Interface requirements between the Aircraft and the ATC systems

Document information	
Project Title	Airborne Initial 4D Trajectory Management
Project Number	09.01._
Project Manager	Airbus
Deliverable Name	Interface requirements between the Aircraft and the ATC systems
Deliverable ID	D58
Edition	01.00.01
Template Version	03.00.00
Task contributors	
Airbus.	

Abstract

This document is an update of the 9.1 D07 interface document [6]. It specifies the set of datalink messages (ADS-C and CPDLC) that are implemented by the Mainline Initial 4D prototype according to the needs expressed in 5.6.1 INTEROP specification [7], that defines the interoperability requirements to be met by the airborne and ground systems to support I4D operations.

Although Project 9.1 studies the Initial 4D function on both Mainline and Regional segments, as the Regional segment's activity was already closed, the document only addresses the Mainline segment (for the regional segment, D07 remains applicable).

Moreover, the document analyses the main differences between the implemented messages set, based on SC214/WG78 INTEROP issue H [1] [2], and the 1st official release [5], and assesses their impacts on the prototype. A similar analysis is done between SPR issue H [3], applied by the prototype, and the 1st official release [4].

Authoring & Approval

Prepared By - *Authors of the document.*		
Name & Company	Position & Title	Date
[redacted] (Airbus)	[redacted]	08/07/2016

Reviewed By - *Reviewers internal to the project.*		
Name & Company	Position & Title	Date
[redacted] (Airbus)	[redacted]	08/07/2016
[redacted] (Honeywell)		08/07/2016
[redacted] (Thales)		08/07/2016
[redacted] (Eurocontrol)		08/07/2016
[redacted] (Alenia)		08/07/2016

Reviewed By - *Other SESAR projects, Airspace Users, staff association, military, Industrial Support, other organisations.*		
Name & Company	Position & Title	Date
[redacted] (SICTA)	[redacted]	08/07/2016
[redacted] (Combitech)		08/07/2016
[redacted] (Eurocontrol)		08/07/2016
[redacted] (Thales)		08/07/2016
[redacted] (DGAC)		08/07/2016
[redacted] (NATS)		08/07/2016
[redacted] (Airbus)		08/07/2016
[redacted] (ENAIRE)		08/07/2016
[redacted] (NATS)		08/07/2016
[redacted] (DGAC)		08/07/2016
[redacted] (SICTA)		08/07/2016

Approved for submission to the SJU By - *Representatives of the company involved in the project.*		
Name & Company	Position & Title	Date
[redacted] (Airbus)	[redacted]	11/07/2016
[redacted] (Honeywell)		12/07/2016
[redacted] (Thales)		12/07/2016
[redacted] (Eurocontrol)		12/07/2016

Rejected By - *Representatives of the company involved in the project.*		
Name & Company	Position & Title	Date

Rational for rejection
None.

Document History

Edition	Date	Status	Author	Justification
01.00.00	13/07/2016			1st issue
01.00.01	16/09/2016			New issue to take into account SJU comments.

Intellectual Property Rights (foreground)

This deliverable consists of SJU foreground.

Table of Contents

List of tables

Executive summary

This document is an update of the 9.1 D07 interface document [6]. It specifies the set of datalink messages (ADS-C and CPDLC) that are implemented by the Mainline Initial 4D prototype according to the needs expressed in 5.6.1 INTEROP specification [7], that defines the interoperability requirements to be met by the airborne and ground systems to support I4D operations (5.6.1 project is in charge of defining CTA operations that rely, among others, on the Initial 4D function).

Although Project 9.1 studies the Initial 4D function on both Mainline and Regional segments, as the Regional segment's activity was already closed, the document only addresses the Mainline segment (for the regional segment, D07 remains applicable).

Moreover, the document analyzes the main differences between the implemented messages set, based on SC214/WG78 INTEROP issue H [1] [2], and the 1st official release [5], and assesses their impacts on the prototype. A similar analysis is done between SPR issue H [3], applied by the prototype, and the 1st official release [4].

1 Introduction

1.1 Purpose of the document

This document is an update of the 09.01 D07 interface document [6].

The IRS is an update of a previous one (D07) that was written using an old template. It was agreed with SJU during the deliverable launch it is acceptable to not strictly follow the layout of the last applicable IRS template. That is why some paragraphs are let empty and none of the requirements of this interface is presented in a formalized way.

1.2 Intended readership

This document is planned to be distributed to relevant operational and ATC System projects. It should be the basis for the further I4D operations coupling activities between ANSP, flight tests aircraft, and Mainline segment integration simulators (e.g. during SESAR 2020 activities).

It can also be used by the members of projects linked to 9.1:

- 4.3 Integrated and pre-operational validation & cross validation
- 5.6.1 Ground & Airborne Capabilities to Implement Sequence
- 10.2.1 ATC trajectory management design
- 10.7.1 Enhanced datalink features for all phase of flight
- 4.2 Operational concept definition and validation (for en-route environment)
- 5.2 Operational concept definition and validation (for TMA environment)
- 9.49 Global interoperability – airborne architecture and avionics interoperability roadmap
- 10.1.7 ATC system specification *****
- 5.3 Integrated and pre-operational validation & cross validation
- 4.5 Trajectory management framework in en-route
- 4.7.2 Separation task in en route trajectory based environment
- 5.5.1 Trajectory management framework in TMA
- 10.9.4 CDA and CCD in high density traffic *****

***** These projects should have been interested by this document. However, they are closed at the time this document is being written.

1.3 Inputs from other projects

This IRS cascades at I4D Mainline prototype level the 5.6.1 D85 Fully validated INTEROP [7], that defines the interoperability requirements to be met by the airborne and ground systems to support I4D operations.

