Network Manager Directorate

EUROCONTROL

Link 2000+ DLS CRO Performance Monitoring Requirements

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DOCUMENT APPROVAL

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DOCUMENT CHANGE RECORD

The following table records the complete history of the successive editions of the present document.

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0.1	11/05/2011	First draft for internal discussion.	
0.2	01/06/2012	Second draft for internal review	
0.3	15/06/2012	First draft for discussion with ANSPs	
0.4	04/07/2012	Second draft for review by ANSPs. This version of the document takes account of initial comments made at the CRO meeting	

		of the 21st June 2012	
0.5	12/09/2012	Third draft distributed internally to EUROCONTROL. Reduces the scope to just the proposed parameters for discussion between the ANSPs and the NSAs	
0.6	19/09/2012	Fourth draft for review by ANSPs. Removes the discussion about the allocation of performance requirements and includes description of the type of in-service monitoring proposed in ED78a	
1.0	25/10/2012	Final version. This version is intended to form a basis for direct discussions between each ANSP and their NSA to agree what level of performance monitoring is required	
1.001	28/02/2014	Draft to propose some targets for the various metrics as requested by Skyguide. Format changed to match DNM procedures.	
1.1	25/03/2014	Draft for review by ANSPs containing proposed target values for the various performance parameters. Also includes some discussion on how best to measure AI continuity.	
1.2	10/04/2014	Correction to the messages in section 4.2	Section 4.2
1.3	19/05/2014	Updated to reflect feedback from the ad-hoc meeting held on the 6th May 2014.	

REVIEW TABLE

Edition No.	Review type, scope, depth & focus	Reviewers	Date	Conclusion
1.001	Content.	Nick Witt, Isabelle Herail, Soren Dissing.		Document updated. Continuity and PA target values updated.

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KEY ACRONYMS

ACL	ATC Clearance service
ACM	ATC Communications Management service
ACSP	Air/Ground Communications Service Provider
AMC	ATC Microphone Check service
ANSP	Air Navigation Service Provider
ATN	Aeronautical Telecommunications Network
ATSU	Air Traffic Service Unit
CM	Context Management
CMU	Communications Management Unit
CPDLC	Controller Pilot Data Link Communications
CRO	Central Reporting Office
DLIC	Data Link Initiation Capability
ET	Expiration Timer
HMI	Human machine interface
LACK	Logical Acknowledgement
RCP	Required communication performance
RCTP	Required Communications Technical Performance
TPDU	Transport Protocol Data Unit
TRN	Transaction
VDR	VHF Digital Radio

1. INTRODUCTION

1.1 Purpose

The purpose of this document is to propose a set of parameters for monitoring the performance of the CPDLC system in Europe as required by EC regulation 29/2009 and to propose how those parameters could be measured as well as a set of target values for the performance parameters. It is intended to form the basis for an agreement between each ANSP and their national supervisory authority as to how to monitor the performance of the system. It is hoped that by starting from a common proposal a high degree of commonality between the different NSAs can be achieved.

The Link CRO will require additional data in order to investigate the causes of any performance or functional problems that may occur in the system. The scope of this additional data is the subject of a separate paper [4].

1.2 Structure

The document is structured as follows:

- Section 1: Introduction.
- Section 2: Proposes a set of parameters for monitoring performance.
- Section 3: Contains a detailed explanation of each parameter and how it would be measured.
- Section 4: Proposes a set of target values for the parameters.
- Section 5: Contains references.
- Appendix A: Describes some practical limitations affecting which requirements from ED120 can be measured.

1.3 Monitoring Objectives

Article 5, paragraph 6 of EC regulation 29/2009 requires the ANPSs to "…monitor the quality of service of communication services and verify their conformance with the level of performance required for the operational environment under their responsibility". The regulation refers to ED120 [1] as the source of the performance requirements.

ED-78a [2] defines the guidelines for the provision and use of services supported by data link and has guided the development of the data link services covered by regulation 29/2009. It defines the purpose of in-service monitoring as being to provide "…creditable operational data to determine that requirements for the CNS/ATM system….continue to be met[1]" and further clarifies that the measurement should be transaction based and not separately measure the performance of individual elements of the system. So it is clear that the purpose of monitoring the system performance is not specifically to measure every requirement from ED120 but rather to assure that the system is operating smoothly and achieving its overall performance requirements.

2. PERFORMANCE MONITORING PARAMETERS

This section proposes a set of parameters to monitor and a supporting rationale.

Regulation 29/2009 only applies to traffic operating above FL285 but in practice CPDLC will also be used in airspace below FL285. Only monitoring flights operating above FL285 would make the calculation of the statistics very difficult and it makes more operational sense to monitor the CPDLC service across the airspace in which it is provided, so it is proposed not to limit the monitoring to flights operating above FL285.

[1] See para 2.5 of Ed78a.

Regulation 29/2009 refers to ED120 as the source for performance requirements and as such it forms the foundation for monitoring the performance of the services required by the regulation.

2.1 How requirements are stated in ED120

The requirements in ED120 are stated in terms of the overall required communication performance (RCP) which is the total time from the initiation to the completion of a transaction. It is made up of a transaction time (TRN) plus the time taken to compose the CPDLC message and display the information to the flight crew or controller (the “Initiator” time). The transaction time (TRN) is divided into two elements: a Required Communications Technical Performance (RCTP) which is the time taken by the technical systems to exchange the data between the air/ground/air and the ‘Responder’ time which is the time taken by the human to react to the message received.

The diagram below illustrates the ED120 terminology using an exchange initiated by the flight crew, but the terms also apply to transactions initiated by the controller.

