

Appendix D

Post-implementation monitoring and corrective action (CPDLC and ADS-C)

1. GENERAL

1.1 This appendix provides guidance additional to that provided in Chapter 4, for local and regional performance-based communication and surveillance (PBCS) monitoring programmes. It contains the post-implementation guidance material relevant to controller-pilot data link communications (CPDLC) and automatic dependent surveillance — contract (ADS-C) for which the required communication performance (RCP)/required surveillance performance (RSP) specifications provided in Appendices B and C are applicable, including:

- a) air navigation services provider (ANSP) data collection — this section defines a common data reporting format, providing guidance on how to obtain the necessary data points;
- b) ANSP monitoring and analysis — this section contains guidance on data analysis, including recommended filtering for completeness of monitoring;
- c) regional performance monitoring and analysis — this section provides guidance on monitoring at a regional level; and
- d) problem reporting and resolution — this section provides guidance on the process for problem identification and resolution.

2. ANSP DATA COLLECTION

2.1 ANSP data collection for CPDLC transaction time/continuity

2.1.1 General

2.1.1.1 This section provides guidance on data collection and performance measurement for the CPDLC application. CPDLC analysis is based on the measurement of actual communication performance (ACP) against required communication monitored performance (RCMP), actual communications technical performance (ACTP) against required communication technical performance (RCTP), and pilot operational response time (PORT) against RCP PORT.

2.1.1.2 While each ANSP may store the data using a database, for the purpose of sharing CPDLC transaction data (e.g. with the regional monitoring entity for regional analysis), the data should be sent as a comma delimited text file. The format for each record will contain, at a minimum, the 20 data points specified below in Table D-1.

2.1.1.3 In addition to monitoring data communications performance as described below, it is suggested that the ANSP conduct a regular analysis of message use statistics for the current CPDLC message set for the development of future CPDLC applications.

2.1.1.4 The CPDLC data set is comprised of controller-initiated transactions. Specifically, the subset of CPDLC uplinks that receive a single DM 0 WILCO response is used. The transactions in which an uplink receives DM 1 UNABLE, DM 2 STANDBY, DM 3 ROGER, DM 4 AFFIRM, DM 5 NEGATIVE responses are not considered. A DM 0 WILCO response following a DM 2 STANDBY is also not measured.

2.1.2 Recording data points for each CPDLC transaction

2.1.2.1 The data points shown in Table D-1 are recommended as the minimum set to be extracted by the ANSP from CPDLC system recordings, to provide sufficient information for RCP analysis and problem investigation. Additional data points that may be extracted for more detailed analysis are listed in Table D-1 below.

2.1.2.2 Most of the data points may be extracted from either the ACARS, ATN B1 header, CPDLC application message, or calculated based on the other data points. However, the aircraft type and operator must be matched to each record from a separate database, using the aircraft registration as the common point.

2.1.2.3 The methods for calculating the ACTP, ACP and PORT are described in 2.1.3 of this appendix.

Table D-1. CPDLC data collection points

<i>Ref</i>	<i>Label</i>	<i>Description and/or remarks</i>
1	ANSP	Four-letter ICAO designator of the facility (e.g. NZZO).
2	Aircraft registration (FANS 1/A)	Aircraft registration in <i>Procedures for Air Navigation Services — Air Traffic Management</i> (PANS-ATM, Doc 4444) format (no hyphens, extraneous characters, etc.) (e.g. N104UA). <i>Note.— Extracted from ACARS header or application message.</i>
2	Aircraft address (ATNB1)	24-bit address in Doc 4444 format (alphanumeric character, in six hexadecimals). <i>Note.— Extracted from CM application message.</i>
3	Aircraft type designator	ICAO aircraft type designator (e.g. B744). <i>Note.— Extracted from the ANSP's database using aircraft registration as key. Aircraft type designators are contained in Doc 8643.</i>
4	Operator designator	ICAO designator for the aircraft operating agency (e.g. UAL). <i>Note.— Extracted from the ANSP's database using aircraft registration as key.</i>
5	Date	In YYYYMMDD format (e.g. 20081114). <i>Note.— Extracted from the ANSP's system data recording timestamp.</i>
6	MAS RGS	RGS designator from which the MAS downlink was received. <i>Note.— This is a 3- or 4-letter designator extracted from the second field of the ACARS header DT line (e.g. DT DDL PORT 121212 M01A).</i>

