White Paper

Review of Aviation Mandates

Introduction

With commercial airspace becoming increasingly crowded, safety and efficiency upgrades mandated by international regulatory agencies are a fact of aviation life.

As the Commission of the European Communities stated in 2009, "Observed and expected increases in air traffic levels within Europe require parallel increases in air traffic control capacity."

However, airline and aviation infrastructure costs are not getting any lower, so aircraft owners and operators – who bear much of the burden of installing equipment and software – are naturally reluctant to add more costs, which include aircraft downtime and maintenance as well as the purchase price for the upgrades.

Outweighing these cost considerations are the safety and operational needs of airlines, business jet operators and the general aviation community to take off and land more efficiently in a variety of weather conditions and to benefit from the wide variety of operational en route efficiencies looming on the horizon. Most of the governmental mandates are already being phased in over a period of months or years in various international airspace domains.

For operators who delay their planning, upgrade decisions can be further complicated by the dilemma of age of their aircraft and the cost of upgrading vs. replacing the systems or even the entire aircraft.

Current international mandates include both familiar and exotic-sounding technical upgrades:

- **Collision Avoidance Systems - TCAS/ACAS 7.1**
- **"Protected Mode" Controller Pilot Data Link Communication (PM-CPDLC)**
- **Automatic Dependent Surveillance – Broadcast (ADS-B Out) to DO-260B**
- **Future Air Navigation System - FANS 1/A, 1/A+, and 2/B+**
- **Single European Sky (SES) Data Link Services/Link 2000+**
- **Flight Data Recording (FDR)**
- **Cockpit Voice Recording (CVR) and Data link recording**
- **Underwater Locating Devices (ULD)**

With all the conversation about mandates, costs benefits and deadlines, it's critical for aerospace decision- makers to understand exactly what they are. This white paper will review these mandates, along with their commensurate benefits and implementation dates for air transport, regional, business and general aviation, which will be required over the next decade.

Collision Avoidance

There's no question that Traffic Alert and Collision Avoidance Systems (TCAS) and Airborne Collision Avoidance Systems (ACAS) have had a significant beneficial impact on aviation safety since initial government-mandated implementations began in the mid-1990s.

Note that "ACAS" was the then-Joint Aviation Authorities' (JAA) term for collision avoidance systems, adopted to distinguish their definition of the system from the FAA version. However, ACAS II is equivalent to TCAS II with minimum operational performance standard (MOPS) 7.0 software. Currently, the only commercially available implementations of ICAO standard for ACAS II are TCAS II versions 7.0 and 7.1.

TCAS is designed to reduce mid-air collisions between aircraft by monitoring the airspace around an aircraft for other aircraft equipped with compliant transponders, independent of air traffic control. The system can proactively warn pilots of the presence of the other transponder-equipped aircraft that may present a collision threat.

According to the European Aviation Safety Agency (EASA), mid-air collision risk for the current implementation, known as "Change 7.0," corresponds to one mid-air collision every three years in European airspace.

Because of this significant improvement to safety, both the European Union and the Hong Kong Civil Aviation Department have approved the final rule requiring Change 7.1 equipage for turbine-powered aircraft of certain weight and passenger classifications.

