The combination of growing air traffic, constrained government budgets and higher fuel prices has generated demand from operators, governmental agencies and passengers alike for more efficient and reliable flight paths. Not only must aircraft be placed in closer proximity but safety must be maintained and even improved.

As a result, regulatory agencies and the aerospace community are using a three-pronged approach to address the transition to this new ecosystem:

1. **Improved positional accuracy** while airborne and during ground operations, primarily through use of GPS-based navigation hardware;

2. **Enhanced communications**, typically addressed with non-voice communications methods;

3. **More direct routing** over land, water and in congested airspace such as approaches to large municipal airports.

Most business aircraft delivered since 2011 (and many delivered prior to 2011) are already equipped to facilitate their integration into the emerging aerospace infrastructure. However, “legacy” aircraft, even those exempted from mandated equipment upgrades, can still be retrofitted with the required hardware, allowing them to take full advantage of these upgrades for more efficient and safe operations.
However, it is critically important that equipage upgrades be thoroughly evaluated and carefully planned. Poor implementations can dramatically increase flight crew workload and make future upgrades inefficient and expensive. To facilitate smooth, flight crew-friendly and future upgrade readiness, we strongly suggest designing solutions around the aircraft’s existing flight management system (FMS). Maintaining this key component of today's highly integrated avionics systems and resisting "bolt-on" solutions will return significant benefits to the operator in the long run.

These benefits, such as future FMS software upgrades to meet other mandates or provide new system functionality, will far outweigh any near-term non-integrated solution.

Another key area for equipage planning concerns communications upgrades. Data link allows some communications to move off the voice channel while providing a viewable record, thus reducing communication errors. It also increases air traffic control efficiency by reducing the time spent on routine tasks such as transfer of communications.

When integrated with the navigation system in the aircraft, data link enables new and more complex information to be exchanged automatically such as more specific or more frequent position reporting in oceanic airspace or clearances containing multiple fixes or waypoints.

The Future Air Navigation System (FANS) is a concept that was developed by the International Civil Aviation Organization (ICAO) in partnership with Boeing, Airbus, Honeywell and others in the aerospace industry to allow more aircraft to safely and efficiently utilize a given volume of airspace. Aircraft equipped with FANS can transmit Automatic Dependent Surveillance-Contract (ADS-C) reports with actual position and intent information at specified time intervals automatically.

FANS ADS-C (Automatic Dependent Surveillance-Contract) is used primarily in oceanic and remote airspace, taking advantage of both satellite communication and satellite navigation to effectively create a virtual radar environment for safe passage of aircraft.

However, the most common implementation of FANS 1/A+ leverages modern nonverbal communications protocols such as Controller Pilot Data Link Communications (CPDLC) for a variety of tasks including clearance requests.

CPDLC contains a set of predefined messages that allow flight crews to communicate nonverbally with air traffic control (ATC). Clearances and messages are exchanged according to CPDLC standards and protocols via VHF, SATCOM and/or HF.

This has played a key role in supporting many of the evolving CNS/ATM strategies and mandates – an evolution that has been underway for more than twenty years.
FANS benefits

FANS provides a variety of benefits, primarily reduced fuel burn and flight time, through more efficient routing and increased payload capability for takeoff-weight-limited flights.

As a result, operators of FANS-capable business aircraft are able to take advantage of numerous much-needed improvements:

- Data link services provide communications that are intended to support more efficient air traffic management and increase airspace capacity.
- In airspace where procedural separation is being applied, the data link services improve communications, surveillance and route conformance monitoring to support operational capabilities that enable reduced separation.
- For example, in addition to navigation performance requirements, the following reduced separations require FANS 1/A aircraft, FANS 1/A ATSU, RCP 240 (Required Probability of Operational Communication Transactions) and RSP 180 (Required Probability of Surveillance Data).
  1. 50 nm longitudinal separation;
  2. 30 nm longitudinal separation;
  3. 30 nm lateral separation.
- Dynamic airborne re-route procedure (DARP) and weather deviation management.
- CPDLC improves communication capabilities by reducing voice channel congestion and enabling the use of CPDLC-related automation.
- Provides direct controller-pilot communications (DCPC) in airspace where it was not previously available.
- Allows the flight crew to print messages.
- Allows messages to be stored and reviewed as needed.
- Reduces flight crew-input errors by allowing the loading of information from specific uplink messages, such as route clearances or frequency change instructions, into other aircraft systems, such as the FMS or radios.
- Allows the flight crew to request complex route clearances, which the controller can respond to without having to manually enter a long string of coordinates.
- Reduces flight crew workload by supporting automatically transmitted reports when a specific event occurs, such as crossing a waypoint and the loading of clearance information directly into the flight management system.
- Reduces controller workload by providing automatic flight plan updates when specific downlink messages (and responses to some uplink messages) are received.
- Reduces separation between airplanes.
- Allows preferred/more direct oceanic routing, particularly through use of North Atlantic Tracks (NATs) in heavily transited North Atlantic airspace.
- Reduces delays on the ground while awaiting clearance.
- Provides fully automated event reporting.
- Digital and nonverbal data link communication with ATC – faster and more efficient communication which can also mitigate translation barriers for non-native English speaking flight crews.
- Request/receive clearances on HMI.
- Auto acceptance of clearances into flight plan on aircraft with fully integrated FMS systems.
- FANS availability even when primary FMS is unavailable via secondary FMS (if Honeywell).
FANS 1/A+

CPDLC, in conjunction with Automatic Dependent Surveillance-Contract, also enables the use of FANS 1/A over oceanic airspace. FANS uses the Airport Facilities Notification (AFN) protocol over existing Aircraft Communication Addressing and Reporting System (ACARS) network via VHF and satellite communications (SATCOM) and enables transoceanic navigation closer to other aircraft than previously permissible.

CPDLC data link communications, coupled with SATCOM, can be used as a primary communications mechanism between ATC and the flight crew, especially when VHF radio coverage does not exist. This can improve flight efficiency and passenger comfort by allowing more frequent flight changes. CPDLC and ADS-C-enabled aircraft may utilize preferred and shorter North Atlantic Track routes while travelling between North America and Europe and may also use newer, more lenient separation standards to other aircraft.

FANS 1/A+ systems, when fully integrated with onboard flight management systems, provide additional benefits including:

- Capability for flight crews to respond nonverbally to ATC messages,
- Workload reduction by removing the need to retype flight plans into the primary FMS, and
- Removal of the potential need for flight crew retraining through continued utilization of the existing FMS

Benefits of an Integrated FANS solution

1. Integrated FANS-FMS solution provides crew integration and human factors benefits.
2. FANS experience: major avionics systems suppliers like Honeywell have been flying FANS routes since the late 1990s.
3. Human-machine interface is consistent with crew interface and flight deck design philosophy of the particular aircraft in which the aircraft data link system is installed. (Per AC 20-140A Page 9).
4. Integrated FANS provides for a high degree of aircraft performance and interoperability.
   a. primary and secondary FMS CDUs in the pilot’s normal field of view;
   b. auto load clearance and flight plans;
   c. integrated FANS 1/A+ navigation and performance with the Honeywell GIV/GV avionics systems;
   d. dual- or triple-redundant FMS with FANS 1A+ functionality.
5. Full FMS functionality: navigation, performance, communications.
6. Standardization with the Gulfstream fleet.
7. Core software already flying on the Planeview G450/550/650 and hundreds of additional aircraft flying the North Atlantic Tracks.
8. Better crew situational awareness through one type of FMS in the cockpit. Dissimilar FMSs could lead to crew confusion in situational awareness situations.
9. Recurrent training will be conducted with integrated system’s FMS supplied as original equipment by the specific aircraft OEM.
10. Integrated growth to performance-based navigation: PM-CPDLC, SESAR, FAA Next Gen
North Atlantic Tracks