<i>Ref</i>	<i>Label</i>	<i>Description and/or remarks</i>
7	OPS RGS	RGS designator from which the operational response was received. <i>Note.— This is a 3 or 4 letter designator extracted from second field of the ACARS header DT line (e.g. DT DDL AKL1 121212 M01A).</i>
8	Uplink time	Timestamp on the uplink CPDLC message sent by the ANSP in HH:MM:SS format (e.g. 03:43:25). <i>Note.— Extracted from the ANSP system data recording timestamp.</i>
9	MAS/LACK receipt time	ANSP timestamp on receipt of the MAS/LACK in HH:MM:SS format (e.g. 03:43:35). <i>Note.— Extracted from the ANSP system data recording timestamp.</i>
10	MAS/LACK round trip time	In seconds (#9-#8) (e.g. 10).
11	Aircraft FMS timestamp	In the operational response messages in HH:MM:SS (e.g. 03:44:15). <i>Note.— For FANS 1/A, extracted from the ATCmessageHeader timestamp in the decoded operational response message. See RTCA DO-258AEUROCAE ED-100A section 4.6.3.3.</i>
12	ANSP timestamp on the receipt of the operational response	In HH:MM:SS format (e.g. 03:44:45). <i>Note.— Extracted from the ANSP system data recording timestamp.</i>
13	Operational message round-trip time	From sending uplink (#8) to receipt of operational response (#12) in seconds (e.g. 80).
14	Downlink response transit time	In seconds (#12-#11) (e.g. 30).
15	Uplink message elements	All uplink message element identifiers preceded by U encapsulated between quotation marks with a space between each element (e.g. "U118 U80"). <i>Note.— Extracted from the decoded operational uplink that initiated the transaction.</i>
16	Downlink message elements	All downlink message elements encapsulated between quotation marks with a space between each element, if required (e.g. "D0"). <i>Note.— Extracted from the decoded operational downlink.</i>
17	ACTP	Actual communication technical performance in seconds (e.g. 35). <i>Note.— Truncated to whole seconds.</i>
18	ACP	Actual communications performance in seconds measured as the difference between the time uplink is sent (#8) and the time the operational response is received (#12) (e.g. 80).

Ref	Label	Description and/or remarks
19	PORT	<p>Pilot operational response time = ACP (#18) – ACTP (#17) (e.g. 45).</p> <p><i>Note.— Implementers should allow for negative values where the operational response is received before the MAS as per above. When graphing, PORT negative values should be counted as 0.</i></p>

2.1.2.4 In comma delimited text file format, these data points would appear as follows:

NZZO,N104UA,B744,UAL,20081114,POR1,AKL1,03:43:25,03:43:35,10,03:44:15,03:44:45,80,30,"U118
U80","D0",35,80,45

2.1.3 Calculating ACP, ACTP and PORT

2.1.3.1 The ACP is calculated by measuring the difference between the time when the uplink message originates from the ANSP and the time when the corresponding response downlink is received by the ANSP.

2.1.3.2 The ACTP is obtained by calculating the difference between the downlink's aircraft timestamp and the received time, and adding it to half the round trip time, determined by the difference between the uplink time when the message is sent from the ANSP and the receipt of the MAS response for the uplink at the ANSP ((uplink transmission time — MAS receipt)/2 + downlink time).

2.1.3.3 The PORT is estimated by measuring the difference between ACP and ACTP. Figure D-1 illustrates how these measurements are calculated.

2.1.3.4 The values for ACTP and PORT are approximations. The assumption that the uplink transit times are half of the MAS/LACK response round trip time is flawed in a small percentage of cases, because it is possible for the MAS to be received at the ANSP after the operational response is received; or for the timestamp on the operational response to be earlier than the MAS receipt time. This happens if:

- the CSP does not hear the network ACK from the aircraft (which is sent on uplink receipt) and resends the uplink later;
- the CSP receives the network ACK from the aircraft (which is sent on uplink receipt) and resends the uplink later; and
- the CSP receives the network ACK to this second uplink and sends the MAS to the ANSP.

