International Civil Aviation Organization

Future Air Navigation Systems Interoperability Team-Asia (FIT-ASIA)

Bangkok, Thailand, 27 March 2013

Agenda Item 3: Review of ADS/CPDLC Operations

DATA LINK PERFORMANCE MONITORING FOR THE L888 ROUTE

(Presented by China)

SUMMARY

This paper provides introduction about China's effort in developing the technical ability of conducting data link performance monitoring, and presents observed performance measures as specified in the Global Operational Data Link Document (GOLD) from the operational data collected along the section of L888 route within China from October 2012 to end January 2013. The results show performance of the Controller Pilot Data Link Communication (CPDLC) and Automatic Dependent Surveillance Contract (ADS-C) services.

This paper relates to –

Strategic Objectives:

*A: **Safety** – Enhance global civil aviation safety*

Global Plan Initiatives:

GPI-17 Data link applications

1. INTRODUCTION

1.1 Data-link communications have been used for CPDLC and ADS-C for many years, and data-link performance requirements have been established. Specific requirements are published in the Global Operational Data-link Document (GOLD), and reflect those contained in Doc 9869, Manual on Required Communication Performance. States are invited to ensure that the appropriate data link performance monitoring is undertaken and reported to CRAs/FITs, as required, in a timely manner.

1.2 China has officially started providing data link services on FANS-L888 routes in in the remote airspace Western China since 2001. The data link system in this airspace comprises a variety of ground systems that may provide data link services to FANS 1/A aircraft.

1.3 China reported to the FIT-ASIA/1 meeting that they would start to prepare and develop technical ability of data-link performance monitoring and report to this FIT-ASIA meeting. In the recent one year, a technical group of data link engineers were designated to this task. This followed a period of research of the GOLD material and the data link performance monitoring reports from the CRAs.

1.4 After the confirmation of the feasibility of the method, China started to collected ADS-C and CPDLC messages from the central data link message database located at the NOC department of ADCC in Beijing, China. At the same time, the technical group also started to design

the local message database and a message processing program to obtain the message format required by the GOLD recommended as the minimum set recordings to enable data link performance analysis and provide sufficient information for problem analysis.

1.5 In January 2013, the data recording was completed. The program was able to process all the data available to produce the required data recordings. The technical group used these data to analyze the data link performance and produced some results as presented in this paper. In this process, China utilized the Java-based software tool kindly offered by the United States.

1.6 This paper provides observed performance measures from the operational data link system collected from four Flight Information Regions (ZLLL, ZPPP, ZUUU, ZWWW). The purpose of this paper is to present recent observed performance of the data link system.

1.7 The performance data observed from the Controller Pilot Data Link Communication (CPDLC) and Automatic Dependent Surveillance - Contract (ADS-C) systems are measured against the Required Communication Performance (RCP) 400 specification to demonstrate that safety objectives which rely on the communications infrastructure can be met by the aircraft and ground systems.

2. DISCUSSION

Data Link Application in China

2.1. ICAO issued the route designation L888 in 1999. The AIP Supplement for L888 was issued in April 2000. China has officially started providing data link services on FANS-L888 routes in Western China since in January, 10th, 2001. It is an air route across European and Asia in West-China, the whole range is over 2800km. It is the first designated CNS/ATM route over land. Compared with the air route across India, Middle-East, the range reduced greatly, and it's very cost-effective. The route map is shown in **Figure 1**.

2.2. The data link system in this remote airspace, as shown in **Figure 2**, comprises a variety of ground systems that may provide data link services to FANS 1/A aircraft. All the workstations are connected to ARINC, SITA and ADCC data-link service. The data link services improve communications and surveillance to support operational capabilities which enables 10 minutes longitudinal separation.

2.3. From 2012 to 2013, the hardware and software for the four CPDLC/ADS-C workstations were updated by ADCC of ATMB CAAC. The new systems in Urumqi are in trial service.

Data Link Performance Monitoring Criteria

2.4. The GOLD manual provides the guidance material for the required data points from the FANS 1/A aircraft communications addressing and reporting system (ACARS) messages, and it also demonstrates the calculation process for the performance criteria for data link services:

- actual communication performance (ACP);
- actual communication technical performance (ACTP);
- pilot operational response time (PORT); and
- surveillance latency.