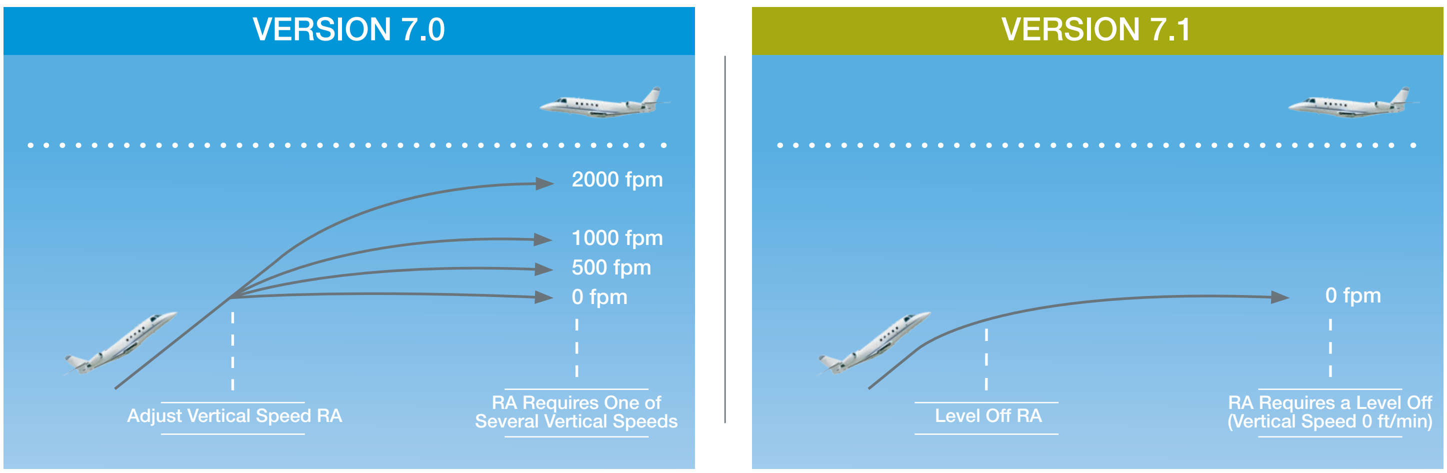
With this design, being implemented between 2012 and 2017, EASA estimates that Change 7.1 will actually reduce mid-air collision risk by factor of four. (see chart, below)

Two primary safety-related issues are addressed in Change 7.1.

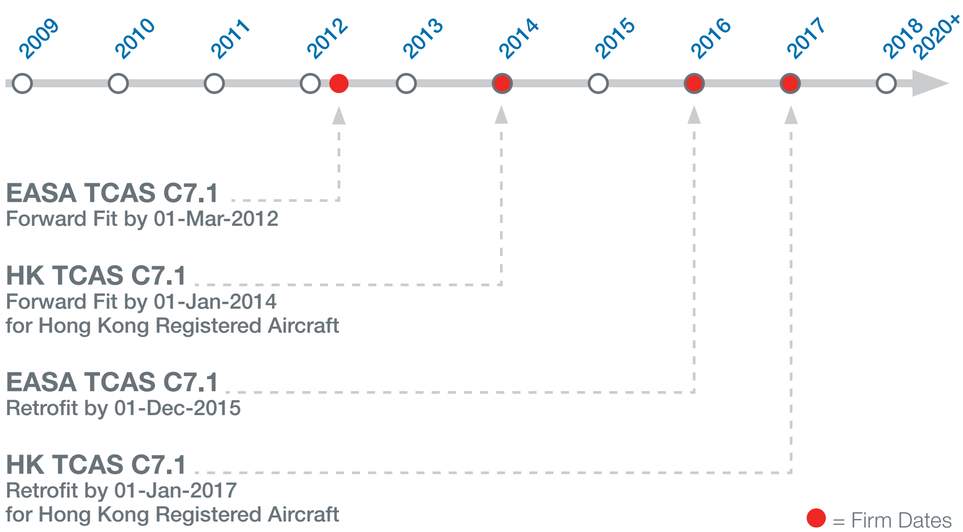
Based on a series of incidents between 2001 and 2002, including one collision, in France, Belgium, Japan and Germany, one change proposal (CP 112E) corrects an issue with TCAS-TCAS reversals. In prior versions, if an equipped aircraft was instructed by TCAS to descend and the "intruder" aircraft either was not equipped or was instructed by Air Traffic Control to descend, a collision could occur. The new version allows TCAS to reverse its instruction far sooner when it senses non-compliance from the other aircraft.

The other proposal (CP 115) changes the current TCAS II aural warning "Adjust Vertical Speed, Adjust" to "Level Off, Level Off."

Eurocontrol's TCAS II Change 7.1 mandate schedule called for March 2012 implementation on forward fit aircraft and December 2015 implementation for existing aircraft (retrofit).



TCAS/ACAS Change 7.1 Timeline



"Protected Mode" Controller Pilot Data Link Communication (PM-CPDLC)

3.1 As a key component of the Single European Sky (see section 6), the European Community has mandated operational use of air-ground data link, in the form of "Protected Mode" Controller Pilot Data Link Communications (PM-CPDLC), for aircraft flying above 28,500 feet (FL285).

