Flight Inspection of Aviation Data Links

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BIOGRAPHIES

Thomas Pinnell began his aviation career with the United Kingdom Royal Air Force, studying both avionic engineering at the Royal Air Force engineering collage, and electrical and electronic engineering at the University of South Wales. Since graduating, he has continuously worked within the aviation industry developing professional engineering experience in maintenance, modification and design. He has worked for the United Kingdom Royal Air Force, United Kingdom Ministry of Defense, the Royal Norwegian Air Force, Airbus Deutschland, and since 2011, Norwegian Special Mission (NSM). Thomas is currently positioned within NSM as a Senior Systems Engineer, Training Manager and Customer Support manager. During the seven years he has worked within the flight inspection industry, he has been responsible for project management of customer deliveries, design of aircraft modifications, development of new technologies for flight Inspection systems, and numerous engineering support roles on flight inspection projects, over six continents. During the data link equipped flight inspection system technology development project between NSM and the Brazilian Air Force, he was one of NSM's lead engineer for the project, overseeing, design, implementation, testing and aircraft certification.

Captain Sérgio Corrêa began his career in the Brazilian Air Force in 1989, when he became an electronic specialist after studying for two years. His experience in air traffic equipment began in 1991 at the Santa Cruz Air Base in Rio de Janeiro, where he was responsible for the maintenance of High Frequency - Single Side Band Transceivers (HF-SSB, Transworld), Very High Frequency Omnidirectional Range (VOR) and Very High Frequency Aeronautic Transceivers (VHF-COM). In 2000 he was transferred to Afonsos Air Force Base, also in Rio de Janeiro, where he studied Non-Directional Beacon (NDB) and Instrument Landing System (ILS) maintenance courses and, after that, he participated in the ILS-AF (Model MARK 20) installation. He graduated in information technology (IT) in 2005 at Estácio de Sá University and in 2006 graduated in aeronautical telecommunications at the Aeronautical Instruction Centre in Belo Horizonte, Minas Gerais. Since then, he has worked at GEIV, the Brazilian Air Force Special Group for Flight Inspection, where he is responsible for the maintenance of the avionics and flight inspection systems used in Brazil. He has managed the UNIFIS3000/Hawker 800 XP aircraft project. He is also the adviser to the project technical manager for the EMBRAER's Legacy 500 /UNIFIS 3000 equipped flight inspection aircraft program. Since 2010 he has been a Flight Inspection instructor.

ABSTRACT

As the congestion of air traffic rises, there is a greater strain put on air traffic control (ATC) to safely manage an air space. Aviation data links contribute towards maintaining and enhancing air navigation services safety and efficiency in all phases of flight. Data link technology can facilitate both communication and surveillance in oceanic and remote airspace. Aviation data links assist in addressing operational shortcomings such as controller pilot misunderstandings, transcription errors, non-standard phraseology and frequency congestion that are typically associated with the use of voice operations and procedures.

The use of air-to-ground datalink has been endorsed by ICAO as a key enabler for the delivery of benefits foreseen in its vision of a performance based Global Air Traffic Management system. Data Links are implemented in controlled airspace around the world and allow ATC to more precisely monitor an aircraft positions, and more efficiently position and separate aircrafts, including positioning with reduced horizontal and vertical separation minimums, and enhance safety for aircrew and passengers by providing automatic alerts to ATC when an aircraft deviates from the approved flight plan. This technology significantly reduces ATC and flight crew workload, especially during the critical phases of flight – within controlled airspace.

Considering that Aviation Data Link technology, such as the Future Air Navigation System (FANS 1/A), which consists of Controller Pilot Data Link Communication (CPDLC) and Automatic Dependent Surveillance Contract (ADS-C), and Pre-FANS services such as Digital Clearance (D-CL) and Digital ATIS (D-ATIS) contain ground to aircraft transmitted information and instructions vital for safe navigation through a controlled airspace, this paper will consider the experiences of the inspection of these aviation data links in Brazil. It will summaries the inspection requirements, and real-life experience of

the flight inspection organization, explore what technology is currently available to allow them, and other flight inspection organizations, to inspect aviation data links to a standard acceptable to the Flight Inspection and aviation industries.