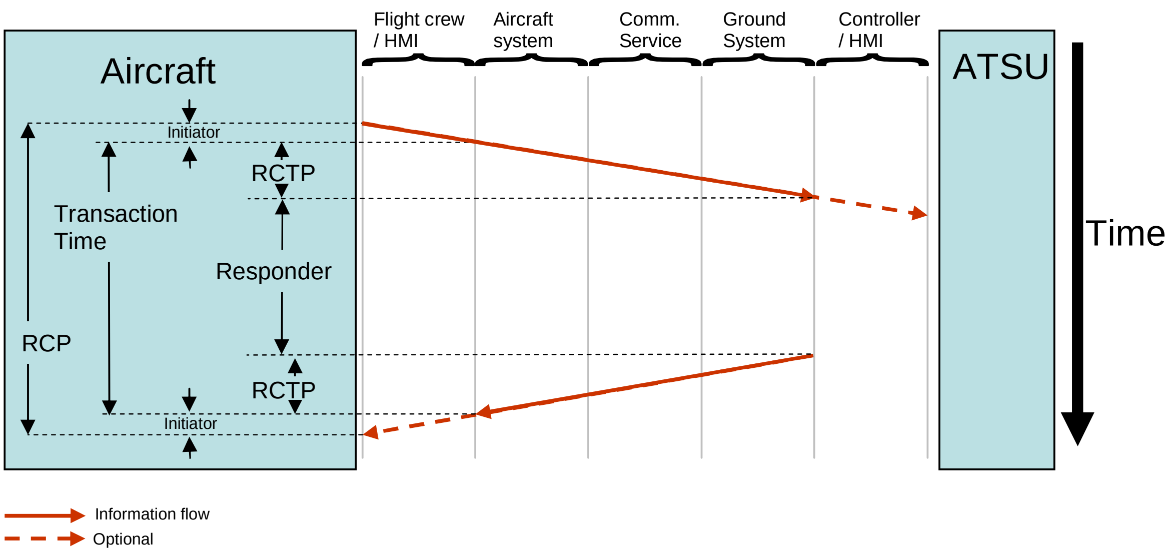

Figure 1: ED120 Breakdown of Transaction Time

Requirements are expressed in ED120 as an expiration time (ET), a transaction time for 95% of all transactions (TT_{95}), a continuity probability (C) , a probability of the availability of the service as a whole ($A_{PROVISION}$), a probability of availability of the service for a particular aircraft (A_{USE}), and an integrity level(I).

The table below shows the descriptions of the various parameters as given in ED-78a.

Parameters	Value	Description
Transaction Expiration Time (ET_{RCP})	Time	Maximum time for completion of a transaction after which peer parties should revert to an alternative procedure. The rate at which a transaction expiration time can be exceeded is determined by the continuity parameter
95% Transaction Time (TT_{95})	Time 95%	Time before which 95% of the transactions are completed. This is the time at which controllers and pilots can

		nominally accept the system performance and represents normal operating performance.
Continuity (C_{RCP})	Probability	That the transaction will be completed before the transaction expiration time, assuming that the communication system is available when the transaction is initiated
Availability (A_{RCP}[2])	Probability	That the communication system between the two parties is in service when it is needed
Availability ($A_{Provision}$)	Probability	That communication with all aircraft in the area is in service.
Integrity (I_{RCP})	Acceptable Rate	Of transactions completed with undetected error.

Figure 2 : ED78a Definitions of performance parameters

It should also be noted that ED120 states[3] that "…communication transactions that have multiple responses i.e. the STANDBY, followed by the operational response, are treated as two transactions…"

2.2 Scope of interest from ED120

There are many requirements in ED120 which are not of interest for the purposes of performance monitoring of the data link services. The regulation 29/2009 only applies to en-route and only to a subset of the services specified in ED120.

The Expiration Timer (ET) is a system parameter after which the transaction is considered to have timed out. It is used in the definition of Continuity (C) such that continuity represents the probability that transactions complete within ET.

The RCP values are often not specified in ED120. In practice it is the transaction (TRN) values that are of interest for monitoring the system performance. The difference between the RCP value and the TRN values is the initiator portion and is governed by the design of the system HMI in the aircraft and the ATSU.

So the performance requirements from ED120 that are of interest are the TRN allocation values for the transaction time, continuity, availability and integrity requirements that apply in the en-route environment for the DLIC, ACM, ACL, and AMC services.

The relevant requirements for the individual services are reproduced in Figure 3 below.

[2] This corresponds to the A_{USE} defined in ED120.
[3] Para 1.4.3.2.2

Parameter	Expiration Timer (ET)	Transaction Time (95%)	Continuity	Availability (Use)	Availability (Provision)	Integrity
DLIC initiation	60	30	0.99	0.993	0.999	10^{-5}
DLIC Contact	120	60	0.99	0.993	0.999	10^{-5}
ACM	120	60	0.99	0.993	0.999	10^{-5}
ACL Flight Crew Initiated	270	60	0.99	0.993	0.999	10^{-5}
ACL Controller Initiated	120	60	0.99	0.993	0.999	10^{-5}
AMC					0.999	10^{-3}

Figure 3 : Key performance requirements from ED120

These are the end-to-end performance requirements for transactions that in principle should be monitored. However Integrity is defined as the acceptable rate of transactions having undetectable errors and so by definition (since the errors are undetectable) cannot be regularly monitored in service. Integrity requirements have to be satisfied at the design stage.

ED-120 expresses Continuity as a probability per flight hour that the transaction completes successfully. However, the concept of probability per flight hour is not considered meaningful so a more straightforward probability per transaction is preferred in [3]. In order to transform the requirement from a value per flight hour to a value per transaction it has been assumed that there will be ten transactions per hour, so the continuity requirement is made more stringent by a factor of ten i.e. the Continuity per transaction should be 99.9%. This value is consistent with the draft material prepared by SC214/WG-78.