2.1.3.5 In the meantime, the aircraft has already responded with the operational response. The ANSP will see this issue reflected in their data with crew response times with negative or extremely small values.

2.1.3.6 Therefore, **all transactions with zero or negative crew response times should be filtered from data prior to analysis.** The time sequence diagram below in Figure D-2 illustrates the issue. Additional errors may arise if there are delays between the ANSP and the CSP on the uplink path. These delays will result in excessive calculated PORT and skewed ACP.

2.1.3.7 The ANSP may find the following additional data points useful for further CPDLC performance analysis, reported problem investigation and other analysis support, such as from monitoring the application of performance-based horizontal separation minima:

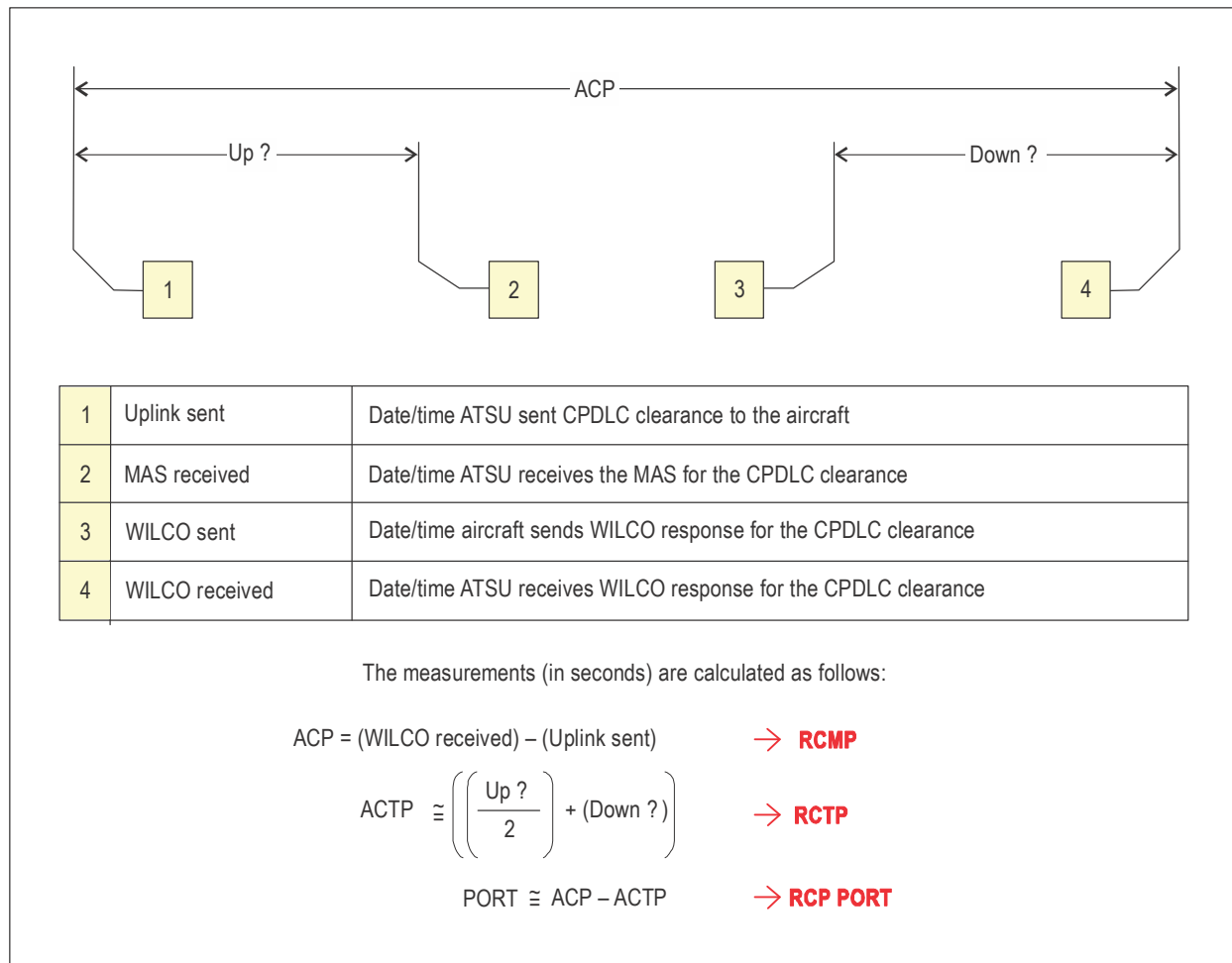


Figure D-1. CPDLC transaction calculations

- the aircraft call sign extracted from either the flight plan (e.g. ANZ123) or the logon request message for the flight (e.g. NZ123) or the FI line in the ACARS header (e.g. NZ0123);
- direction of flight calculated by the flight data processor and displayed as a three figure group representing degrees true (e.g. 275);
- the estimated position in latitude and longitude of the aircraft when a CPDLC downlink is sent and calculated by the flight data processor. For consistency, the following formats are recommended: for latitude use "+" for North and "-" for South followed by a decimal number of degrees (e.g. -33.456732). For longitude use "+" for East and "-" for West followed by a decimal number of degrees (e.g. +173.276554);
- the communication type (COMTYP) identifying the media used for delivering CPDLC uplink and downlink messages. This is determined based on the MAS RGS field (#6) and OPS RGS field (#7). Table D-2 lists the nine possible entries for COMTYP: SAT, VHF, HF, SV, SH, VS, VH, HS, HV; and
- the regional monitoring entity should consider promulgating a list of RGS designators applicable to their respective region.