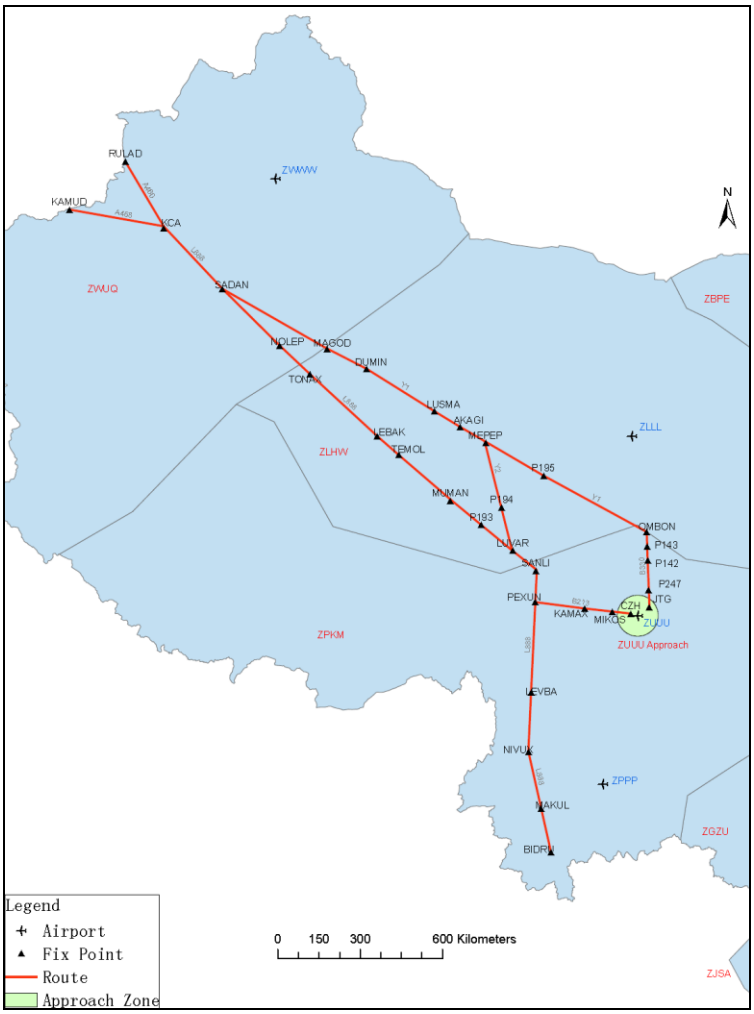


Figure 1 L888 Route Map

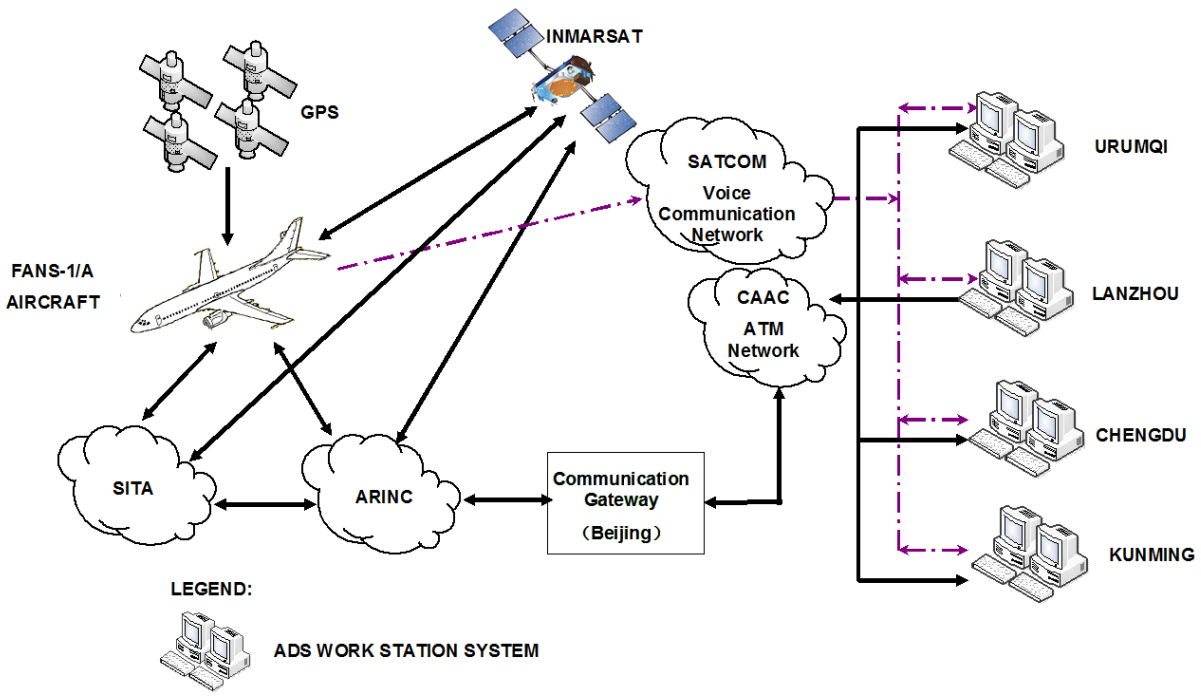
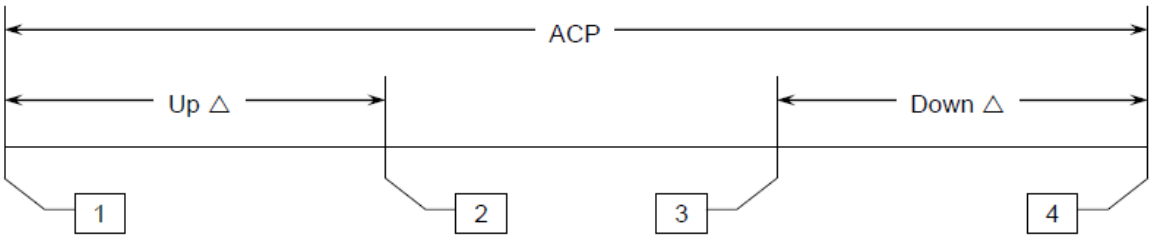


Figure 2 L888 Route ADS System Illustration

2.5. The ACP is used for monitoring the RCP requirement time allocation for the communication transaction (TRN). The TRN is the portion of the total transaction time that does not include the message composition time or recognition of the operational response. Actual communications technical performance (ACTP) is used to monitor required communication technical performance (RCTP) time allocations, and pilot operational response time (PORT) is used to monitor the flight deck responder element of the transaction.

2.6. As described in the GOLD, this analysis uses the measurement of transit and response times to those CPDLC uplinks that receive a single Will Comply (WILCO) and/or an Unable response. These messages are considered to be intervention messages critical to the communications used when applying reduced separation standards. Other message types, such as free text queries or information requests, are not included in the analysis because the corresponding longer response time from the flight deck would skew the results. All messages with a WILCO and/or Unable response attribute are assessed. These include communications transfer messages in addition to the typical intervention messages such as climb clearances. The ACP is computed by the difference between the time the uplink message is originated at the air traffic service provider (ATSP) and the time the corresponding response downlink is received at the ATSP.



1. Uplink Sent. This is the date/time that the CPDLC clearance was sent to the aircraft.
2. MAS Received. This is the date/time that the MAS for the CPDLC clearance was received.
3. WILCO Sent. This is the date/time that the WILCO reply is transmitted.
4. WILCO Received. This is the date/time that the WILCO reply for the CPDLC clearance was received.

The measurements (in seconds) are calculated as follows:

$$ACP = (WILCO\_Received) - (Uplink\_Sent) \rightarrow \textbf{TRN}$$

$$ACTP \cong \left(\left(\frac{Up\Delta}{2} \right) + (Down\Delta) \right) \rightarrow \textbf{RCTP}$$

$$PORT \cong ACP - ACTP \rightarrow \textbf{Responder}$$

Figure 3 CPDLC transaction calculations

2.7. The ACTP is computed in three steps. The first step is to estimate the downlink time from the difference between the time stamp on the aircraft-originated downlink message and the ATSP received time. Then, the round trip time of the uplink message is estimated from the difference between the time the uplink message was sent from the ATSP and the receipt of the message assurance (MAS) response for the uplink at the ATSP. The last step is to divide the estimated round trip time by two and add the result to the estimated downlink time. Equation 1 provides the estimate of ACTP:

((MAS receipt – Uplink transmission time)/2 + Downlink time) (1)

2.8. The GOLD also describes the estimation of the PORT latency, which is calculated by the difference between ACP and ACTP. **Figure 3**, taken from the GOLD, illustrates these measurements.

Data Source and Data Preparation

2.9. The first usable set of data started from 1 October, 2012. For this paper, China used the data up to January 2013. All the data-link messages are extracted through the Data-link Service Provider Gateway and stored in the central database in database file format. China developed a data-link performance monitoring local database and several filter and analysing software tools to support the performance measurement. The detailed information about this process and the content of local database design is provided in Appendix A of this paper.

Data-link Performance Analysis

2.10. Observed Data Link Performance by Media Type

2.10.1. There were up to 224274 ADS-C messages and 3078 CPDLC data collected from four Flight Information Regions (ZLLL, ZPPP, ZUUU, ZWWW) utilized, in which there were 2105 SATCOM, 955 VHF, and 18 HF data link messages in the data set.

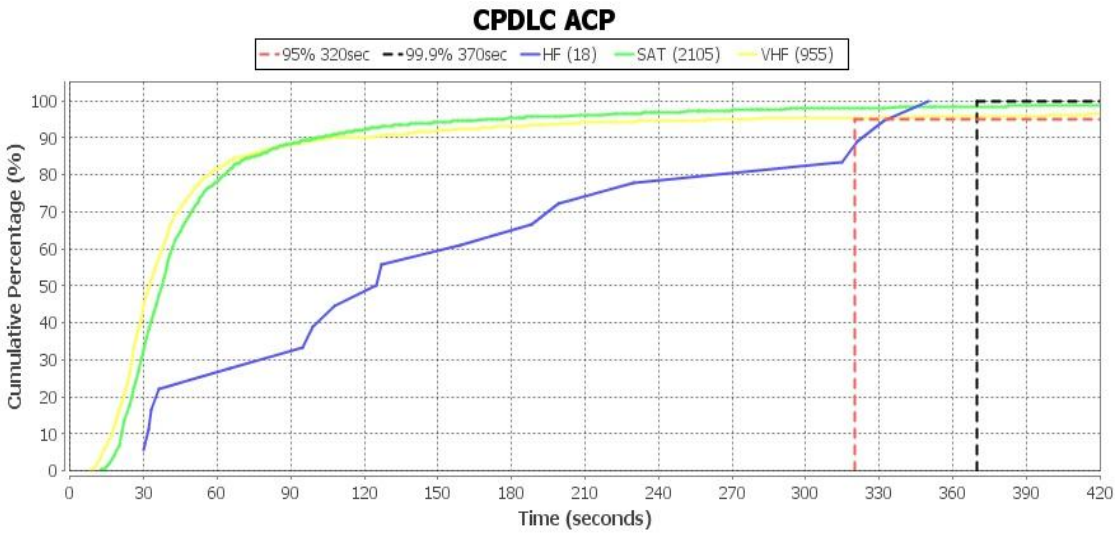


Figure 4 ACP-by media

2.10.2. **Figure 4** presents the ACP measurement for the messages sent to and from the L888 route in aggregate and by media (Satellite, VHF, and HF) during the collection period. The 95 percent requirement for ACP is 320 seconds and the 99.9 percent requirement for ACP is 370 seconds. Figure 4 shows that:

- the observed 95 percent level for ACP for SATCOM is 172 seconds, VHF 274 seconds , HF 332 seconds and aggregate performance 199 seconds;
- the observed 99.9 percent level for SATCOM is 2348 seconds, VHF 2004 seconds , HF 350 seconds and aggregate performance 2348 seconds;
- the observed SATCOM and VHF performance are meeting the 95 percent requirement, but not meeting the 99.9 percent requirement. HF performance is meeting the 99.9 percent requirement, but SATCOM and VHF fall below both the 99.9 criteria.