The end-to-end performance requirements in Figure 3 are further broken down in ED120 to differentiate between the time taken by the system (“RCTP”) and the time taken by the pilot/controller to respond (“Responder”). The RCTP component is further broken down in ED120 to allocate time to the avionics and the ground system (including ACSP).

Whether all these requirements need to be monitored and how far the end-to-end requirements should be broken down for monitoring is a matter of judgment and is discussed in the following section.

2.3 Appropriate level of monitoring performance from ED120

This section discusses to what level of granularity the performance requirements from ED120 should be monitored.

It is clear that the end-to-end performance requirements should be monitored, but whether each requirement needs to be measured for each service and how far those overall figures should be broken down is open to question. There are several factors to consider:

- Whether to monitor the response time of the system separately from the pilot/controller response time.
- Whether to monitor the technical performance of the system separately.
- Whether to differentiate between the different services.
- How to measure availability.

As mentioned earlier it is not the objective of the ongoing performance monitoring to establish formal compliance with all the ED120 requirements; monitoring is not a form of acceptance testing. The objective is to monitor the performance of CPDLC at a suitable level to ensure that performance problems can be identified for more detailed investigation and also to monitor trends in performance so that action can be taken before the performance becomes unacceptable. So although the ED120 requirements are used as the basis for identifying a set of parameters to monitor and provides guidance for the expected performance, it is not necessary and indeed not practical in some cases[4], to measure performance using the precise definitions given in ED120.

2.3.1 System v Human

The overall transaction times (including both the human element and the system element) will be measured as this is a key performance measure and is the scope of the operational monitoring proposed by ED-78a.

In the event of the overall transaction times failing to meet the requirements a more detailed investigation of the causes will be required and this may include looking at different elements of the system or the human performance of the pilots and controllers, but it is not considered necessary to do this on a regular, systematic basis.

2.3.2 Monitoring the system

The requirements given in Figure 3 represent the end-to-end performance requirements including both the system and the human. As stated previously these requirements have been broken down and allocated between the human and the system, and the system allocation has been divided between the avionics, the ACSP and the ATSU.

ED-78a does not propose monitoring the performance of individual elements of the system as part of operational monitoring. So rather than attempting to separately monitor the performance of the different elements of the technical systems, it is proposed to include a single measure, the 'Technical round trip delay' to provide a good indicator of the performance of the technical system as a whole (the ATSU system, the ACSP and the avionics). It will measure the delay between the ground system sending a CPDLC message and receiving the corresponding logical acknowledgement from the aircraft. Monitoring the overall technical performance of the system will allow any adverse trends or events to be identified which may then require more detailed investigation to discover the cause.

2.3.3 Differentiating between Services

Although the requirements have been stated separately for each type of service, it could be argued that it is not necessary to monitor the performance separately for each service. If the actual implementation treats the different services the same then there is little to be gained by separately monitoring the performance of each service as it would not have any real significance.

The total set of data link services are provided by two different applications (CM and CPDLC) which are implemented differently so it is proposed to monitor the CM application service (DLIC) separately from the CPDLC application services (ACM, ACL and AMC).

In practice there will be very little difference between sending one type of CPDLC message and another; they all use the same systems, it is just the operational meaning of the messages that differs between the services used. So it is not proposed to monitor the performance of the different CPDLC services separately. However the CPDLC transactions initiated by the controller should be monitored separately from the CPDLC transactions initiated by the pilot as they have different expiration timers.

2.3.4 Measuring Availability

Gathering data to measure availability accurately is also problematic. The most obvious indication of availability(use) i.e. the loss of availability for an individual aircraft is a Provider Abort[5]. This occurs when there is a lack of Air Ground connectivity for 6 minutes after which the system is considered to be unavailable. However it is not simple to determine precisely at what time the system becomes available again. It is possible that the pilot or controller may choose not to re-establish CPDLC even though it would be technically possible and so the system should be considered as available.

[4] Appendix A identifies some of the practical limitations on strictly measuring ED120 requirements.

[5] It may be possible to identify other common errors that indicate a loss of availability. Measuring the provider aborts is considered to be a good starting point, but others may be added later.

It is proposed therefore to report the number of Provider Aborts rather than to calculate a formal probability of the availability(use).

For measuring the availability(provision) i.e. the availability of the service in the area as a whole it is proposed to report a simple metric based on unplanned outages of the service which affect more than one aircraft.

2.4 Proposed set of parameters for performance monitoring

It is proposed to regularly monitor the parameters listed below. A report for each parameter should be created per ANSP.

- **Technical Round Trip Delay**. The distribution of the delay between when a uplink CPDLC message is sent and the corresponding LACK message is received. This will give a good indication of the overall performance of the technical system (i.e. the ACSP, avionics and the ground end-system).
- **DLIC Initiation Logon Counts.** The number of unsuccessful logon attempts, the number of successful logon attempts followed by the establishment of a CPDLC connection, and the number of successful logon attempts that are not followed by the establishment of a CPDLC connection.
- **DLIC Contact Transaction Delay.** The distribution of the delay between the ground system issuing a contact request and it receiving a contact response.
- **DLIC Contact Continuity.** The probability that a contact request results in the reception of a contact response before the expiration timer expires.
- **CPDLC Transaction Delay**. Two separate distributions of the delay for all CPDLC ACL and ACM transactions; one for air initiated transactions and the second for ground initiated transactions, plus a count of any error responses.
- **CPDLC Continuity**. The probability that CPDLC transactions are closed before the expiration timer expires. Calculated separately for air initiated and ground initiated transactions.
- **Availability (Use)**. The number of Provider Aborts experienced.
- **Availability (Provision)**. The probability that the CPDLC service is available within a planned service area for planned hours of CPDLC operation.