A system of tracks have been designated over the North Atlantic to allow passage of aircraft across the busy intercontinental regions. The tracks can vary based on congestion and weather conditions. In order to make this flow more efficiently, FANS1/A+ based CPDLC shall be implemented in track region. The number of tracks and the regions that that CPDLC must be used is planned to be increased over time per the following phases:

<table>
<thead>
<tr>
<th>Phase</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1:</td>
<td>February 2013 - Center Tracks across FL350-390</td>
</tr>
<tr>
<td>Phase 2A:</td>
<td>February 2015 - FL350 to FL390 within the NAT OTS</td>
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<tr>
<td>Phase 2B:</td>
<td>Dec 2017 FL350 - FL390 throughout the ICAO NAT Region</td>
</tr>
<tr>
<td>Phase 2C:</td>
<td>Jan 2020 - Above FL290 throughout the ICAO NAT Region</td>
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</tbody>
</table>

US Airspace

The United States airspace via the FAA NextGen program plans to implement FANS 1/A+ based CPDLC. The initial phase currently under trial plan to implement departure clearances (DLC) starting in late 2015 through 2016. Subsequent phases shall expand the messages for use during en-route.

European Airspace

CPDLC is a key initiative in Europe to alleviate congestion. However, a new network and messages are are required which are different from current FANS 1/A+ technology. The LINK 2000+ Programme is co-ordinating the European implementation of CPDLC in upper airspace. Data link communications is a key element of the Single European Sky (SES) and is the subject of the SES Data Link Services Implementing Rule (DLS IR) legislation published in January 2009 (EC Reg. 29/2009) which specifies European implementation dates and requirements.

The European version of CPDLC uses the Aeronautical Telecommunications Network (ATN) and requires VHF Data Link Mode 2 (VDL-M2) radios. The CPDLC message set is referred to Protected Mode CPDLC (PM-CPDLC) and sometimes the protocol is also referred by its standards name SC214 ATN B1.

Some functions provided by the PM-CPDLC application are:

- The ATC Communication: Management (ACM) Service
- The ATC Clearance (ACL) Service
- The ATC Microphone Check (AMC) Service

As a newer technology, it features improved data integrity and ensures that messages are delivered to intended aircraft. It will be implemented in Europe and will be required for operation above 28,500 feet (FL 285) unless exempt.
Exemptions

When PM-CPDLC completes all of its objectives, mandates for an even more recent CPDLC implementation, PM-CPDLC, were planned and required for new aircraft operating at or above FL285 within European airspace. Existing non-exempted aircraft will eventually need to equip with PM-CPDLC for operation in Europe. Currently, EASA is offering FANS 1/A-equipped airframes lifetime exemptions from PM-CPDLC if equipped with FANS 1/A and operationally approved on or before January 2014. This is a major benefit for business aircraft operators who equip with FANS 1/A and most notably for oceanic aircraft.

A number of aircraft, mainly for long-haul oceanic operations, have already been equipped with data link capability using FANS I/A standards. It would not be economically justified to request operators to install further data link equipment on such aircraft to comply with the requirements of this regulation.

Exemption is a lifetime authorization to be relieved of the obligation stated in the mandate with the implication that there would be no limitation.

Exemptions for which Eurocontrol agreement is needed include aircraft types for which re-engineering costs required would be disproportionate. Exemption requests must be submitted to Eurocontrol.

A list of permanent and temporary exemptions is available from the following source:


Eurocontrol provided clarification of some key questions including the consequences of an aircraft not being data link-capable.

- According to the DLS IR, if the aircraft is exempted there will be no operational restrictions; they will be controlled via voice.
- If the aircraft is not exempted, it should be operated below FL285

Honeywell solutions for business jets

**Business Jet Legacy Aircraft**

Honeywell is the leader in the CPDLC data link solution. Solutions have been deployed on air transport and business jet aircraft on both integrated cockpits and federated systems including the Epic suite.