Although complex in name, PM-CPDLC is straightforward in practice. The system is similar to text messaging on cell phones, allowing pilots and Air Traffic Control (ATC) to send pre-set or "canned" data messages between the ground and the aircraft. CPDLC messages enable automation of routine tasks that can take up to 50 percent of a controller's time. Using data link systems can also mitigate common communication problems such as unclear radio communication or misinterpretation due to language differences or poor clarity.

Indeed, studies within the European Community have confirmed the capability of datalink services to provide additional air traffic control capacity. Datalink solutions provide airline and business aircraft operators with significant benefits at reduced cost, including enhanced flight operations efficiency and lower airline maintenance, administration and air traffic control costs.

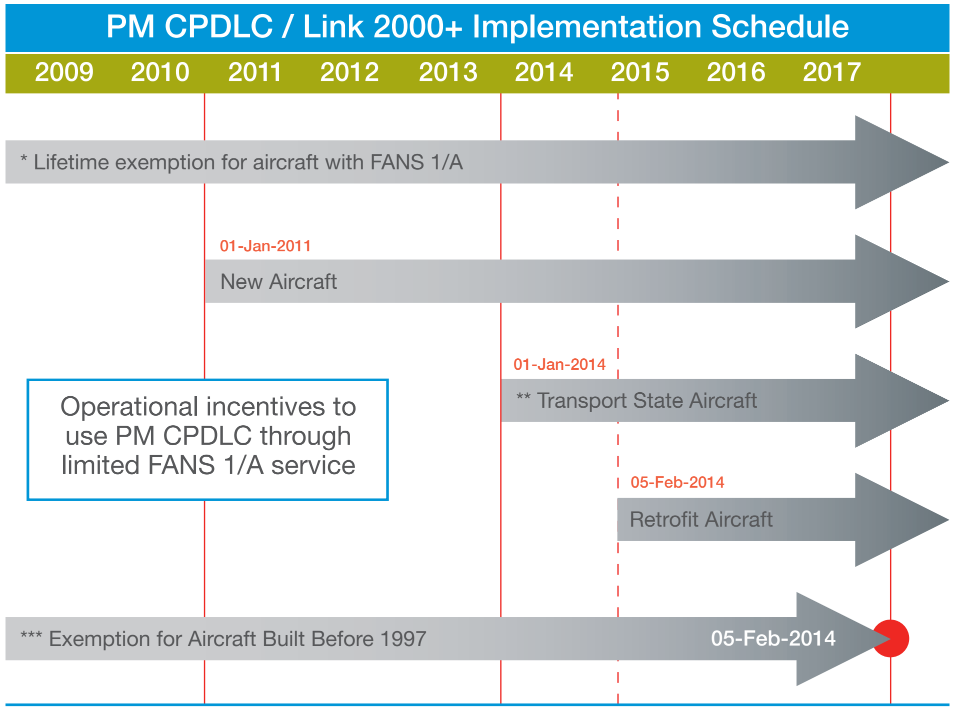
Once all the modernization initiatives are complete, this should lead to a threefold increase in airspace capacity and a 50 percent reduction in air navigation costs.

Of course, the increased capacity enabled by datalink services depends on the percentage of flights operating with this capability. The European commission states that a minimum of 75 percent of flights need to be suitably equipped to give the hoped-for capacity increase.

Implementation of PM-CPDLC is on a rolling schedule which began in January 2011 for new aircraft. Existing aircraft in the defined European airspace must be upgraded by February 2015. In the U.S., meanwhile, the FAA's NextGen Air Traffic Management System requirements are not expected to take effect until later in this decade and in 2020 and beyond.

3.2. Key upcoming dates and exemptions:

Feb. 5, 2015—By this date, all aircraft operating within European airspace above FL 285 must be equipped with a compliant PM-CPDLC datalink system (aircraft built before 1997 and which will be removed from service by December 31, 2017 are exempt from this requirement). Some business aircraft which will remain in service after this date are also permanently exempted, as detailed in Appendix A.



*Aircraft with airworthiness certificates issued prior to 1 January 2014 with ED-100 certified FANS 1/A have a lifetime exemptionto Link 2000+PM CPDLC

**Transport Sate Aircraft entering service after 1 January 2014 and using civilian data link services must have Link 2000+ PM CPDLC

***Aircraft built before 1997 are exempt if out of service by 31 December 2017

Automatic Dependent Surveillance-Broadcast (ADS-B Out) to DO-260B

Many current or upcoming mandates add functionality that actually provide cost savings to the operator.

