

The Many Faces of Air-Ground Data Link

It is widely recognized that data link or digital communication for air-ground communications is the cornerstone of the 21st century aviation system. What is less certain is which data link. Data link is a generic term for a communications technique that has many different forms, protocols and applications. Having a single name – data link for these multiple alternatives affects the investment decisions of the aviation industry. The barrier to rapid implementation of CNS/ATM is the difficulty in charting the best way forward when competing alternatives allow different technical solutions. In some cases we are faced with the traditional aviation industry dilemma of choosing between what exists today and that tantalizing prospect of what better alternatives may exist tomorrow. The purpose of this paper is to provide information on data link alternatives to assist the aviation community in creating a global, seamless infrastructure.

1.0 Data Link Defined

1.1 Data Link Connects End Systems

What is data link? This question is not as simple as it may first seem. As shown in Figure 1, data link is the actual connection between an end system aboard one aircraft and an end system located on the ground, onboard another aircraft, or both. The data link is the communications media (or pipe) that transfer the message content between information applications that are operating in the end systems. The end systems and the information applications use the data link to exchange information. Therefore, the end systems and the applications are independent of the data link in use. Today private Data Link Service Providers (DSPs) use a variety of different air-to-ground data links (VHF, HF and satellite) as well as an operations center and terrestrial data link network (ground-to-ground) to provide a high reliability, availability and integrity message service that ensures the end-to-end delivery of the information (or content application) being transferred between end systems. The original ARINC Communications and Reporting System message service has evolved over the past two decades to the generic Aircraft Communications and Reporting System or ACARS.

DSPs provide a variety of air-to-ground data links operating in different frequency bands to ensure continuous coverage in a cost-effective manner on a global basis. VHF data links are the most commonly used civil aviation data links today. VHF data links are economical to implement and provide excellent operational performance (e.g., fast response times (2 to 8 seconds)), but are limited to line of site coverage. This means a nominal range of about 240 NM at 30,000 feet and this range limit will apply to any VHF-based data link. Existing satellite data links can provide global coverage but the current implementation provides no coverage in the polar regions north or south of about 80 Degrees of latitude. Satellite data links are more expensive per message transmitted and also slower than VHF in response time (12 to 25 seconds). HF data link, as implemented, provides near global coverage including over the northern Polar Regions. HF is an economic alternative to satellite data link for wide area coverage, but its message transit time (80 seconds) is slower than satellite.

(Note: Message delivery times are measured on the basis of a successful delivery of an uplink from the time the message is sent until a acknowledgement is received from the aircraft. This

includes any required retransmission of the messages. Delivery is affected by data rate, transmission media, protocol and retransmission timers that ensure reliability and integrity of the message.)