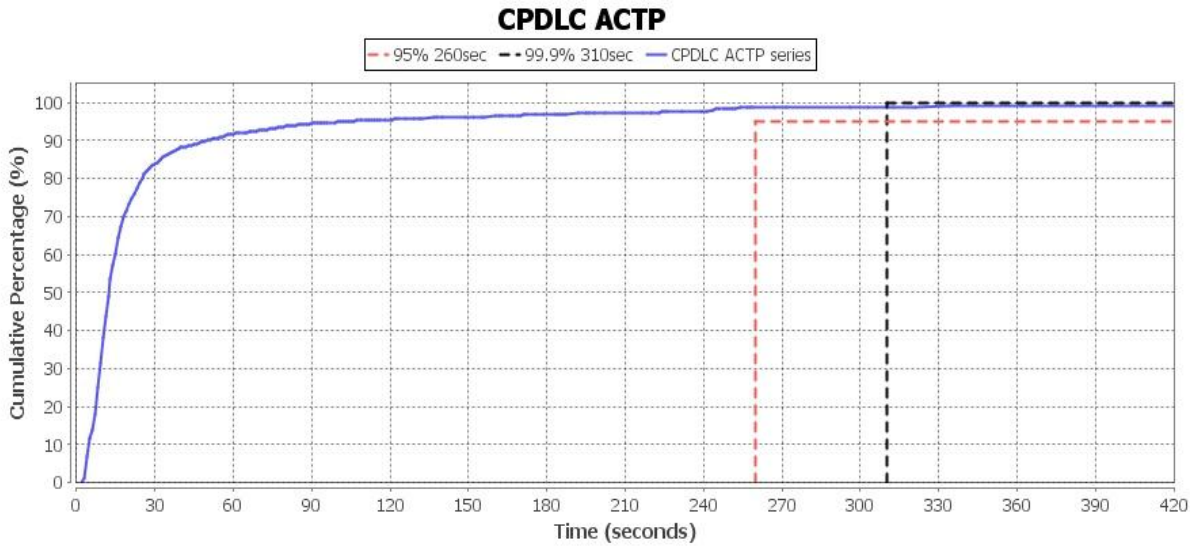


Figure 5 ACTP-Aggregate

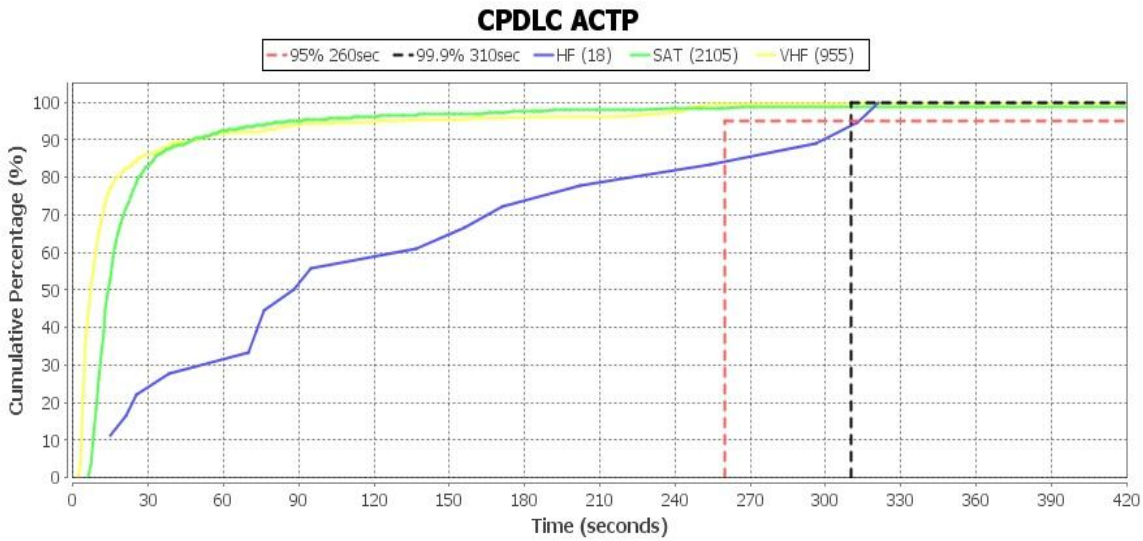


Figure 6 ACTP-by media

2.10.3. **Figure 5** and **Figure 6** present the ACTP measurements for messages sent from the L888 route by media (Satellite, VHF, and HF) during the collection period. The 95 percent requirement for ACTP is 260 seconds and the 99.9 percent requirement for ACP is 310 seconds. Figure 5 and Figure 6 show that:

- the observed 95 percent level for ACTP for SATCOM is 89 seconds, VHF 122 seconds , HF 313 seconds and aggregate performance 104 seconds;
- and the observed 99.9 percent level for ACTP for SATCOM is 1701 seconds, VHF 1592 seconds , HF 313 seconds and aggregate performance 1686 seconds;
- the observed SATCOM and VHF performance are meeting the 95 percent requirement, but not meeting the 99.9 percent requirement. HF performance falls below both the 95 and 99.9 criteria.

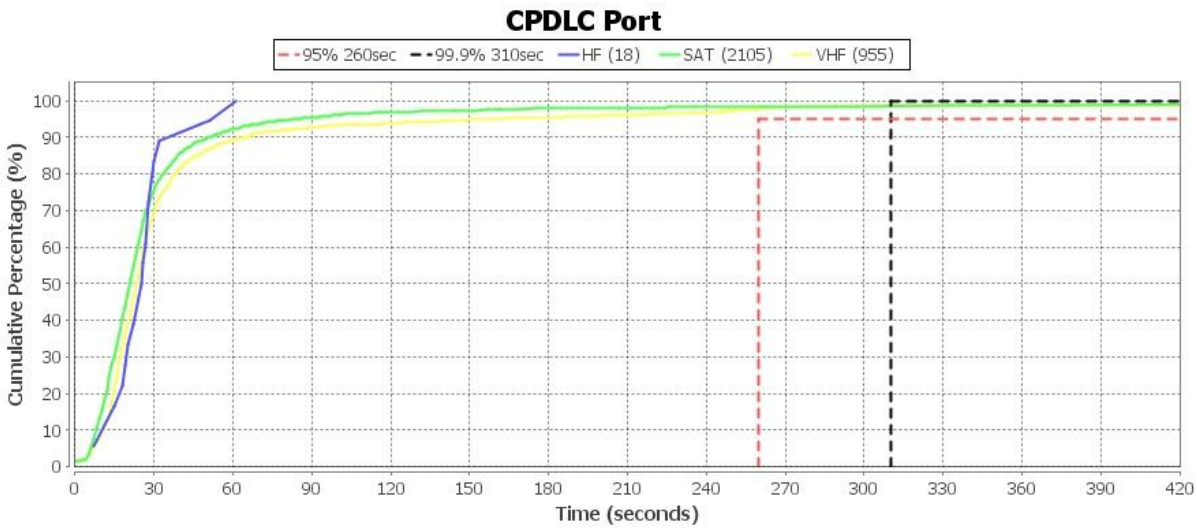


Figure 7 PORT-by media

2.10.4. The requirement for PORT is 60 seconds**. Figure 7** shows that:

- the observed 95 percent level for PORT for SATCOM is 83 seconds, VHF 162 seconds , HF 51 seconds and aggregate performance 96 seconds;
- and the observed 99.9 percent level for SATCOM is 2237 seconds, VHF 1992 seconds , HF 51 seconds and aggregate performance 2237 seconds;
- the observed performance are not meeting the requirement.