1.4 Document Overview

Refer to the executive summary

1.5 Requirements Definitions – General Guidance

N/A

1.6 Functional block Identification

N/A

1.7 Glossary of terms

Term	Definition
CTA	Controlled Time of Arrival – An ATM imposed time constraint on a defined merging point associated to an arrival runway [SESAR lexicon]. CTA may be the original ETA of the aircraft converted to a CTA, or it may be the aircraft's original ETA with a time-adjustment, used, in either case, to 'control' the required time/position for the aircraft in the arrival sequence. ***Note:*** *This term is sometimes used interchangeably with CTO.*
CTO	Controlled Time Over – An ATM imposed time constraint over a point [SESAR Lexicon] CTO is an ATM constraint for an aircraft to pass a designated point at a designated time. It may be the original ETO of the aircraft converted to a CTO or it may be the aircraft's original ETO with a time-adjustment, used, in either case, to 'control' the required time for the aircraft to pass a designated point. ***Note:*** *This term is sometimes used interchangeably with CTA.*
EPP data	Extended Projected Profile data - Specifies the aircraft predicted trajectory up to 128 waypoints including for each waypoint, Latitude, Longitude and when available, Fix, Level, ETA, Airspeed, Vertical type(s), Lateral type(s), Level constraint, Time constraint, Speed constraint. When available, provides the relevant data for the trajectory as Current gross mass and EPP trajectory intent status. It indicates the data and time these values were computed [SESAR lexicon].
ETA	Estimated Time of Arrival - The time computed by the FMS for the flight arriving at a point related to the destination airport [SESAR lexicon].
ETO	Estimated Time Over - The time computed by the FMS for the flight to pass a point on its intended trajectory [P5.6.1 use].
RTA	Required Time of Arrival – the aircraft FMS RTA function / The aircraft function to follow a CTA (Controlled Time of Arrival) [SESAR lexicon].

1.8 Acronyms and Terminology

Term	Definition

Term	Definition
ANSP	Air Navigation Service Provider
4D	Four Dimensional
4DTRAD	4D Trajectory Data Link
ACL	ATC Clearance (service)
ADS-C	Automatic Dependent Surveillance - Contract
AOC	Airline Operation Center
ATC	Air Traffic Control
ATM	Air Traffic Management
ATS	Air Traffic Service
ATSU	Air Traffic Service Unit Depending of the context: either the Mainline prototype, or an ATC center
CM	Context Management
COP	Coordination Point
CPDLC	Controller Pilot Data Link Communication
CTA	Controlled Time of Arrival
CTO	Controlled Time Over
DM	Downlink Message
EPP	Extended Projected Profile
ETA	Estimated Time of Arrival
FL	Flight Level
FMS	Flight Management System
FOM	Figure Of Merit
FPL	Flight Plan (as filled and received by the ground system)
HMI	Human Machine Interface
I4D	Initial 4D
INTEROP	Interoperability Requirement Standard

Term	Definition
IRS	Interface Requirements Specification
PDR	Proposed Defect Report
RTA	Required Time of Arrival
SESAR	Single European Sky ATM Research Programme
SESAR Programme	The programme which defines the Research and Development activities and Projects for the SJU.
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SJU Work Programme	The programme which addresses all activities of the SESAR Joint Undertaking Agency.
SPR	Operational, Safety and Performance Requirements
TOC	Top of Climb
TOD	Top of Descent
UM	Uplink Message
VHF	Very High Frequency
WILCO	Will Comply

2 Functional block(s) and Interface(s) Overview

N/A

3 Detailed Interface Requirements

3.1 Exchanged messages

3.1.1 Mainline segment

The CPDLC and ADS-C messages sets used for the purpose of the I4D operations derive from the SC214/WG78 INTEROP issue H [1] [2], but with some specificities that are explained in §3.2.

The following table contains, for the Mainline prototype, the CPDLC and ADS-C messages. The applicability of each message was determined using a V&V iterative process involving all the actors of the I4D function (i.e. ground actors, airborne actors, operational actors, etc). In addition, the specificities of the prototype were also taken into account.

The operational concept and needs were provided thanks to close coordination with SC214/WG78 working group and upstream feedback from en-route ATC operational stakeholders.

ATS Interop CPDLC messages (based on ATS Interop Part 1 Version H, dated 03-02-2010)		**WP9.1 Mainline aircraft status**	
		Mainline aircraft status	**Mainline notes**
CPDLC uplinks			
Responses/Acknowledgements (uplink)			
UM2	REQUEST DEFERRED	Available but not used in 9.1	Not part of I4D
Vertical clearances (uplink)			
UM245 (new UM7)	EXPECT CLIMB AT [timesec]	Not supported	Not part of I4D
UM246 (new UM9)	EXPECT DESCEND AT [timesec]	Not supported	Not part of I4D
UM247 (new UM11)	EXPECT CRUISE CLIMB AT [timesec]	Not supported	Not part of I4D
UM248 (new UM21)	AT [timesec] CLIMB TO [level]	Available but not used in 9.1	Not part of I4D
UM249 (new UM24)	AT [timesec] DESCEND TO [level]	Available but not used in 9.1	Not part of I4D
UM250	CLIMB TO REACH [level] BY	Not supported	Not part of I4D