INTRODUCTION

Norwegian Special Mission have been working with the Brazilian flight inspection organisation – Grupo Especial de Inspeção em Vôo (GEIV), to assist with improving their role in the inspection of aviation data links.

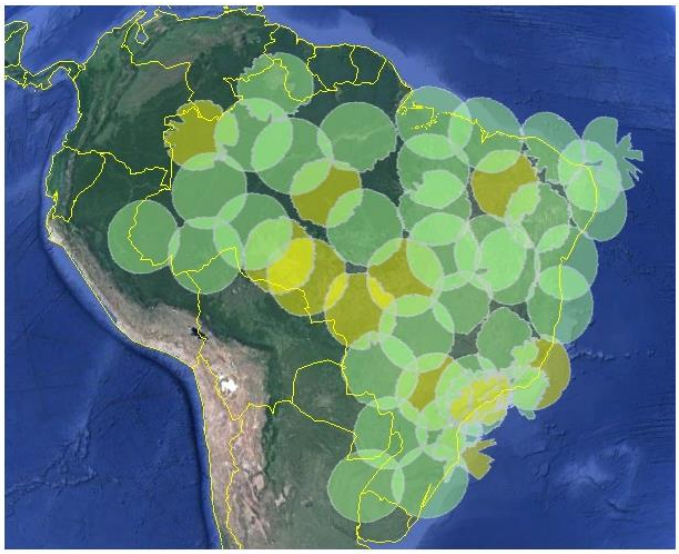
Considering that aviation datalinks data links are used for air traffic management (ATM), communication and safety purposes, for many years the Brazilian Air Navigation Service Provider (ANSP), DECEA asked the following question to the international flight inspection community: Who makes sure that the data link is flyable, and who ensures that it is commissioned and inspected, either routinely or in special cases of antenna replacement or accidents?

The conclusion was that there were no flight inspection requirements, there was not much data to get access to, and very often verification tests of data link performance are carried out by the data link service providers. Concluding that this was not by any means compatible with proper quality aviation ATM safety standards, DECEA decided to study this and a brief requirement for flight inspection was discussed. DECEA wanted to verify that all data messages were transmitted from the ground station correctly and that this could be documented properly. As the right quality way to do this is always by the flight inspection organization, their first task was to enable GEIV to have full data link transmit, receive and logging capability on board their flight inspection aircrafts. Subsequently a contract was awarded to NSM who have successfully provided GEIV with this capability.

OVERVIEW AND EVOLUTION OF AVIATION DATA LINKS IN BRAZIL

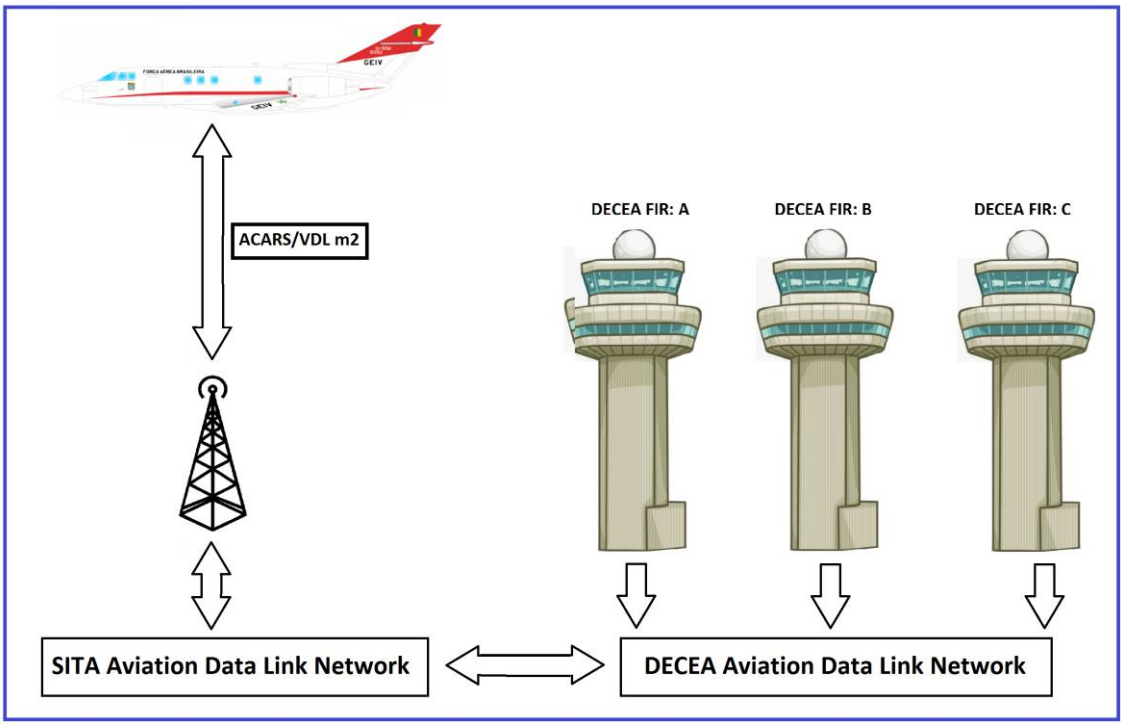
To combat the strain put on ATC with increasing airspace congestion, DECEA have committed to improving the Communication Navigation Surveillance /Air Traffic Management (CNS/ATM) capabilities within the within the countries, over land (Continental) territory of 8,511,000 Km².