A more complete description of each parameter explaining more precisely what will be measured is given in 3.

3. DETAILED DESCRIPTION OF PROPOSED PARAMETERS

This section provides a more detailed description of each parameter. The relevant message flows are illustrated. In some diagrams LACKs (shown in blue) have been omitted for clarity. They are included where they are used as a measuring point.

For CPDLC the time provided in the header of the LACK message sent from the aircraft can be considered as giving a fairly accurate indication of when the associated uplink message has been processed and is available to the pilot. Similarly the timestamp in the header of the CPDLC request from the aircraft can be considered as giving a reasonable indication of when the pilot made the request.

3.1 Technical Round Trip Delay

The Technical Round Trip Delay (TRTD) is the time taken by the system to uplink a CPDLC message and receive its application level acknowledgement.

TRTD = LACK reception time – CPDLC Uplink message transmission time

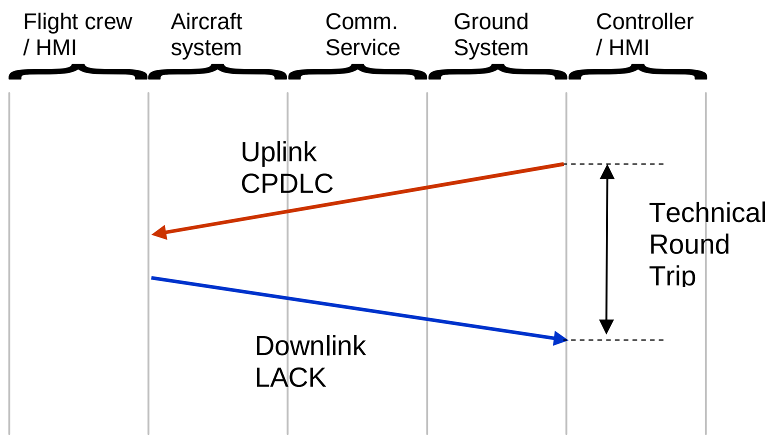

Figure 4: Technical Round-Trip Delay

Technical Round-Trip Delay can be readily measured by recordings made by the ANSP. Uplink CPDLC messages requesting a LACK may be logged with their time-stamp, and downlink LACK[6]s from the aircraft can be logged with time of receipt recorded by reference to the same time source. The uplink messages may be associated with their corresponding LACKs as a post-process through use of the CPDLC Message Reference Number, and the round trip delay calculated.

TRTD = First LACK response reception time – Uplink message transmission time.

The data would be analysed to produce a graph showing the distribution of delay and the 50%, 95% and 99% values would be stated, and the size of sample used to create the graph would be stated.

[6] Note the application acknowledgement may be an ERROR, if for example the latency timer has been exceeded. This means that the CPDLC transaction will fail, but the round trip delay is valid and should still be counted

3.2 DLIC Initiation Logon Counts

The ground system logs would be analysed and three separate counts maintained:

i) The number of unsuccessful logon attempts.i.e. the number of times the ground system has received a Logon request but has been unable to accept the logon request (e.g. due to not being able to match it with a corresponding flight plan).

ii) The number of Logon requests that have been accepted and for which at some point in the flight a CPDLC connection has been established.

iii) The number of Logon requests that have been accepted and for which at no point in the flight has a CPDLC connection been established.

3.3 DLIC Contact Transaction Delay

The DLIC Contact Transaction Delay (DCTD) is the time taken to complete the contact function.

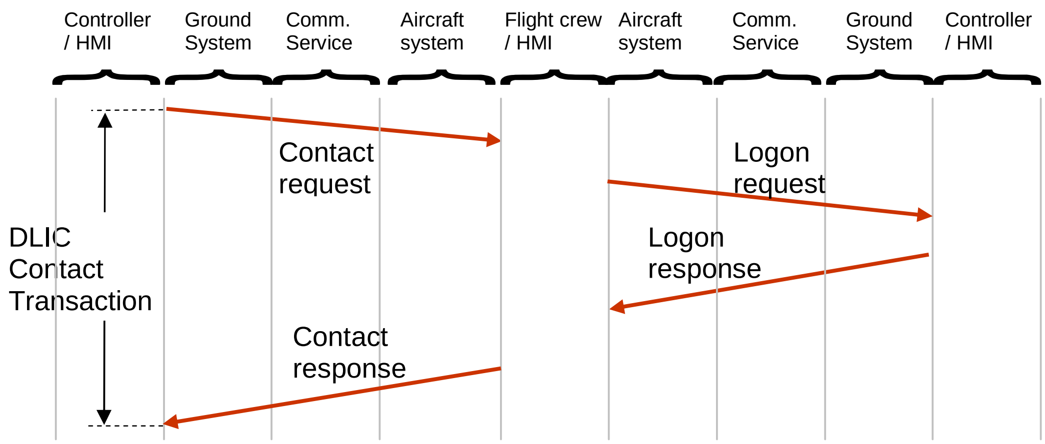

Figure 5 DLIC Contact Transaction Delay

The ANSP ground system would record the time at which the Contact Request was sent and the corresponding Contact Response was received.

DCTD = Contact response reception time – Contact request transmission time

The data would be analysed to produce a graph showing the distribution of delay and the 50%, 95% and 99% values would be stated, and the size of sample used to create the graph would be stated.

3.4 DLIC Contact Continuity

The DLIC Contact Continuity (DCC) is the probability that the DLIC contact transaction completes before the expiration timer expires (120s).

The ANSP ground system would record for the time at which the Contact Request was sent and would also record the time at which a corresponding contact response was received.

The recordings would be analysed and in the event that no corresponding contact response is received within 120 seconds of the contact request being sent a “contact expired event” would be counted.