(new UM26)	[timesec]		
UM251 (new UM28)	DESCEND TO REACH [level] BY [timesec]	Not supported	Not part of I4D
UM281 (new UM192)	REACH [level] BY [timesec]	Not supported	Not part of I4D
Crossing constraints (uplink)			
UM252 (NEW UM51)	CROSS [position] AT [RTAtimesec]	Are supported	
UM253 (NEW UM52)	CROSS [position] AT OR BEFORE [RTAtimesec]	Are supported	
UM254 (NEW UM53)	CROSS [position] AT OR AFTER [RTAtimesec]	Are supported	
UM255 (NEW UM54)	CROSS [position] BETWEEN [RTAtimesec] AND [RTAtimesec]	Are supported	No auto upload into FMS
UM256 (NEW UM58)	CROSS [position] AT [RTAtimesec] AT [level]	Are supported	
UM257 (NEW UM59)	CROSS [position] AT OR BEFORE [RTAtimesec] AT [level]	Are supported	
UM258 (NEW UM60)	CROSS [position] AT OR AFTER [RTAtimesec] AT [level]	Are supported	
UM259 (NEW UM62)	CROSS [position] AT [RTAtimesec] AT AND MAINTAIN [level]	Available but not used in 9.1	Not part of I4D
UM260 (NEW UM63)	CROSS [position] AT [RTAtimesec] AT AND MAINTAIN [level] AT [speed]	Available but not used in 9.1	Not part of I4D
Lateral offsets (uplink)			
UM261 (new UM66)	AT [timesec] OFFSET [specified distance] [directions] OFF ROUTE	Available but not used in 9.1	Not part of I4D
UM262 (new	REJOIN ROUTE BY[timesec]	Not supported	Not part of I4D

UM69)			
UM263 (new UM71)	EXPECT BACK ON ROUTE BY [timesec]	Not supported	Not part of I4D
Route modifications (uplink)			
UM73R (new UM73)	[departure clearance enhanced]	Available but not used in 9.1	Not part of I4D
UM265 (new UM76)	AT [timesec] PROCEED DIRECT TO [position]	Available but not used in 9.1	Not part of I4D
UM266 (NEW UM79)	CLEARED TO [position] VIA [routeClearanceEnhanced]	Are supported	
UM267 (NEW UM80)	CLEARED [routeClearance enhanced]	Are supported	
UM81	CLEARED [procedureName]	Are supported	No auto upload into FMS
UM268 (NEW UM83)	AT [position] CLEARED [routeClearance enhanced]	Are supported	
UM84	AT [position] CLEARED [procedureName]	Are supported	No auto upload into FMS
UM269 (NEW UM85)	EXPECT [routeClearance enhanced]	Available but not used in 9.1	"EXPECT"s are not part of these WP9.1 step 1&2 validations.
UM270 (NEW UM86)	AT [position] EXPECT [routeClearanceEnhanced]	Available but not used in 9.1	"EXPECT"s are not part of these WP9.1 Step 1&2 validations.
UM271 (new UM89)	AT [timesec] EXPECT DIRECT TO [position]	Not supported	Not part of I4D
UM272 (new UM93)	EXPECT FURTHER CLEARANCE AT [timesec]	Not supported	Not part of I4D
Speed changes (uplink)			
UM273 (new UM100)	AT [timesec] EXPECT [speed]	Not supported	Not part of I4D
UM274 (new	AT [timesec] EXPECT [speed] TO	Not supported	Not part of I4D

UM103)	[speed]		
UM106	MAINTAIN [speed]	Available but not used in 9.1	Not part of I4D
UM188	AFTER PASSING [position] MAINTAIN [speed]	Available but not used in 9.1	Not part of I4D
UM107	MAINTAIN PRESENT SPEED	Available but not used in 9.1	Not part of I4D
UM108	MAINTAIN [speed] OR GREATER	Available but not used in 9.1	Not part of I4D
UM109	MAINTAIN [speed] OR LESS	Available but not used in 9.1	Not part of I4D
UM110	MAINTAIN [speed] TO [speed]	Not supported	Not part of I4D
UM111	INCREASE SPEED TO [speed]	Available but not used in 9.1	Not part of I4D
UM116	RESUME NORMAL SPEED	Available but not used in 9.1	Not part of I4D
UM222	NO SPEED RESTRICTION	Available but not used in 9.1	Not part of I4D
UM308 (new ACL 20)	MAINTAIN MAXIMUM FORWARD SPEED	Not supported	Not part of I4D
UM309 (new ACL 21)	MAINTAIN SLOWEST PRACTICAL SPEED	Not supported	Not part of I4D
UM310 (new ACL 22)	AT [level] MAINTAIN SPEED	Not supported	Not part of I4D
Contact/monitor/surveillance requests (uplink)			
UM275 (new UM119)	AT [timesec] CONTACT [unitname] [frequency]	Available but not used in 9.1	Not part of I4D
UM276 (new UM122)	AT [timesec] MONITOR [unitname] [frequency]	Available but not used in 9.1	Not part of I4D
Report/confirmation requests (uplink)			
UM280 (new UM184)	AT [timesec] REPORT DISTANCE [toFrom] [position]	Not supported	Not part of I4D
Negotiation requests (uplink)			

