Step 1 - Fully Validated Interop

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Abstract

The document includes the fully validated set of the interoperability requirements (INTEROP) for the implementation of the Ground & Airborne Capabilities to Implement Sequence based on the Controlled Time of Arrival (CTA) concept. Interoperability requirements are the minimum technical and functional requirements that provide the basis for ensuring compatibility among the various elements of the CNS/ATM system using a specific technology. These elements comprise the distributed communication services and ATS applications in the aircraft system, the communication service providers' system and the ATS provider system.

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This deliverable consists of SJU foreground.

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Executive summary

This document presents the final and fully validated set of interoperability requirements on CTA when used in the context of arrival management extended to en-route, a concept developed and validated in SESAR projects 05.06.04 and 05.06.07.

The CTA concept as represented in OI TS-0103, is intended for use within the context of Extended AMAN in a MED/MED environment.

The concept seeks to make use of airborne (RTA) capability in ground sequencing – including some currently available capabilities (FMS providing 'Basic RTA' to a fix in descent) and also capabilities being developed within i4D (FMS with enhanced RTA to a fix in descent, with guaranteed performance, together with air/ground trajectory information exchanges via datalink).

Earlier, project 05.06.01 internal INTEROP addressed requirements related to the Airbus Mainline i4D Prototype which was used in SESAR flight trial with great success. This final edition the air-ground interoperability requirements to full compatibility with the latest datalink standard. Finally, a gap analysis to the i4D Mainline Prototype implementation is provided.

This INTEROP is intended as a complement to the Extended AMAN INTEROP which was produced in the above listed projects.

1 Introduction

1.1 Purpose of the document

This INTEROP aims at defining the interoperability requirements the CNS/ATM systems shall implement to comply with the safety, performance and security requirements defined in 5.6.1 D84 Fully validated SPR (ref[9]) derived on the basis of the operational concept detailed within the 5.6.1 OSED Step 1 Final (ref [8]).

The intent of interoperability requirements is to establish the minimum requirements that all interacting systems shall apply in order to operate together as intended, and perform their intended functions.

This INTEROP (and the SPR) applies to the project's Step 1 activities. The scope is limited to the study of the CTA operations in single ACC in low and medium density area. The use of CTA in high density-complexity environments will be investigated in SESAR 2020.

This document is an evolution of an earlier project internal INTEROP that was developed as part of the third iteration of Step 1 documentation, itself having been inspired by INTEROP (D11) released by the 5.5.1 Trajectory Management Framework in TMA project (ref.[11]) from 2011.

