# Title

4.3.7 ATS Datalink

# Background

This section was originally composed to be a broader view of CNS/ATM functions with a focus on ATS datalink and the possible future requirements for the FMS. As CNS/ATM functions have evolved over the past 15 years not all the functions described in this section have imposed requirements for the FMS. As a result this section contains subsections that may or may not be relevant to the FMS characteristic. Several relevant documents have been published (or are being finalized) since the original draft of this section that bring clarity to the requirements for ATS datalink (such as DO-258, DO-280, DO-350).

# Describe What Is Needed

It is proposed to clean up this entire section to focus on ATS datalink functions which the FMS has significant participation and to either remove sections that have no relevance to the FMS or move subsections to an interface section if the FMS provides a small amount of data for that function (such as flight number for ADS-B). All the text and references will be updated to reflect current requirements for the FMS functions. Please refer to the proposed outline at the end of this document.

# Recommended Changes

* Original text

**4.3.7 CNS/ATM Functions**

The Air Traffic Services (ATS) providers are implementing, or have plans to implement, Communication, Navigation, Surveillance/Air Traffic Management (CNS/ATM) functions using existing and future data link systems. These include:

* ARINC 618 and 620 (ACARS)
* ARINC 622
* Aeronautical Telecommunications Network (ATN)
* Broadcast Data Link
* Mode S Specific Services

The FMS system should support functions operating over all of these data links.

**COMMENTARY**

For some proposed architectures, the CNS/ATM functions may be performed in whole or in part by units other than the FMC. The discussions in these sections apply primarily to architectures for which the FMC serves as the end system for the function. For other architectures where the ARINC 758 CMU is the end system, the FMC should provide interface data to support the application. It is the responsibility of the end system to control this interface to achieve the functionality described herein.

**4.3.7.1 CNS/ATM Data Links**

**4.3.7.1.1 CNS/ATM Functions Using ACARS**

CNS/ATM functions which are character encoded and transmitted over ACARS are specified in ARINC 623. These include:

* Predeparture Clearance (PDC)
* Oceanic Clearance Message (OCM) for North Atlantic operations
* Automatic Terminal Information Service (ATIS)

Other functions being planned include:

* Terminal Weather Information for Pilots (TWIP)
* Taxi Clearance

All of these functions are defined as printer compatible, character encoded, messages and are not compatible with automatic loading. Clearance data and weather data in these messages must be manually loaded by the pilot. Alternatively, if these messages are routed to AOC, relevant data can be transposed into the formats defined in Attachment 7 and transmitted to the airplane for autoloading.

**4.3.7.1.2 CNS/ATM Functions Using ARINC 622**

ARINC 622 defines how binary formatted CNS/ATM functions are transposed into hexadecimal characters and transmitted over ACARS, Satellite Communication (SATCOM), and HF data links using the service provider networks, e.g., ARINC, SITA, Air Canada, AVICOM, etc. The system should support the following ARINC 622 mechanized functions:

* ATS Facilities Notification (AFN)
* ADS (RTCA DO-212 and ARINC 745)
* Controller/Pilot Data Link Communication (CPDLC) (RTCA DO-219)

**4.3.7.1.3 Aeronautical Telecommunications Network (ATN)**

The system should support the CNS/ATM functions being defined in the ICAO CNS/ATM-1 SARPS.

These include:

* ATN
* Data Link Initiation of Communications (DLIC)
* CPDLC
* ADS
* Flight Information Service (FIS)

**COMMENTARY**

ARINC Report 660B describes the avionics architectures for implementing CNS/ATM functions. The basic architectures that define the roles of the FMS and the CMU in an ATN data link environment are:

* FMS is the ATN and application end system. The CMU is an ATN router.
* FMS is the application end system. The CMU is the ATN end system and gateway to the FMS.
* CMU is the ATN and application end system, i.e., single end system.

The following sections define the functions of the FMS when it is serving as the application end system.

**4.3.7.1.4 Broadcast Data Links**

Standards for broadcast data links have not been defined. Potential applications include:

* Surveillance by ADS-Broadcast
* Air to air conflict resolution
* Ground to air traffic information
* Hazardous weather alerts
* Atmospheric data

**COMMENTARY**

Broadcast data link using Mode-S Squitter and VHF Time Division Multiple Access (TDMA) are both under consideration.