UM277 (new UM150)	CAN YOU ACCEPT [level] AT [timesec]	Available but not used in 9.1	Not part of I4D
Air Traffic Advisories (uplink)			
UM278 (new UM153)	ALTIMETER [altimeter] [timesec]	Available but not used in 9.1	Not part of I4D
UM282 (new UM213)	[facilityDesignator] ALTIMETER [altimiter] [timesec]	Available but not used in 9.1	Not part of I4D
UM279 (new UM157)	CHECK STUCK MICROPHONE [frequencyValue]	Available but not used in 9.1	Not part of I4D
UM283 (new UM214)	RVR RUNWAY [runwayRVREnhanced]	Available but not used in 9.1	Not part of I4D
UM284 (new UM226)	EXPECTED APPROACH TIME [timesec]	Available but not used in 9.1	Not part of I4D
System management messages (uplink)			
UM285 (new UM-ACM1)	CURRENT ATC UNIT [UnitName]	Available but not used in 9.1	Not part of I4D
UM286 (new UM-ACM2)	CPDLC IN USE	Available but not used in 9.1	Not part of I4D
UM287 (new UM-ACM3)	CPDLC NOT IN USE	Available but not used in 9.1	Not part of I4D
UM288 (new UM-ACM4)	VERIFY MONITORED FREQUENCY [frequency]	Available but not used in 9.1	Not part of I4D
Additional ACL messages (uplink)			
UM289 (NEW UM-ACL1)	REST OF ROUTE UNCHANGED	Are supported	No auto upload into FMS
UM290 (New UM ACL2)	DESCEND VIA [procedure name]	Available but not used in 9.1	Not part of I4D
UM291 (New UM ACL3)	AT [timesec] DESCEND VIA [procedure name]	Available but not used in 9.1	Not part of I4D

UM292 (New UM ACL4)	AT [position] DESCEND VIA [procedure name]	Available but not used in 9.1	Not part of I4D
UM293 (New UM ACL5)	CLIMB VIA [procedure name]	Available but not used in 9.1	Not part of I4D
UM294 (New UM ACL6)	AT [timesec] CLIMB VIA [procedure name]	Available but not used in 9.1	Not part of I4D
UM295 (New UM ACL7)	AT [position] CLIMB VIA [procedure name]	Available but not used in 9.1	Not part of I4D
UM296 (New UM ACL8)	EXPECT HIGHER AT [timesec]	Not supported	Not part of I4D
UM297 (New UM ACL9)	EXPECT HIGHER AT [position]	Not supported	Not part of I4D
UM298 (New UM ACL10)	EXPECT LOWER AT [timesec]	Not supported	Not part of I4D
UM299 (New UM ACL11)	EXPECT LOWER AT [position]	Not supported	Not part of I4D
UM300 (New UM ACL12)	AT [timesec] EXPECT [level]	Not supported	Not part of I4D
UM301 (New UM ACL13)	AT [position] EXPECT [level]	Not supported	Not part of I4D
UM302 (New UM ACL14)	EXPECT [level] [timeduration] AFTER DEPARTURE	Available but not used in 9.1	Not part of I4D
UM303 (New UM ACL15)	CLEARED TO DEVIATE UP TO [degrees] DEGREES [direction] OF ROUTE	Available but not used in 9.1	Not part of I4D
UM304 (New UM ACL16)	CLEARED TO [position]	Available but not used in 9.1	Not part of I4D
UM305 (New UM ACL17)	HOLD [direction] AS PUBLISHED	Available but not used in 9.1	Not part of I4D
UM306	HOLD [direction] ON [inbound radial]	Available but not	Not part of I4D

(New UM ACL18)	RADIAL / [airway] [direction] TURNS [leg type] LEGS	used in 9.1	
UM307 (New UM-ACL19)	REPORT REQUIRED RVR	Not supported	Not part of I4D
Additional 4DTRAD messages (uplink)			
UM334 (UM-4D01 UMX3)	IN THE CLIMB [speedSchedule]	Available but not used in 9.1	Speed schedules are not considered to be part of WP9.1
UM335 (UM-4D02 UMX6)	IN THE DESCENT [speedSchedule]	Available but not used in 9.1	Speed schedules are not considered to be part of WP9.1
UM336 (UM-4D03 UMX2)	CANCEL [position] TIME CONSTRAINT	Are supported	No auto upload into FMS
UM337 (UM-4D04 UMX1)	CLEARANCE LIMIT [position]	Are supported	No auto upload into FMS
UM338 (UM-4D05 UMX7)	MAINTAIN TIME CONSTRAINT	Are supported	No auto upload into FMS
UM339 (UM-4D06 UMX5)	AT [position] CLEARED TO [position] VIA [routeClearanceEnhanced]	Are supported	No auto upload into FMS
UM0	UNABLE	Are supported	No auto upload in FMS
UM1	STANDBY	Are supported	No auto upload in FMS
UM168	DISREGARD	Are supported	No auto upload in FMS
UM227	LACK	Are supported	No auto upload in FMS
CPDLC downlinks			
Vertical requests (downlink)			
DM118 (new DM13)	AT [timesec] REQUEST CLIMB TO [level]	Not supported	Not part of I4D
DM119 (new DM14)	AT [timesec] REQUEST DESCENT TO [level]	Not supported	Not part of I4D
DM120 (new DM17)	AT [timesec] REQUEST OFFSET [specified distance] [direction] OF ROUTE	Not supported	Not part of I4D

Voice contact requests (downlink)			
DM136 (new DM-ACM1)	REQUEST FREQUENCY CHANGE	Available but not used in 9.1	Not part of I4D
Route modification requests (downlink)			
DM121 (new DM24)	REQUEST CLEARANCE [routeClearanceEnhanced]	Are supported	
DM122 (new DM26)	REQUEST WEATHER DEVIATION TO [position] VIA [route clearance enhanced]	Not supported	Not part of I4D
DM139 (new DM73)	[DepartureClearanceDataRouting]	Available but not used in 9.1	Not part of I4D
Reports (downlink)			
DM129 (new DM78)	AT [timesec] [distance] [to/from] [position]	Not supported	Not part of I4D
DM123 (new DM40)	ASSIGNED ROUTE [route clearance enhanced]	Not supported	Not part of I4D
DM123 (new DM40)	NEXT WAYPOINT ETA [timesec]	Not supported	Not part of I4D
DM124 (new DM46)	REPORTED WAYPOINT [timesec]	Not supported	Not part of I4D
DM126 (new DM48)	POSITION REPORT [position report enhanced]	Not supported	Not part of I4D
DM133 (new DM104)	ETA [position][timesec]	Available but not used in 9.1	Not part of I4D
DM134 (new DM109)	TOP OF DESCENT [timesec]	Available but not used in 9.1	Not part of I4D
DM135 (new DM111)	TOP OF DESCENT [timesec] [position]	Available but not used in 9.1	Not part of I4D
DM139 (new DM-DCL-1)	REQUEST DEPARTURE CLEARANCE [departure clearance request data]	Available but not used in 9.1	Not part of I4D

