

Large numbers of aircraft need to have their flightdecks modified to comply with the European Commission's mandate that operations in European airspace above 28,500 feet will have to be conducted with Protected Mode CPDLC from February 2015.

Equipping aircraft with CPDLC to comply with Europe's SES

In 1999 the European Commission (EC) launched the Single European Sky (SES) scheme with the objective of meeting future capacity demands and safety needs. The US will follow with the next generation (NextGEN) air transport system.

The SES concept was conceived in response to increasing traffic flows and a desire to cut costs and improve the performance of European airspace. The idea of a SES is based on organising airspace into functional blocks according to traffic flows, rather than being based on national borders.

The main changes over the current system are that aircraft will define their own optimum flightpaths, altitude and speed. The complete trajectory of a flight will be determined by an upgraded flight management system (FMS). Part of the process of operating in the new system will require aircraft to have datalinks in order to allow aircraft to communicate with each other and the air traffic control (ATC) system.

Several technologies have emerged to make this possible. These include automatic dependent surveillance broadcast (ADS-B), global positioning system (GPS) satellite communication, and controller-pilot datalink communication (CPDLC).

An important step towards realisation of a SES came in 2009 following the EC's publication of datalink Services Implementing Rule (IR) EC No 29/2009. This is EC legislation that prescribes the use of Protected Mode CPDLC in upper European Airspace.

An element of the IR is that all aircraft flying above Flight Level (FL) 285

(28,500 feet) in the effected airspace will need to comply.

There are exceptions to the rule including some oceanic or long-haul aircraft with Future Air Navigation Systems (FANS) capability. This is because these aircraft already have a certain standard of datalink capability.

CPDLC

The IR highlights that expected increases in European air traffic will require related increases in air traffic control (ATC) capacity. Among the operational improvements required is a need to improve the efficiency of communications between controllers and pilots. The legislation states that: 'Voice communications channels between air traffic controllers and pilots are becoming progressively congested and should be supplemented by air-ground datalink communications.'

CPDLC is an air-ground datalink application that provides an additional communication option to supplement traditional voice transmissions via radio. This allows the exchange of pre-formatted text messages between controllers and pilots. The widespread introduction of this technology will have direct efficiency and safety benefits. First there will be reduced congestion on voice channels. Reduced voice communication requirements could also lead to less pilot fatigue.

At the same time the ability to read messages on a screen should reduce the risk of pilots and controllers misunderstanding each other. In terms of efficiency gains it is estimated that an

increase of 11% in air traffic capacity could be achieved if 75% of flights operating within the qualifying European airspace comply with CPDLC.

The IR states that in terms of acceptable CPDLC compliance: 'Protocols defined by the International Civil Aviation Organisation (ICAO) are based on the aeronautical telecommunication network (ATN) and the very high frequency digital link Mode 2 (VDL2) are currently considered to be the only validated solution for harmonised deployment.' This means that airlines have to use VDL2 over the ATN to send and receive datalink messages.

The existing aircraft communications addressing and reporting system (ACARS) predominantly allows datalink communications, air-ground communications, and airline operational communications (AOC). ACARS uses VHF radio, high frequency datalink (HFDL) and satellite communication to send and receive messages. VDL2 offers a greater digital bandwidth so it is able to deliver information at 10 times the rate of ACARS. This makes it suitable for ATC communication in high-density European airspace.

Link 2000+

The Eurocontrol Link 2000+ programme was created in 2000 to coordinate the implementation of air and ground datalink services in Europe using the ATN and VDL2, which is now legally governed by the IR. In 2005 Eurocontrol was mandated by the EC to develop the provisions of the IR for the coordinated introduction of datalink services.



Importantly, the provisions of the IR only apply to routine ATC tasks in upper airspace. The three basic services that will be automated are:

- ATC communications relating to repetitive frequency changes.
- ATC clearances providing standard clearance commands.
- ATC microphone check.