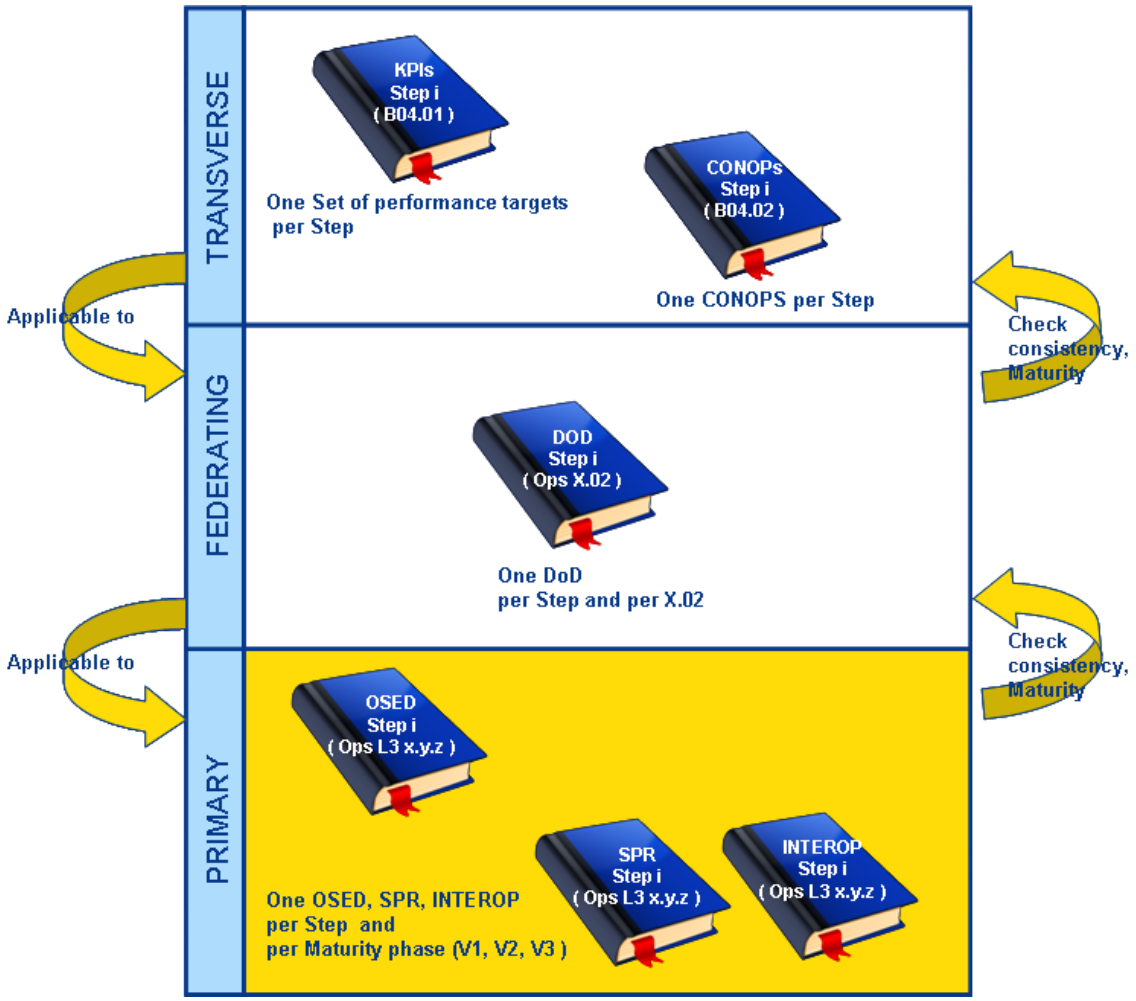

Figure 1: INTEROP document with regards to other SESAR deliverables

In Figure 1, the Steps are driven by the OI Steps addressed by the project in the Integrated Roadmap document.

1.2 Intended readership

This document is intended to all stakeholders invested in ongoing and planned R&D activities on CTA within SESAR 2020 as well as relevant bodies involved in the regulatory drafting and deployment activities surrounding PCP AF6 and its eventual evolutions.

Specific SESAR projects

- SPRWP4; P4.3, P4.5
- P4.2, P5.2, P5.3 (federating projects)
- WP5; P5.5.1, P5.6.7
- WP9; P9.1
- WP10; P10.2.1, P10.2.5, P10.7.1, P10.9.4

1.3 Inputs from other projects

Early input was sourced from TMF defined in SESAR 5.5.1.

10.01.07 and 9.49 Technical Architecture Descriptions ([19],[20]) were used as sources of architectural design for the respective domains.

Coordination and collaboration with SESAR 9.01 was undertaken to ensure harmonization and in particular to investigate the impact of the updated standard for ATN Baseline 2 (Revision A) on interoperability of the Mainline I4D Prototype, as detailed in 3.3.

SESAR 5.6.7 was consulted in the production of this document with respect to Information Exchange Requirements and the delineation of scopes between Arrival management and CTA applied therein.

1.4 Glossary of terms

Term	Definition
Basic CTA (aircraft) – Basic RTA	A term, frequently used especially within P5.6.1 discussions and documents, normally to distinguish between the CTA-related capability of currently equipped aircraft (i.e. those aircraft that are equipped with today's RTA functionality), and the capability of i4D aircraft (i.e. those aircraft that are equipped with the enhanced RTA capability/functionality being considered/developed within i4D). ***Note:*** *The term could – and probably should in most cases – be read as "Basic RTA", since the CTA is simply the ground-derived time delivered to the flight and it is the airborne RTA function that controls the aircraft to the time.*
CTA	Controlled Time of Arrival – An ATM imposed time constraint on a defined merging[1] 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.

[1] The CTA definition provided is extracted from the SESAR Lexicon. For practical purposes the CTA is more likely to be used on 'a defined point' associated to an arrival runway, rather than specifically being 'a defined merging point.