DCC= 1 – (number of contact expired events / total number of contact requests transmitted)

3.5 CPDLC Transaction Delay

The CPDLC Transaction Delay (CTD) is the time taken between the message that initiates a transaction being sent and the corresponding message that closes the transaction being received.

Air initiated transactions and ground initiated transactions will be analysed separately since they have different performance requirements (ET is different).

Each different type of transaction will have to be considered separately to determine which message initiates the transaction and which closes it.

If the initial response is an ERROR message then the transaction should not be included in the statistic (since the transaction will not be closed) but the error should be counted. Also if the initial response is a LACK but an ERROR message is received subsequently for this transaction (because the pilot or the controller did not respond before the timer expired) then the transaction should also not be included in the statistic[7] but again the error should be counted.

The ground system would record all ground initiated requests and associated closing responses and all aircraft initiated requests and associated closing responses.

For transactions that are initiated by the ground the times can be derived directly from recordings in the ground system of when the initiating message was sent and the closing message received, as illustrated below.

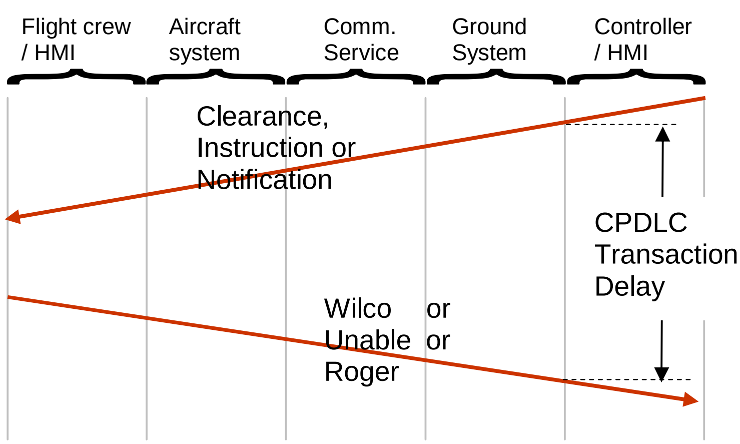

Figure 6 Ground Initiated CPDLC Transaction Delay

An operational exchange that involves a STANDBY message is considered as two separate transactions as illustrated below.

[7] These are cases where the pilot or controller has not responded for some reason. They are important events that should be counted and will impact the Continuity performance but if included in the CPDLC transaction delay would obscure the normal transaction delay which is what this parameter is trying to measure.

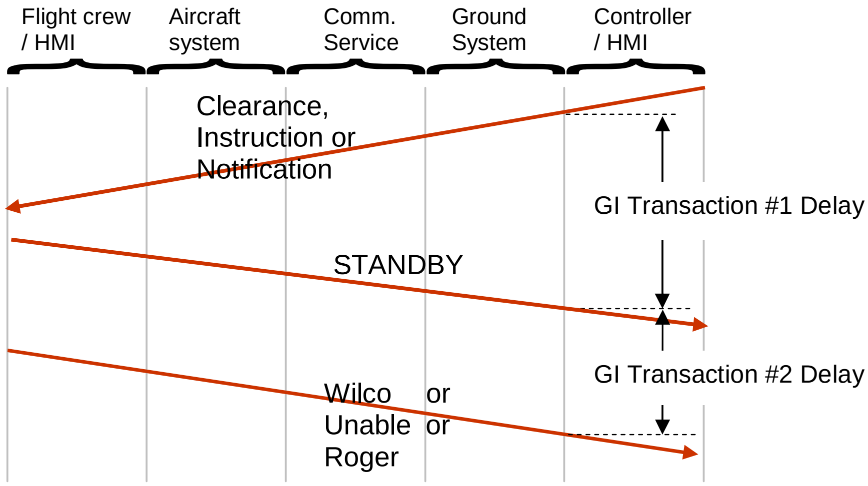

Figure 7 Ground Initiated CPDLC Transaction Delay involving a STANDBY

For transactions that are initiated by the aircraft the time given in the header of the downlink LACK message acknowledging the uplink closure response will be used to approximate the time at which the aircraft received an uplink message, as illustrated below.

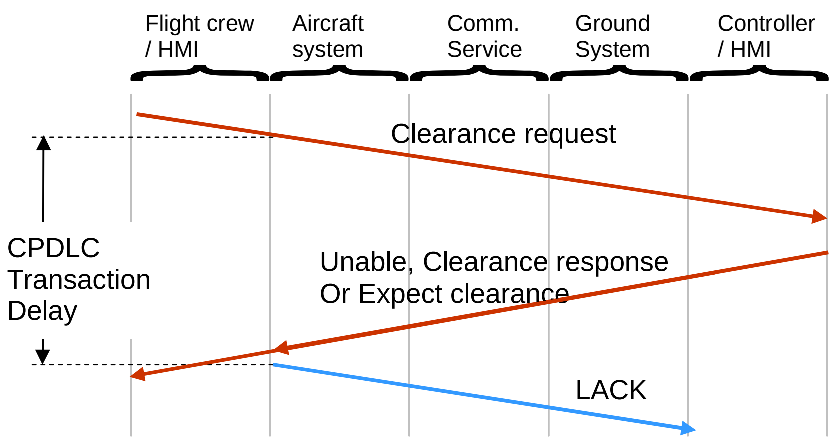

Figure 8 Air Initiated CPDLC Transaction Delay

As for ground initiated transactions an air initiated operational exchange that involves a STANDBY message is considered as two separate transactions as illustrated below.