The ADS-B Out mandate is a case in point. As the name implies, Automatic Dependent Surveillance-Broadcast periodically broadcasts information about each aircraft, such as identification, current position, altitude, and velocity, through an onboard transmitter. ADS-B Out provides air traffic controllers with real-time position information that is, in most cases, more accurate than the information available with current radar-based systems. With more accurate information, ATC will be able to position and separate aircraft with improved precision and timing..

The next evolution of ADS-B is already here and use by several airlines in the form of ADS-B In. There are no current mandates for ADS-B In but there are significant benefits for aircraft so equipped. At present, aircraft crossing the ocean at altitudes commonly used by most airlines are required to stay in a track at a given flight level with defined time-based separation "in-trail." However, what happens when one aircraft is able to climb to a higher, more fuel-efficient altitude, but is blocked by nearby aircraft?

ADS-B In allows airlines to utilize In-Trail Procedures (ITP) that will allow the lower aircraft to safely climb to a more efficient altitude, thus reducing fuel costs and improving ride quality. In this way, more aircraft will be able to fly at the most optimum altitudes for overall fuel savings.

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Global ADS-B Out Timeline

Future Air Navigation System (FANS)

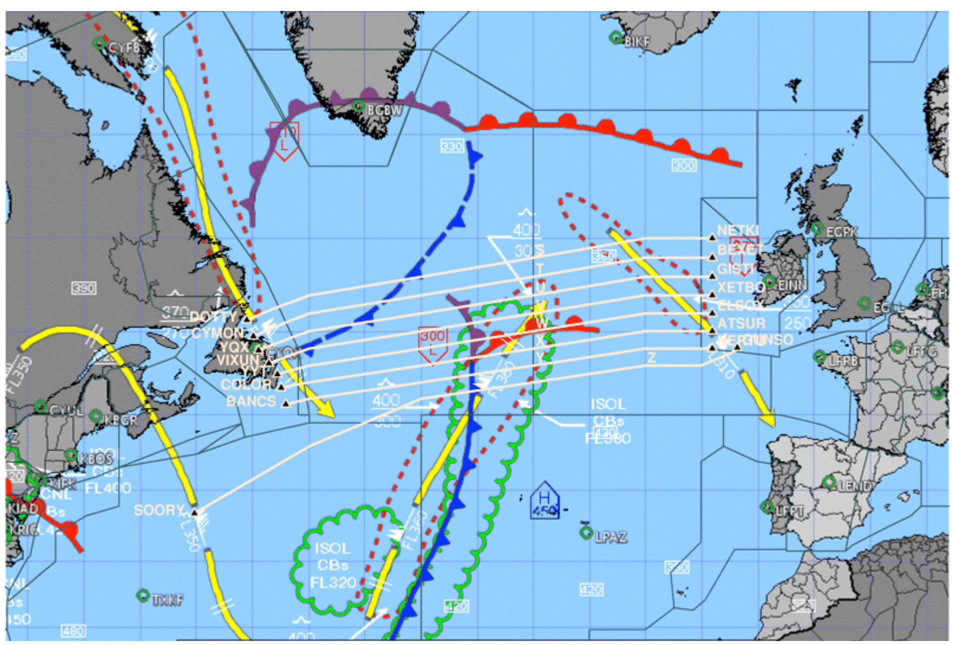
5.1. The Future Air Navigation System (FANS) is a concept that was developed by the International Civil Aviation Organization (ICAO) in partnership with Boeing, Airbus, Honeywell and others in the aerospace industry to allow more aircraft to safely and efficiently utilize a given volume of airspace.

Until the Aeronautical Telecommunications Network (ATN) became available, Boeing and Honeywell built a FANS application to run on the existing ACARS system. This avionics package became known as FANS-1 and was certified on a Qantas 747-400 in June 1995. The Airbus equivalent system is known FANS-A or A+, and these systems are known collectively as FANS-1/A.

Today FANS is used primarily in the oceanic regions, taking advantage of both satellite communication and satellite navigation to effectively create a virtual radar environment for safe passage of aircraft.