Term	Definition
	Note: *This term is sometimes used interchangeably with CTO.* ***Note:*** *The term 'CTA Operations' are sometimes used as a generic term to describe the application of the CTA concept.*
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	ADS-C EPP (Extended Projected Profile) report is the ADS-C report containing the sequence of 1 to 128 waypoints or pseudo waypoints with associated constraints or estimates (altitude, time, speed, etc…), Gross Mass and estimate at Top Of Descent, speed schedule and other items, see [12].
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].
ETA Min/Max Request	A request made by ATC ground systems to an A/C to provide information on the earliest and the latest ETA for the position the request is made for according to current airborne predictions. I4D equipped A/C downlink 'Reliable RTA Interval' as ADS-C ETA Min/Max parameter.
E-TMA	Extended TMA – a terminal manoeuvring area extending to the aircraft top of descent. The E-TMA usually includes the TMA and nearby feeder sectors.
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 – A function of the airborne FMS that allows the flight to comply with a CTA/CTO.
RTA Accuracy	RTA accuracy is the targeted maximum discrepancy between RTA value and a/c actual crossing time on RTA waypoint, associated with the RTA reliability figure. (Taken from P9.1).
RTA Reliability	RTA reliability is the probability (in %) that the a/c will actually sequence RTA waypoint with the required accuracy (assuming the RTA has been set within the reliable ETA min/ETA max window). (Taken from P9.1). ***Note:*** *Airbus define this as, 'The reliable ETA Min/Max window defines the range of arrival times at a specified lateral fix which are achievable using the RTA function, with a level of confidence of 95% assuming standard meteorological uncertainty'.*
Reliable RTA Interval	Reliable RTA interval is computed by FMS in order to guarantee that any RTA defined within this interval will be satisfied with reliability on a 95% probability basis. The interval is defined by reliable ETA Min and reliable ETA Max values. Reliable ETA Min (respectively reliable ETA Max) is the earliest (respectively latest) ETA at a waypoint, provided the aircraft flies the 4D trajectory at its maximum (respectively minimum) allowable speed taking into account wind/temperature error.
I4D Aircraft	Aircraft equipped with CPDLC, ADS-C for communication of RTA reliable interval and EPP downlink and enhanced FMS RTA functionality, as developed by Airbus within P09.01, with enhanced accuracy and predictability (Assurance of 95% fulfilment of CTA with +/- 10 seconds accuracy).
I4D Operations	I4D Operations is a generic term used to describe the use of i4D services to enhance CTA operations.
I4D Services	I4D service is a generic term used to encompass the use of information that is available from i4D equipped aircraft only, such as ADS-C information, ETA Min/Max information and EPP downlink.
Non-CTA Aircraft	Aircraft unable to participate in CTA operations (neither Basic CTA nor i4D capability).

1.5 Acronyms and Terminology

Term	Definition
4DTRAD	Four Dimension Trajectory Data Link Service defined in ATN B2
AC	Aircraft (including Aircraft Systems)
ADS-C	Automatic Dependant Surveillance – Contract, an application in ATN B2.
AMA	OLDI Arrival Management Message
AMAN	Arrival Manager
AoR	Area of Responsibility
ASAS	Airborne Self Separation
ASPA	ASAS Spacing
ATC	Air Traffic Control
ATM	Air Traffic Management
ATMS	Air Traffic Management System
ATN	Aeronautical Telecommunications Network
ATN B1	ATN Baseline 1
ATN B2	ATN Baseline 2
ATS	Air Traffic Services
ATSU	Air Traffic Service Unit
ATCO	Air Traffic Controller
B2B	Business to Business
CDA	Current Data Authority; CPDLC designation of the ground system with which the current connection is established
CM	Context Management, a datalink application
CNS	Communication, Navigation, Surveillance, three functional domains underpinning the technical operation of the ATM system model.
CPDLC	Controller Pilot Datalink Communication
CTA	Controlled Time of Arrival
CTO	Controlled Time Over
DLS IR	Data Link Services Implementing Rule, refers to EC 29/2009 amended by EC 2015/310
EPP	Extended Projected Profile
ETA	Estimated Time of Arrival

Term	Definition
E-TMA	Extended Terminal Manoeuvring Area
EUROCAE	European Organization for Civil Aviation Equipment, an industry based standardization body
FAF	Final Approach Fix
FDPS	Flight Data Processing System
FMS	Flight Management System
GD	Ground Domain
i4D	initial 4D Trajectory operations
ICAO	International Civil Aviation Organisation
LoA	Letters of Agreement
MET	Meteorological entity or related object
MF	Metering Fix
OFA	Operational Focus Area
OI	Operational Improvement (Step)
OLDI	Online Data Interchange, a specification for interfacility data exchange
OSED	Operational Service and Environment Description
P2P	Peer-to-peer
R/T	Receiver/Transmitter
RTA	Required Time of Arrival
TMA	Terminal Manoeuvring Area
TMF	Trajectory Management Framework
TOA	Time of Arrival
ToD	Top of Descent
VDL	VHF Datalink
VHF	Very High Frequency
WILCO	Will comply, a datalink affirmative reply message

2 System Description

2.1 Air-Ground Selected Technology

Where i4D technique is used in support of CTA, the technology supporting air-ground data communications required by OSED is the ATN B2 service '4DTRAD', developed in RTCA SC-214 / EUROCAE WG-78.

