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Understanding Data Comm Systems with Domestic and Oceanic FANS 1/A+ and ATN B1 Services

White Paper

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Executive Summary

Regulatory efforts to promote Data Communications (Data Comm) enabled capability, establish equipage mandates, and further develop Communication, Navigation and Surveillance/Air Traffic Management (CNS/ATM) systems have been ongoing for years. Data Comm is one of the most complex system developments undertaken by domestic and international Air Traffic Control (ATC) organizations and their associated regulatory agencies in the history of aviation.

The technology of Data Comm has been utilized in the North Atlantic for over three decades, originally rolled out as a cost-saving feature from aircraft OEMs, with the improved communication having positive safety effects as well. U.S. and Canadian authorities established Future Air Navigation System (FANS) 1/A+ requirements in certain North Atlantic airspaces, and European authorities have corresponding requirements for Aeronautical Telecommunications Network Baseline 1 (ATN B1) capability in European airspace. In the United States, the FAA implemented FANS Domestic functions through Controller-Pilot Data Link Communications Departure Clearance (CPDLC DCL) and CPDLC en route services capability in order to more effectively manage airspace, address communication frequency congestion, and improve safety. Since 30 Jan 2020, FANS 1/A+ is required between FL290-FL410 throughout the entire North Atlantic Track (NAT) region. Concurrently, the feasibility and necessity of Data Comm as both a forward fit and retrofit installation for aircraft has become a reality.

Let's Break It Down: What Are the Elements of Data Comm?

Data Comm is a term that is applicable to a growing set of data communication elements and systems, which may be neatly integrated into a single system for flight crew transparency. There may be multiple CPDLC type systems with significantly differing ground infrastructure that will largely look and operate the same on the flight deck. Some elements of Data Comm are almost completely transparent to the flight crew.

Key elements of Data Comm primarily consist of:

- CPDLC or Controller-Pilot Data Link Communications (required for FANS Oceanic and U.S. domestic en route)
- ADS-C or Automatic Dependent Surveillance–Contract (required for FANS Oceanic)
- VDL Mode 2 data link radio and/or appropriate SATCOM
- ADS-B Out or Automatic Dependent Surveillance–Broadcast Out

The FANS capability embedded in the Universal Avionics (UA) UniLink™ UL-800/801 Communications Management Unit (CMU) consists of both CPDLC and ADS-C functionality and provides a means for direct communication between the pilot and ATC through CPDLC technology. Very High Frequency (VHF) radio or satellite communication (SATCOM) systems are used to enable digital transmission of short, relatively simple messages between the aircraft and ATC.

Improved Communications

The goal of Data Comm is to improve safety and performance related to Communication, Navigation and Surveillance (CNS) / Air Traffic Management (ATM) activities within the operating environment.

- VHF and HF voice traffic is reduced, clearing the channel
- Standardized message set removes language barrier
- Push-to-load of revised CPDLC clearances reduces errors from manually updating route

The ADS-C capability is largely transparent. It allows ATC to independently negotiate a periodic transmission of aircraft information to the responsible air traffic center for monitoring and management of traffic in remote areas of operation, versus ADS-B which automatically transmits aircraft position data once per second and is primarily intended for support of domestic ATC operations. Please reference UA White Paper, *Understanding Compliance with Automatic Dependent Surveillance – Broadcast (ADS-B) Out* for additional information including requirements and solutions.

FANS Domestic is an evolving capability and currently supports CPDLC DCL and initial en route services. This capability has been successfully deployed to over 62 major airports across the United States, with three U.S. Air Route Traffic Control Centers (ARTCC) currently operating and phased expansion planned across the country. CPDLC DCL improves safety and efficiency of operations and is now the method of choice for clearance delivery at all major airports.

Development of Data Comm and FANS 1/A+

For aircraft to fly across oceanic/remote areas of airspace, a method of communication and surveillance had to be established to manage aircraft out of range of traditional ground-based VHF radio and radar systems for an extended period.

For decades, the only means of communication in remote/oceanic airspace had been a High Frequency (HF) radio system that uses line of sight or the atmosphere to bounce the transmissions to the recipient. The pilots report their position to a radio operator who relays the aircraft position report over a telephone line to the responsible Oceanic Center. HF Radio is known to be problematic due to noisy transmissions caused by atmospheric conditions, and language barriers.

FANS improved HF radio communication by using data link communication through satellite communications. The existing satellite-based Aircraft Communications Addressing and Reporting System (ACARS) was used during the first implementation of Data Comm FANS systems.