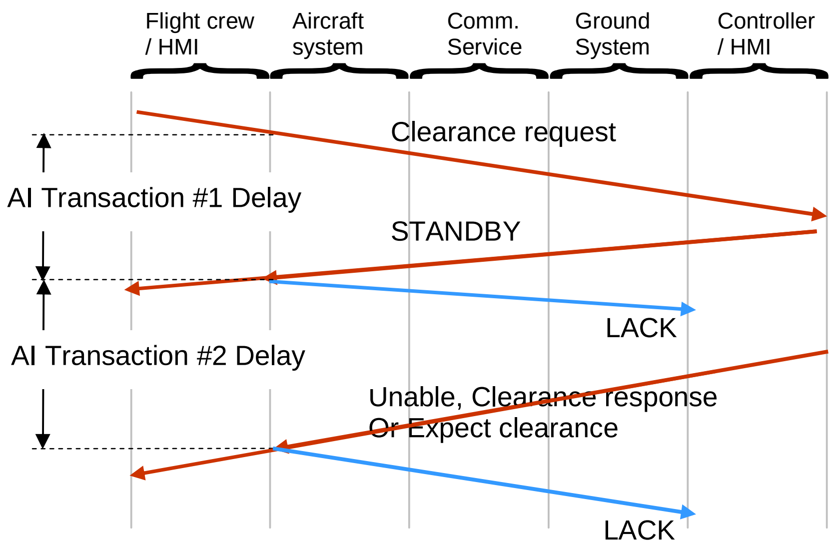

Figure 9 Air Initiated CPDLC Transaction Delay involving a STANDBY

For ground initiated clearances:

CTD_{GI} = Downlinked response message reception time – uplinked message transmission time

The data for each set of transactions (air initiated and ground initiated) would be analysed to produce a graph showing the distribution of delay and the 50%, 95% and 99% values would be stated, and the size of sample used to create the graph would be stated. Also a count of the different types of error would be produced.

For air initiated requests:

CTD_{AI} = Time in the header of the LACK message acknowledging the response - Time in the CPDLC header of the downlinked request message.

3.6 CPDLC Continuity

The CPDLC Continuity (CC) is the probability that the CPDLC transaction completes before the expiration timer expires. The requirements are different for controller initiated transactions (120 seconds) and flight crew initiated transactions (270 seconds) so a continuity probability is calculated separately for each:

- CC_{AI}: The CPDLC Continuity for Air Initiated Transactions
- CC_{GI}: The CPDLC Continuity for Ground Initiated Transactions

The ground system would record all ground initiated requests and associated closing responses and all aircraft initiated requests and associated closing responses as described in 3.5 above.

The recordings would be analysed and in the event that no closing response[8] is received before the expiration timer expires (120 or 270 seconds depending on the type of transaction) a "CPDLC expired

[8] An ERROR message indicating that the pilot or controller has not responded is not to be considered as a closing response for measuring continuity.

event" would be counted.

CC_{AI} = 1 – (number of air initiated CPDLC expired events / total number of air initiated CPDLC requests made)

CC_{GI} = 1 – (number of ground initiated CPDLC expired events / total number of ground initiated CPDLC requests made)

3.7 Availability (Use)

A PA rate would be calculated as the number of PAs experienced per 100 hours of Aircraft CPDLC usage i.e.

$$\left(\frac{NumberOfPAs}{TotalDurationOfCPDLCInHours}\right)x100$$

For example if 5 aircraft each had CPDLC sessions with a total duration of 50 hours and of those five aircraft two suffered a single PA each, then the PA rate would be:

$$\left(\frac{1+1}{50x5}\right)x100 = 0.8\ PAs\ per\ 100\ Hours\ CPDLC$$

The ground system would record all provider abort indications and CPDLC session start and end times which would then be used to calculate the PA rate as given above.

3.8 Availability (Provision)

Availability provision is defined in ED120 as the probability that communication with all aircraft in the area is in service. This is interpreted as meaning the probability that the CPDLC system is in service within a planned service area for planned hours of CPDLC operation i.e. it excludes planned outages of the service.

Availability(provision) = Actual hours of CDPLC Operations / Planned Hours of CPDLC Operations

where:
1) Actual hours of CDPLC Operations = Planned Hours of CPDLC Operations - Accumulated declared unplanned service outages.
2) Planned Hours of CPDLC Operations = 24x7 operations over a certain period – planned service outages
-3) Accumulated declared **unplanned** service outages = sum of all partial failures (affecting multiple aircraft) or total failure (affecting all aircraft) over a certain period.

The date, time and duration of any unplanned service outages affecting more than one aircraft should be reported, regardless of where the problem originated e.g. FDP, ACSP, VDL GS, router problem etc.

4. TARGET VALUES

Table 1 below proposes a set of target values for the parameters identified in section 3 above. These values are intended to support an agreement between each ANSP and their NSA about the expected performance levels.
The source of each target and some discussion is included in the notes below the table and following sections.

Note	Parameter	Target Value (max)
	Technical Round Trip Delay	
1	• 50^{th} Percentile	No performance target
2	• 95^{th} Percentile	16 seconds
3	• 99^{th} Percentile	20 seconds
	DLIC Initiation Logon Counts	
4	• Failed Logon Attempts	No performance target
5	• Logons followed by CPDLC	No performance target
6	• Logons not followed by CPDLC	No performance target
	DLIC Contact Transaction Delay	
7	• 50^{th} Percentile	No performance target
8	• 95^{th} Percentile	60 seconds
9	• 99.9^{th} Percentile	120 seconds
10	**DLIC Contact Continuity**	99.9%
	Ground Initiated CPDLC Transaction Delay	
11	• 50^{th} Percentile	No performance target
12	• 95^{th} Percentile	60 seconds
13	• 99.9^{th} Percentile	120 seconds
14	• Error Counts	No performance target
	Air Initiated CPDLC Transaction Delay	
15	• 50^{th} Percentile	No performance target
16	• 95^{th} Percentile	60 seconds
17	• 99.9^{th} Percentile	270 seconds
18	• Error Counts	No performance target
19	**CPDLC Continuity for Air Initiated Transactions**	99.9%
20	**CPDLC Continuity for Ground Initiated Transactions**	99.9%

	Availability (Use)	
21	• PA Rate	1 PA per 100 hours CPDLC
22	**Availability (Provision)**	99.9%

Table 1: Target values for performance parameters

NOTES:

1: There is no 50th percentile requirement defined in ED120 for the RCTP so it is unlikely to be defined in any performance specification with an ACSP. So it is not proposed to define an explicit target for this. Instead the trend of this parameter should be monitored and any significant increase in it should be investigated. In practice this value has varied between 3 and 4 seconds over 2013.