CTA operations supported by i4D rely on interoperation at several levels:

- Procedural and operational
- Air-Traffic applications service level,
- Data transmission protocol level, and
- Low level infrastructure level.

For operational guidance on aeronautical datalink refer to ICAO GOLD [6] which addresses data link service provision, operator readiness, controller and flight crew procedures, performance-based specifications and post-implementation monitoring and analysis.

CTA operations supported by voice RT (Basic CTA) do not rely in any specific Air-Ground Technology at application service or data transmission levels. Low level infrastructure required consists of voice RT communications and are out of scope of this document. Procedural and operational matters apply as per SPR and OSED.

2.1.1 Technical INTEROP at Application level

CTA operations supported by i4D use the following ATS applications:

- Context Management (CM)
- Controller pilot data link communication (CPDLC)
- Automatic dependent surveillance contract (ADS-C).

The applications are jointly defined in ATN Baseline 2 SPR [12].

2.1.2 Technical INTEROP at Protocol level

In CTA operations supported by i4D, application service interactions rely on data communications protocols.

For ATS data traffic the ATN Baseline 2 Revision A was assumed as the standard. This standard features continental ADS-C with full support for i4D operations as well as an improved CPDLC application compared to the SESAR Step 1 Standard[2].

Detailed specifications and interoperability requirements for ATN are found in the technical documents relevant to the DLS IR. (Namely ICAO Annex 10, ICAO Document 9880 (ref [16]) & ICAO Document 9705 (ref [15]) – which will eventually be republished through additions into ICAO 9880).

For encoding/decoding the ASN.1 CPDLC message structure and content of ADS-C contracts and reports: PER as defined in ISO/IEC 8825-2 (ref [17]), using the Basic Unaligned variant. The norm ITU X.691 shall apply to all messages exchanged between air and ground

[2] SESAR Step 1 standard is assumed as ATN/OSI communications service with the ATN-compliant VDL-2 sub-network compliant to the EC 29/2009 Implementing Rule on Data Link Services (DLS IR), more commonly known as Link2000+. It is sometimes recognized under the acronym "CPDLC version 1" among operational staff.

2.1.3 Technical Interop at lower levels: Links and Radio Infrastructure

VHF Datalink Mode 2 as an ATN mobile sub-network as defined in ICAO Annex 10 [18].

3 Interoperability Requirements

3.1 Requirements for ATS CNS/ATM Applications

3.1.1 Requirements on Air-Ground applications

[REQ]

Identifier	REQ-05.06.01-INTEROP-AGDL-0101
Requirement	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 “Official release” CPDLC message set indicated in 3.3.1.
Title	Airborne A/G datalink capability, i4D.
Status	<Validated>
Rationale	There are two flavours of ADS-C defined as of currently; an older FANS 1/A application, in use, and the ATN B2 application, defined and validated but not yet widely implemented. To use i4D, the latter is required as it supports the necessary contract types and EPP extent to comply with SPR requirements. CPDLC v2 is required as per SPR.
Category	<Interoperability>
Validation Method	<Real Time Simulation>
Verification Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0009	<Full>
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A
<ALLOCATED_TO>	<Functional block>	Air-Ground Datalink Services	N/A

[REQ]

Identifier	REQ-05.06.01-INTEROP-AGDL-0102
Requirement	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 “Official release” CPDLC message set indicated in 3.3.1.
Title	Ground A/G datalink capability, i4D.
Status	<Validated>
Rationale	There are two flavours of ADS-C defined as of currently; an older FANS 1/A application, in use, and the ATN B2 application, defined and validated but not yet widely implemented. To use i4D, the latter is required as it supports the necessary contract types and EPP extent to comply with SPR requirements. CPDLC v2 is required as per SPR.
Category	<Interoperability>
Validation Method	<Real Time Simulation>
Verification Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0001	<Full>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0002	<Full>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0003	<Full>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0061	<Full>
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

<ALLOCATED_TO>	<Functional block>	Air-Ground Datalink Services	N/A

[REQ]

Identifier	REQ-05.06.01-INTEROP-AGDL-0103
Requirement	The ground system of the facility that intends to operate CTA shall be able to process CPDLC messages required for CTA operation.
Title	Ground CPDLC messages processing
Status	<Validated>
Rationale	Process incoming CPDLC data and present results at interface as required. For a provision by means of i4D, CPDLC elements associated with standard ED75D/DO236C Change 1 message set/capability. For a provision Basic CTA, CPDLC of either version is optional and an alternative to voice.
Category	<Interoperability>
Validation Method	<Real Time Simulation>
Verification Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0001	<Full>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0002	<Full>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0003	<Full>
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A
<ALLOCATED_TO>	<Functional block>	Air-Ground Datalink Services	N/A