**4.3.7.1.5 Mode-S Services**

The system should provide data to support Mode-S data link services when defined.

**COMMENTARY**

Current Mode-S definition is provided by ICAO document Manual on Mode-S Specific Service issued by SSR Improvements and Collision Avoidance Systems Panel (SICASP)/5.

**4.3.7.2 CNS/ATM Applications**

**4.3.7.2.1 ATC Log On**

In order to establish the proper network connections, the system should provide for an ATS log on function.

In the interim ATS communications environment with ARINC 622, this function is known as Air Traffic Services Facilities Notification (AFN). This function should provide a simple crew interface that allows for an ATC logon based on parameters such as ICAO names for airport facilities and airline flight number. The detailed log on protocol for AFN is specified in ARINC 622.

In the ATN communications environment this function is provided by the CNS/ATM-1 SARPS.

**4.3.7.2.2 Controller/Pilot Data Link Communication (CPDLC)**

In the interim ATS communications environment with ARINC 622, the CPDLC specific messages supported should be those defined by RTCA DO-219. These messages include some which are loadable and others which are display only. The FMC provides for the capability to receive and send these messages over the data link channel defined in Section 4.3.7.1.2 as the end user. The FMC will provide the capability to interface with the network protocol and integrity checking. As defined by ARINC 622, these data link messages will be identified with an Imbedded Message Identifier (IMI) of ATx to distinguish them from AOC messages and take priority over any other pending data link messages.

It is anticipated that the CNS/ATM-1 Open System Interconnect network known as ATN will be developed in parallel with ARINC 622. The eventual network will be defined by ARINC 637 and 638. The new CPDLC messages will be defined in CNS/ATM-1 SARPS.

**4.3.7.2.2.1 Crew Interface and Operation**

Interpretation of the message is based on the CPDLC application defined by RTCA DO-219 or CNS/ATM-1 message element number. Upon receipt of an ATC uplink, the system should annunciate an alerting level message in the primary field of view and set an output discrete that will be used to control an aural warning. These messages may be of the form ATC X, where X can be ROUTE, ALTITUDE, SPEED, etc. The system should also provide for a crew interface that details these messages for crew review along with the appropriate prompts for crew responses such as accept, reject, standby, or response data that may be required.

**4.3.7.2.2.2 Flight Plan Autoload**

As a minimum, the FMC functions should provide the capability to autoload the following message types:

* RTA waypoints and required times
* Lateral offsets
* Flight plans and modifications

For all autoload functions, the changes should be displayed for review of the effect of the changes by the flight crew. The changes should be activated with positive confirmation from the crew.

**4.3.7.2.3 Automatic Dependent Surveillance (ADS)**

This function should provide for the Periodic Contract, On Demand Contract, Event Contract, Emergency Reports, Cancel Contract, and Cancel All Contracts and Terminate Connection uplink messages as well as Acknowledgment, Negative Acknowledgment, Noncompliance Notification, and data downlink messages as defined in ARINC 745 and RTCA DO-212.

This function must be able to support connections to at least 4 ATC and 1 AOC centers, each of which can have one contract of each type and report the right data to the right one at the right time.

In the interim ATS communication environment, the ADS application should be supported using ARINC 622 data links.

The ADS contracts should be established automatically by the contract protocol defined in ARINC 745 without the need for crew intervention. Each contract specifies the data groups as well as the report interval and other report downlink triggers that are desired.

Until superseded by the ATN, the ADS function must keep track of the ATC center address of each of these centers.

All time stamps associated with data groups should be based on the UTC received from the GNSS. UTC based on aircraft clocks should only be used in case of GNSS outage or failure.

The function should also provide a crew interface for the control and display of the ADS function.