In 2012, DECEA entered into a contract with Société Internationale de Télécommunications Aéronautiques (SITA) to upgrade all the countries aviation data link infrastructure facilities from VHF Data Link (VDL) Mode A to VDL Mode 2. At the commencement of the project there where 44 VDL Mode A facilities, and 4 VDL Mode 2 facilities within Brazil's continental territory. As of March 2018, a full infrastructure upgrade has been completed and a network of 53 VDL Mode 2 facilities are installed, online, or awaiting commissioning by the Flight Inspection Division. Today the VDL Mode 2 network has national coverage above flight level FL245. DECEA plans to implement operational use of the CPDLC Continental in four phases, starting in 2020.



Current VDL Mode 2 coverage in Brazil

The data link facilities, are all installed by SITA and operated by DECEA. There is a shared connection between the DECEA aviation data link network and the SITA network. The SITA network, connects to the VDL Mode 2 Facilities in Brazil, and shares Pre-Fans data link services with the global aviation datalink network, that can be accesses worldwide via VDL Mode A, VDL Mode 2 and SATCOM.



Overview of the DECEA/SITA VDL Mode 2 Aviation Data Link Network

DECEA's aviation data link network is run by Flight Information Region (FIR) ATC Service Units (ATSU), which manages the following FANS and Pre-FANS Data Link services:

CPDLC

CPDLC is a communications application that allows for the direct exchange of text-based messages between ATC and an air crew. The controller is provided with the capability to issue level assignments, crossing constraints, lateral deviations, route changes and clearances, speed assignments, radio frequency assignments, and various requests for information. The air crew is provided with the capability to respond to messages, to request clearances and information, to report information, and to declare/rescind an emergency. A 'free text' messaging option is also provided to both parties so that information not conforming to defined formats may be exchanged. Before CPDLC, the standard method of communication between ATC and an air crew was voice radio: VHF bands for line-of-sight or HF bands for long-distance communication. A major problem with voice radio communication is that all pilots being handled by a controller are tuned to the same frequency. This raises the chance that one pilot will accidentally override another, thus requiring the transmission to be repeated.

ADS-C

ADS-C is a surveillance application that provides ATC with accurate surveillance reports from an aircraft in remote and oceanic regions. Reports are sent automatically in accordance with the parameters of a contract that an air traffic controller has set up. Under normal circumstances, ADS-C requires no pilot interaction. The introduction of ADS-C has provided ATC with a means of managing a whole airspace more efficiently. Not only can ATC track an aircraft more accurately, they can also be alerted immediately if an aircraft deviates from its predefined flight track.