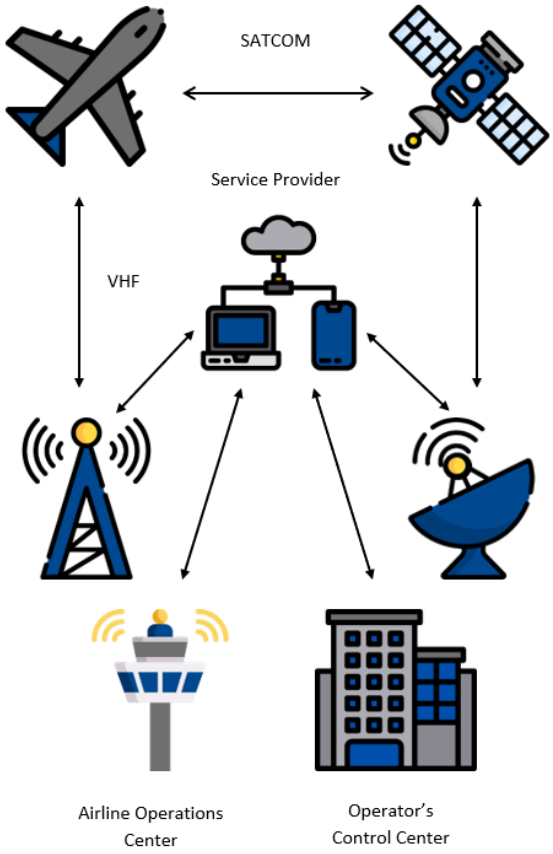
As far back as 1983, industry officials concerned about the rise in air traffic sought to address an aging infrastructure, unable to effectively handle increasing congestion. Responding to the issue, the International Civil Aviation Organization (ICAO) established the Special Committee on Data Comm FANS, which was tasked with identifying new technologies for the future development of communication and surveillance that would aid in the management of air traffic under the Data Comm FANS infrastructure.

The initial FANS report was published in 1988, laying the basis for the industry's future strategy for the CNS/ATM concept; ATM through digital CNS. Work then started on the development of the technical standards needed to realize the Data Comm FANS concept.

The Boeing Company, reportedly seeking the cost saving benefit that Data Comm FANS technology provides by opening more direct oceanic routing, certified the first implementation of FANS in mid-1995, known as FANS-1. It used existing satellite- based ACARS communications, targeting operations in the remote South Pacific Oceanic region. The deployment of FANS-1 was to improve route choice available to operators, and thereby reduce fuel burn.

Later, a similar product was developed by Airbus, known as "FANS A." Today, the two technologies are collectively known as "FANS 1/A." With the addition of minor enhancements, most notably the detection of late delivery of data link updates, it has now become known as FANS 1/A+. Data Comm FANS today uses ADS-C and CPDLC to directly communicate to ATC over VHF or SATCOM (Inmarsat or Iridium) to enable more efficient communications between the aircraft and ATC, although the older Mode 0/A for FANS can still be used in many regions. En route services in the continental U.S. require using VDL Mode 2.

How the Data Comm System Pieces Work



The current data link system relies on the networks of Data Link Service Providers (DSP) such as SITA and Collins IMS (ARINC) for the delivery of data link messages.

Also referred to as Communication Service Providers (CSP), the DSPs are commercial entities that offer similar services, but run their networks in different configurations.

While the DSP networks are used to transfer messages between the aircraft and the Operator's Control Centers, the Control Centers are responsible for processing and providing information through the network back to the aircraft operators.

Controller-Pilot Data Link Communications

CPDLC is a method by which ATC can communicate with pilots over a data link system, increasing the effective capacity and improving the availability of the communications channel. Data link communication permits the exchange of text-based messages between ATC controllers at ground stations and the aircraft flight crew. It is intended to supplement traditional voice over VHF and HF radio frequencies, and free up voice radio channels.

The CPDLC message set provides a fixed set of responses to clearances, information, or request message elements which correspond to standard ATC voice phraseology (such as "climb and maintain FL350") which both the ATC controller and the pilot can send and respond to. "Free Text" messages are used when information needs to be exchanged that is not conforming to these pre-defined formats, however, the use of Free Text is not allowed in certain regions and generally discouraged. Flight crews are encouraged to check regional Aeronautical Information Publications (AIP)/Aeronautical Information Circulars (AIC) regarding use of Free Text.