Industry committees, including the Air Navigation Service Providers (ANSPs), have determined that the short-term solution to alleviate route congestion, primarily in the North Atlantic routes (see map), is to reduce the aircraft lateral separation minimums (RLSM). This permits more aircraft to fly in reduced airspace. To accomplish this, the ANSPs have designated certain routes as “FANS routes,” reserving the best airspace for the best-equipped aircraft. Although the FANS routes are currently confined to FL360 – FL390, this airspace will expand to FL350 – FL390 in 2015 and again to all airspace FL290 and above in 2020. http://www.icg.aero/FOI.aspx#A2

Atlantic Ocean Eastbound Tracks



Additionally, regulatory agencies are encouraging operators to outfit their aircraft with the necessary avionics to become FANS 1/A-compliant so they may take advantage of flying FANS routes, per the North Atlantic Track System (NATS) mandate. The FANS 1/A equipment suite must be certified to meet equipment requirements per AC 20-140B, and safety and performance requirements per RTCA DO-306. To achieve the benefits of flying the select FANS routes, the equipment suite must demonstrate an RTCA DO-306 Required Communications Performance of RCP 240/Type 180 for CPDLC/ADS-C messaging. <http://www.icg.aero/FOI.aspx#A2>

FANS utilizes Aircraft Communications

Addressing and Reporting System (ACARS) over VHF and satellite communication for message transmissions. The use of ACARS restricts the amount of air traffic on the system due to bandwidth limitations of the technology. The FAA is currently planning to utilize FANS 1/A+ over U.S. continental airspace as an initial ATC data link deployment phase, but requiring operators to use VDL Mode 2 radios for increased bandwidth.

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A number of pioneering European airlines have already equipped their domestic fleets with PM/CPDLC (section 3) equipment, although FANS-1/A currently remains the only data link option for oceanic traffic. <http://members.optusnet.com.au/~cjr/introduction.htm>

Meanwhile the business jet community, with most of the avionics hardware (such as SATCOM, GPS and FMS) already onboard, has started taking advantage of the growing FANS infrastructure. Super-long-range business jet aircraft — including the Boeing Business Jet (BBJ), Bombardier, Dassault Falcon and Gulfstream aircraft families — have been FANS-certified for three years.

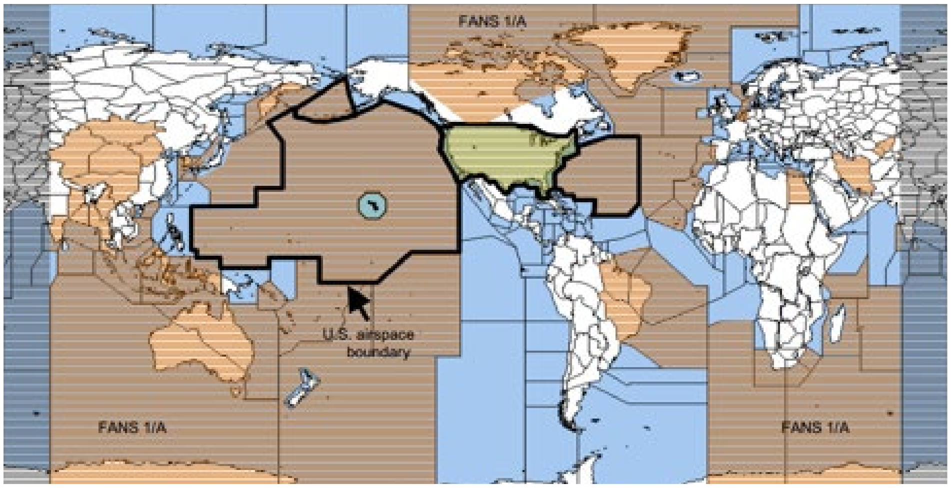
The business case to install FANS systems on long-range jets is based on a set of well-defined benefits and paybacks:

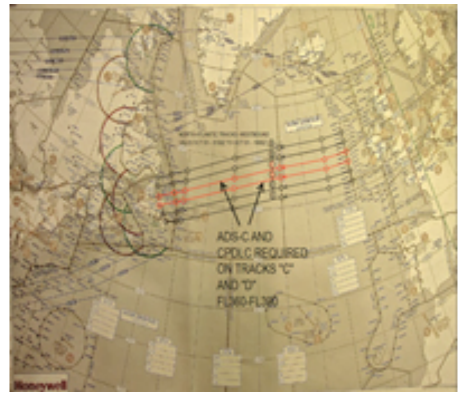
- Reduced separation between airplanes
- More efficient route changes
- Satellite communication
- No altitude loss when crossing tracks
- More direct routings
- Reduced user charges for using the FANS infrastructure
- Automatic position reporting via ADS-C

http://www.honeywell.com/sites/servlet/com.merx.npoint.servlets.DocumentServlet?docid=D60671A93-51BD-1C36-20CF-446F85B0FD6C

The FAA is now embarking upon its NextGen system, which saw an initial rollout of the delivery of Pre-Departure Clearances (PDC) via data link from domestic control towers in 2013 and will expand to a “dual-stacked” (FANS and ATN) CPDLC service in U.S. domestic airspace starting in 2017.

http://members.optusnet.com.au/~cjr/introduction.htm





5.2. Key upcoming dates:

The North Atlantic Track System (NATS) has implemented FANS operational requirements and additional follow-on requirements that will require FANS operations for virtually all aircraft by the end of this decade. Since February 2013, in order to fly the two most optimum center tracks in the NATS airspace between FL 360 and FL 390, the aircraft must be FANS-equipped.

In addition, there are three additional phases of proposed FANS 1A+ tracks:

- **2A – Feb. 5, 2015, throughout the tracks in the NATS between FL 360 – FL 390.**
- **2B – Dec. 7, 2017, throughout the North Atlantic Region between FL 350 – FL 390.**
- **2C – Jan. 30, 2020, all MNPS airspace throughout all ICAO North Atlantic airspace FL 290 and above.**

http://aerospace.honeywell.com/news/mandates#sthash.dYSwVkp3.dpuf

Single European Sky/ LINK 2000+ Programme

Single European Sky ATM Research (SESAR) is the name given to the collaborative project that is intended to completely overhaul the European airspace and its Air Traffic Management (ATM) with a deployment running through 2020.

Instigated to overcome fragmentation and capacity limitations, the SESAR program is intended to set the ATM standards that the FAA's Next Gen program will follow — as well as the rest of the world over time.

The LINK 2000+ Programme is coordinating the European implementation of CPDLC in upper airspace. Data link communications is a key element of the Single European Sky 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.

The LINK 2000+DLS implementation mandate in Europe thus provides the ground and airborne infrastructure for future ATM. SES-DLS installs the Aeronautical Telecommunications Network (ATN) and requires VHF Data Link Mode 2 (VDL-M2) radios on aircraft to remove the bandwidth limitations of the ACARS/satellite system.

Flight Data Recording (FDR)

A flight data recorder (FDR) is an electronic device employed to record instructions sent to electronic systems on an aircraft. Until the late 1990s, only a very limited set of parameters were required; however, there are now 88 specific aircraft performance parameters required as a minimum (some systems monitor many more variables) under current U.S. federal regulations. These include the control and actuator positions, engine information and time of day.

As of December 2010, an 8 Hz sampling rate for pilot input and corresponding control surface positions were mandated for new aircraft, which increased the recording rate to 512 or 1024 words per second.

Cockpit Voice Recording (CVR) + Datalink recording

A cockpit voice recorder (CVR), as well as the companion FDR, is most often referred to as a "black box." The CVR is a flight recorder used to record the audio environment in the flight deck of an aircraft — conversation in the cockpit, radio communications between the cockpit crew and others including air traffic control personnel as well as ambient sounds — for the purpose of investigation of accidents and incidents. Developed in the 1950s, Australia became the first country in the world to make cockpit-voice recording compulsory, with the U.S. following suit by March 1967. Until 2012, the FAA required a minimum 30-minute recording duration, but new requirements have since come into play. (See chart, next page)

FAA requirements for cockpit voice recorders as of April 2012 included:

- **Mandatory 120-minute recording capacity in the cockpit voice recorder for all forward-fit and retrofit aircraft**
- **Solid state design, that is, no magnetic tape recording or other technology**
- **Datalink (CPDLC) Recording**
- **10-minute Recorder Independent Power Supply (RIPS)**

This affects recorders, datalink/communication management function (CMF) and flight data acquisition functions. New HFR5 recorders from Honeywell are required in order to meet these new CVR datalink recording and FDR increased sampling rate requirements.