**4.3.7.2.4 Position/Intent Broadcast (ADS-B)**

**COMMENTARY**

The FMC provides position/altitude/time and intent at a specified interval, depending on whether flying terminal, enroute, oceanic or domestic. It also allows continuous conflict predictions to be performed on the ground by ATM and by other aircraft. This broadcast is being defined by RTCA SC-186 MASPS and may include:

* Position (latitude and longitude or possibly earth centered position vector)
* Altitude
* Time stamp
* Velocity vector (3D)
* Intent data in the form of waypoint positions, altitude, and ETA
* Selected altitude and ETA (if climbing or descending)
* RNP
* Estimate of actual performance

**4.3.7.3 ATM Functions to Support Free Flight**

**COMMENTARY**

The Final Report of RTCA Task Force 3, Free Flight Implementation was released on October 26, 1995. It defines Free Flight as a safe and efficient flight operating capability under Instrument Flight Rules (IFR) in which operators have freedom to select their path and speed in real time. Air traffic restrictions are only imposed to ensure separation, to preclude exceeding airport capacity, to prevent unauthorized flight through Special Use Airspace (SUA), and to ensure safety of flight. Restrictions are limited in extent and duration to correct the identified problem. Any activity which removes restrictions represents a move toward free flight.

The Free Flight report identifies a three phase program to achieve the goal, with continuing evolution. These phases are:

* Phase 1-Near Term (through 1997)
* Phase 2-Mid Term (1998 through 2000)
* Phase 3-Far Term (2001 and beyond)

Each phase addresses the multiple domains of domestic enroute, terminal (including airport ground operations), oceanic, and the preflight traffic flow management collaborative processes.

In Phase 1 the existing capability of aircraft equipage, especially the ARINC 702 FMCS, are to be exploited.

In Phase 2 the additional capabilities defined in ARINC Characteristic 702A, including Controller/Pilot Data Link Communications (CPDLC) and Automatic Dependent Surveillance (ADS), will be required.

Phase 3 requires additional functionality in the form of ADS Broadcast (ADS-B) to provide enhanced surveillance. Note that RTCA SC-186 is responsible for the definition of ADS-B. The transition from ACARS supported by ARINC 622 data links to the Aeronautical Telecommunications Network (ATN) is expected in Phase 3.

The development of free flight is likely to follow independent paths in the USA domestic and the international oceanic airspaces. Because the free flight operational concept goes beyond that envisioned by the ICAO FANS concepts, considerable international debate is expected.

The Task Force #3 report identifies numerous FMC functions which may be required to facilitate the transition to a free flight environment. These include:

* Area navigation (RNAV) providing optimum lateral and vertical trajectories
* GNSS navigation sensors and time reference (Sections 4.3.1.1 and 4.3.1.2)
* RTCA DO-236 compliant navigation (RNP) (Section 4.3.1.3)
* Automatic monitoring of available navigation performance versus required RNP (Section 4.3.1.3)
* Data linking of trajectory and winds/temperatures via AOC automatic flight plan loading (Section 4.3.2.4)
* Controller/Pilot Data Link Communication (CPDLC) with ATS automatic Route clearance loading (Section 4.3.7.1.2)
* Required Time of Arrival (RTA) capability to ± 30 seconds enroute,   
  ± 5 seconds terminal (Section 4.3.3.2.3)
* Ability to designate, create, or modify a waypoint using the navigation (map) display and a pointing device (Section 4.3.2.4.3.8)
* Separation assurance from terrain and fixed obstacles (Section 4.3.9)
* Consideration of Special Use Airspace and FIR boundaries   
  (Section 4.3.2.2)
* Airport surface maps with taxi guidance (Section 4.3.8)
* Surveillance data for ADS and ADS-Broadcast (including state, intent, and deviation from intent) (Section 4.3.7.2)

**4.3.7.4 ACAS Interface**

The role of the FMS and the standard interface between the Aircraft Collision Avoidance System (ACAS) unit and the flight management function have not been defined.

* Proposed text

**4.3.7 ATS Datalink**

The Air Traffic Services (ATS) providers are implementing, or have plans to implement, Air Traffic Services Datalink functions using existing and future data link systems. These include:

* FANS 1/A
* Link 2000+ (subset of ATN Baseline 1)
* ATN Baseline 2 (ATN B2)

The FMS system should support these datalink environments. FANS 1/A is utilized primarily in trans oceanic ATC environments. Link 2000+ is mandated as the datalink environment in Europe. ATN Baseline 2 is applicable to airspace in North America and eventually replace Link 2000+ in Europe. The Many of the avionics system implementations have elected to support multiple ATS datalink environments.