2.10.5. The 95 percent requirement for ADS-C performance is 300 seconds and the 99.9 percent requirement for ADS-C performance is 400 seconds. **Figure 8** shows that:

- the observed 95 percent level for ADS-C performance for satellite, VHF and HF data link messages in the L888 route are 43, 15 and 398 seconds, respectively;
- the observed 99.9 percent level for ADS-C performance for satellite, VHF and HF data link messages in the L888 route are 542, 338 and 2225 seconds, respectively;
- the observed performance are VHF and SATCOM are meeting the 95 percent requirement, and the observed performance of VHF is meeting the 99.9 criteria.

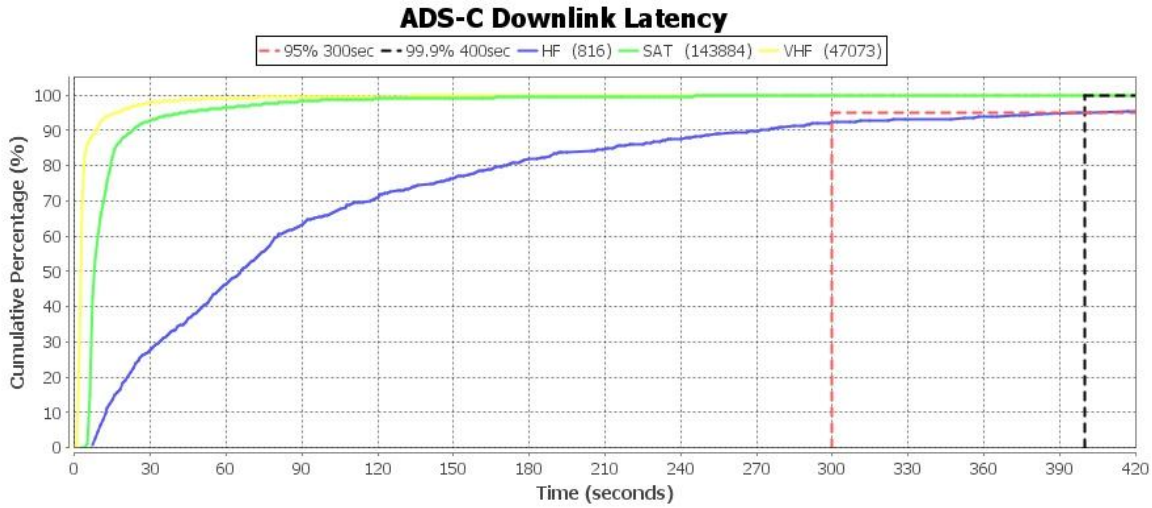


Figure 8 ADS-C performance-by media

2.10.6. **Figure 9 through Figure 12** present the ACP, ACTP, PORT and ADS-C performance by month for the October 2012 through January 2013 time period. Figure 9 through Figure 12 include message performances from by all data link media (Sat, VHF, and HF). The numbers of messages observed during each month are shown in the legend key of each figure. The results in Figure 9 through Figure 12 include all data link sources; satellite, VHF, and HF.