Automatic Dependent Surveillance-Contract

ADS-C reports the current flight position, flight intent such as next locations and ETAs, and can be set up to report events that might indicate an emergency maneuver via SATCOM or VHF data link to ATC which also improves the surveillance capability of the airline's operational control center. It improves the surveillance of en route aircraft participating in the NAT and other regions such as the Hudson Bay and areas in Northern Canada. ADS-C requires a peer-to-peer relationship with a ground facility (aircraft to the controlling ATC facility,) to acknowledge receipt of ADS-C messages. This capability is embedded within the UA UniLink UL-800/801 CMU and is largely transparent to the flight crew.

Data Comm FANS 1/A+ Benefit Highlights

Reduced Separation Between Aircraft

For non-Data Comm aircraft traveling through remote/Oceanic airspace, procedural aircraft separation, errors in navigation, and potential errors in voice communication between the flight crew and ATC are considered when determining the necessary airspace separation between aircraft. Through a satellite data link, aircraft equipped with Data Comm FANS and that are RCP240/RSP180 Performance-Based Communication and Surveillance (PBCS) compliant can communicate with ATC using CPDLC and transmit required ADS-C reports with actual position and intent information at specified time intervals automatically within the required communication and surveillance performance requirements. The position report is based on the accuracy of the GPS position sensing, which is typically accurate to within a few meters.

Additional FANS Benefits

- Workload reduction
- Reduction in miscommunication
- Faster communication
- Improved safety of flight
- Access to preferred routing
- Reduced CO2 emissions
- No altitude loss when crossing tracks
- More direct routings
- Reduction of aircraft operating costs

CPDLC communication between the flight crew and the ATC drastically reduces the possibility of communication error and allows for reduced aircraft separations in airspace. Increased airspace capacity means a greater availability of desired routes for the aircraft operating within that airspace.

Data Link Communication

VHF Data Link (VDL) is a means of sending information between aircraft and VHF ground stations. The new VDL Mode 2 network, a high-speed and high-capacity digital communications network, provides over 20 times the message capacity than the older VHF mode 0/A subnetwork. Use of VDL Mode 2 tends to be more cost efficient than traditional VHF and service providers are encouraging its users to transition to the VDL Mode 2 network.

Worldwide Requirements and Mandates

FANS and CPDLC operations are used around the world, thanks to the multiple benefits it offers in both safety and efficiency. While it is not required everywhere, there are multiple mandates in different regions which dictate how and when CPDLC needs to be used.

HF Radio Requirements

FANS services outside the range of VHF data link networks require a SATCOM system to support CPDLC. Some systems support both data and voice functionality, called SATVoice, which is a safety service used to communicate with ATC. Depending on the regional requirements in which flight operations are taking place, aircraft with the ability to tune and communicate via SATVoice (when meeting the system design requirements for Safety Services Communications) can utilize SATVoice as a primary means of communicating with ATC in lieu of HF. However, until HF requirements are completely replaced by Long Range Communication System (LRCS), operators may still need to keep at least one functional HF radio.

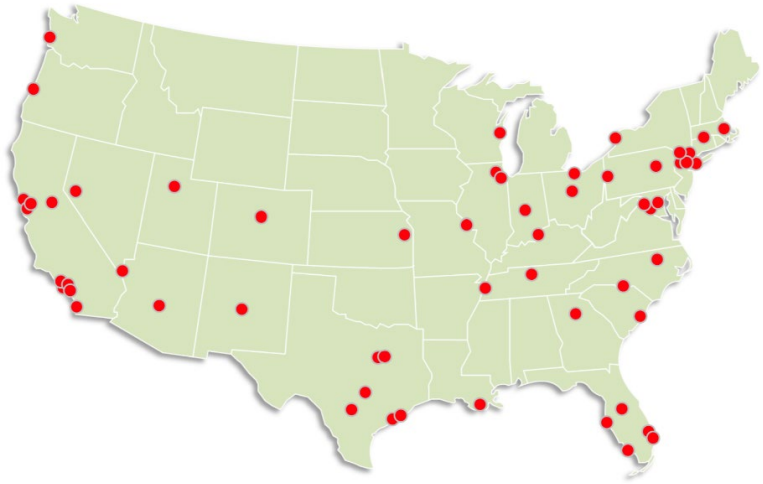
NAT HLA Requirements

With the FANS mandate in the North Atlantic, even aircraft that would normally fly a random route outside of the affected tracks will not be allowed to transition through the NAT if they are not equipped for FANS 1/A+/PBCS, resulting is less-than-optimal routing. The number of affected tracks will continue to expand as equipage rises and demand for more operations in the airspace increases. As of 29 March 2018, RCP240 and RSP180 communications capability is now required on PBCS NAT tracks. Those tracks designated as requiring PBCS is fluid, and you should check when filing for a particular track by using the NAT Organized Track System (OTS) Message. These requirements are fulfilled with the UA FANS 1/A+ solution and the appropriate A056 Letter of Authorization (LOA), which operators are required to obtain.