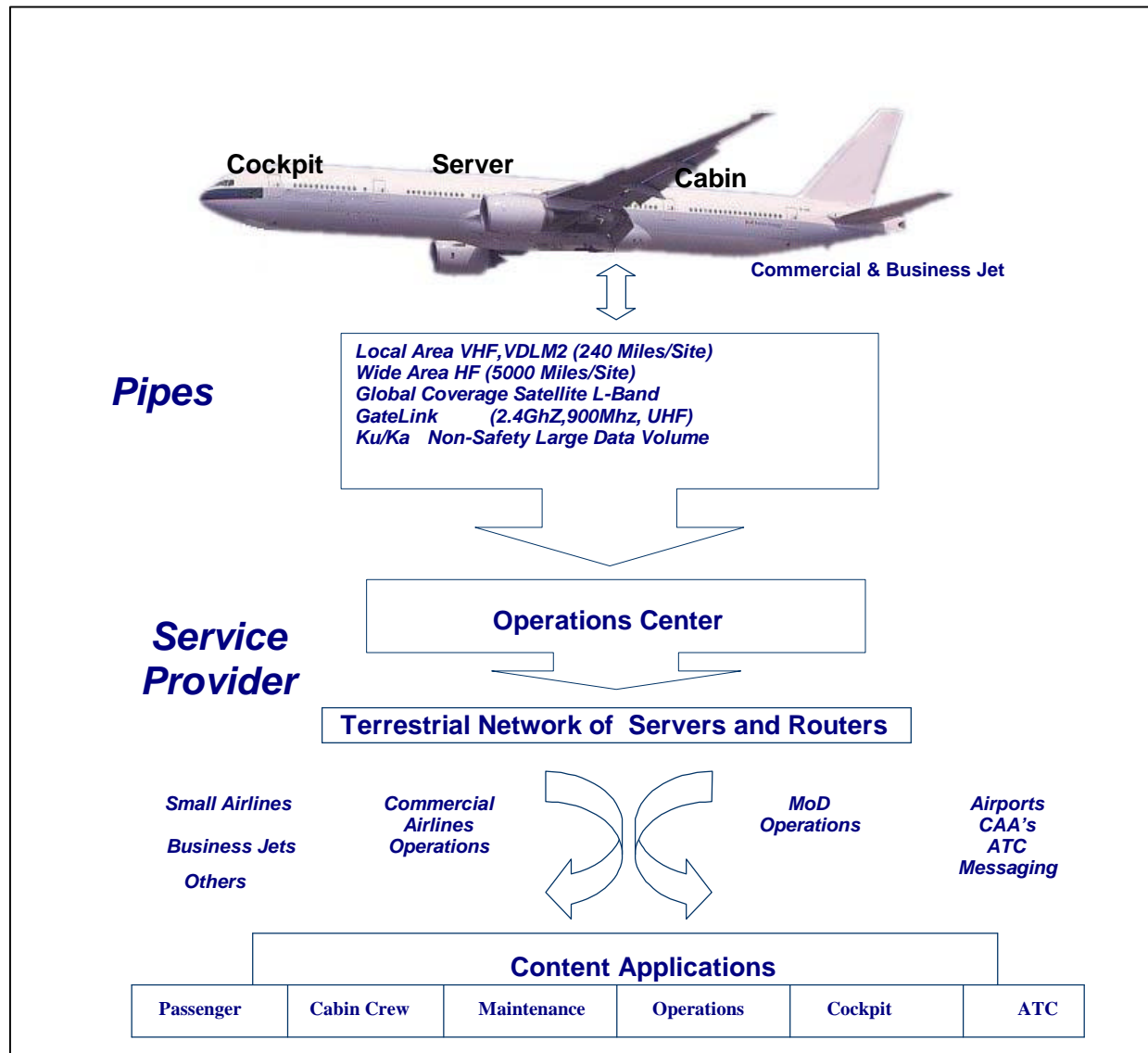


Figure 1: Data Link Connects End Systems to Transfer Content Applications

Existing operational air-ground data links include low-speed VHF (2.4 kbps), high-speed VHF (31.5 kbps) known as VDLM2 (VHF Digital Link Mode 2), satellite data link, HF data link and Mode S data link. VHF, VDLM2, Satellite and HF data links can transfer character-oriented ACARS messages and bit-oriented FANS messages between appropriately equipped aircraft and end systems. VDLM2, Mode S and satellite data link can also transfer messages that use the Aeronautical Telecommunications Network (ATN) to communicate with appropriately equipped aircraft.

VHF, VDLM2, HF, satellite and Mode S data links are operational data links. Other data links that have been demonstrated include VDL Mode 4 (VDLM4), Universal Access Transceiver (UAT) and VDL Mode 3 (VDLM3). VDLM4 and UAT, if implemented, will require both new avionics and new antennas for the aircraft.

1.2 Value is in Content Applications

Figure 2 expands the content applications presented in Figure 1. There are six classes of content applications that range from passenger to ATC. Within these classes the applications can be further subdivided into functions or services.