When Eurocontrol began the Link2000+ programme, the EC mandate was still some way off. “Link 2000+ was split into three phases,” explains Søren Dissing, datalink implementation manager at Eurocontrol. “These were the pioneer phase, the incentives phase and the mandatory implementation phase.”

As the pioneer phase developed, safety analysis determined a need for better mitigation against the possibility of incorrectly delivered datalink messages. Technical solutions were developed and these led to what became known as Protected Mode CPDLC. “This adds a checksum to every CPDLC message that includes an aircraft’s 24-bit ICAO address and other operational information to ensure that they are only acted upon by the intended recipient,” continues Dissing. This ‘Protected Mode’ has been mandated under the EC IR for all CPDLC exchanges.

Requirements and key dates

“There are several important dates to consider with regard to the mandate,” explains Dissing. “The next key date is 7th February 2013. By this date all link region air navigation service providers (ANSPs) need to have in place CPDLC-

compliant ground infrastructure.”

The ANSPs affected here are the flight information regions (FIRs) of Amsterdam and Wein, and the upper flight information regions (UIRs) of Barcelona, Brindisi, Brussels, Canarias, France, Hannover, Lisboa, London, Madrid, Milano, Rhein, Roma, Scottish and Shannon.

“The next key date is 5th February 2015,” continues Dissing. “By then all aircraft operating above flight level (FL) 285 will need to have been retrofitted with a compliant CPDLC system, and the remaining EU region ANSPs will need to have implemented the appropriate ground infrastructure.”

When the IR was initially published the first date of note was 1st January 2011. According to the mandate, all new aircraft operating above FL 285 with a certificate of airworthiness (C of A) registered after this date should have been delivered with a datalink compliant system. “In practice, a hardware and software supply shortfall meant that many operators could not meet this requirement, so a series of temporary exemptions was granted,” says Dissing.

Exemptions

Aircraft operating in the qualifying airspace above FL 285 will need to comply with the mandate, but there are some important exceptions.

Aircraft meeting the following four criteria are automatically exempt from the IR.

1). Aircraft with an individual airworthiness certificate issued before 1st January 2014 that are equipped with

The key feature of the EC’s mandate is that all aircraft flying above Flight Level 285 will have to be equipped with Protected Mode CPDLC. There are several exemptions to this. One important exemption is aircraft certified before 1st of January that are equipped with FANS 1/A navigation systems.

future air navigation systems (FANS) ED-100 and ED-100A certified datalink equipment.

This refers to FANS 1/A, which is mainly used (by long-haul aircraft) in remote or oceanic areas and provides datalink capability via VHF or satellite communication (SATCOM) ACARS networks. “FANS over ACARS cannot react as fast as VDL2 using the ATN,” says Dissing.

With a large number of long-haul aircraft already equipped with FANS datalink, however, it was considered unjustified to force operators to carry out further modifications.

While aircraft equipped with FANS 1/A before January 2014 are exempt for the lifetime of the airframe, those registered after this date will be required to have an IR-compliant solution;

2). Aircraft for which the individual certificate of airworthiness was issued prior to 1st January 1998, and which are planned to be withdrawn from service before 31st December 2017;

3). Aircraft flying for testing, delivery and maintenance purposes; and

4). State aircraft.

Operators can also apply to the EC for exemptions. These applications are usually intended for aircraft meeting one of the following two criteria:

1). Aircraft types that are reaching the end of their production life and are subsequently being produced in limited numbers; and

2). Aircraft types for which the required re-engineering costs would be disproportionately high due to the age of the design.

The Eurocontrol exemption cell has produced two reports for the EC, based on such applications. The Commission has since published decisions based on these recommendations. These awarded permanent exemptions to Embraer ERJ-135 and -145 family aircraft along with Fokker 70s, Fokker 100s, A318-112s, Avro RJ100s, MD-11s, A330-200/-300s and A340-200/-300/-500/-600s.

Temporary exemptions, or an extension to the modification deadline,



were also granted to new aircraft in the 737, A320, E-Jet and CRJ families, beyond 1st January 2011.