In addition, EU Regulation No 965/2012, enacted October 2012, laid down a variety of technical requirements for data link communication messages applicable to aircraft first issued with an individual Certificate of Airworthiness on or after April 8, 2014. This includes also providing the datalink recording capability of all CPDLC traffic to the CVR.

Underwater Locating Devices (ULD)

SAE International specifies minimum performance standards for acoustic Underwater Locating Devices (ULDs), which are intended for use with both fixed and rotary wing civil aircraft. ULDs are designed to assist in finding flight recorders, cockpit recorders or aircraft or both. Such ULDs are installed adjacent to the recorders in a manner that they are unlikely to become separated during crash conditions.

In 2012, the FAA issued a notice for planned revocation of the current Technical Standard Order Authorizations (TSOA) for TSO C121 and C121(a) to make way for a new authorization that would increase the devices' 30-day minimum battery operating life.

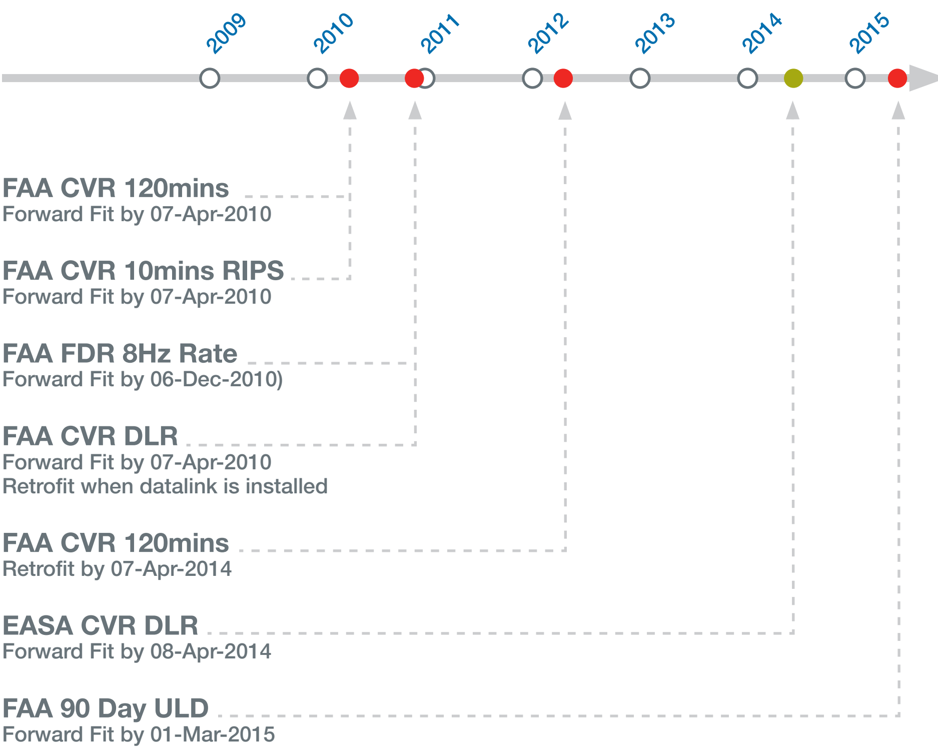
Under the new mandate, effective March 1, 2015, the ULD must have a minimum operating life of 90 days and be qualified for TSO-C121(b). (see chart, below)

However, existing TSO-C121(a) ULDs can be maintained on existing line-replaceable units (LRUs).

The Civil Aviation Authority of Singapore (CAAS) began requiring 90-day ULDs on new, locally registered aircraft from February 2013 and for all aircraft by January 1, 2018.

Developments in March 2014 relating to the flight of Malaysia Airlines Flight 370 (MH370), which instigated a massive weeks-long search, underscore the importance of the 90-day operating life rule as well as potential requirements for more exacting standards of long-range detection.

Recorders Mandates Timeline



DLR = Datalink Recording   = Preliminary Dates   = Firm Dates

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