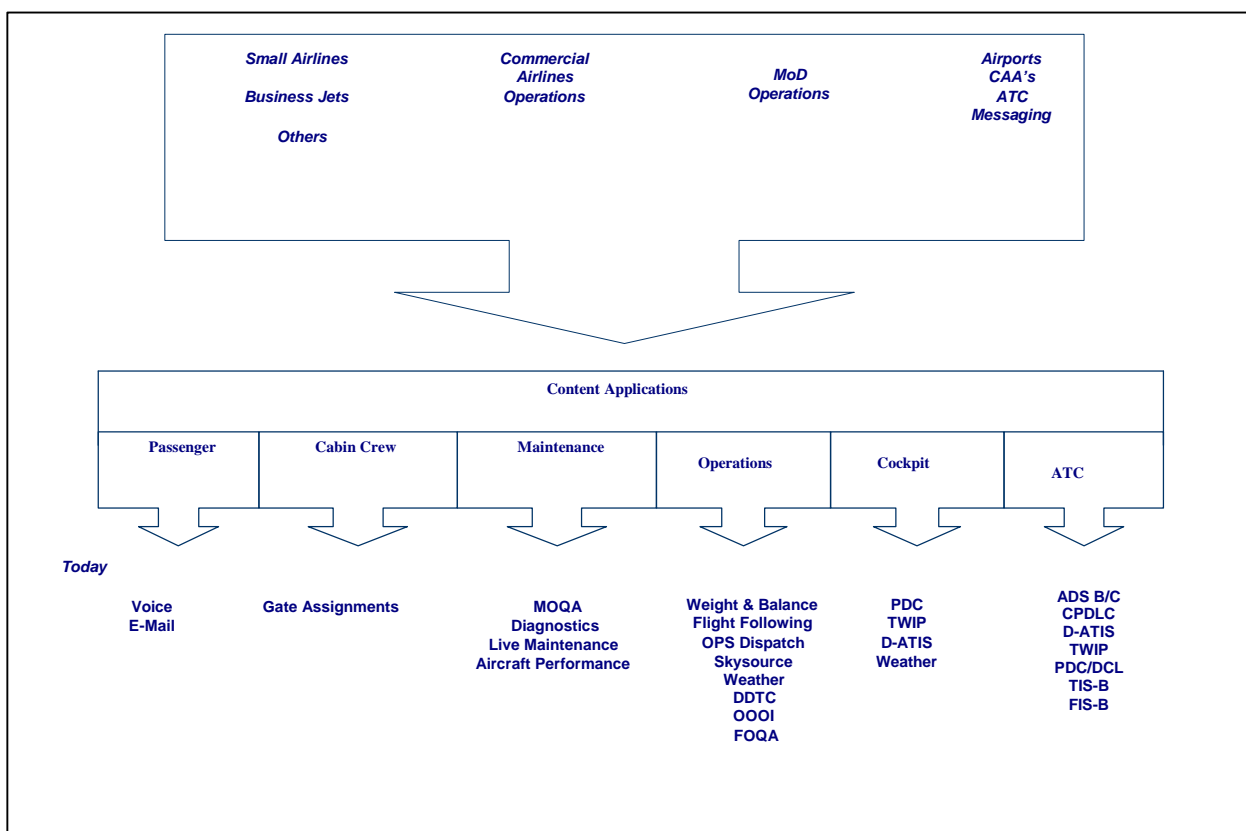


Figure 2: Content Applications are a Variety of Functions and Services

As stated earlier the content applications should be considered independently of the data link to be used. This is particularly important because while many applications can be transmitted over a variety of data links, other applications require the use of a specific data link communications technology. As an example Controller Pilot Data Link Communications (CPDLC) requires an addressable data link as found in current VHF, VDLM2, HF and satellite data links, whereas Automatic Dependent Surveillance Broadcast or ADS-B requires a different technique not suitable for discrete applications such as CPDLC. This means that a State that wants to provide ATC service through data link using CPDLC and ADS-B functions may require two different data links. Whereas a State that wanted to provide ATC service through CPDLC and ADS-

contract could do so with a single data link. Conversely, some on-board parameters used for ATM improvement may be transferred through an addressable or broadcast data link.

The relationship of application to data link has a cost impact to both provider and user especially when it requires multiple, independent systems to meet diverse requirements.

1.3 Aviation Communications Message Service

The third important point in implementing data link is the message service. The data link is the transmission media, the content application is the function or message transferred over the data link and the message service organization is responsible for the reliability of the transmission media and the integrity of the message. The aviation communications message service organization has become known as the Data Link Service Provider or DSP. The DSP is expected to create and manage the multiple data links that transmit a variety of messages related to specific applications. Enabled by data link communications, it is the applications that produce the beneficial outcomes for the aircraft operators. Each application has specific performance requirements (e.g., reliability, delivery times and message integrity) that must be met.

Message service capacity performance is dependent upon the individual architecture implemented by the DSP.

2.0 Air-Ground Data Link for Air Traffic Service

Air-Ground data link for Air Traffic Service may be divided into four (4) broad categories:

- 1) Addressable in that the data link addresses a single aircraft/ground unit similar to a cell phone,
- 2) Broadcast in that the data link broadcasts to multiple aircraft/ground units similar to a radio station,
- 3) Actual in that the data link exists in operational service, and
- 4) Potential in that the data link is experimental or theoretical.

The first two categories, addressable and broadcast, apply to the functional use of data link and the content applications that are proposed. This may be restated as ...for what purpose will the data link be used?

The third and fourth categories, actual and potential, address the operational implementation questions of cost, schedule and expected return on investment.

2.1 Functional Use of Data Link

2.1.1 Addressable Data Link

Addressable data link is an inquiry /response system much like a cellular telephone connection between two individuals. Except in aviation it is communication between an individual aircraft

and an individual ground system. Addressable data link became operational for civil aviation in 1978 when ARINC began offering Aeronautical Operational Communications (AOC) for OUT, OFF, ON, IN (OOOI) content application. The AOC content applications continued to grow over the years until gradually the ACARS message service has nearly eliminated voice communications for AOC as shown in Figure 3.