D-ATIS

D-ATIS consists of digital transcript transmissions of the Departure ATIS standard Automatic Terminal Information Service (ATIS) messages, and the En-route ATIS, or D-VOLMET meteorological information for aircraft in flight (VOLMET) message. Traditionally a pilot must listen to the transmissions prior to departure and approach procedures and hand transcribe the message. At times, the voice message may be difficult to understand and can lead to potential misunderstandings and

transcription errors. The data link service which unlike its voice counterpart is available during all phases of flight – reduces ATC and pilot workload and eliminates the risk of misunderstandings due to poor VHF voice quality.

D-CL

D-CL, is a per-departure Air Traffic Control clearance service that is available via "Data Link". It can also be referred to as data link clearance. D-CL provides ATC with increased efficiency and a reduced workload.

INSPECTION OF AVIATION DATALINKS IN BRAZIL

Necessity

With the increasing implementation of data link services in Brazilian Air Space, GEIV has been frequently asked to perform verification and validation on the new services offered. For DECEA, the possibility to use flight inspection aircraft and testing its products before delivering to the end users has been extremely important for the continuity of the project.

With the technological evolution and the need for DECEA to follow the innovations of the new CNS/ATM concepts, GEIV was forced not only to train its personnel, but also to equip its aircraft with the necessary resources to support DECEA's vision for the future CNS/ATM of Brazil's airspace. DECEA's mandate to GEIV was that it would not only offer modern aviation data link capabilities to all users of it's airspace, but also ensure that the services ate tested to aviation standards with traceability and proof of inspection, and ensure a guarantee of integrity, availability, precision and continuity of data link service.

Technology

In 2008, DECEA entered into a contract with NSM to outfit four Hawker 800-XP aircrafts with UNIFIS 3000 Flight Inspection Systems (UNIFIS 3000) equipped with the functionality to access and log, on ground and in flight the transmitted and received aviation data link network traffic. After the successful completion of this contract, DECEA further increased GEIV's data link inspection capabilities by ordering six Embraer Legacy 500 aircrafts, outfitted with data link inspection capable UNIFIS 3000 Flight Inspection systems. The flight inspection data link aircrafts which are operational and in use today, allow GEIV to successfully assist DECEA to realise their CNS/ATM vision.

The UNIFIS 3000 provides GEIV the capability to transmit, receive all data link messages over the following mediums:

1. VDL - Mode A using Plain Old ACARS (POA)
2. VDL - Mode 2 using ACARS (Aircraft Communications Addressing and Reporting System) over AVLC (Aviation VHF Link Control) (AOA)
3. VDL - Mode 2 using Aeronautical Telecommunication Network (ATN)
4. SATCOM

Additionally, the UNIFIS 3000 can decode the CMU information intended for the aircraft Flight Data Recorder. By logging the data at this level, GEIV are insured of high integrity record of all transmitted and received data link traffic.

By comparing the data link network logs to the UNIFIS 3000 data link logs, it is possible to verify with evidence if all uplink and downlink messages can be received correctly.

GEIV Data Link Equipped (UNIFIS 3000) Flight Inspection aircraft

Method of Inspection

With the increasing demand for checking the data link services, the GEIV has adopted the strategy to verify the services first on ground, and then in flight. First a communication test of the data link is performed; the objective is to verify the flow of network traffic. With the flight inspection aircraft on ground and connecting to the servers through the Galeão VDL station antenna, close to GEIV's base in Santos Dumont Airport, Rio de Janeiro, GEIV perform a test of all possible data link messages, verifying if they can or cannot be transmitted and received for a particular airport, or FIR. This test allows GEIV to have a high integrity record of the that can be used to prove the data link messages that flow from ATC to DECEA's network, to SITA's network and then to the VDL facility(s) are all correct.

After a successful ground test, the next stage is to verify the VDL signal in space for the airport of FIR under test. A flight inspection can be done to commission every VDL before a commercial aircraft is approved to use their services. The purpose of the commissioning flight is not to confirm reception of the VDL signal/message during a 360-degree orbit at a set distance of the VDL Facility, but to ensure that coverage with perfect reception is possible in the intended service area. Until CPDLC Continental becomes active and mandatory within the territory of continental Brazil, the inspection flight verifies the ACARS/VDL Mode 2 coverage is available in the controlled terminal airspace where the VDL facility operation is intended. A flight inspection would also be performed during special inspection situations. Coverage inspection flights for CPDLC Continental are still in the planning stage, but due to the nature of the intended service volume, the flight will inspect coverage over a greater commissioning area.