Some of these extensions have already expired, while others run until December 2012. "It is important that operators realise that the temporary exemption deadlines apply not only to new aircraft manufactured after the extended dates, but also to aircraft with an individual C of A issued after 1st January 2011," cautions Dissing.

Full details of previous exemptions for each aircraft type can be found in the Commission Decision documents dated 20th May 2011 and 9th December 2011. The final opportunity for the submission of exemption requests closes on 31st December 2012. A final decision on any additional exemptions is expected in the first quarter of 2013.

The exemptions referred to above, including those for oceanic FANS-equipped aircraft and the fact that most turboprops will fly below the qualifying flight level, indicates that 737 and A320 family aircraft operating in the qualifying European Airspace will represent a large percentage of those requiring modification.

Operator requirements

Eurocontrol guidance material identifies several key areas of consideration for aircraft operators preparing to comply with the CPDLC mandate. The first of these is ensuring that aircraft are equipped with certified datalink capability. Appropriate training for flightcrews and maintenance staff also needs to be planned, along with airworthiness certification and operational approval considerations.

Incentives

Several attempts have been made to incentivise operators to equip early with datalink functionality.

During the pioneering phase of Link2000+, Eurocontrol gave financial assistance to participating operators for up to 20 aircraft each. "This amounted to €20,000 (\$25,000) per aircraft, which at the time was a ballpark figure for modification if the aircraft already had VDL mode2 capability for AOC purposes," says Dissing.

Aircraft that had undergone initial pioneer phase modifications subsequently required additional software upgrades to bring them up to Protected Mode CPDLC standard.

Funding was also available during the Incentive Phase of Link 2000+ for retrofit aircraft only. Financial support in this phase was provided by the TENT Executive Agency of the EC. "The scheme, which is now closed to further applicants, covered 20% of aircraft equipage costs for participants, and will result in about 500 aircraft meeting compliance by early 2013," says Dissing.

Equipment

The level of hardware and software upgrades required could vary considerably, depending upon aircraft type, age and current capability. "The chances are that the older the aircraft, the more invasive, costly and logistically impairing the required upgrade will be," suggests Craig Peterson, director avionics and flight controls at Rockwell Collins.

Referring to aircraft with federated avionics systems Peterson explains that: "There are four primary domains of

There are four main changes airlines need to make to aircraft to comply with the mandate to be equipped with Protected Mode CPDLC. These are the installation of: a VHF radio with VDL2 capability, a compliant router, a MCDU to send & receive text messages, and visual and oral attention-getters for pilots.

change that operators need to consider when equipping aircraft to comply with the mandate. First, they need to have a VHF radio with embedded VDL2 capability. Second, they need to have a compliant router. This would be the communications management unit (CMU) or an air traffic services unit (ATSU) on Airbus aircraft. These units prioritise incoming messages and direct incoming and outgoing messages to the appropriate systems."

"Third, operators also need to have compliant human machine interface (HMI) devices. On some aircraft this would be referred to as a multifunction control display unit (MCDU) which allows the user to enter and receive text messages," adds Peterson. "The fourth element of infrastructure to consider is the need for visual and oral attention-getters to alert crews when a message has been received."

Current capabilities are likely to vary considerably. "Some aircraft might have no existing datalink capability and require significant hardware additions or upgrades including CMUs, VDL Radios, MCDUs and affiliated wiring or re-wiring," explains Ian Gilbert, European representative for Spectralux Avionics. "Others may already have some infrastructure in place. Most 737s delivered in the past 10-12 years will probably be equipped with wiring provisions that could reduce the man-hours (MH) needed to modify an aircraft.

"Modern aircraft such as the 777 and E-Jet family have integrated avionics systems that in some circumstances may only require a software upgrade to make them compliant," highlights Gilbert.

One operator that is well advanced in terms of equipping its fleet for the CPDLC mandate is Scandinavian Airlines (SAS). "We have about 60 737NGs in service with the mandated Protected Mode CPDLC Software," says Bjorn Syren, datalink & EFB coordinator development and support at SAS.