U.S. Domestic CPDLC DCL and En Route

The FAA rolled out an extensive, phased plan to implement CPDLC DCL capabilities in the domestic U.S. airspace beginning in February 2013 and culminating in the last phase being completed January 2020. Flight crews can verify the CPDLC DCL is available at the tower simply by checking the flight chart. They can then set the aircraft profile in the flight plan service so the correct codes are uploaded when the flight plan is filed, and then logon to CPDLC. Once operational on the aircraft, CPDLC DCL can provide the flight crew with a departure clearance in a matter of seconds instead of potentially waiting many minutes for an opening on the voice channel. If the crew does not receive clearance or has concerns with revisions, they should revert to basic voice protocol.

CPDLC DCL can be used for clearances over the older Mode 0/A subsystem or a VHF Data Link Mode 2 system. CPDLC DCL allows operators to obtain clearances rapidly and begin start and pushback much faster than using standard departure clearance voice protocol. Using Data Link Communications for en route operations requires use of the newer Data Link Mode 2 system.



1) Map of U.S. CPDLC Airports

Neither domestic CPDLC DCL or en route operations require an LOA for operational approval for Part 91 operators, however, an LOA is required if the aircraft is flown internationally. Amendments to air carrier Ops Specs will be required for Part 135 or 121 operators and may be accommodated using the same process as any other Ops Spec amendment.

En route services are reducing communication time between controllers and flight crews with over 99,000 minutes eliminated in the first year of activity with only three active centers providing the service. En Route services improve the efficiency of the path taken as part of a reroute around congestion or bad weather, saving distance and time over what a controller might clear using voice, which reduces fuel burn and emissions.

Controllers can use a track ball to select an efficient route around the weather or congestion, using latitude/longitude or PBD waypoints. Digital delivery of even complex clearances is quickly delivered via data link, followed by pushing to load the clearance into the Flight Management System (FMS) and then a quick WILCO or ROGER response sent back to ATC.

Data Comm FANS in the North Atlantic Tracks

Mandates for FANS 1/A+ began in 2013 for the most efficient tracks in the North Atlantic. In 2015, this was expanded, and all of the NAT required FANS 1/A+ technology at optimum altitudes, which increased to the North Atlantic airspace between FL290-FL410 in January 2020.

The North Atlantic airspace utilizes a constantly changing 12-hour track system designed around the high-altitude winds and weather to optimize flights each day. Because of the growing number of aircraft crossing the North Atlantic each day, ATC needed a technology to increase airspace capacity on the NAT and provide a higher level of safety for all aircraft operating in that airspace.

Utilizing FANS 1/A+ allows ATC in the North Atlantic regions to reduce the required separation standard to half degree tracks on the core tracks in the airspace for aircraft with an LOA and a flight plan indicating RCP240/RSP180 compliance. This allows for dramatically increased air traffic capacity of the region and reduces in trail requirements to 5 minutes between aircraft.

Operators not equipped for FANS 1/A+ capabilities will be excluded from airspace which requires it, increasing total trip distance, time, emissions and ultimately more money. Some aircraft simply do not have the range to get across the Atlantic without operating on the NAT at optimum altitudes. Operating outside of those optimum altitudes may mean not being able to make the trip nonstop.

European Mandate: DLS IR – Data Link Services Implementing Rule

The European implementation of ATN B1 CPDLC in upper airspace is outlined in the Single European Sky ATM Research (SESAR) Data Link Services Implementing Rule (DLS IR) legislation published in January 2009 (EC Reg. 29/2009) and amended by Commission Implementing Regulation 310/2015 in February 2015. As of February 2020, all aircraft that fly above FL285 are required to have ATN B1 equipment unless they have a temporary or permanent exemption. Regulation 2019/1070 and Commission Implementing Decision 2019/2012 released in Nov 2019 give an expanded list of eligible exempted aircraft.