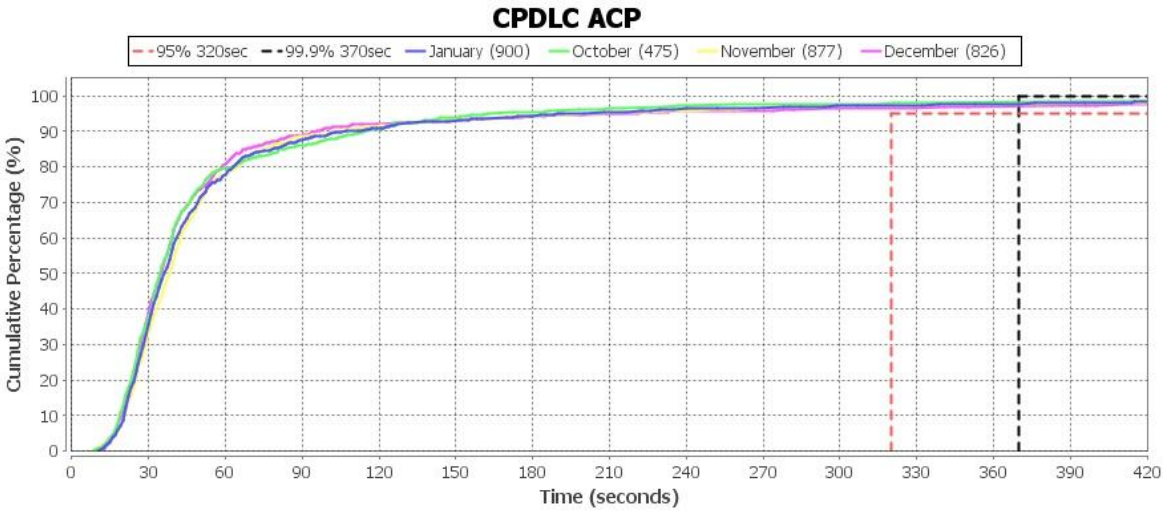


Figure 9 ACP-by month

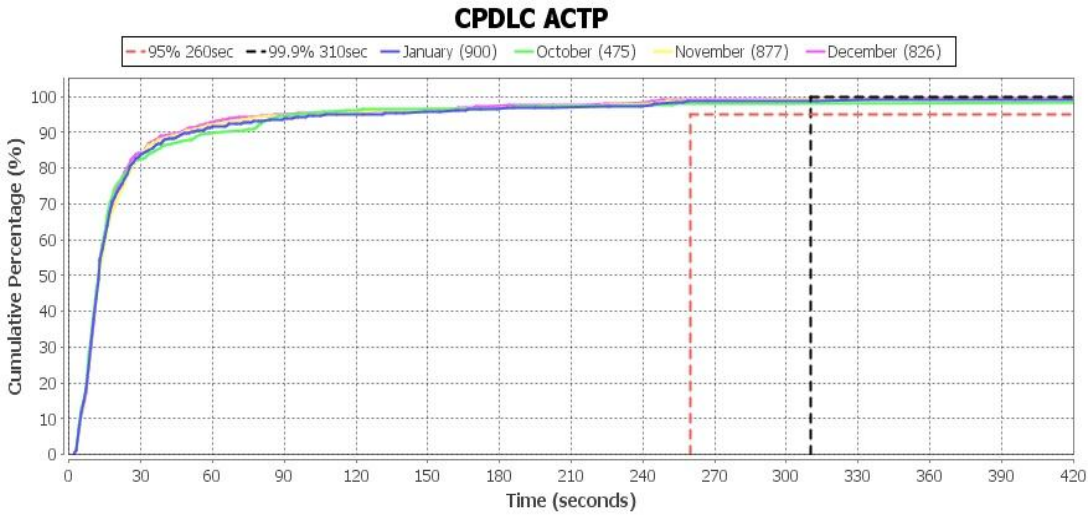


Figure 10 ACTP-by month

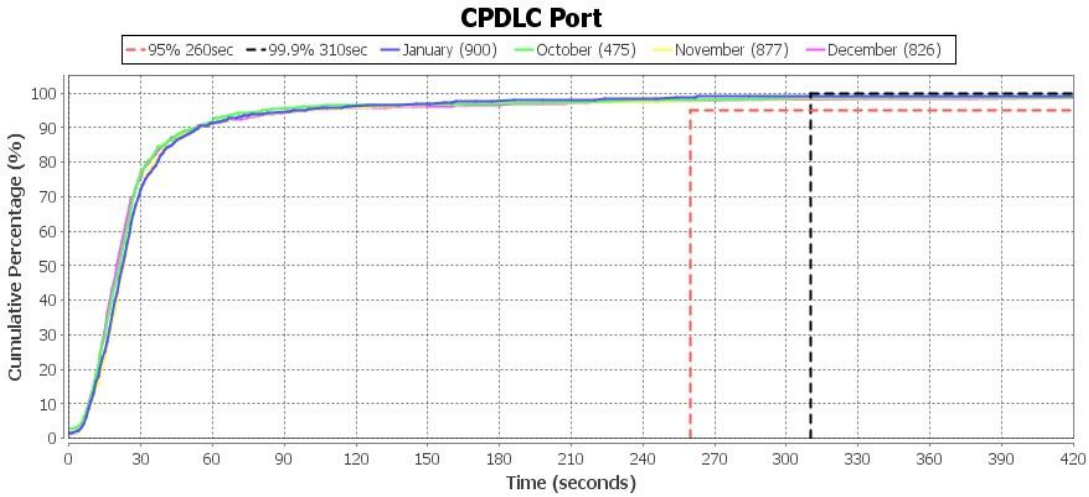


Figure 11 PORT-by month

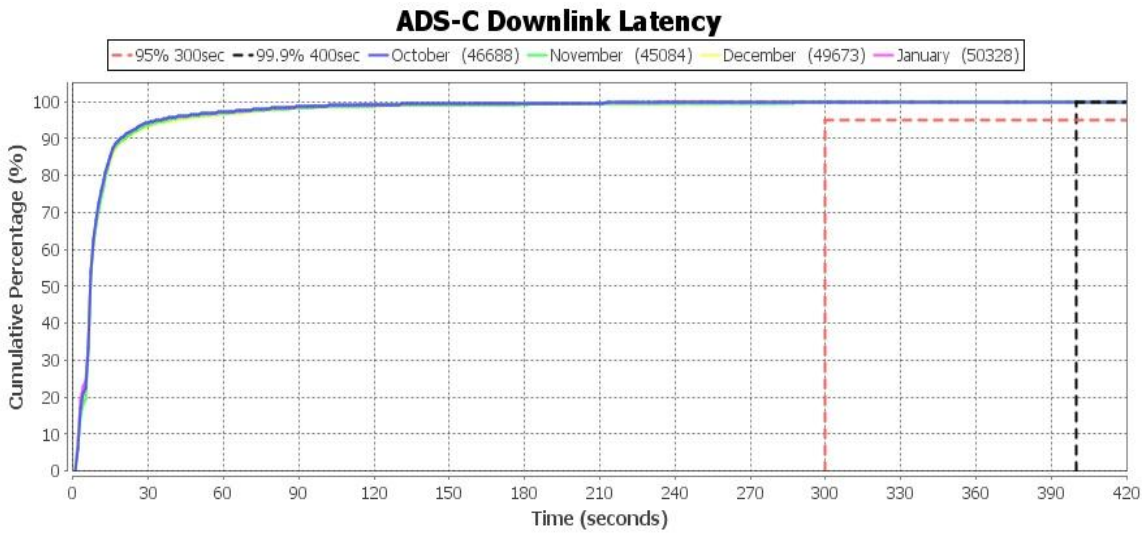


Figure 12 ADS-C performance – by month

2.11. Observed Data Link Performance by Operator

2.11.1. **Figure 13 through Figure 16** present the ACP, ACTP, PORT and ADS-C performance by operator for the October 2012 through January 2013 time period. Figure 13 through Figure 16 include message performance from by all data link media (Sat, VHF, and HF). The numbers of messages observed during each month are shown in the legend key of each figure. The results in Figure 13 through Figure 16 include all data link sources; satellite, VHF, and HF.