Emergency messages (downlink)			
DM127 (new DM57)	[remaining fuel enhanced] OF FUEL REMAINING AND [persons on board] PERSONS ON BOARD	Not supported	Not part of I4D
DM128 (new DM59)	DIVERTING TO [position] VIA [route clearance enhanced]	Not supported	Not part of I4D
Negotiation responses (downlink)			
DM130 (new DM81)	WE CAN ACCEPT [level] AT [timesec]	Available but not used in 9.1	Not part of I4D
DM131 (new DM83)	WE CAN ACCEPT [speed] AT [timesec]	Not supported	Not part of I4D
DM132 (new DM85)	WE CAN ACCEPT [specified distance] [direction] at [timesec]	Not supported	Not part of I4D
Additional 4DTRAD messages (downlink)			
DM156 (DM-4D01 DMX1)	PLANNED SPEED IN THE CLIMB [speedSchedule]	Available but not used in 9.1	Speed schedules are not considered to be part of WP9.1
DM157 (DM-4D02 DMX2)	PLANNED SPEED IN THE DESCENT [speedSchedule]	Available but not used in 9.1	Speed schedules are not considered to be part of WP9.1
DM158 (DM-4D03 DMX5)	PLANNED SPEED IN THE CRUISE [speedSchedule]	Available but not used in 9.1	Speed schedules are not considered to be part of WP9.1
DM159 (DM-4D04 DMX4)	REQUEST CLIMB SPEED [speedSchedule]	Available but not used in 9.1	Speed schedules are not considered to be part of WP9.1
DM160 (DM-4D05 DMX3)	REQUEST DESCENT SPEED [speedSchedule]	Available but not used in 9.1	Speed schedules are not considered to be part of WP9.1
DM0	WILCO	Are supported	No auto upload into FMS
DM1	UNABLE	Are supported	No auto upload into FMS
DM2	STANDBY	Are supported	No auto upload into FMS
DM55	PANPAN	Available but not used in 9.1	Not part of I4D

DM56	MAYDAY	Available but not used in 9.1	Not part of I4D
DM58	CANCEL EMERGENCY	Available but not used in 9.1	Not part of I4D
DM62	ERROR [ErrorInfo]	Are supported	No auto upload into FMS
DM67	[Freetext]	Are supported	No auto upload into FMS

Table 1 - Mainline prototype - supported CPDLC and ADS-C messages

Note: No modification was done compared to the messages set attached to the D07 interface document [6] to the exception of these editorial changes (no repercussion on the prototype):

- Tab ADS-C: Choice 'IAS' of the 'Waypoint speed' element switched from 'not supported' to 'are supported'
- Tab CPDLC: Change of the 2nd occurrence of DM123 NEXT WAYPOINT ETA by DM124 NEXT WAYPOINT ETA

The following statuses are used in the messages table:

Are supported	Implemented / tested / validated in P09.01 validations.
Not supported	Topic out of scope for the foreseen P09.01 validations.
Available but not used in P09.01	As the P09.01 Mainline prototype is common with other WP9 projects, some CPDLC messages will be available, but will not be validated nor used in this project.
N/A (Not applicable)	No direct status can be performed. Used when it is a generic parameter that is used in other messages. The status is provided in the relevant containing message.

Table 2 - Definition of statuses

Maximum compliance with the INTEROP issue H [1] [2] standard on I4D related messages is targeted. The basic assumptions are the following:

- CPDLC Speed schedule and Speed change messages are not considered to be part of P09.01 validation objectives
- Trajectory Negotiations via Datalink are limited to a single iteration in P09.01 validation objectives. Negotiations will revert to voice procedures when not agreed in one cycle
- Ground-ground coordination is part of the validation objectives of P09.01 affiliated projects; i4D requirements for ground-ground communication are being defined
- CPDLC Expect messages are not part of the validation objectives
- ADS-C downlinked Met data are not part of the validation objectives

The prototype implements also the CM messages as defined in the INTEROP issue H [1] [2]. But as they are strictly identical to the CM messages of the ED110B ATN baseline 1 INTEROP [8], for a convenience reason, they have not been recalled in the above table.

3.1.2 Regional segment

As the Regional part of the project is closed, the above file contains no indication on the messages sets supported by the Regional prototype. To get them, refer to the D07 [6].

3.2 Messages particularities

Particularities of the Mainline prototype's messages with regard to the ED229 INTEROP issue H [1] [2] are:

3.2.1 CPDLC messages

Only messages with a Time constraint of the 4DTRAD subset of the ED229 INTEROP message sets are implemented (i.e. messages with Speed schedule are not supported).

The prototype is also capable of LINK2000+ CPDLC messages.

3.2.2 ADS-C 4D predicted trajectory and $ETA_{min/max}$

I4D function supports the 4DTRAD concept using aircraft predicted trajectory through ADS-C EPP. The functional and interface specifications were derived from the SPR version H [3] and INTEROP version H [1] [2].