The program previously called “Link 2000+” has been replaced by the DLS IR monitored by the Data Link Services Central Reporting Office (DLS–CRO) at EUROCONTROL. Data link communications is a key element of the SESAR initiative and equipage for ATN B1 CPDLC.

Compliance with the updated European CPDLC initiatives, including the required CPDLC message set, can be accomplished via the UA UL-800/801 CMU with Software Control Number (SCN) 31.3 or later with the ATN option.

EASA does require an LOA to utilize ATN B1 services in European airspace. Additionally, the regional controllers MUAC, Skyguide, and DSNA require the operating aircraft to be on the Logon List. This is an extra precaution to prevent aircraft with known or suspected performance issues from using the service. Please check the EASA website for further information.

Installation Requirements for Data Link Systems

Aircraft approval for FANS Oceanic operations require an LOA from the FAA and equipment installation under a Supplemental Type Certificate (STC) or OEM Service Bulletin in accordance with AC 20-140 (as amended), to include:

- Flight Management System (FMS), i.e. UA SBAS-FMS, SCN 1000.5/1100.5 or later
- Communications Management Unit (CMU), i.e. UA UniLink UL-800 or UL-801 (Note: SCN 31.X required for ATN B1 capability if needed)
- A DO -178B Level 'D' software SATCOM system, i.e. Inmarsat or Iridium
- External "ATC" annunciator "cube" or installation integrated into flight displays
- Aural Alert - a sonalert or some other means to provide a "Signature" aural advisory to alert the flight crew of incoming CPDLC messages
- Data capable Cockpit Voice Recorder (CVR) (AC 20-160), i.e. UA CVR/Flight Data Recorder (FDR)

Systems limited to U.S. domestic CPDLC DCL and en route do not require SATCOM capability. En route operations do require push-to-load capabilities.

SATCOM Considerations

FANS 1/A+ data link operations in remote oceanic airspace are transmitted via SATCOM or VDL Mode 2 if within range of a VHF remote ground station. Most SATCOM manufacturers produce ARINC 741 part 2-compliant systems.

Per AC 20-140c, the SATCOM Technical Standard Order (TSO) requirements are as follows:

- Inmarsat's SATCOM (Classic Aero)-TSO-C132A
- Inmarsat's SATCOM (Swift Broadband, SBB)-TSO-C159c
- Iridium's SATCOM (Short Burst Data, SBD)-TSO-C159c

Obtaining FANS Oceanic Operational Approval

Crew Training

In order for the operator to receive an LOA for FANS 1/A+ operations from the FAA, the flight crew must complete an FAA approved training course. Upon request, UA can supply a list of FAA certified FANS training providers.

AC 20-140 Considerations

Advisory Circular (AC) 20-140 (as amended), *Guidelines for Design Approval of Aircraft Data Link Communication Systems Supporting Air Traffic Services (ATS)* provides one acceptable means of compliance, but not the only means, for type design approval of aircraft that have a data link system installed. It is a valuable resource for installers looking to gain more information on requirements for data link systems.

This AC provides airworthiness requirements for aircraft with an installed data link system intended to support air traffic services. It identifies specific configurations of aircraft data link systems for applicants seeking approval for STCs in order to facilitate operational approvals. In addition, UA provides compliance reports in support of installation of the UniLink UL-800/801 CMU systems to aid in demonstration of compliance for your aircraft installation.

AC 90-117 Considerations

AC 90-117 is a great resource for operators seeking more information about data link communications systems usage. It provides guidance for aircraft eligibility and operational use of data link communications, including information about how to start the LOA application process. The information covered in the AC pertains to data link communications in the U.S. and in oceanic and remote continental airspace. The document also provides informational explanations of data link systems, particularly for those who may be new to using digital aircraft communication and surveillance systems.

Summary

Data Comm systems have matured over the past three decades from an aircraft OEM cost saving feature to a necessity for effective worldwide airspace management and communication advancements. Several areas are mandating Data Comm capabilities and excluding non-equipped aircraft from airspaces with the most desirable and cost saving routes. Equipping for FANS 1/A+, CPDLC DCL and/or en route, or ATN B1 operations can meet regulatory requirements and provide a substantial return on investment for aircraft dependent upon operating in those airspaces. The addition of FANS Domestic initial en route capabilities such as CPDLC DCL at major U.S. airports can virtually eliminate wait times for aircraft clearance delivery, potentially reducing operating costs significantly over time. In all cases, the UniLink UL-800/801 CMU Data Comm capabilities can provide compliant operations and reduction of aircraft operating costs.