2: ED120 defines the 95th percentile value for RCTP for the ACL service as 16 seconds. DLIC initiation and contact have less stringent RCTP 95th percentile requirements (24 seconds and 48 seconds).

3: ED120 defines the 99th percentile value for RCTP for the ACL service as 20 seconds. Again DLIC has less stringent requirements.

4, 5, 6: ED120 does not define requirements relating to logon counts. These parameters are included to highlight how widely CPDLC is being used and also any problems with the verification of the aircraft details during logon.

7: ED120 does not define requirements for the 50th percentile delay so it is not proposed to define an explicit target for this. As for the TRTD the trend should be monitored for any significant increase.

8: ED120 specifies this requirement.

9, 10: ED120 specifies a value of 120 seconds as the expiration timer for continuity purposes. ED120 specifies continuity at the 99% level per flight hour however as discussed in section 2.2 above[9] a figure 99.9% per transaction is preferred. For further discussion see section 4.1 below.

11: No performance requirement is defined in ED120. So it is not proposed to define an explicit target for this. Instead the trend of this parameter should be monitored and any significant increase in it should be investigated.

12: ED120 specifies this requirement..

13: ED120 specifies a value of 120 seconds as the expiration timer for continuity purposes. ED120 specifies continuity at the 99% level per flight hour however as discussed in section 2.2 above a figure 99.9% per transaction is preferred. For further discussion see section 4.1 below.

14,15: No performance requirement is defined in ED120. So it is not proposed to define an explicit target for this. Instead the trend of this parameter should be monitored and any significant increase in it should be investigated.

16: ED120 specifies this requirement.

17: ED120 specifies a value of 270 seconds as the expiration timer for continuity purposes. ED120 specifies continuity at the 99% level per flight hour however as discussed in section 2.2 above a figure 99.9% per transaction is preferred. For further discussion see section 4.1 below.

18: No performance requirement is defined in ED120. So it is not proposed to define an explicit target for this. Instead the trend of this parameter should be monitored and any significant increase in it should be investigated.

[9] Note: 10 transactions per hour were assumed in [3]. In 2013 the actual rate was around 6 ground initiated transaction and 0.2 air initiated transaction per hour, but the usage of CPDLC would be expected to grow as confidence in the service increases.

19,20: ED120 specifies these requirements. The precise definition is discussed below in section 4.1 below.
21: This is discussed in section 4.2 below.
22: ED120 specifies this requirement.

4.1 Measuring Continuity

Continuity is defined in ED78a as the probability "...That the transaction will be completed before the transaction expiration time, assuming that the communication system is available when the transaction is initiated..." and in the definition given in section 3.6 above it is stated that '…An ERROR message indicating that the pilot or controller has not responded is not to be considered as a closing response for measuring continuity errors…'

In the case of air initiated transactions ground systems are required to uplink an error message with UM183 'ATC TIMEOUT - REPEAT REQUEST' after 250 seconds i.e. before the expiration timer expires.

According to the definitions given above these transactions should be considered to have been delayed beyond the expiration timer and so contribute negatively towards the AI continuity figure.

Similarly for ground initiated transactions aircraft will time-out an uplinked message after 100 seconds (i.e. before the 120 seconds when the expiration timer will expire) and downlink 'DM98 AIR SYSTEM TIMEOUT' if no response is created by the flight crew.

Whether or not these transactions are considered to have expired makes a significant difference to the continuity value. For example if the AI continuity is calculated on the basis that the 'ATC TIMEOUT' is not considered a closing response to the transaction, then the AI continuity measured from Jan 1st 2014 to April 2014 would be around 83% whereas if the ATC TIMEOUT is considered as a closing response then the figure would be 99.74%. The 83% figure represents the percentage of transaction for which the flight crew does not receive an operational response within the required delay. The same consideration applies to the ground continuity value although in practice the impact is much less; the ground continuity value over the same period would be around 97.5%.

It is proposed to keep the definitions as they are i.e. to use the calculation that would lead to the 83% figure for air initiated continuity. It is to be noted however that the targets derived from the requirements are very challenging and probably not very realistic considering the delay includes the human element. To achieve the 99.9% continuity value the controller (or pilot) would only be 'allowed' to respond late to 1 transaction out of every 1000 transactions. This is very difficult to achieve in practice, and if the targets were applied too rigorously there is a risk that the controllers or pilots might choose to use CPDLC much less in order to be certain to achieve the defined target; there is no target defined for using CPDLC so in the extreme case the continuity value could be achieved by not using CPDLC at all – no transaction would be too late because there would be no transactions at all. So NSAs are advised to use this target as a measure of performance to be monitored but it should be considered in a wider context and not applied too strictly.

4.2 What is an acceptable PA Rate?

As discussed in section 2.3.4 above measuring availability is not straightforward. Measuring the provider abort rate provides a practical way to monitor the availability of the service to individual aircraft and is therefore proposed as the parameter used to monitor 'Availability (use)'. However the target PA rate cannot be directly derived from the ED120 availability requirement of 99.3%. So how should the target PA rate be set?