For retrofit aircraft, Honeywell provides a complete and integrated avionics solution to support the rollout of FANS 1/A+, including FANS messaging, Data link and SATCOM certified for safety services, and cockpit voice recorders, with the specific hardware detailed below.

Since there are numerous elements to deploy FANS, requiring equipment, operations and certification support, the Honeywell solution enables an operator to quickly deploy FANS, taking advantage of the data link.

One of clear benefits of the Honeywell solution is that the FANS 1/A+ messaging is integrated with the Honeywell flight management system. This allows the same flight computer to do both the navigation and communications. This level of integration in Honeywell avionics reduces pilot workload and potential errors since no retyping is necessary.

FANS 1/A functionality has been previously developed in the Honeywell NZ 6.1 FMS. The MARK III CMU from Honeywell provides management and access to the ACARS-compatible data link networks and services available to the aircraft.

### Benefits of Honeywell FANS 1/A+ Solution

- Fully integrated system tested end to end
- Integrates with existing Flight Management Computers
- Integrates with existing Control Display Units
- Fully compliant to AC20-140B
- Ensures that the FMS providing aircraft guidance is same FMS that is processing FANS messages and data to ATC
- FANS operation available if either FMS 1 or FMS 2 fails
- Proven: Over 1,000 Mark III’s in service, Boeing 717, 737, 747, 757, Embraer 135, 145

The MKIII CMU hosts a variety of data link applications including those related to Aeronautical Operational Control (AOC) and Air Traffic Services (ATS) communications. Additionally, the MKIII CMU interfaces with other Honeywell avionics including alerting systems, printers, flight management systems, CVR, SATCOM and VHF radio. To support Honeywell FMS-FANS the following equipment is required:

- FMS with NZ 6.1 (IC-800 or NZ-2000)
- CD-820 or CD-810
- SATCOM (approved for FANS use, ARINC 741)
- CMU with FANS routing capability
- VHF data radio (A716- or A750-compatible, VDL mode 2)
- CVR with data link recording capability
CMU MKIII – ACARS protocols, VDL mode A, VDL mode 2 (optional), SATCOM and HF data link are supported. Oceanic clearance messages as required for FANS 1/A+ in the North Atlantic are supported. FMS, cockpit voice recorder and printer interfaces as well as message routing priorities for FANS are supported.

FMS 6.1 – The actual message generation of the CPDLC message set occurs at the FMS. Therefore the FMS will need to be upgraded to software release 6.1 with FANS upgrade package.

Cockpit Display Unit – The CD 820/810 is Honeywell’s control display unit that provides the graphical display. FMS-FANS requires a CD-820 CDU for display and control of FANS messaging.

Cockpit Voice Recorder (CVR) – Data link recording of certain message sets is required, for which data link communication equipment is installed. Therefore, in most cases the CVR will need to be upgraded to record this information.

SATCOM – In order to provide efficient communications across oceanic flights, satellite communications are required. The Mark III supports satellite communications via ARINC-741, Inmarsat Swift Broadband and Iridium with traditional ARINC 429 inputs. However, SATCOM-provided safety services must be certified Level D for safety services.

VHF Radios – The CMU system provides an interface with the VHF radio and VHF radio control panel. The CMU interfaces to the third VHF radio. This radio may or may not be used for voice communication in addition to data link communication. When radio tuning is controlled by the CMU while in data mode, the CMU automatically controls the VHF frequency to be used. No flight crew involvement is required. As a minimum, a VHF Data Mode-VDL Mode A radio is required to support oceanic FANS services; however, a VDL Mode 2 radio, which provides high data rates, is recommended.
FANS Alerting – FANS requires aural and visual alerting. Basically, the FMS hosting FANS application is outputting alerting information on ARINC 429. The CMU will be software-updated to convert these 429 outputs into discrete alerts for alerting systems which require discrete alerts (in lieu of 429 word alerts). The Mark III provides the necessary outputs to support two additional discretes.