After the inspection, on ground and in flight, the flight inspection system will create a time stamped log detailing all transmitted and received data link messages. SITA provide logs of the network traffic from their server during the time of the inspection. The flight inspection organization assesses the logs to determine if any messages sent from aircraft to ground, and vice-versa was lost of corrupt. For the tests performed, documentation the logs of the messages transmitted and received are recorded and archived together with the inspection reports.

For the commissioning of the FANS 1/A (ADS-C and CPDLC) data link in FIR Recife, GEIV followed the guidance from the ICAO Global Operational Data Link Document (GOLD). The GOLD addresses data link service provision, operator readiness, controller and flight crew, procedures, performance-based specifications and postimplementation monitoring and analysis. Although it does not directly address any kind of flight inspection of FANS data links, it does make the following recommendations for monitoring their performance:

1. To enable adequate system performance monitoring the ANSP should at minimum perform a monthly analysis of CPDLC Required Communication Performance (RCP) and ADS-C performance data. This monitoring will verify system performance and also enable continuous performance improvement by detecting where specific aircraft or fleets are not meeting the performance standards. [1]

   Every month, DECEA receives a report from SITA that contains an analysis of data link performance by airline and VDL station.

2. The ANSP should conduct trials with aircraft to ensure that the system meets the requirements for interoperability such as is defined for FANS-1/A in RTCA DO-258A. [2] RTCA DO-258A defines the requirements for FANS-1/A ATS applications. It covers the ATS Facilities Notification (AFN), ADS-C and CPDLC.

   This was performed by GEIV on commissioning of the data Link, both on ground, and in flight using the procedures for data link inspection described above. As a result, GEIV could deliver a report to DECEA, with proof of inspection results, stating that all FANS-1/A ATS applications are working correct within the intended VDL Mode 2 service volume, and are available via SATCOM. Based on these results the DECEA approved the FANS-1/A for commercial airline use.

Data Flow for, request, approval, and logging of aviation data link traffic

CONCLUSIONS

The testing performed so far in Brazil allows the ANSP, DECEA to be confident that all aviation data links that provide communication, navigation and surveillance information to aircrafts within their airspace are operating correctly. With validation on ground and in flight, the flight inspection department have been able conduct inspections and produce reports backed up by evidence that certify the following:

- ADS-C Periodic, Event and Demand contracts uplink correctly according to the parameters stipulated by ATC.
- All ADS-C downlink messages are received and archived in the ATSU logs correctly.
- All CPDLC requests downlinked to the ATSU is received correctly and that no downlinked message generates an incorrect automatic response.
- All CPDLC Uplink messages are received correctly by the aircraft.
- Transition of messages between VDL (Mode A and 2) and SATCOM, and transition of messages between VDL stations operates correctly.
- Pre-FANS Data Link facilities, operate correctly within their intended service volume.

All Data Link facilities can be inspected and approved first on ground, and then by flight before being made available for use commercial air traffic. Performing the majority of data link testing on the ground can not only save money for a flight inspection organization, it can also assist in overcoming the difficulty of scheduling a time that both testing can take place with ATC, and that a flight crew can be airborne. It was observed during testing that it was more efficient if the flight inspector performed the testing as he/she could visually assess the data that is being both uplinked and downlinked in real time using the UNIFIS 3000 live data log. Having the flight inspector perform this testing during flight allows the pilot to concentrate on flight operations whilst still having the ability to monitor the test.

Since all VHF and SATCOM data link information is routed to the ATSU, it is reasonable to assume that if the ATSU can correctly uplink and receive downlinks of all FANS applications via VHF data link without a problem, then with it will also be able to do the same via a SATCOM data link.

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[2] ICAO, 26 April 2013, ICAO Global Operational Data Link Document (GOLD), 3.1.1.5