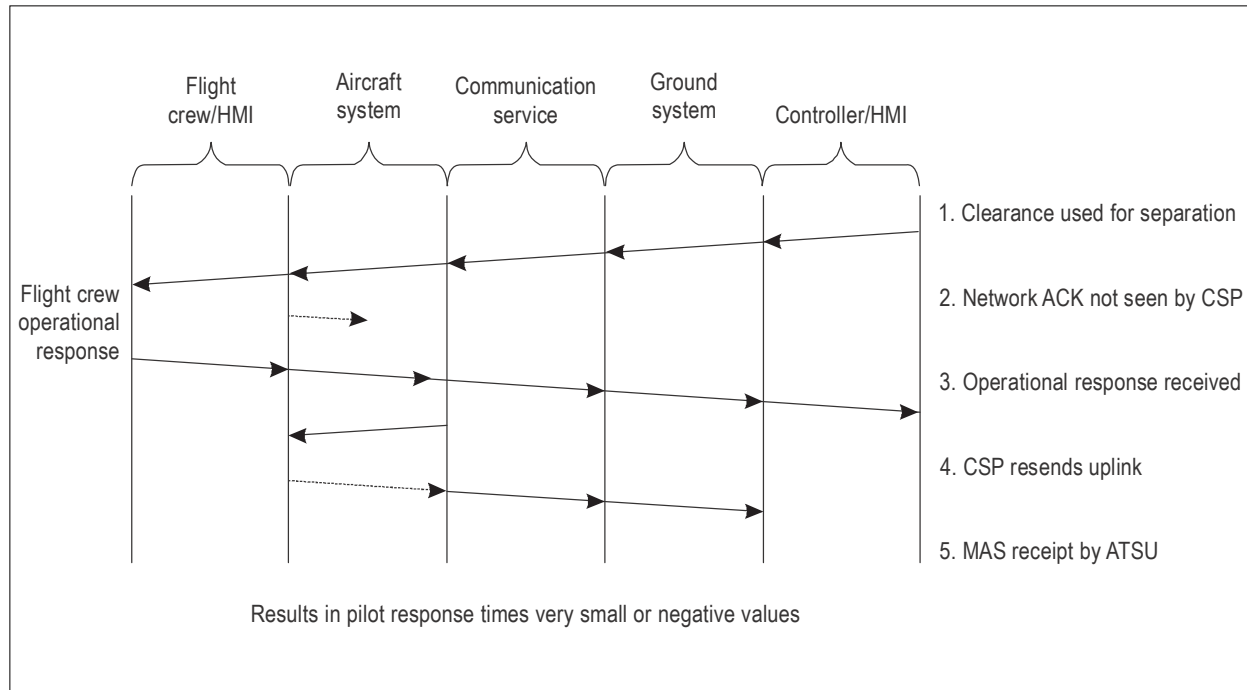


Figure D-2. Issue with estimating uplink transit time as half MAS round trip

Table D-2. Determination of COMTYP indicators

<i>MAS RGS communication type</i>	<i>OPS RGS communication type</i>	<i>COMTYP</i>
SAT (e.g. MAS RGS = POR1)	SAT (e.g. OPS RGS = POR1)	SAT
VHF (e.g. MAS RGS = ADK)	VHF (e.g. OPS RGS = ADK)	VHF
HF (e.g. MAS RGS = H02)	HF (e.g. OPS RGS = H02)	HF
SAT (e.g. MAS RGS = POR1)	VHF (e.g. OPS RGS = ADK)	SV
SAT (e.g. MAS RGS = POR1)	HF (e.g. OPS RGS = H02)	SH
VHF (e.g. MAS RGS = ADK)	SAT (e.g. OPS RGS = POR1)	VS
VHF (e.g. MAS RGS = ADK)	HF (e.g. OPS RGS = H02)	VH
HF (e.g. MAS RGS = H02)	VHF (e.g. OPS RGS = ADK)	HV
HF (e.g. MAS RGS = H02)	SAT (e.g. OPS RGS = POR1)	HS

2.2 ANSP data collection for ADS-C report delivery time/continuity

2.2.1 General

2.2.1.1 This section provides guidance on data collection and performance measurement for the ADS-C application. The ADS-C analysis is based on the measurement of actual surveillance performance (ASP), against the required surveillance performance (RSP). The ASP is the measurement of the difference between the time extracted from the decoded ADS-C basic group timestamp (i.e. time at position) and the time the ADS-C report is received at the ANSP.

2.2.1.2 While each ANSP may store the data using a database, for the purpose of sharing ADS-C transaction data (e.g. with the regional monitoring entity for regional analysis), the data should be sent as a comma delimited text file. The format for each record will contain, at a minimum, the 12 data points specified below in Table D-3.

2.2.2 Recording data points for each ADS-C report