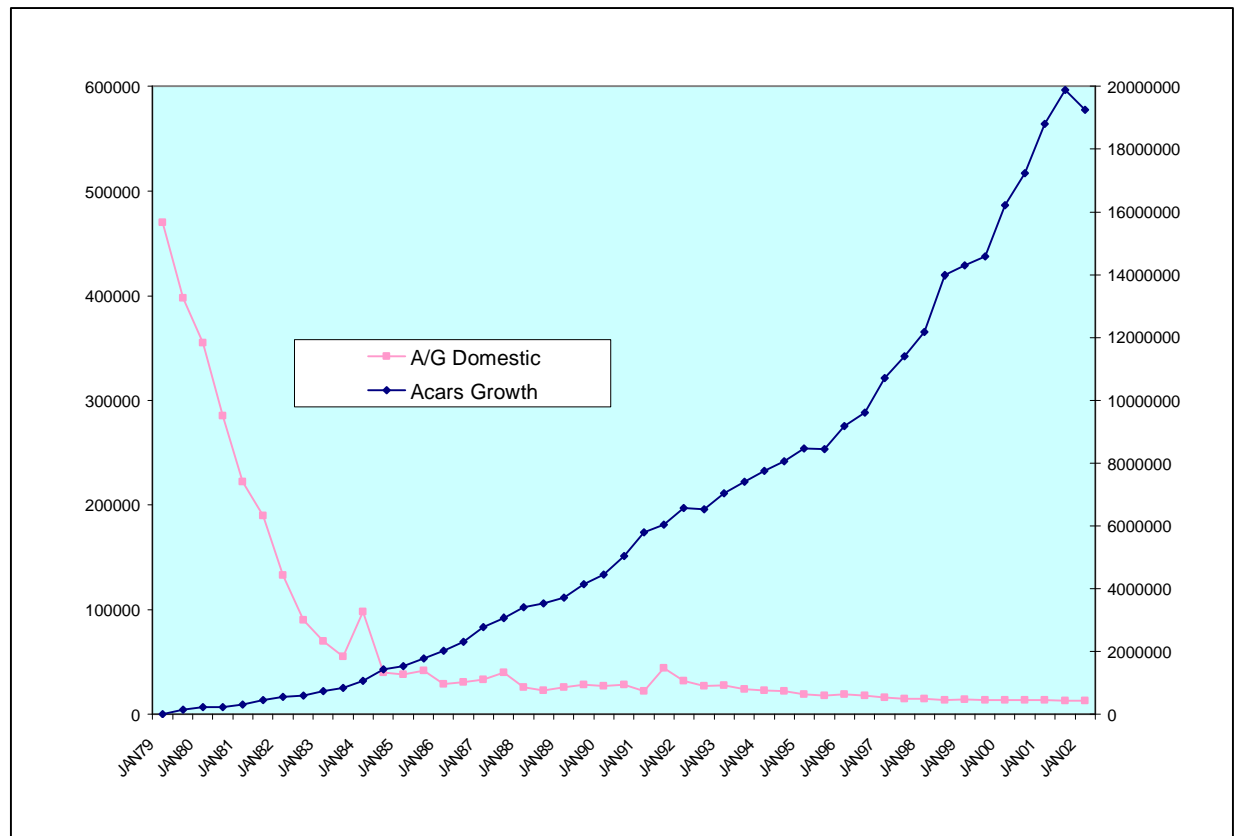


Figure 3: Data link has grown in preference to AOC voice throughout the past 24 years

Air Traffic Service began using the ACARS Message Service addressable data link for Predeparture Clearance (PDC) in 1991. This was followed by satellite/ACARS data link communications in March 1992 when satellite data link received operational approval to pass waypoint position reports to air traffic control.

In July 1995 FANS 1 was approved for air traffic purposes with air-to-ground VHF and satellite data links. FANS 1/A provides Controller Pilot Data Link Communications (CPDLC), Automatic Dependent Surveillance (ADS) and Airways Facilities Notification (AFN) to air traffic service. CPDLC will always be an addressable ATS content application, ADS may be addressable or broadcast, and AFN will be addressable.

2.1.2 Broadcast Data Link

Broadcast data link allows all receivers within range and on frequency to receive the messages from a transmitter. The broadcaster may or may not have knowledge of the users receiving the message or what information utility the receiver will take from the message. Whereas addressable data link acts like a cellular telephone connection between two entities, broadcast data link acts like a radio station where all entities monitoring the frequency receive the information being broadcast.

Mode S Broadcast (Squitter) is currently used in air-to-air Airborne Collision Avoidance Systems (ACAS) as a means of establishing selective interrogation.

Currently there are three additional broadcast applications proposed for aviation: Automatic Dependent Surveillance-Broadcast (ADS-B), Flight Information Service-Broadcast (FIS-B) and Traffic Information Service-Broadcast (TIS-B).

ADS-B is an application on an aircraft or surface vehicle that uses vehicle established data to periodically broadcast horizontal and vertical position as well as horizontal and vertical velocity along with possible other information. ADS-B is proposed to support both improved use of airspace and surface surveillance.

FIS-B broadcasts flight service information from the ground to the aircraft. Potential information includes NOTAMs, weather text, graphical weather and terminal information. FIS-B information is normally generated external to the aircraft or surface vehicle and broadcasting station. It would be expected to have less demanding performance requirements as compared to ADS-B. FIS-B weather information is currently being broadcast in the United States over a VDL M2 data link system operated by Honeywell.

TIS-B is proposed to broadcast surveillance reports that are collected by a ground-based systems to participating aircraft for use as cockpit display of traffic information or other more advanced applications

It should be noted that as of the 2nd quarter 2002, ADS-B and TIS-B air/ground broadcast data link functions are at various stages of development and that there are multiple candidate data links for broadcast applications. An ADS-B operational broadcast data link architecture has not been established nor have broadcast functions been stress-tested under high-density operational conditions of a high number of equipped vehicles. A major issue in broadcast data link is how many participants can be on a single frequency.