Nominal use of this EPP report is via ADS-C, using an "EPP change" "on event" contract or a "periodic" contract (refer to "EPP report definition" for details about the "on event" type of ADS-C contract).

The "on event" type contract offers a variety of possibilities to the ATC to customize the monitoring of the 4D Trajectory and to tune the datalink exchanges with regards to specific EPP parameters evolution. This type of contract avoids useless datalink exchanges between the aircraft and the ATC during I4D operations and allows the ATC to have a 4D Trajectory downlink only when needed.

I4D function also supports the future ADS-C "$ETA_{min/max}$" report, which includes FMS computed ETA_{min} and ETA_{max} for waypoints chosen by ATC. Nominal use of this report is via ADS-C "On demand" contract, as defined in SPR version H [3] (Refer to "EPP report definition" for details about the "On demand" type of ADS-C contract).

Several evolutions, agreed with the ATC then proposed as PDR amending the INTEROP issue H [1] [2], have been implemented on the Mainline prototype to improve the ADS-C behaviour:

- Addition of 2 EPP events: EPP Level constraint change and EPP Speed constraint change, that allow a better monitoring of an I4D aircraft from ground (PDR 34)
- EPP Tolerance speed events have been improved so that the ground can ask Tolerance on speed IAS and MACH at the same time. This modification permits the aircraft to monitor its speed in every phase of flight and send corresponding events (PDR 80 and 154)
- A Computation Time is added in the ADS-C EPP Group. It indicates when the data contained in the report have been computed on board, so that the ATC can evaluate their integrity (PDR 323)

Others improvements were discussed with ATC but, as they were agreed as being not mandatory for I4D validation purpose, they were not implemented:

- A timer shall be added on the aircraft side so that it waits for the predicted data to be calculated before sending reports. As a consequence, some reports will be sent with a short delay, that will minimise the amount of unavailable data (PDR 317)

- Concerning the waypoints to be included in the EPP Reports, the need agreed between partners was only the next waypoints (that excludes the A/C position projection on trajectory and the FROM points) shall be downlinked

For information, the above PDR, as well as the point related to the exclusion of points from the EPP Reports have been accepted by the WG78/SC214, and thus have been implemented in the official release of the ED229.

4 Traceability towards 5.6.1 INTEROP

The below file provides for the Mainline prototype an implementation status of each Air Ground Data Link requirement of the 5.6.1 D85 Fully validated INTEROP [7], that defines the requirements both the airborne prototype and the ATC platforms must meet to support the I4D operations.

Mainline i4D prototype compliance to AGDL requirements of 05.06.01 D85 Interop				
Identifier	Text	Title	Applicable to the airborne i4D function	Mainline i4D prototype compliance status
REQ-05.06.01-INTEROP-AGDL-0101	The airborne system of an i4D aircraft shall be compliant with ATN B2 applications (CM, CPDLC, ADS-C) requirements for 4DTRAD service as defined in ED-228A and implement, at the minimum, the CPDLC message set indicated in 3.3.1.	Airborne A/G datalink capability, i4D.	YES	PARTIALLY: - Prototype implements the messages set defined in §3.3.1 except UM110 MAINTAIN [speed] TO [speed], UM143 CONFIRM REQUEST and DM97 [freetext]. - Regarding ED-228, it implements a draft version (based on draft H).
REQ-05.06.01-INTEROP-AGDL-0102	The ground system of the facility that intends to operate CTA enabled by i4D, with aircraft suitably equipped and capable, shall be compliant with ATN B2 applications (CM, CPDLC, ADS-C) requirements for 4DTRAD service as defined in ED-228A and implement, at the minimum, the CPDLC message set indicated in 3.3.1.	Ground A/G datalink capability, i4D.	NO	
REQ-05.06.01-INTEROP-AGDL-0103	The ground system of the facility that intends to operate CTA shall be able to process CPDLC messages required for CTA operation.	Ground CPDLC messages processing	NO	
REQ-05.06.01-INTEROP-AGDL-0104	The airborne system of a Basic CTA aircraft should be compliant with ATN B1 applications (CM, CPDLC) requirements, as defined in ED-120, OR ATN B2 applications (CM, CPDLC) requirements as defined in ED-228A.	Airborne A/G datalink capability, Basic CTA	YES	PARTIALLY: Prototype implements a draft version (based on the draft H) of the ED-228.
REQ-05.06.01-INTEROP-	Aircraft intending to receive i4D service operate CTA enabled by i4D shall establish CPDLC connection and appropriate ADS-C contracts required for 4DTRAD	Establish ADS-C and CPDLC connections,	YES	COMPLIANT WITH CLARIFICATION: Protype supports the establishment of

AGDL-0105	service, with ATSU_CTRL.	i4D		CPDLC connection and ADS-C contracts with the ATSU_CTRL. Nevertheless, it is the responsibility of the ATSU_CTRL to initiate them.
REQ-05.06.01-INTEROP-AGDL-0106	Aircraft intending to operate CTA enabled by i4D may establish the appropriate ADS-C contract required for 4DTRAD service, with ATSU_DEST.	Establish ADS-C with ATSU_DEST for ETA Min Max	YES	COMPLIANT WITH CLARIFICATION: same clarification than for ADGL-0105.
REQ-05.06.01-INTEROP-AGDL-0107	The airborne system of an i4D aircraft shall be compliant with ED75D	Airborne navigation capability	Refer to 9.1 D57 Aircraft & System Performance and Functional requirements [9] for applicability and compliance status	

Table 3 - Mainline prototype – compliance to 5.6.1 INTEROP requirements

(The INTEROP contains also requirements related to Ground-Ground Data Communication, Arrival Management and Flight Data Processing System. Nevertheless, as these requirements do not apply to the air segment of the i4D, they have not been recalled in the file.)