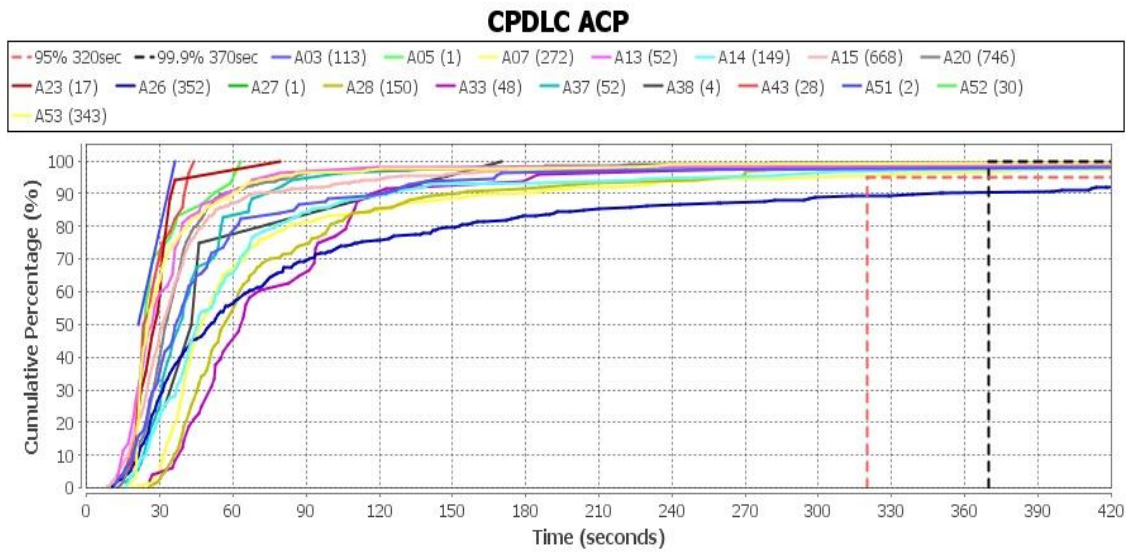


Figure 13 ACP-by operator

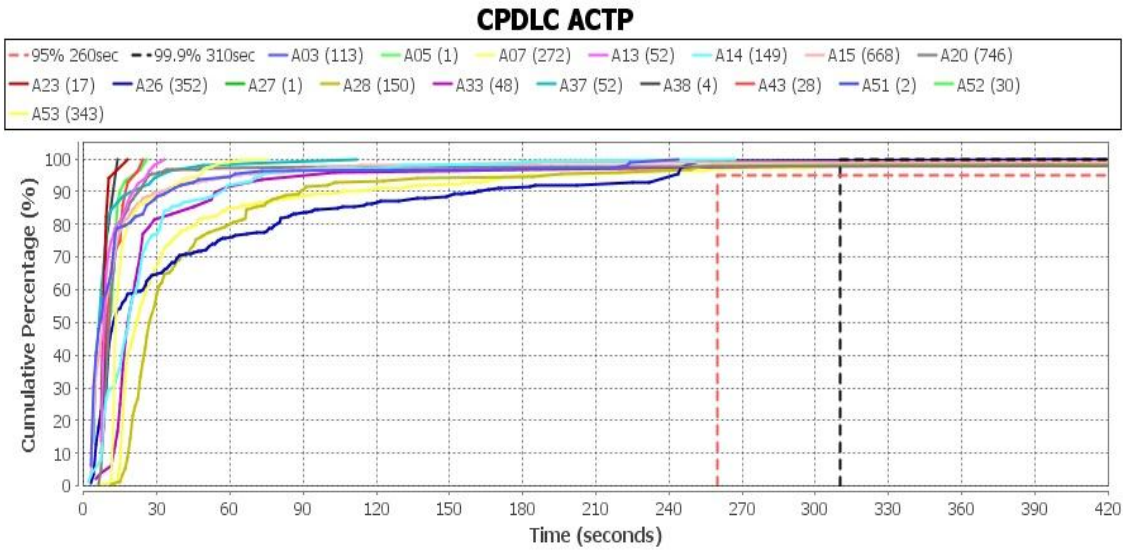


Figure 14 ACTP-by operator

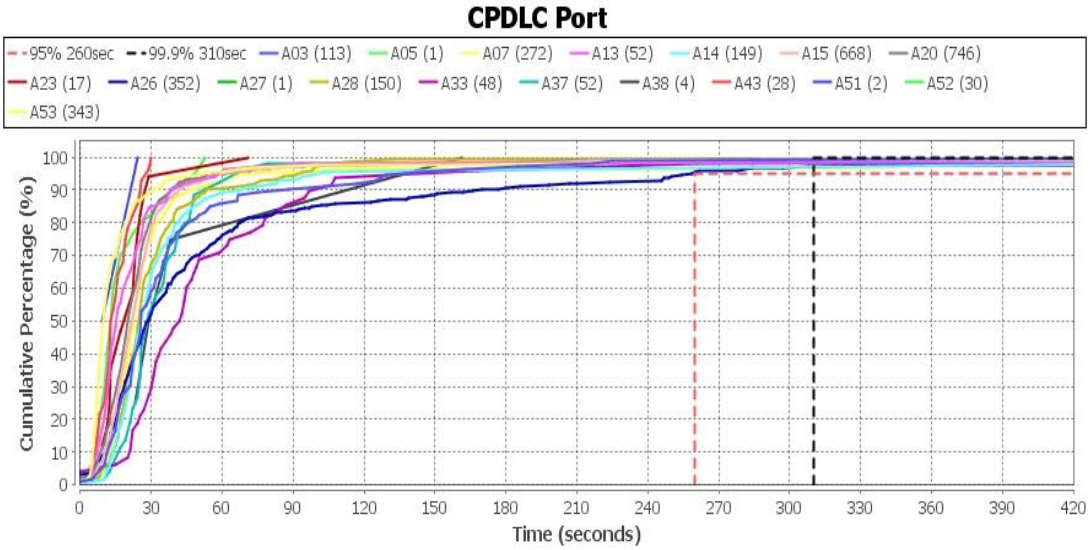


Figure 15 PORT-by operator

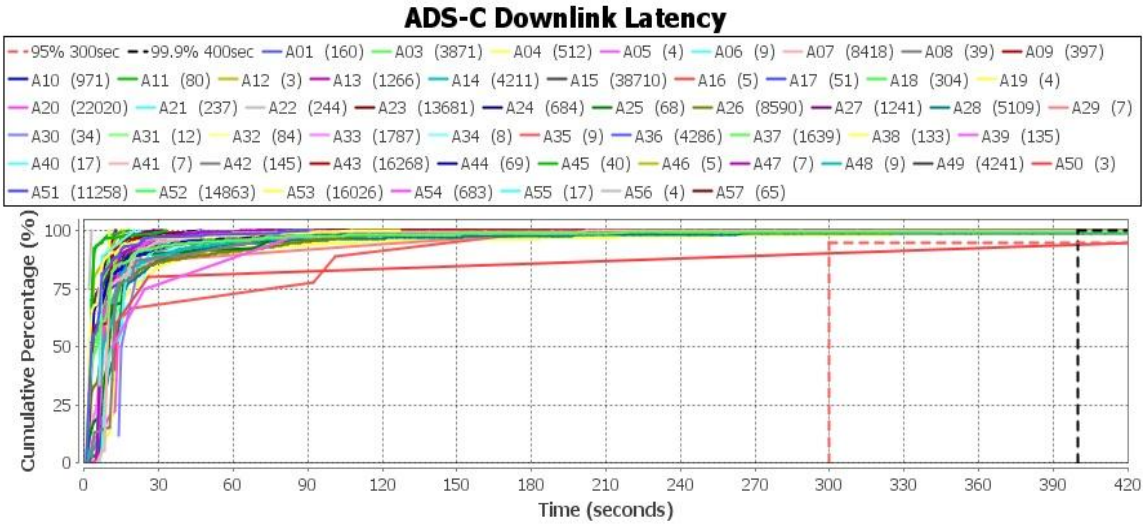


Figure 16 ADS-C performance-by operator

2.11.2. The observed CPDLC performance by operator for the ACTP shown in Figure 14

meets the 95 percent criteria. However, not all of the operators shown in Figure 16 meet the 95 percent requirement for ADS-C of 300 seconds. In addition, the observed PORT performance for one operator shown in Figure 15 does not meet the requirement of 60 seconds.

2.12. Observed Data Link Performance by Operator and Aircraft Type

2.12.1. **Figure 17 through Figure 20** present the ACP, ACTP, PORT and ADS-C performance for B744 aircraft by operator from the L888 route for the October 2012 through January 2013 time period. Figure 17 through Figure 20 include message performance from by all data link media (Sat, VHF, and HF). The numbers of messages observed during each month are shown in the legend key of each figure. The results in Figure 17 through Figure 20 include all data link sources; satellite, VHF, and HF.