Notable broadcast data link trials include North European ADS-B Network (NEAN) in northern Europe during 1996 –1998, the European NEAN Update Program (NUP) started in 1999, the Mediterranean Upgrade Program (MEDUP) started in 2000, Performance Experiments in Germany on ADS-B using Mode S Extended Squitter (PEGASUS) during 2000-2001, CAPSTONE in Alaska that started in 1999 and is continuing, and the Ohio Valley Trials in the United States that also started in 1999 and are continuing.

2.2 Operational Implementation of Data Link

2.2.1 Operational Data Links

Table 1 presents the multiple data links in operational use for civil aviation for AOC and ATS content applications on a global basis and with multiple service providers. The importance of existing data links is they are in operational service for AOC and ATS applications. The data link capabilities are generally well understood by the users. Costs are understood for equipment and service. The operating characteristics of the data links have been refined to optimize performance. Operational resolution of issues is based on the demonstrated actual parameters rather than the theoretical potential parameters.

Table 1: Operational Dates for Existing Civil Aviation Data Links

Type	Maximum Data Rate (1)	AOC Operational Date	ATS Operational Date	ICAO SARPs	Address Or Broadcast
Low Speed VHF	2.4 kbps	1978	1991	No (2)	Address
Mode S	4.0 Mbps	N.A. (3)	1991 (4)	Yes	Broadcast/ Address
Satellite	9.6 kbps	1990	1992	Yes	Address
HF	1800 bps	1998	2002 (5)	Yes	Address
High Speed VHF	31.5 kbps	2000	2002 (5)	Yes	Address/ Broadcast

(1) Mode S, satellite and HF data links have multiple data rates lower than the maximum

(2) Low speed data link has evolved over the years to various ARINC specifications such as ARINC 618, 620, 622, 623

(3) Non-applicable because Mode S data link was built for ATS purposes, not AOC use

(4) Air-to-air use only

(5) Expected ATS certification date

2.2.1.1 Low Speed VHF

Low-speed VHF, character oriented data link provides a data rate of up to 2.4 kbps. It was introduced into civil aviation operation in 1978 and is the basic VHF data link for ACARS. High-speed VHF will gradually replace low-speed VHF over the next few years. Low-speed VHF is used on a global basis to transmit approximately 35 million VHF messages per month to about 10,000 data link equipped aircraft.

Low-speed VHF data link has been used for ATS applications since 1991 in accordance with ARINC Specifications 618, 620, 622, and 623. Since the existing low-speed VHF character oriented data link is not intended to be part of the open systems interconnection (OSI) Aeronautical Telecommunications Network (ATN) ICAO Standards and Recommended Practices (SARPs) have not been developed. Additionally the low-speed characteristic of the data link requires a number of frequencies to fully service all users. As examples, ARINC uses

ten (10) VHF frequencies in the United States to provide reliable service and SITA uses three (3) frequencies in Europe.

ICAO SARPs were written for a low-speed (2.4 kbps) VHF Digital Link known as VDL Mode 1 (VDLM1). However VDLM1 was never implemented for operations because VDLM2 offered a higher data rate and consequently the ICAO SARPs for VDLM1 have been removed.

2.2.1.2 Mode S

Mode S data link was developed to be used with Mode S Monopulse Secondary Surveillance Radar. The only operational use of Mode S data link at this time is in the Mode S Transponder air-to-air mode for coordinating Airborne Collision Avoidance System maneuvers that has been operational since 1991. The Enhanced Mode S surveillance services being planned for implementation in Europe will use the addressed Mode S data link for the readout of various onboard data items.

Mode S extended squitter avionics, broadcasting at 1090 MHz, is available as a broadcast data link. This is commonly referred to as 1090 extended squitter (ES). Currently a small number of aircraft have implemented Mode S 1090ES capable of ADS-Broadcast.

The United States Federal Aviation Administration (US FAA) announced in July 2002 that Mode S 1090ES had been selected as the ADS-B link for air transport and other high-performance categories of aircraft. The 1090 MHz downlink transmits at 1.0 Mbps, whereas the Mode S 1030 MHz uplink transmits at 4.0 Mbps. Mode S data link is included in ICAO SARPs.

2.2.1.3 Satellite

Satellite data link is based on IMARSAT service offerings that are resold as ARINC and SITA data link services. Satellite data link for aviation went operational in 1990 and was first certified for Air Traffic Management use in 1992. AERO L at 600 bps, AERO I at up to 4.8 kbps and AERO H at 9.6 kbps are all certified for air traffic management services. Service at 64 kbps is now available but not yet certified for ATC.