All these ATS datalink systems provide the capability to establish a connection between the airplane and the ground service, communicate with air traffic control using datalink messages instead of voice contact and may provide other functions such as position reports and air traffic information. The datalink systems utilize different air/ground networks. FANS 1/A operates over the ACARS network as described in ARINC 622. ATN B1 Link 2000+ operate over the Aeronautical Telecommunication Network (ATN). . ATN B2 is network agnostic.

The datalink communication architecture on the aircraft has evolved with variation in the allocation of the datalink subfunctions to physical units.



Figure - ATS Datalink Airborne Architecture

Some architectures have chosen to integrate the ATS end system into the FMS, some have chosen to allocate the ATS end system to a different unit and establish a significant data interface with the FMS to support the various datalink functions. Some implementations have a minimal interface with the FMS and depend on the crew to manually support the data needs of the datalink function, The following sections describe all the potential FMS requirements for thedatalink functions without regard to the functional allocation of the specific airborne architecture. **It’s left to the FMS manufacturer to understand the specific airborne architecture they’re designing for and which requirements are appropriate for that environment.**

**4.3.7.1 Future Air Navigation System 1/A (FANS 1/A)**

The ATN applications used in FANS 1/A are Air Traffic Services Facilities Notification (AFN), automatic dependent surveillance-contract (ADS-C), controller pilot data link communication (CPDLC) as defined in DO-258 and ARINC 622. These applications support the following ATM functions:

* + - ATS Log on
    - Position Reporting
    - Clearances and Crossing Constraints
    - Altitude and Speed assignments
    - Route Modifications
    - Radio frequency assignments
    - Requests for information

**4.3.7.1.1 Air Traffic Services Facilities Notification(AFN)**

In order to establish the proper air/ground connections, the system should provide for an ATS log on function and indications of the connection status

In the FANS 1/A environment using the ARINC 622 network, this function is known as Air Traffic Services Facilities Notification (AFN). This function should provide a simple crew interface that allows for an ATC logon based on parameters such as ICAO names for airport facilities and airline flight number. The detailed log on protocol for AFN is specified in DO-258 and ARINC 622.

**4.3.7.1.2 Controller/Pilot Data Link Communication(CPDLC)**

The CPDLC specific messages supported should be those defined by RTCA DO-258 to provide the following functions:

* + - Clearances and Crossing Constraints
    - Altitude and Speed assignments
    - Route Modifications
    - Radio frequency assignments
    - Requests for information
    - Free text messages

These messages include some which are loadable and others which are display only. The FMS provides for the capability to receive and send these messages over the data link channel. The FMS should provide the capability to interface with the network protocol and integrity checking as defined by ARINC 622, These data link messages will be identified with an Imbedded Message Identifier (IMI) of ATx and Message Format Identifier (MFI) of AA/BA to distinguish them from AOC messages and take priority over any other pending data link messages.

Interpretation of the message is based on the CPDLC application defined by RTCA DO-258 message element number. Upon receipt of an ATC uplink, the system should annunciate an alerting level message in the primary field of view and set an output discrete that will be used to control an aural warning. The system should also provide for a crew interface that details these messages for crew review along with the appropriate prompts for crew responses such as accept, reject, standby, or response data that may be required.

As a minimum, the FMC functions should provide the capability to load the following message types:

* RTA waypoints and required times
* Route modifications (such as direct to, lateral offset, procedure insertion, full flight plan)

For all load functions, the changes should be displayed for review of the effect of the changes by the flight crew. The changes should be activated with positive confirmation from the crew.

**4.3.7.1.3 Automatic Dependent Surveillance - Contract (ADS-C)**

This function should provide for uplink messages to establish

* + - Periodic Contract
    - On Demand Contract
    - Event Contract
    - Normal/Emergency Reports
    - Cancel Contract
    - Cancel All Contracts

as well as Acknowledgment, Negative Acknowledgment, Noncompliance Notification, and data downlink messages as defined in RTCA DO-258.

This function must be able to support connections to at least 4 ATC and 1 AOC centers, each of which can have one contract of each type and report the right data to the right one at the right time.