"This number will grow to about 70 by the end of 2012. The remainder of the European fleet, including 25 A320 series and 12 CRJ900s, will be equipped by 2013-2014," adds Syren. "The MD-80 and 737 classic fleets in operation will not be modified, since they will be phased out before December 2017, while the A330s and A340s are FANS-equipped,

and therefore exempt.”

In terms of SAS's 737NG fleet, some of its older aircraft already had ACARS capability, but they required a new CMU, a VDL2-capable radio and re-wiring from ARINC 724B to 758 standard, while the 737 cockpit display system required a re-programming. “The re-wiring, including a GPS time source input, was rather time consuming and represented a sizeable share of MH,” explains Syren. “Some of the newer 737s have only required software updates.” The cost to bring a 737 to compliant standards will vary, depending upon the starting point. “It is likely to cost \$50,000-100,000 per aircraft if you have nothing to start with, including certification costs,” estimates Syren.

Where its CRJ-900 fleet is concerned, SAS is looking for an alternative to the modification solution currently offered by Bombardier. “It offers CPDLC capability bundled together with other avionics upgrades, and is looking expensive,” explains Syren. “We are investigating whether there are alternatives that will provide just the datalink functions.”

The A320 family in SAS's fleet will also require modifications. “We have not started on the A320s yet, but plan to upgrade one aircraft per month in conjunction with other checks,” says Syren.

Airbus has developed its own solution for the Link 2000+ requirements. This is known as FANS B+, and it will use VDL2 over the ATN. It is now being offered as an option for A320 series operators.

As a standard on A320, A330 and A340 series aircraft, the FANS functions (FANS A or FANS B) rely on the ATSU. Airbus aircraft have been delivered with these units since late 1999. The ATSU acts as the datalink communication router and hosts FANS applications. It also interfaces with other relevant avionics systems to transmit and receive datalink messages. ATC software on the ATSU is offered by Airbus only. AOC standard software is offered by Airbus, although airlines can choose a customised AOC from other suppliers.

In the cockpit there are two datalink control and display units (DCDUs). These are dedicated displays for the transmission and reception of CPDLC messages.

Airbus groups A320 series aircraft that require modification to FANS B+ standard into three categories: Configuration A, B and C.

Aircraft in Configuration A are those with no ATSU and no or partial provisions only. Such provisions include structural and wiring requirements. According to Airbus, aircraft in this configuration will require full installation,

including provision of an ATSU, DCDUs, GPS-synchronised clock, and a VDR capable of VDL2. It is estimated that this level of modification could require up to 350MH, and Airbus suggests that the procedures could be completed as part of a C check.

Configuration B covers those aircraft that are Pre-FANS, with an ATSU and partial provisions installed. These require partial installation, including an ATSU upgrade, DCDUs, GPS-synchronised clock, and a VDR capable of VDL2. It is estimated that these modifications will use 20-50MH and could be completed on an A check.

Configuration C covers aircraft that already have FANS B capability. These will require an ATSU software upgrade and potentially additional wiring. It is estimated that this modification could be completed in 3-6MH, and might therefore be possible during a night stop.

In terms of the current worldwide A320 family fleet Marc Laffont, manager of FANS and satellite communications at Airbus, estimates that about 950 aircraft are in Configuration A status, 3,150 are in Configuration B, and 650 are in Configuration C. “Of course the situation is dynamic, since more aircraft become equipped as we approach the mandate,” says Laffont. “Airbus has received orders for over 1,000 aircraft so far,” he adds,

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It is estimated that the cost of modifying a 737 to compliant standards will be \$50,000-100,000, depending on the aircraft's original configuration.

referring to those airlines that have selected the FANS B+ option.

Asked whether operators with aircraft equipped with an ATSU might select an alternative federated solution to the manufacturer's FANS B+ offering, Laffont sounded a note of caution: "While it is technically feasible, it would be very complex. It may also not be economically viable, and would not provide the same capacity for future growth."