2.2.1.4 HF

HF data link was developed as a low cost alternative to satellite data link. HF data link, which went operational in 1998, transmits at 300, 600, 1200 and 1800 bps. HF data link, as currently implemented, provides complete coverage over the northern polar region whereas satellite coverage stops at about 80 degrees latitude.

HF data link is included in ICAO SARPs and is currently establishing the data required for ATC certification. Certification is expected in 2002.

2.2.1.5 High Speed VHF

VDL Mode 2 (VDLM2) is a high-speed (31.5 kbps) VHF data link. The higher data rate of VDLM2 will allow a reduction in the number of frequencies used. VDLM2 should allow an 8 to 1 reduction in VHF frequency use. VDLM2 when paired with 8.33 kHz spacing for voice should allow a considerable increase in frequency capacity even though the data and voice channels will be operated on different frequencies. VDLM2 has been developed to be compatible with ACARS message applications and ATN ATS applications. VDLM2 has been operational for AOC applications since November 2000 and is expected to be certified for ATS use in 3rd quarter 2002. VDLM2 is ICAO SARPs approved.

2.2.2 Developmental Data Links

Developmental data links are programs that are underway to evaluate attributes and identify issues associated with potential technologies or programs that are in the initial stages of procurement. Operational data links are distinguished from developmental data links in that operational data links are in daily service with production equipment. Developmental data links include VDLM4, UAT, and VDLM3.

2.2.2.1 VDLM4

VDLM4 has evolved from a VHF link that was first tested in 1988 as a broadcast link. The current ATN-compliant VDLM4 data link operates at 19.2 kbps and has ICAO SARPs for surveillance applications. The extension of VDLM4 ICAO SARPs as an addressable data link is being examined. Eurocontrol initiated 1-year VDLM4 airborne architecture study in June 2002.

“To date this link [VDLM4] has not been approved for non-surveillance communications and requires serious safety analysis due to the proposal to reduce the independence of the communications, navigation and surveillance systems in the NAS [National Airspace System]. Combination of communications and surveillance functions in one system increases the risk of common mode failures causing a loss of both of these services. Further, in order for this link to achieve the capacity required for its various proposed roles, multiple RF carriers are required.”¹

There are four basic issues with VDLM4:

- 1) VDLM4 currently offers a surveillance only capability.
- 2) Multiple RF receivers with single transmitter implementation require multiple antennas, which introduces frequency separation and interference issues for antenna placement on aircraft fuselage.
- 3) Multiple antennas have a large cost impact on aircraft equipage.
- 4) After 14 years of testing it is still a developmental system operating in a low-density traffic environment.

2.2.2.2 Universal Access Transceiver (UAT)

The UAT is a wideband, broadcast type data link with a signaling rate of approximately 1.04 Mbps operating at 978 MHz for the common global channel (which is outside the crowded VHF band). UAT is a broadcast type system that is being used in the United States for the Alaska CAPSTONE demonstrations and was used in the Ohio Valley trials. UAT was selected by the US FAA in July 2002 as the U.S. ADS-B link for use on the majority of general aviation aircraft. UAT has similar issues to VDLM4:

- 1) UAT offers a surveillance only capability. A separate data link would be required for CPDLC.
- 2) Multiple RF receivers with single transmitter implementation require multiple antennas, which introduces potential interference issues for antenna placement on aircraft fuselage.
- 3) Multiple antennas have a large cost impact on aircraft equipage.
- 4) UAT has only had limited testing. It is still a developmental system operating in a low-density traffic environment.

2.2.2.3 VDL Mode 3 (VDLM3)

VDLM3 is an ATN-compliant digital technology with ICAO SARPS proposed as a means of spectrum conservation. VDLM3 is intended to allow the transmission of voice and data over the same link. Currently only the US FAA is proposing a VDLM3 system. There are multiple issues with VDLM3:

- 1) VDLM3 is under development. Limited testing has been done, but actual technology demonstrations are expected in 2003/2004.
- 2) The US FAA has proposed VDLM3 for ATS only which means aircraft will have to carry an additional data link in the U.S. for AOC that in turn has an equipage impact on aircraft.
- 3) NEXCOM Aviation Rulemaking Committee chartered by FAA identified five uncertainties² associated with VDLM3 implementation:
 - a) Can affordable certified avionics be developed in a timely manner?
 - b) How will the VDLM3 voice features be integrated and utilized in the NAS?
 - c) Will VDLM3 data link be required to support ATC requirements beyond the capabilities assumed by VDLM2?
 - d) Can the ground system for VDLM3 (voice and data) be developed and deployed in a timely manner?
 - e) Will there be continued international support for the VDLM3 communications standard?

2.2.2.4 Broadband

Broadband, defined as a carrying capacity greater than 200 kbps, is a developing technology that offers high data rates for a variety of applications on an aircraft. Broadband solutions have concentrated on passenger applications more so than ATC applications. Broadband is currently in limited operational use providing high data rate communications to aircraft passengers for internet, email, television and other business/entertainment applications. One service provider advertises a data rate of 20 Mbps to the aircraft and 1 Mbps from the aircraft.