5 SPR & INTEROP evolutions

This section synthesizes the evolutions, for the I4D function, between the SPR/INTEROP version H [1] [2] [3] (used by the Mainline I4D prototype) with the official release [4] [5] (to be used for SESAR 2020 activities) and assesses their impacts on the Mainline I4D prototype.

5.1 CPDLC

Several messages have had changes impacting the air/ground interoperability.

I4D uplink messages			
Version H		Official release	
UNABLE	0	0	UNABLE
STANDBY	1	1	STANDBY
REQ DEFFERED	2	2	REQ DEFFERED
CROSS [position] AT [level]	46	46R	CROSS [position ATW] AT [level]
CROSS [position] AT OR ABOVE [level]	47	47R	CROSS [position ATW] AT OR ABOVE [level single]
CROSS [position] AT OR BELOW [level]	48	48R	CROSS [position ATW] AT OR BELOW [level single]
CROSS [position] AT [RTAtimesec]	252	51R	CROSS [position ATW] AT TIME [RTAtimesec]
CROSS [position] AT OR BEFORE [RTAtimesec]	253	52R	CROSS [position ATW] BEFORE TIME [RTAtimesec]
CROSS [position] AT OR AFTER [RTAtimesec]	254	53R	CROSS [position ATW] AFTER TIME [RTAtimesec]
CROSS [position] BETWEEN [RTAtimesec] AND [RTAtimesec]	255	54R	CROSS [position ATW] BETWEEN TIME [RTAtimesec] AND TIME [RTAtimesec]
CROSS [position] AT [speed]	55	55R	CROSS [position ATW] AT [speed]
CROSS [position] AT OR LESS THAN [speed]	56	56R	CROSS [position ATW] AT [speed] OR LESS
CROSS [position] AT OR GREATER THAN [speed]	57	57R	CROSS [position ATW] AT [speed] OR GREATER
CROSS [position] AT [RTAtimesec] AT [level]	256	58R	CROSS [position ATW] AT TIME [RTAtimesec] AT [level]
CROSS [position] AT OR BEFORE [RTAtimesec] AT [level]	257	59R	CROSS [position ATW] BEFORE TIME [RTAtimesec] AT [level]
CROSS [position] AT OR AFTER [RTAtimesec] AT [level]	258	60R	CROSS [position ATW] AFTER TIME [RTAtimesec] AT [level]
CROSS [position] AT [RTAtimesec] AT AND MAINTAIN [level]	259		
		61R	CROSS [position ATW] AT [level] AT [speed]
CROSS [position] AT [RTAtimesec] AT AND MAINTAIN [level] AT [speed]	260	63R	CROSS [position ATW] AT TIME [RTAtimesec] AT [level] AT [speed]
CLEARED TO [position] VIA [route clearance enhanced]	266	79R	CLEARED TO [positionR] VIA [departure dataO] [route clearanceR]
CLEARED [route clearance enhanced]	267	80R	CLEARED [departure dataO] [route clearanceR] [arrival approach data]
	81	81R	CLEARED [procedure nameR]
AT [position] CLEARED [route clearance enhanced]	268	83R	AT [position ATW] CLEARED [route clearanceR] [arrival approach data]
EXPECT [route clearance enhanced]	269		

AT [position] EXPECT [route clearance enhanced]	270		
AT [position] CLEARED [procedure name]	84	84R	AT [positionR] CLEARED [procedure nameR]
MAINTAIN [speed]	106	106	MAINTAIN [speed]
MAINTAIN PRESENT SPEED	107	107	MAINTAIN PRESENT SPEED
MAINTAIN [speed] OR GREATER	108	108	MAINTAIN [speed] OR GREATER
MAINTAIN [speed] OR LESS	109	109	MAINTAIN [speed] OR LESS
MAINTAIN [speed] TO [speed]	110	110	MAINTAIN [speed] TO [speed]
RESUME NORMAL SPEED	116	116R	RESUME NORMAL SPEED [flight phaseO]
CONFIRM REQUEST	143	143	CONFIRM REQUEST
ERROR [error information]	159	159R	ERROR [error informationR]
MESSAGE NOT SUPPORTED BY THIS ATC UNIT	162	162	MESSAGE NOT SUPPORTED BY THIS ATC UNIT
DISREGARD	168		
[free text]	169	169	[free text]
[free text]	183	183	[free text]
[free text]	187	187	[free text]
AFTER PASSING [position] MAINTAIN [speed]	188	188R	AFTER PASSING [positionR] MAINTAIN [speed]
REQUEST FORWARDED	211	211	REQUEST FORWARDED
REQUEST ALREADY RECEIVED	218	218	REQUEST ALREADY RECEIVED
NO SPEED RESTRICTION	222	222	NO SPEED RESTRICTION
NO DELAY EXPECTED	224	224	NO DELAY EXPECTED
DELAY NOT DETERMINED	225	225	DELAY NOT DETERMINED
LOGICAL ACKNOWLEDGMENT	227	227	LOGICAL ACKNOWLEDGMENT
REQUEST AGAIN WITH NEXT ATC UNIT	237	237	REQUEST AGAIN WITH NEXT ATC UNIT
REST OF ROUTE UNCHANGED	289	247	REST OF ROUTE UNCHANGED
REVISED	325	249	REVISED [revision reasonO]
CANCEL [position] TIME CONSTRAINT	336	265	CANCEL TIME CONSTRAINT FOR [position ATW]
[clearance name] CLEARANCE LIMIT [position]	337		
AT [position] CLEARED TO [position] VIA [route clearance enhanced]	339	266	AT [position ATW] CLEARED TO [positionR] VIA [route clearanceR]
IN THE CLIMB [speed schedule]	334	288	MAINTAIN [speed schedule] IN THE CLIMB
IN THE DESCENT [speed schedule]	335	289	MAINTAIN [speed schedule] IN THE DESCENT
		290	MAINTAIN [speed IAS Mach] IN THE CRUISE
INCREASE SPEED TO [speed]	111	291	INCREASE SPEED [speed delta]
REDUCE SPEED TO [speed]	113	292	REDUCE SPEED [speed delta]
MAINTAIN TIME CONSTRAINT	338	293	MAINTAIN TIME CONSTRAINT
		322	CROSS [position ATW] AT TIME [RTAtimesec] AT [speed]
		323	CROSS [position ATW] AT TIME [RTAtimesec] AT [speed] OR LESS
		324	CROSS [position ATW] AT TIME [RTAtimesec] AT [speed] OR GREATER
I4D downlink messages			
WILCO	0	0	WILCO
UNABLE	1	1	UNABLE
STANDBY	2	2	STANDBY