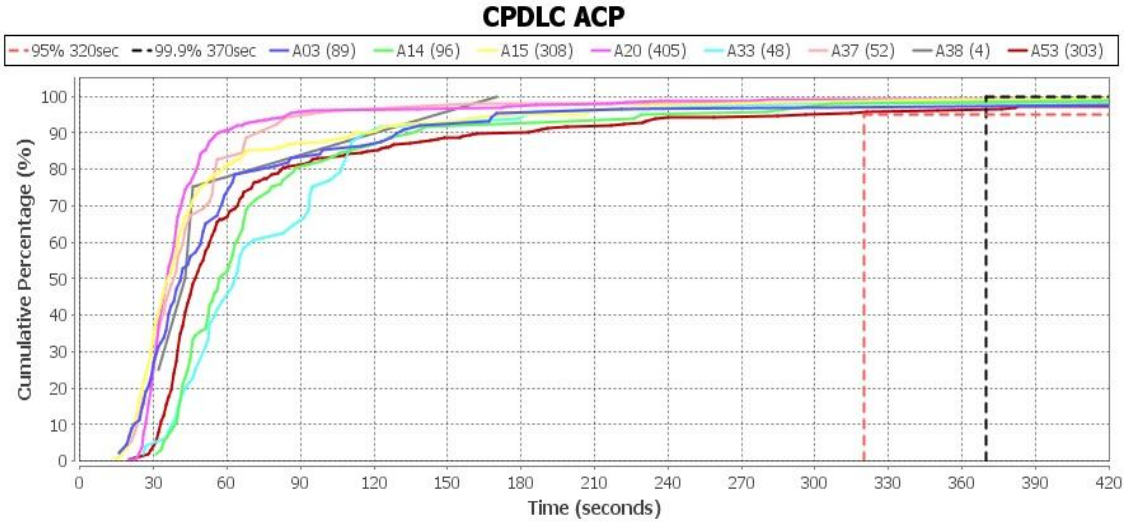


Figure 17 ACP-B744 by operator

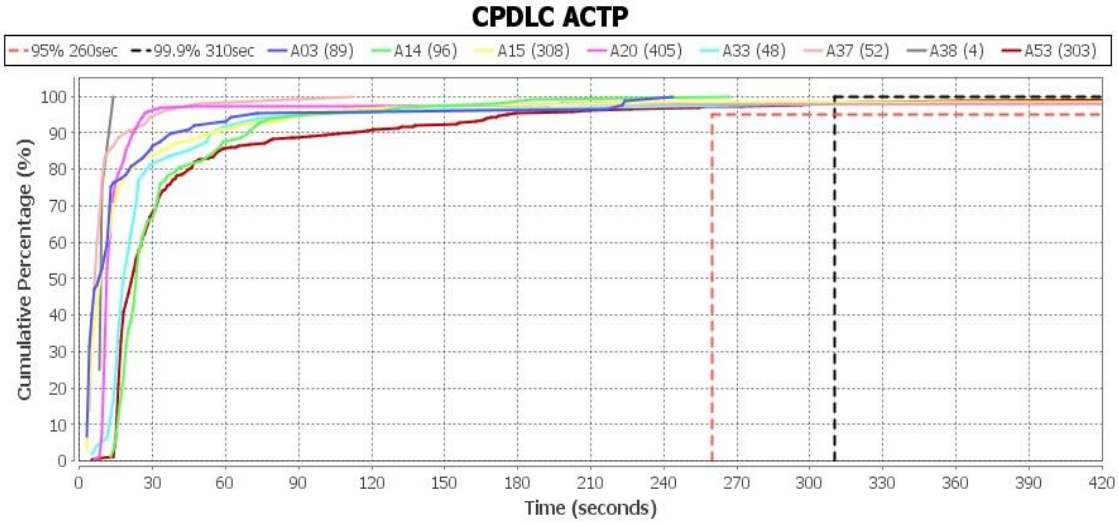


Figure 18 ACTP-B744 by operator

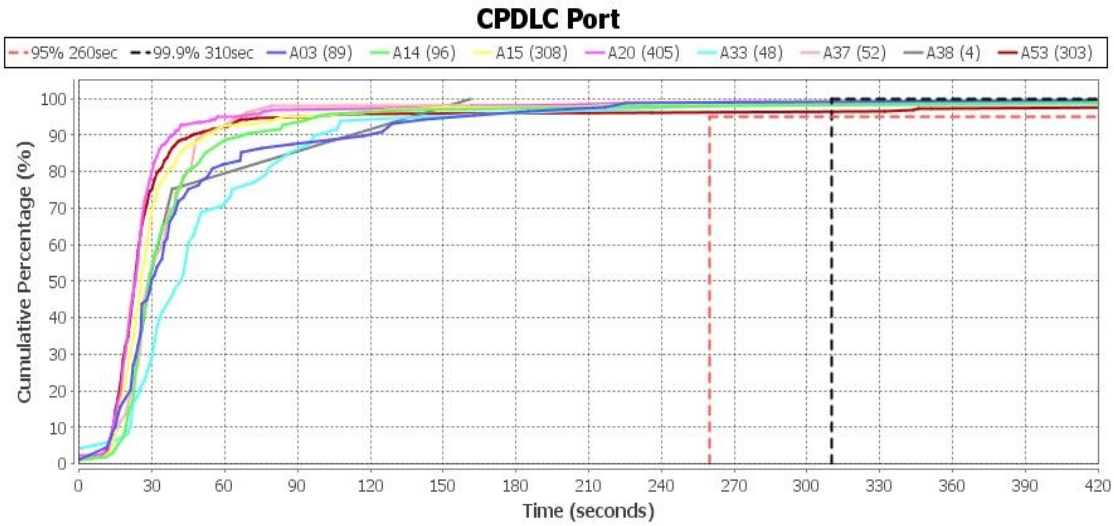


Figure 19 CPDLC-B744 by operator

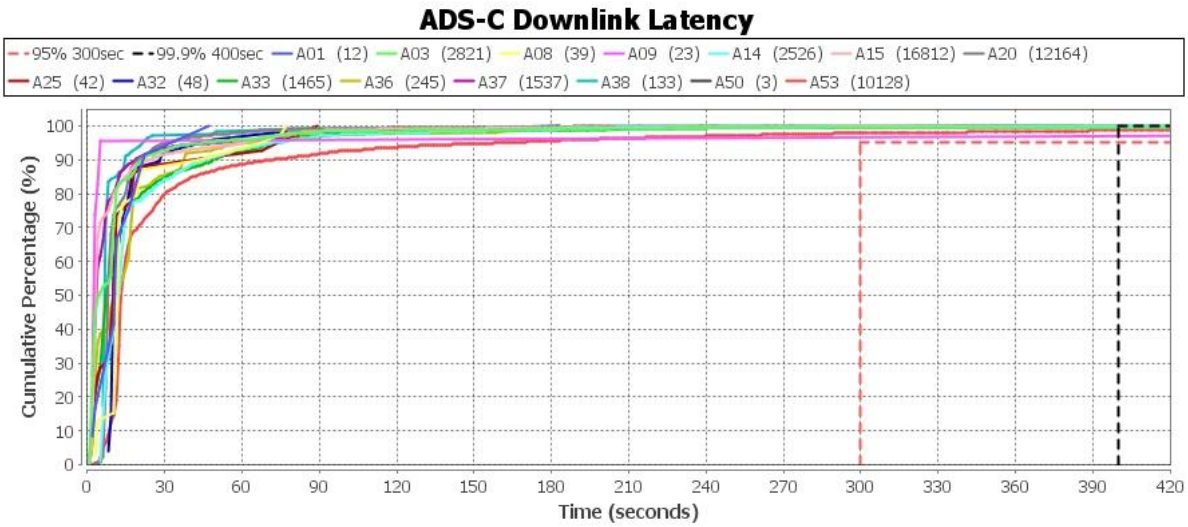


Figure 20 ADS-C performance-B744 by operator

2.12.2. All observed performance by operator for the ACP, ACTP and ADS-C performance shown in Figure 17 through Figure 20 meet the respective 95 percent requirements.

2.12.3. **Figure 21 through Figure 24** present the ACP, ACTP, PORT and ADS-C performance for A346 aircraft by operator from the L888 route for the October 2012 through January 2013 time period. Figure 21 through Figure 24 include message performance from by all data link media (Sat, VHF, and HF). The numbers of messages observed during each month are shown in the legend key of each figure. The results in Figure 21 through Figure 24 include all data link sources; satellite, VHF, and HF.