The technological infancy of broadband when considered in the context of certification for the safety and regularity of flight precludes any statement of expectation for ATS service.

3.0 IMPLEMENTING DATA LINK FOR ATS

There are many studies documenting the benefits of data link for ATS. In high-density areas there is an expected 70% reduction in frequency usage for routine communications. In oceanic and remote areas there is the use of CPDLC and ADS to provide unambiguous communication and surveillance capability. At the airports there is predeparture clearance and Digital ATIS. Given these proven benefits, some ATS providers continue to ask the question of which data link?

Implementation decisions on data link for ATS should consider three basic factors:

- 1) What is the intended application?
- 2) What is the cost to the provider and the user?
- 3) What is the time schedule for implementation?

3.1 The Intended Application of Data Link for ATS

Addressable data link has been used for ATS purposes since 1991 when it was first used for predeparture clearance. In 1995 the CNS/ATM functions of FANS-based CPDLC, ADS and AFN were added to ATS services. Today existing low-speed VHF and satellite data link are used for ATS. HF data link is under test for ATS and VDLM2 will be used for ATN-based CPDLC operations by October 2002.

Low-speed VHF, satellite and HF have been demonstrated to be suitable for low-density or procedural based remote/oceanic airspace for en route applications such as FANS CPDLC or ADS. These operations have less demanding message delivery times or surveillance update rates. High-speed VHF will provide superior performance to low-speed VHF in these same areas.

Low-speed VHF or high-speed VHF is also suited for non-time critical application such as PDC and D-ATIS.

High-speed VHF (VDLM2) is suited for the introduction of CPDLC in high-density traffic areas. VDLM3 is planned to be used for both voice and data when data is implemented in 2011. Both VDLM2 and VDLM3 are ICAO SARPs compliant whereas low-speed VHF is not.

Broadcast data link has been tested with Mode S, VDLM4 and UAT. Mode S transponders are currently part of normal aircraft equipment and modern Mode S transponders are being updated for 1090ES ADS-B with a minimal wiring change for delivery 1st quarter 2003. ICAO has recently begun consideration of UAT SARPS.

(Note: Low-speed VHF, VDLM2, VDLM3, VDLM4, Mode S and UAT are line-of-sight systems with range limitations between 200 to 300 miles around the radio site. Oceanic/remote area data link services will require a satellite or HF data link.)

3.2 Cost of Data Link Implementation

3.2.1 Addressable Data Link

There is an assumption in the aviation industry that data link in commercial aircraft will be used about 98% for AOC and 2% for ATS. (One DSP's current experience for VHF data link is about 92% for Airline Operational Communications (AOC) and 8% for ATS [predominantly for D-ATIS]). This statistic implies that commercial aircraft have and will equip for addressable data link for AOC with the expectation of using that same data link for ATS as is currently done with VHF, HF and satellite data link systems.

Addressable data link service is offered globally by two private service providers (ARINC and SITA) and regionally by Avicom of Japan, DEPV of Brazil (which is an international partner of SITA), Aeronautical Data Communications Corporation of China (with its international partner ARINC) and AeroThai of Southeast Asia (with its international partner ARINC). ARINC and SITA provide data link services to a number of ANS providers. All service providers are internetworked for ATC communications.

The recognized AOC benefits of data link has resulted in near-global air and ground equipment of addressable data link with the aircraft operators and DSPs providing the capital investment for this data link service. This same data link infrastructure is used for ATC purposes and may be expanded to additional ATC uses. This existing operational infrastructure means that ANS providers do not have to create their own data link infrastructure to achieve data link benefits. The ANS providers may expect a service cost for the opportunity to use the data link air-to-ground infrastructure. This would be similar to paying the telephone company for ground-to-ground communications.

3.2.2 Broadcast Data Link

The need for broadcast data link depends on successfully developing and proving the benefits associated with proposed new operational concepts. The question of broadcast data link is more challenging since, except for Mode S, the experience is in limited demonstrations rather than operational use under a variety of conditions. Currently no non-ANS private service provider is

implementing broadcast data link as a “pure” ATC-service function since DSP return on investment is normally based on some form of measured usage. Honeywell has implemented FIS-B as a public and commercial service in the United State. Indications are that the ANS and public sector will be expected to pay for implementing broadcast data link.

From a public perspective Mode S 1090ES is being made available for broadcast by a wiring change to the modern Mode S transponder (i.e., Transponders meeting ICAO Annex 10, Amendment 73). Mode S SSRs are being upgraded to a broadcast data link. Eurocontrol is considering VDLM4 for the 2008 time period and the U.S is planning UAT implementation for the 2007-2012 time period,

One study³ created a common scenario for a cost study on Mode S 1090ES, UAT and VDLM4 on the basis of implementing 547 broadcast sites in the United States. In the common implementation scenario Mode S 1090ES was projected to cost \$141M USD, UAT was projected to cost \$152M USD and VDLM4 was projected to cost \$214M USD to implement.