2.2.2.1 The data points shown in Table D-3 are recommended as the minimum set to be extracted by the ANSP from ADS-C system recordings, to provide sufficient information for ASP analysis and problem investigation. Additional data points that may be extracted for more detailed analysis are listed in Table D-3 below. Most of the data points can be extracted from either the ACARS header or the ADS-C application message. However, the aircraft type and operator will need to be matched to each record from a separate database using the aircraft registration as the common point.

Table D-3. ADS-C data collection points

<i>Ref:</i>	<i>Label</i>	<i>Description and/or remarks</i>
1	ANSP	Four-letter ICAO designator for the facility (e.g. NZZO).
2	Aircraft registration	Aircraft registration in Doc 4444 format (no hyphens, extraneous characters, etc.) (e.g. N104UA). <i>Note.— Extracted from ACARS header or application message.</i>
3	Aircraft type designator	ICAO aircraft type designator (e.g. B744). <i>Note.— Extracted from the ANSP's database using aircraft registration as key. Aircraft type designators are contained in Doc 8643.</i>
4	Operator Designator	ICAO designator for the aircraft operating agency (e.g. UAL). <i>Note.— Extracted from the ANSP's database using aircraft registration as key.</i>
5	Date	In YYYYMMDD format (e.g. 20081114). <i>Note.— Extracted from the ANSP's system data recording timestamp.</i>
6	RGS	RGS designator from which the ADS-C downlink was received. <i>Note.— This is a 3- or 4-letter designator extracted from the second field of the ACARS header DT line (e.g. DT DDL POR1 121212 M01A).</i>