References

- FAA AC 20-140C, *Guidelines for Design Approval of Aircraft Data Link Communication Systems Supporting Air Traffic Services (ATS)*
- FAA AC 20-160, *Onboard Recording of Controller Pilot Data Link Communication in Crash Survivable Memory*
- FAA AC 120-70B, *Operational Authorization Process for use of Data Link Communication System*
- FAA AC 91-70A, *Oceanic and International Operations*
- FAA A056, *Data Link Communications Compliance Guide*
- Global Operational Data Link Document (GOLD), 2nd Edition, 26 April 2013
- FAATSO-C160, *VDL Mode 2 Communications Equipment*
- RTCA/DO-258A, *Interoperability Requirements for ATS Applications Using ARINC 622 Data Communications (FANS 1/A+ Interoperability Standard)*
- FAA AC 90-117, *Data Link Communications*
- DO-306 Chg 1, *Safety and Performance Standards for Air Traffic Data Link Services in Oceanic and Remote Airspace (Oceanic SPR Standard)*
- ED-85A, *Data Link Application System Document (DLASD) for the "Departure Clearance" Data Link Service*
- ED-89A, *Data Link Application System Document (DLASD) for the "ATIS" Data Link Service*
- ED-106A, *Data Link Application System Document (DLASD) for the Oceanic Clearance Data Link Service*
- RTCA/DO-290, *Safety and Performance Requirements Standard for Air Traffic Data Link Services in Continental Airspace (Continental SPR Standard)*
- ED-154A, *Future Air Navigation System 1/A - Aeronautical Telecommunication Network Interoperability Standard*
- www.nbaa.org/ops/cns/datalink/20151105-faa- introduces-controller-pilot-data-link-communications-departure-clearance.php
- Figure 1 Map of CPDLC Airports L3Harris https://www.l3harris.com/datacomm

Acronyms and Abbreviations

The following are industry standard acronyms, abbreviations, and terms used in this white paper.

- AC - Advisory Circular
- ACARS - Aircraft Communications Addressing and Reporting System
- ADC - Air Data Computer
- ADS–B - Automatic Dependent Surveillance–Broadcast
- ADS–C - Automatic Dependent Surveillance–Contract
- AFN - ATS Facilities Notification
- AIC - Aeronautical Information Circular
- AIP - Aeronautical Information Publication
- AMOC - Alternate Means of Compliance
- AOC - Airline Operational Control
- ATC - Air Traffic Control
- ATM - Air Traffic Management
- ATN B1 - Aeronautical Telecommunications Network Baseline 1
- ATS - Air Traffic Service
- CMU - Communications Management Unit
- CNS - Communication, Navigation and Surveillance
- CPDLC - Controller-Pilot Data Link Communications
- CPDLC DCL - Controller-Pilot Data Link Communications Departure Clearance
- CSP - Communication Service Provider
- CVR - Cockpit Voice Recorder
- DCL - Departure Clearance
- DLS IR - Data Link Services Implementing Rule
- DSP - Data Link Service Providers
- FANS - Future Air Navigation System
- FMS - Flight Management System
- GPS - Global Positioning System
- HF - High Frequency
- ICAO - International Civil Aviation Organization
- LOA - Letter of Authorization
- NAT - North Atlantic Track
- OEM - Original Equipment Manufacturer
- OTS - Organized Track System
- RCP - Required Communication Performance
- RLatSM - Reduced Lateral Separation Minimum
- RLongSM - Reduced Longitudinal Separation Minimum
- RSP - Required Surveillance Performance
- SATCOM - Satellite Communications
- SBAS - Satellite-Based Augmentation System
- SCN - Software Control Number
- SESAR - Single European Sky ATM Research
- STC - Supplemental Type Certificate
- TC - Type Certificate
- VDL - VHF Data Link

About Universal Avionics

Universal Avionics, an Elbit Systems Company, is a leading manufacturer of innovative commercial avionics systems offered as retrofit and forward-fit solutions for the largest diversification of aircraft types in the industry. To learn more, visit uasc.com.

UNIVERSAL AVIONICS
an Elbit Systems Company

Corporate Offices

Tucson, Arizona USA
+1 520 295 2300
800 321 5253
Fax: +1 520 295 2395

Internet

uasc.com
E-mail: info@uasc.com