Aircraft equipage costs varied by type of aircraft class. For the modern integrated flight deck air carrier the per unit cost was estimated as \$295K for Mode S ES 1090, \$292K for UAT and \$366K for VDLM4. This is for full cockpit ADS B implementation.

(Note: The referenced study³ assumed that commercial aircraft costs would include full cost for the link system and 85% of the display costs. This may be true for UAT or VDLM4, but probably is not true for Mode S given current equipage.)

Given the different capabilities of the systems, when implemented to a common scenario, Mode S 1090ES had a benefit to cost ratio of 1.08, UAT had a benefit to cost ratio of 1.19 and VDLM4 had a benefit to cost ratio of 0.72. These relatively low benefit to cost ratios for all systems suggest that implementing broadcast data link should be carefully considered.

3.2.3 Time Schedule for Data Link Implementation

Low-speed VHF, VDLM2, satellite and HF addressable data links are in operational use today and immediately available to any ANS provider. EUROCONTROL has selected VDLM2 to support LINK 2000+ services. The Federal Aviation Administration has selected VDLM2 for CPDLC Build 1/1A trials and AVICOM of Japan is upgrading its data link system with VDLM2.

VDLM3 is proposed to be implemented in the United States during the period 2007 – 2011. The multimode radios are planned to be data link capable, but initial use will be for voice.¹

Mode S 1090ES will be available from the 1st quarter of 2003.

The US FAA July 2002 decision to support a combination of Mode S 1090ES and UAT for ADS-B services should result in the implementation of a ground ADS-B infrastructure in the U.S. between 2007 and 2012. A limited number of earlier implementations of U.S. local/regional 1090ES and/or UAT ground systems will continue as part of the U.S. Safe Flight 21 and Capstone initiatives.

VDLM4 is currently planned on a regional scale. Russia has included VDLM4-based ADS-B along with other means of ADS in its ATC modernization program plan, but the plan has not been funded.⁵ Sweden has also proposed a limited VDLM4 implementation.

The issue faced by users is if an aircraft is equipped, how long can they expect to be allowed to use the equipment without being required to add different equipment.

4.0 SUMMARY

The many faces of data link offer alternative implementation scenarios for Air Navigation Service Providers. It becomes a matter of choice based on three factors:

- 1) Intended application
- 2) Return on Investment
- 3) Time Period

4.1 Intended Application

The projected benefits from addressable data link for air traffic service is a 70% reduction in frequency usage while obtaining unambiguous communications. This is demonstrated by the operational use of Predeparture Clearance, Digital ATIS, Controller Pilot Data Link Communications, and Automatic Dependent Surveillance over existing addressable data links.

In frequency-constrained environments the combination of 8.33 kHz voice channels with the high data rate of 31.5 kbps for VDLM2 offers to provide substantial improvement in frequency utilization. Similarly, VDLM3 as a voice and data combination will provide substantial improvement in frequency utilization.

Broadcast data link, currently under trial, can support greater situational awareness for the aircraft and improved surveillance..

It is noted that addressable data link and broadcast data link perform different functions and may require different sets of equipment on the ground and in the aircraft. Current Mode S transponders are being upgraded to provide a broadcast and addressable data link. Other types of broadcast data link will require new avionics and antenna installations.

4.2 Return on Investment

A global infrastructure for addressable data link has been established by private data link service providers. This infrastructure is used by commercial aircraft operators and Air Navigation Service providers. A decision for any ANS provider is whether to use the existing infrastructure for a fee or invest in building a compatible infrastructure. EUROCONTROL notes..."the LINK 2000+ Business Case has indicated that benefits will be maximized when a shared infrastructure is used for AOC [Airline Operational Communications] and ATC applications."⁶

The aviation industry, CNS/ATM Focused Team (C/AFT) investment analysis indicates VDL M3 will cost 46% more to implement than the VDL M2/8.33 alternative for data and voice.⁷

It is doubtful that any private DSP will build an independent broadcast data link system.

It is noted that users have an expectation that they will be allowed to use specified equipment for a minimum of 10 years from an ANS specified implementation date.

4.3 Time Period

Low-speed VHF, VDL M2, satellite and HF addressable data links are in operational use today and immediately available to any ANS provider. Mode S 1090ES will be available in the 1st quarter of 2003. Any combination of these data links can satisfy current proposed ATS applications.

Australia's Mode S-based ADS-B ground station is fully installed and operating near Bundaberg, Queensland as of 14 June 2002. Operational trials are planned in early 2003.

The United States proposes to implement VDL M3 multimode radios planned to be capable of data link during the period 2007 – 2011 (initially to be used for voice) and UAT during the time period 2007 – 2012.

There are no firm deployment plans for VDL M4 other than regional applications. A Eurocontrol target date for surveillance purposes has been proposed as 2008.⁸

References

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