The data link community has become used to describing the PA rate in terms of the percentage of CPDLC sessions that suffer a PA. But since the length of a session has a direct effect on how likely the session is to suffer a PA (the longer a session lasts the more likely it is to suffer from a PA) and since the length of CPDLC session can vary considerably between different ATSUs it is proposed to define the metric in terms of the number of PAs suffered per 100 hours of CPDLC usage (see 3.7 above). So the question now becomes how many PAs per 100 hours CPDLC is acceptable?

A provider abort implies a loss of communications of 6 minutes. So if we consider that (with hindsight) the system was not available during those 6 minutes, then one PA in an hour would constitute a 10% loss of availability (i.e. for 6 minutes out of 60 minutes the system was not available) so each PA suffered per 100 hours would constitute a 0.1% loss of availability. On this basis a target PA rate of 7 PAs per 100 hours would 'match' the ED120 target figure of 99.3% availability. However not all unavailability of the system will result in a PA; the system may be unavailable for a shorter period of time without triggering a PA, so the figure of 7 PAs/100 hours is certainly too high.

If we consider the continuity target which states that 99.9% of transactions must complete before the expiration timer and we assume 10 transactions per hour[10], then a single PA in an hour would result in the loss of one transaction (i.e. given 10 transactions in 60 minutes then in the six minute period of the PA we would expect one transaction to fail). So each PA per hour would imply a 10% reduction in continuity, hence in order to achieve the desired continuity of 99.9% a PA rate of 1 PA/100 hours is required.

The lower PA rate of 1 PA/100 hours CPDLC is proposed as the target, although it is recognised that the system is far from achieving this target. The measured PA rate per 100 hours over 2013 as a whole was 36 PAs/100 hours, and since the white list was introduced at MUAC and Skyguide the PA rate has been reduced to 10 PAs/100 hours.

5. REFERENCES

[1]: ED120. Safety and performance requirements standards for air traffic data link services in continental airspace (continental SPR standard). May 2004.

[2]: ED-78a. Guidelines for approval of the provision and use of air traffic services supported by data communications. December 2000

[3]: White paper on VDL Performance Monitoring. Version 1.0, Dated: 15-October-2009

[4]: DLS Central Reporting Office. Provision of ANSP data to the CRO. Edition 0.4, Dated 19th Sept 2012

References [3] and [4] are available from the CRO wiki: http://www.eurocontrol.int/link2000/wiki/index.php/Library

[10] As ED120 does when assessing risk.

Appendix A Some practical limitations

It is not the objective of the performance monitoring to measure all requirements given in ED120 and indeed with the current system design it would not be possible without special equipment. This appendix describes some of the practical limitations to measuring some ED120 requirements in the operational system.

Differentiating between the time taken by the avionics, ACSP and the ATSU would help identify the source of any system performance problems but it poses some problems. Firstly there is no current means of measuring the time taken by the avionics to process an incoming or outgoing message (without special instrumented versions of the avionics). So regularly monitoring the performance of the avionics is not possible. However it is possible to investigate the performance of specific aircraft/avionic configurations using specialist recording equipment and this must continue to be the case after deployment when necessary.

Similarly establishing the time taken by the ATSU systems would mean recording and timestamping each message as it was received from the ACSP and as it was displayed to the controller. Typically ground systems will not record the time at which the information was actually displayed to the controller and there is no requirement to do so. Similarly systems may not record the data at the precise point of reception from the ACSP. So regularly monitoring the performance against a strict definition of sub system boundaries is not practical. However it must be possible to investigate the performance of the ground systems in detail when required using specialist recording equipment if necessary, in much the same way as for the avionics. The general performance of the system will be monitored using other parameters, but if a performance problem is identified it must be possible to investigate whether this problem occurs within the ground system and if so where.

Measuring the ACSP performance precisely would require recording information as it was received in the aircraft and this is not done except for specific flight trials when specialist equipment is installed.

In practice it will not be possible to regularly receive recorded data from the aircraft, as the systems are not designed to do this. Special recording equipment can be installed in the aircraft when required for debugging purposes, but it is not practical to do this permanently and so it will not be practical to regularly receive data recorded in the aircraft for the purposes of monitoring performance. This means that only recordings made on the ground will be available for analysis and this places some restrictions on which ED120 parameters can be monitored regularly.

From ground based recordings:

- It is not possible to detect when an aircraft fails to receive a response to the logon request before the timer expires. This is because it is not possible to detect in the ground system recordings when the aircraft system initiated a logon request. It is possible the aircraft initiated a logon request which was never received on the ground, so no record of it exists. This means it is not possible to calculate the integrity of the DLIC Initiation function.
- Since there is no application level timestamp in the CM application messages it is not possible to determine from ground recordings at what time the aircraft systems generated a logon request message. This means
    - It is not possible to accurately measure the DLIC Initiation Transaction delay.[11]
    - For the contact function of the DLIC service it is not possible to differentiate between the responder time (i.e. reaction time of the airborne system) and the RCTP. This is because although the time at which the contact request was sent is known and the time at which the corresponding logon request at the next ACC was received is

[11] It would be possible to measure the time difference between when the logon request was received by the ground system and the time at which the logon response was sent by the ground system. This measure combined with the technical round trip delay would give a reasonable indication of the typical DLIC transaction delay.

known, it is not known how much of that delay is attributable to the communication system and how much is attributable to the application.

- It is not possible to monitor the performance of the AMC service since no LACK message is returned so it is not possible to detect from the ground logs at what time an AMC message was received or even if it was received successfully. Problems with the AMC service will be reported via normal problem reporting procedures, but there can be no systematic monitoring of its performance.