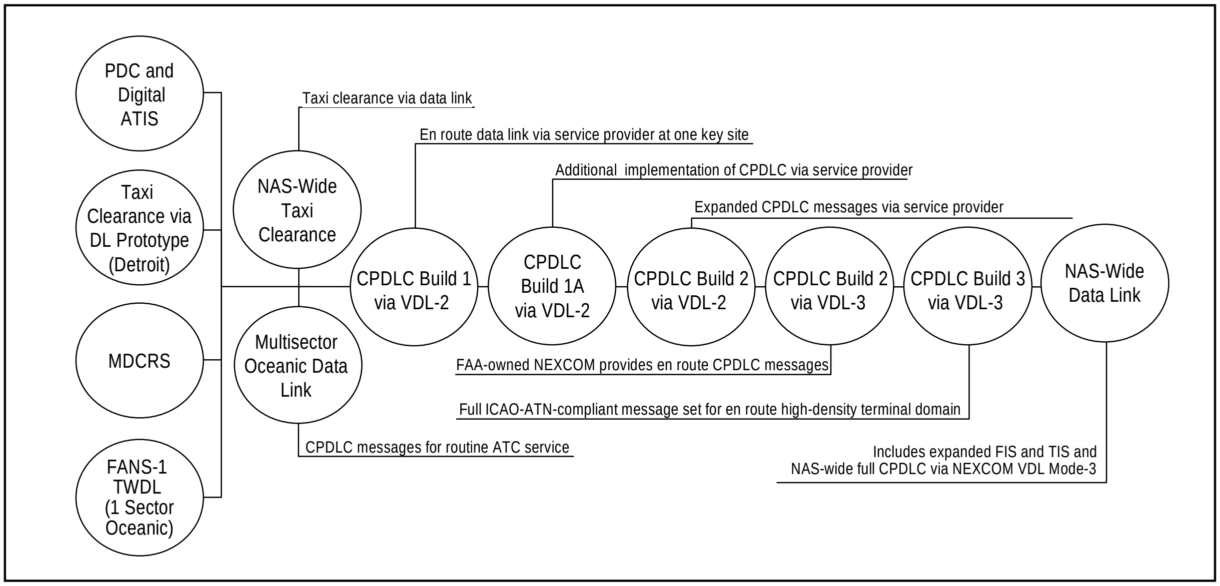

Figure 17-10. Data Link Services Capabilities Summary

(F&E); and operations (OPS) life-cycle costs for the communications and data link architecture from 1998 through 2015 are presented in constant FY98 dollars in Figure 17-11.

17.5 Watch Items

The most significant implementation factor in modernizing FAA communications and migrating to Free Flight will be the transition to NEXCOM radios and specification of minimum avionics equipage for all en route and high-density terminal areas. The FAA needs to work through appropriate government and industry forums to develop proposed rulemaking for NEXCOM equipage.

The cost for data link messages needs to be addressed so that the additional cost does not deter users from equipping with the avionics necessary to use the capability.

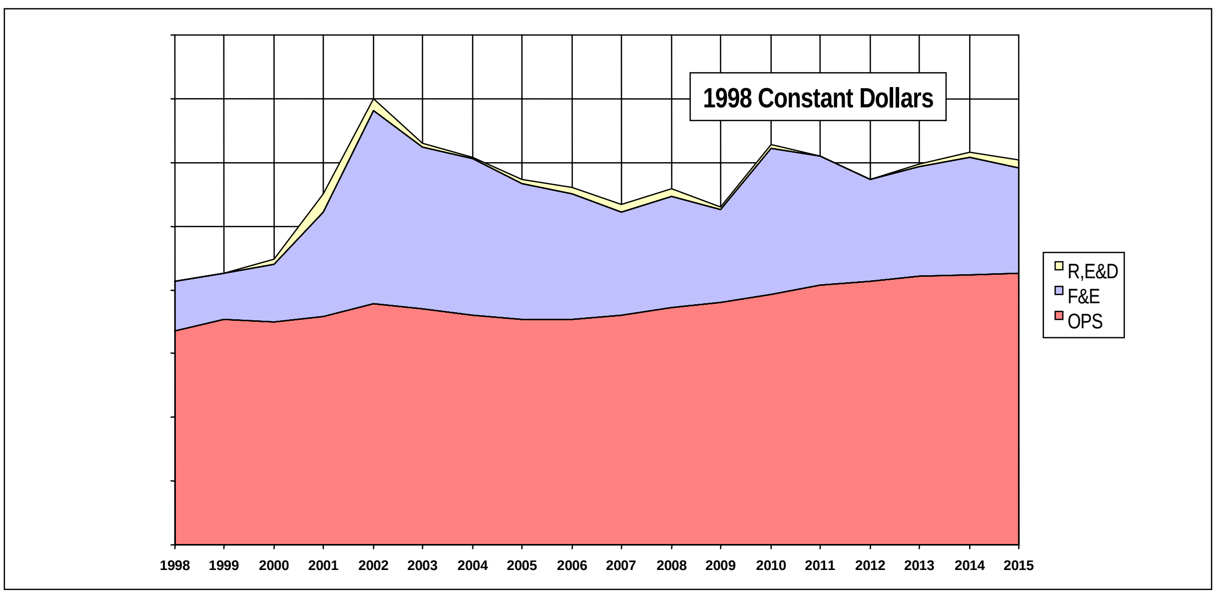

Figure 17-11. Estimated Interfacility Communications and Data Link Costs