Ref:	Label	Description and/or remarks
7	Report type	The type of ADS-C report extracted from the ADS-C basic group report tag where tag value 7=PER, 9=EMG, 10=LDE, 18=VRE, 19=LRDE, 20=WCE. As some aircraft concatenate more than one report in the same downlink extract, the ADS-C report tag from each ADS-C basic group and identify them in the REP_TYPE column by using the first letter of the report type as an identifier (e.g. for a concatenated report containing two ADS-C basic groups for a periodic report and a waypoint event report the field will contain PW). Where a downlink does not contain an ADS-C basic group, the REP_TYPE field will be left blank.
8	Latitude	The current latitude decoded from the ADS-C basic group. The format is "+" for North and "-" for South followed by a decimal number of degrees (e.g. -33.456732).
9	Longitude	The current longitude decoded from the ADS-C basic group. The format is "+" for East and "-" for West followed by a decimal number of degrees (e.g. +173.276554).
10	Aircraft time	The time the aircraft was at the position (latitude and longitude) in the ADS-C report to within the accuracy specified by the RSP specification in HH:MM:SS format (e.g. 03:44:15). <i>Note.— Decoded from the ADS-C basic group timestamp extracted as seconds since the most recent hour. See RTCA DO-258A/EUROCAE ED-100A, section 4.5.1.4.</i>
11	Received time	The ANSP timestamp on the receipt of the ADS-C message in HH:MM:SS format (e.g. 03:44:45). <i>Note.— Extracted from the ANSP's system data recording timestamp.</i>
12	Transit time	The transit time of the ADS-C downlink in seconds calculated as the difference between #10 aircraft time and #11 received time (e.g. 30).

2.2.2.1 In a comma delimited text file format, these data would appear as follows:

NZZO,N104UA,B744,UAL,20081114,POR1,PER,-33.456732,+173.276554,03:44:15,03:44:45,30

2.2.2.2 The ANSP may find the following additional data useful for performance analysis, reported problem investigation and other analysis support, such as from monitoring the application of performance-based horizontal separation minima:

- the aircraft call sign extracted from either the flight plan (e.g. ANZ123), the AFN logon for the flight (e.g. NZ123) or the FI line in the ACARS header (e.g. NZ0123);
- direction of flight calculated by the ANSP flight data processor and displayed as a three figure group representing degrees true (e.g. 275);
- the current altitude (e.g. 35 000) decoded from the ADS-C basic group. The altitude combined with the latitude, longitude, and time, provide the aircraft position at the time the report was generated. Aircraft movement data is needed in airspace safety assessments and/or airspace safety monitoring analyses. Inclusion of altitude in the data sample would allow it to be used for both ADS-C performance monitoring and airspace safety monitoring analyses;

- d) ADS-C predicted position latitude and longitude and time when available.

(Note.— Time decoded from the ADS-C predicted group where the timestamp is extracted as seconds since the most recent hour (see RTCA DO-258A section 4.5.1.4).

For consistency, the following formats are recommended: for latitude use “+” for North or “-” for South followed by a decimal number of degrees (e.g. -33.456732); for longitude use “+” for East or “-” for West followed by a decimal number of degrees (e.g. +173.276554); and

- e) the communications type (COMTYP) identifying the media used for delivering the ADS-C report. This is determined based on the RGS field (#6). Satellite (SAT), very high frequency (VHF), high frequency (HF). (Refer to Table D-2.)

2.2.3 Calculating ADS-C report delivery time

2.2.3.1 The ADS-C report delivery time is calculated by measuring the difference between the times when the ADS-C report indicated the aircraft was at the reported position, to when the ATS unit received the report.

2.3 ANSP data collection for CPDLC and ADS-C availability

2.3.1 The ANSP should collect data on CSP-notified system outages, as well as detected outages not observed or notified by the CSP, as these data are used to calculate the actual availability of CPDLC and ADS-C.

2.3.2 For each outage, the following information should be collected:

- a) time of CSP outage notification: in YYYYMMDDHHMM format or “Not Notified” if no CSP notification was received;
- b) CSP name: name of CSP supplying outage notification, if applicable;
- c) type of outage: report media affected SATCOM, VHF, HF, ALL;
- d) outage start time: in YYYYMMDDHHMM format;
- e) outage end time: in YYYYMMDDHHMM format; and
- f) duration of outage: in minutes.

2.3.3 As per Appendix B, only outages lasting longer than 10 minutes are reported.

2.3.4 Data sets should also be examined in order to identify cases where outages are not detected or notified by the CSP. For example, when delays are observed from multiple aircraft and messages are received by the ANSP at similar times, this may indicate a system outage. An example of an outage not notified by any CSP is illustrated in Table D-4, with large ADS-C downlink delays observed from 3 aircraft during the period from 11h20m and 12h13m.