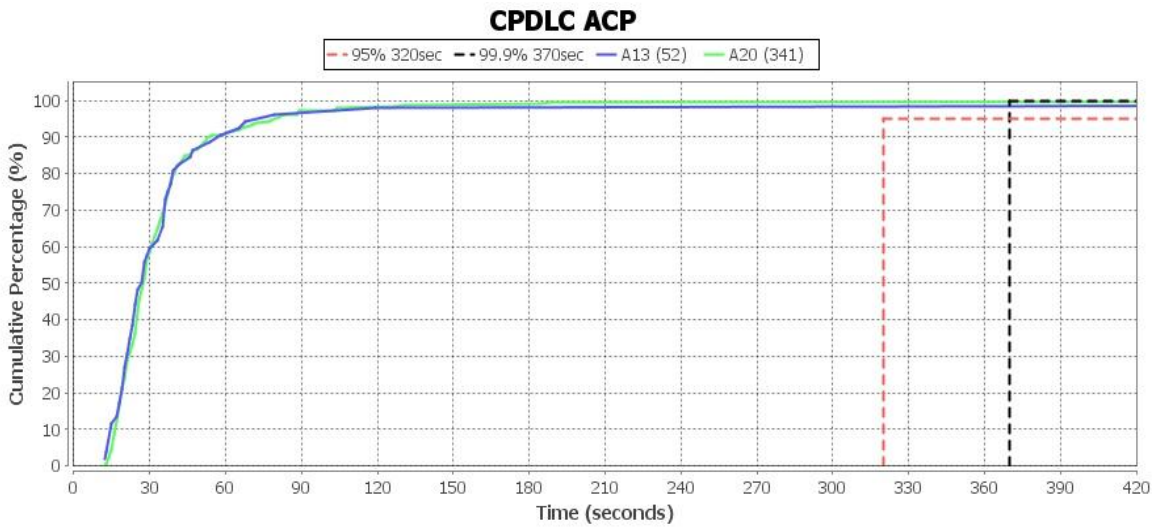


Figure 21 ACP-A346 by operator

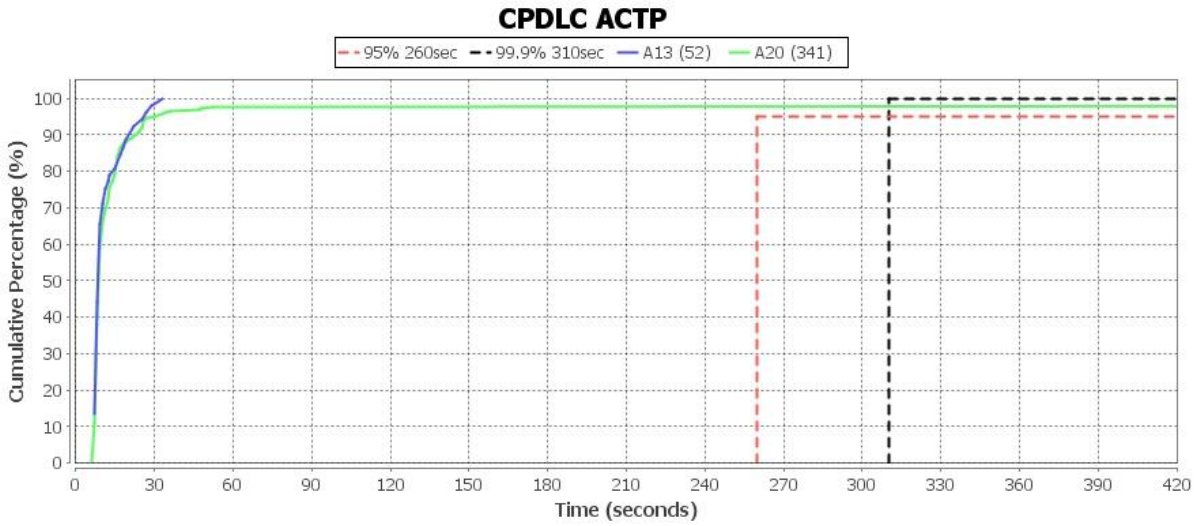


Figure 22 ACTP-A346 by operator

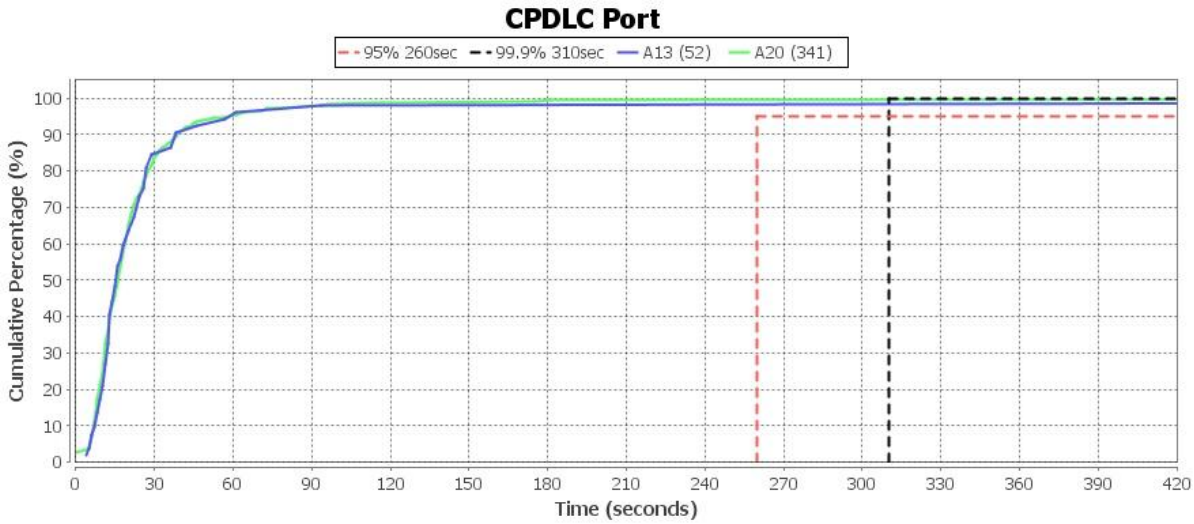


Figure 23 PORT-A346 by operator

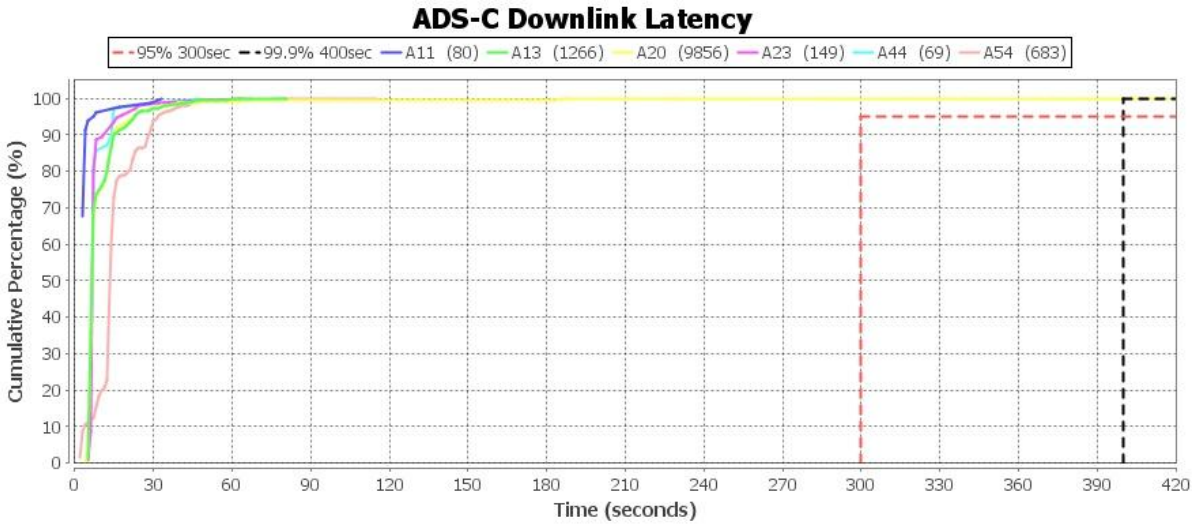


Figure 24 ADS-C performance- A346 by operator

2.12.4. All observed performance by operator for the ACP, ACTP and ADS-C performance shown in Figure 21 through Figure 24 meet the respective 95 percent requirements.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

a) note the information contained in this paper;

b) discuss any relevant matters concerning the problems raised in this paper and give suggestions.

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Appendix A Data Source and Data Preparation