Suppliers

Rockwell Collins offers a range of required datalink equipment including MCDUs, CMUs, VHF VDL2-capable radios, forward field and aural alerting equipment, and a GPS interface for date and time stamping.

Another significant supplier is Honeywell. It has developed CMU upgrades to support the ATN stack with Protected Mode CPDLC messages, supported on the flight management system (FMS).

The CMU MarkII+ supports ARINC 758 and ARINC 724B wiring. The ARINC 758 version is already available, with the ARINC 724B version expected to follow in 2013. These have been developed for legacy aircraft such as the 747, 737, 717, 757 and 767.

Honeywell also provides all the other related avionics needed to support datalink processing within the aircraft, including VHF radios, SATCOM systems, HF Voice/Data radios, cockpit printers and MCDUs. It also supplies the communication management function (CMF) for 777s and 787s. This is the term for the datalink software within Honeywell's integrated avionics platforms. The CMF will allow for Protected Mode CPDLC for 777s and 787s from late 2013.

A supplier with a different approach to the Link 2000+ requirements is Spectralux Avionics. Its Dlink+w/CPDLC unit provides an all-in-one line replaceable unit solution for the CPDLC IR. "Dlink+ is aimed at the retrofit market and combines in a single unit the radio, HMI and communication management functions needed to comply with Link 2000+," explains Ian Gilbert, European representative for Spectralux Avionics. "Typical federated datalink systems will comprise separate HMI, CMU and VDR units in addition to a GPS time stamp capability, VHF antenna



and oral/visual attention-getters."

Where such federated systems require substantial upgrade, Gilbert believes that the Spectralux product will prove easier to install and therefore need fewer MH. "Generally, I estimate that 60-120MH are needed to install the Dlink+ unit on a retrofit aircraft," says Gilbert. "It would be more efficient to carry out the work in conjunction with other checks when the aircraft is already undergoing an extensive inspection."

"The Dlink+ can be incorporated into existing aircraft wiring configurations, including ARINC standard 724B and 758," continues Gilbert. This could reduce the need for time-consuming re-wiring work. The unit has ATS, AOC and baseline ACARS capabilities, and can interface with SATCOM devices and an aircraft condition and monitoring function (ACMF). "Dlink+ could cost less than half the price of some OEM solutions," says Gilbert, "However, GPS clock input, oral and visual attention-getters and a VHF antenna are still needed to work in conjunction with the unit." Dlink+ has so far been awarded EASA supplemental type certificates (STCs) for 737Classics and NGs. Spectralux is waiting on approval for the 757, 767, A320 and A330 platforms.

Other considerations

Along with equipment considerations, Eurocontrol highlights the mandated requirement for airlines to contract with one or more air-ground communications service providers for ATN VDL2 service. These organisations provide the communication network, including ground transmitters and receivers, necessary to facilitate air-to-ground

communications. The main providers in this field are ARINC and SITA.

Pilots must be trained in the use of ATS supported by CPDLC, while airworthiness certification must be obtained relating to EASA requirements including CPDLC IR compliance.

Airlines will need to update aircraft operating manuals to provide applicable information about operations of ATS supported by CPDLC. For operations in Link 2000+ airspace flight plans will require specific information including the aircraft's 24-bit ICAO address.

NextGen

In the US, the NextGen project is working towards enhancing safety, reducing delays, saving fuel and limiting the aviation industry's environmental impact. One crucial element in the implementation of NextGen is the data communication (data comm) programme, similar to Europe's IR for CPDLC.

This is the first phase of a transition from complete reliance on voice communication between aircraft and ATC, to shared voice and datalink systems, and eventually the predominant use of digital communication. At this time the Federal Aviation Administration (FAA) does not plan to impose a mandate related to its data comm programme.

EC IR No 29/2009 is a significant step towards a SES. Airlines have to know which of their aircraft are affected, and plan modifications to ensure compliance with the February 2015 deadline. [AC](#)

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