The ADS-C contracts should be established automatically by the contract protocol defined in DO-258 without the need for crew intervention. Each contract specifies the data groups as well as the report interval and other report downlink triggers that are desired. Each contract request can specify the data groups to be transmitted:

* + - Basic ADS-C
    - Flight ID
    - Airframe ID
    - Air vector
    - Ground vector
    - Projected profile
    - Aircraft Intent
    - MET data

The ADS-C function must keep track of the ATC center address of each of these centers.

All time stamps associated with data groups should be based on the UTC received from the GNSS. UTC based on aircraft clocks should only be used in case of GNSS outage or failure.

**4.3.7.2 Link 2000+**

The ATN applications used in ATN Baseline 1 Link 2000+ are subsets of context management (CM), automatic dependent surveillance (ADS), controller pilot data link communication (CPDLC),) as defined in DO-280. These applications support the following ATM functions:

* + - Data Link Initiation (DLIC)
    - ATC Communications Management (ACM)
    - Air Traffic Clearance (ACL)
    - ATC Microphone Check (AMC)

**4.3.7.2.1 Context Management(CM)**

The ATN Baseline 1 Link 2000+ CM logon function can only be air initiated. The aircraft system uses the logon function to provide an application name, address, and version number for each application that the aircraft wishes to use that can be ground initiated, along with flight plan information as required by the ground system. In response, the ground provides an application name and version number for each ground-only initiated requested application

To support auto transfer from one center to the next, tLink 2000+

**4.3.7.2.2 Controller Pilot Data Link Communication (CPDLC)**

The LINK 2000+ CPDLC is a small subset of the ATN Baseline 1 CPDLC as defined in RTCA DO-280. The ATN Baseline 1Link 2000+ controller-pilot message exchange function defines a method for a controller and pilot to exchange information via data link as detailed in DO-280. This function provides messages for the following:

* ATC Communication Management (ACM)
  + - Air Traffic Clearance (ACL)
    - ATC Microphone Check (AMC)

The ATN Baseline 1 Link 2000+ CPDLC message elements encompass level assignments, crossing constraints, lateral deviations, route changes and clearances, speed assignments, radio frequency assignments, and various requests for information. The pilot has the capability to respond to messages, request clearances and report information. An uplink “free text” capability is also provided to exchange information not conforming to defined formats and to append information explaining error reasons. A downlink “free text” capability is provided to append information explaining error reasons.

The ATN Baseline 1 transfer of data authority function provides the capability for the current data authority (CDA) to designate another air traffic service unit (ATSU) as the next data authority (NDA). A CPDLC connection can be established by the NDA at a time before becoming the CDA. This capability is intended to prevent a loss of communication that would occur if the NDA were prevented from actually setting up a connection with an aircraft system element until it became the CDA. The designation of a NDA is accomplished using a CPDLC message.

**4.3.7.3 ATN Baseline 2 (ATN B2)**

The ATN applications used in ATN Baseline 2 are context management (CM), automatic dependent surveillance-contract (ADS-C), controller pilot data link communication (CPDLC), and flight information services (FIS) as defined in DO-350 and DO-xxx. These applications support the following ATM functions:

* + - Data Link Initiation (DLIC)
    - ATC Communications Management (ACM)
    - Clearance Request and Delivery (CRD)
    - ATC Microphone Check (AMC)
    - Departure Clearance (DCL)
    - Data Link Taxi (D-TAXI)
    - In Trail Procedure (ITP)
    - Interval Management (IM)
    - Oceanic Clearance Delivery (OCL)
    - Information Exchange and Reporting (IER)
    - Position Reporting (PR)
    - 4-Dimensional Trajectory Data Link (4DTRAD)
    - Dynamic Required Navigation Performance (DRNP).

**4.3.7.3.1 Context Management**

Context Management provides a method for a ground station to contact an aircraft using a data link initiation (DLIC) contact message and a method for the aircraft to respond with an data link initiation (DLIC) request as detailed in DO-350.