REQUEST [procedure name]	23	23R	REQUEST [named instruction]
REQUEST CLEARANCE [route clearance enhanced]	121	24R	REQUEST CLEARANCE [departure dataO] [route clearanceR] [arrival approach dataO]
ERROR [error information]	62	62R	ERROR [error informationR]
DUE TO WEATHER/DUE TO AIRCRAFT PERFORMANCE	65/66	65R	DUE TO [due to reason downlink]
[free text]	97	97	[free text]
[free text]	98	98	[free text]
LOGICAL ACKNOWLEDGMENT	100	100	LOGICAL ACKNOWLEDGMENT
PLANNED SPEED IN THE CLIMB [speed schedule]	156	139	REQUEST [speed schedule] IN THE CLIMB
PLANNED SPEED IN THE DESCENT [speed schedule]	157	140	REQUEST [speed schedule] IN THE DESCENT
		145	MESSAGE RECEIVED TOO LATE, RESEND MESSAGE OR CONTACT BY VOICE
PLANNED SPEED IN THE CRUISE [speed schedule]	158		
REQUEST CLIMB SPEED [speed schedule]	159		
REQUEST DESCENT SPEED [speed schedule]	160		

Table 4 – CPDLC changes

Legend (from the mainline prototypes perspective):

- Blue: change without impact on interoperability,
- Yellow: change with impact on interoperability,
- <no colour>: no change.

5.2 ADS-C

- Type of reports
  - Additional ADS-C reports have been integrated in the official release:
    - "RTA status data" in order to indicate the earliest and latest ETA as well as the current ETA at the specified waypoint with the time of computation and the RTA status as "achievable" or "non-achievable". (Moreover, the group containing the ETAs has been renamed in "TOArange")
    - "Speed Schedule Profile" in order to indicate the predicted gross mass at top of descent and the nominal speed, and when available; the minimum and/or maximum speed for: the climb, the initial cruise at top of climb, the final cruise at top of descent, and for the descent.
  - As a consequence, the types of "ADS Request Contract" and associated "ADS Request" have been updated accordingly (e.g. the "Speed Schedule Profile" is now an ADS-C report and this report can be included in a demand or a periodic "Contract Request").
- Structure and content of ADS-C reports
  - The "Speed Schedule Profile" (i.e. predicted gross mass at top of descent and speed schedule) is not anymore in the EPP ADS-C report but is now a dedicated ADS-C report (refer to previous bullet).
    Note that the "RTA status data" can be a dedicated ADS-C report but is also part of the EPP.

  - Only one type of ADS-C data report which contains basic and optional information is now applicable to the 3 types of ADS-C contract (demand, periodic, event) compared to specific ADS-C report for each type of contract in version H.
  - The “Connected ATSU List” has been added in some ADS-C downlink messages (“positive acknowledgement”, “non compliance notification”, and “reject notification”) in order to have the information on ATSU having an ADS-C connection and associated priority.
- Types of contract
  - the conditions set in the event contract requests for the monitoring of the EPP have been reworked: when receiving an on event EPP ADS-C report, ATC center have now a clear view of which event has triggered its sending

5.3 Impacts on prototype

These evolutions make the Mainline I4D prototype not compatible with the new ED-228/ED-229 release ([4] and [5]).

6 Assumptions

Refer to §3.1.1

7 References

[1] WG78/SC214 Advanced ATS datalink services Interop - version H

[2] WG78/SC214 PMADS ADS-C application Protected Mode V07 – version H

[3] WG78/SC214 Safety and Performances - version H

[4] EUROCAE ED-228A (/RTCA DO-350A) Safety and Performance Requirements Standard for Baseline 2 ATS Data Communications (Baseline 2 SPR Standard)

[5] EUROCAE ED-229A (/RTCA DO-351A) Interoperability Requirements Standard for Baseline 2 ATS Data Communications (Baseline 2 INTEROP Standard)

[6] 09.01 D07 Interface document between Aircraft and ATC systems - step 2 (WA1)

[7] 05.06.01 D85 Fully validated INTEROP

[8] EUROCAE ED110 ATN baseline 1 INTEROP – issue B

[9] 09.01 D57 Aircraft & System Performance and functional requirements

[10]09.49 D04 Batch 1, 2 & 3 – Consolidated functional airborne architecture

-END OF DOCUMENT-