Printer - The data link messages may be printed out for archiving and retrieval for incidence investigations. This requires an ARINC429-compatible printer.

- The Ground Based Software Tool (GBST) allows an airline to develop, reconfigure and verify the data that drive the CMU Airline Operation Centre (AOC) applications.
- The user-programmable Airline Modifiable Information (AMI) database allows an operator to customise data link message formats and cockpit display and printer formats to meet data link communications requirements without updating the Mark III software, thereby avoiding recertification.
- Provides ARINC 623 ATS data link application.

**Honeywell FANS Program**

<table>
<thead>
<tr>
<th>Required/Option</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>FMS 6.1 Required</td>
<td>Load based on aircraft type</td>
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<tr>
<td>FMS 6.1 FANS Update Required</td>
<td>FANS &quot;mini&quot; load</td>
</tr>
<tr>
<td>CD-810 or 820 Required</td>
<td>2888-07 to -10-1</td>
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<tr>
<td>MK III Comm Management Unit Required</td>
<td>7519200-921</td>
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<tr>
<td>Aircraft Personality Module</td>
<td>964-0465-001</td>
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<tr>
<td>SATCOM Level D Certified Required</td>
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<td></td>
<td>MCS7000/HDS711</td>
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<td>VHF Data Radio Mode 2 Required</td>
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<td>Aural and Visual Alerting Required</td>
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<td>HFRS: 680-6032-001</td>
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</table>

*Additional configurations possible

**Timeline for FANS via Mark III**

The Mark III CMU hardware platform is currently in production, and is primarily used with airlines, regional jets and military applications. With its aircraft operator-reconfigurable approach, the Mark III, along with its core software, can be quickly deployed for customers in the business and general aviation market who want to reap the immediate benefits of FANS1/A+ solution.

Honeywell hardware is available now and the company is in the process of completing software enhancements. Certification activities are planned to start in the second quarter of 2014.
Appendix I

**Mark III General Specifications**

- **Size**: 4MCU
- **Weight**: 12lbs / 5.44kgs
- **Cooling**: ARINC 600 or ARINC 404
  - 115 VAC, 400 Hz or 28 VDC
- **Power requirement**: < 40W
- **Environmental**: DO160D
- **Software**: DO178B Level C

**Input/Output**

- MIL STD Transceivers: 2
- ARINC 429 Transmit: 12
- ARINC 429 Receive: 48
- Discrete inputs: 34
- Discrete outputs: 15
- CHF (MSK) Audio: 1
- CMU Crosstalk: 1
- Printer: 1
- Ethernet: 4
- ARINC 615 data-loader port: 1
- PCMCIA: 1
- APM: 1
- RS-232: 2
- RS-422: 3
- Relay Contacts: 2

**Glossary**

- **ACARS**: Aircraft Communication Addressing and Reporting System
- **AOC**: Airline Operations Communications
- **ATC**: Air Traffic Control
- **ATN**: Aeronautical Telecommunication Network
- **CPDLC**: Controller-Pilot Data Link Communication
- **CVR**: Cockpit Voice Recording
- **DLS-IR**: Data Link Service
- **FANS**: Future Air Navigation System
- **FMS**: Flight Management System
- **NAS**: National Air Space
- **PM-CPDLC**: Protected Mode-Controller Pilot Data Link Communication
- **SATCOM**: Satellite Communications
- **SES**: Single European Sky
- **VHF**: Very High Frequency
- **VDL**: Very High Frequency Data Link

**References**

- [1](www.eurocontrol.int/articles/data-link-services-dls-mandate)
- [2](www.eurocontrol.int/articles/data-link-services-implementing-rule)
- [3](www.eurocontrol.int/sites/default/files/content/documents/nm/link2000/link2000-2nd-decision-on-dls-exemptions-20111209.pdf)