The requesting ground system sends a contact message to the aircraft system instructing the aircraft system to perform DLIC initiation with the specified DLIC ground system. The contact instruction indicates the ATS facility designation (and the associated DLIC address) of the ATSU system with which the aircraft is to perform the initiation function. The flight crew responds by sending the initiation message to the DLIC ground system including:

the facility designation of the ATSU with which the initiation information is requested if the DLIC ground system is different than the specified ATSU system

information on each requested application for data link service

flight plan information to allow unambiguous correlation of the aircraft with the flight plan information

The ground system responds by sending an initiation response to the aircraft

including information on each application that was requested by the aircraft and is accepted for use with this aircraft

**4.3.7.3.2 Controller Pilot Data Link Communication(CPDLC)**

The ATN Baseline 2 controller-pilot message exchange function defines a method for a controller and pilot to exchange information via data link as detailed in Do-350. This function provides messages for the following:

* General information exchange
* Clearance delivery, request, and response
* Departure Clearance
* Taxi Instructions
* Separation Assurance
* Route modification
* In trail procedure
* Interval management
* 4D trajectory based operation
* Dynamic RNP

The aircraft system shall allow the flight crew to view the message with no more than a single action and allow the flight crew to access the list/queue of unread messages with no more than a single action. The aircraft system should display the messages on a dedicated display in the primary field of view.

The aircraft data link system shall provide the flight crew with the capability to load CPDLC uplink messages into the FMS to avoid hazards associated with human entry errors and/or increased workload. The following clearance messages are prone to these hazards:

* + - A clearance that will require the creation, in the resulting flight plan, of more than one waypoint unless the route is described by a procedure name that can be loaded from the navigation database,
    - A clearance that will require the creation, in the resulting flight plan, of one waypoint specified by place-bearing-distance or latitude/longitude with a resolution smaller than whole degrees.

The aircraft data link system will provide the flight crew with assistance to create CPDLC downlink messages to avoid any safety implications (i.e., human entry errors and/or significant increased workload). The following downlink messages are prone to these hazards:

* + - request messages which contain more than one waypoint
    - report messages of the present aircraft position or containing one (or more) waypoint(s) from the FMS active flight plan.

**4.3.7.3.3 Automatic Dependent Surveillance (ADS-C)**

The ADS-C application provides automatic reports from an aircraft system to an ATSU as detailed in DO-350. The ATSU is capable of requesting the aircraft system to provide the ADS-C reports to the ATSU system in three ways:

* + - on demand
    - on a periodic basis
    - when triggered by an event

Only one contract of a given type per aircraft is permitted at one time per ATSU. When the ATSU sends a contract request to an aircraft system for a periodic or event contract, and either of these two contracts already exists with that aircraft, then the new contract will override the previous contract for that type. Acceptance of an event or periodic contract request implicitly cancels an existing respective event or periodic contract. Since the demand contract is satisfied by sending a single report, any number of demand contracts may be sequentially

established with a given aircraft. The ATSU is capable to cancel either a single contract or all contracts in operation that it has established with an aircraft. The ATSU specifies either which contract(s) to cancel by identifying the contract type(s), or specifying to cancel all contracts. The aircraft system acknowledges the cancellation and ceases sending the ADS-C reports for the cancelled

contract(s). The aircraft system is capable of providing ADS-C reports to support contract requests. The ADS-C reports content and the conditions under which the report is sent vary depending on the type of contract request and the conditions specified in the request. The aircraft system is capable of supporting contract requests with at least four ATSUs simultaneously. It is also capable of supporting one demand, one event and one periodic contract request with each ATSU simultaneously. In addition, when in emergency mode, the aircraft system provides an emergency/urgency indication as part of each downlink ADS-C messages including the ADS-C report.

Each contract request can specify the data groups to be transmitted:

* + - Basic ADS-C
    - air vector
    - ground vector
    - projected profile
    - MET data
    - RTA status data
    - extended projected profile
    - planned final approach speed
    - RNP status

Commentary

The predicted altitudes in ADS reports should be the level at which the aircraft is predicted to sequence the point. When the aircraft is off the vertical reference path this altitude may be different than the predicted reference path altitude.

**4.3.7.3.4 Flight Information Service (FIS)**

Flight Information Services (FIS) is an ATN application by which the aircrew can

retrieve operational data from a ground system providing flight information services. There is currently a proposal to remove this service from the ATS data link package because of the evolving scope/definition of the data elements being exchanged and the level integration required with the FMS.

# Information Sources

DO-258, DO-280, DO-350, ARINC 622