[REQ]

Identifier	REQ-05.06.01-INTEROP-AGDL-0104
Requirement	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.
Title	Airborne A/G datalink capability, Basic CTA.
Status	<Validated>
Rationale	Basic CTA aircraft may use either Baseline 1 or 2 to conduct CTA operation. Voice R/T will be used as a complement or substitute communication channel.
Category	<Interoperability>
Validation Method	<Real Time Simulation>
Verification Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0008	<Full>
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A
<ALLOCATED_TO>	<Functional block>	Air-Ground Datalink	N/A

[REQ]

Identifier	REQ-05.06.01-INTEROP-AGDL-0105
Requirement	Aircraft intending to operate CTA enabled by i4D shall establish CPDLC connection and appropriate ADS-C contracts required for 4DTRAD service, with ATSU_CTRL.
Title	Establish ADS-C and CPDLC connections, i4D.
Status	<Validated>
Rationale	Unlike in the basic CTA case, CPDLC v2 (ATN B2) is required for i4D aircraft to use the service.
Category	<Interoperability>
Validation Method	<Real Time Simulation>
Verification Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0010	<Full>
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A
<ALLOCATED_TO>	<Functional block>	Air-Ground Datalink Services	N/A

[REQ]

Identifier	REQ-05.06.01-INTEROP-AGDL-0106
Requirement	Aircraft intending to operate CTA enabled by i4D may establish the appropriate ADS-C contract required for 4DTRAD service, with ATSU_DEST.
Title	Establish ADS-C with ATSU_DEST for ETA Min Max
Status	<Validated>
Rationale	To be able to provide ETA Min Max information to ATSU_DEST directly, rather than passing it through ATSU_CTRL.
Category	<Interoperability>
Validation Method	<Real Time Simulation>
Verification Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0010	<Full>
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A
<ALLOCATED_TO>	<Functional block>	Air-Ground Datalink Services	N/A

[REQ]

Identifier	REQ-05.06.01-INTEROP-AGDL-0107
Requirement	The airborne system of an i4D aircraft shall be compliant with ED75D.
Title	Airborne navigation capability
Status	<Validated>
Rationale	To be able to navigate in 4D with performance guarantee.
Category	<Interoperability>
Validation Method	<Real Time Simulation>
Verification Method	<Test>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0012	<Full>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0023	<Full>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0082	<Full>
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A
<ALLOCATED_TO>	<Functional block>	Air-Ground Datalink Services	N/A

3.2 Dynamic functions / operations

SC-214/WG78 carried out a thorough OSA/OPA process for CPDLC and ADS-C, taking into account the operational needs of the i4D/CTA concept and concluding on performance specifications addressing link transaction time, continuity, availability and integrity. These specifications are published as RCP-130 for CPDLC and RSP-160 for ADS-C including EPP and are considered sufficient to fulfil the needs of the concept.

3.3 Unique characteristics

Earlier iterations of this document as well as all other SESAR validation documentation that pointed to it, were based on an early draft version 0.h of the Baseline 2 datalink standard then under development. This includes the Airbus Mainline prototype specification developed to support i4D / CTA trials that contributed validation evidences during the production of this Fully Validated INTEROP.

In the meantime, the aforementioned datalink standard matured and was published as ED-228A in March 2016, rendering the earlier draft obsolete.

During the production of this INTEROP a decision was taken to review all interoperability requirements and ensure consistency with the applicable standard then in force, that is, ED-228A. As a consequence, backward compatibility with the Airbus mainline prototype used in the validations was broken.

To mitigate this effect, a gap analysis is provided in this chapter describing the change from 0.h to Revision A of the ATN Baseline 2 standard.

3.3.1 CPDLC

Several messages have had changes impacting the air/ground interoperability. Colour coding convention is as follows:

White field: No change

Yellow field: Change with impact on interoperability of the mainline prototype in ATN B2 environment

Blue field: Change without impact on interoperability of the mainline prototype in ATN B2 environment

3.3.1.1 Uplink messages

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

		320	MESSAGE RECEIVED TOO LATE, RESEND MESSAGE OR CONTACT BY VOICE
		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
		340	CANCEL SPEED CONSTRAINT FOR [*position R*]
		341	CANCEL LEVEL CONSTRAINT FOR [*position R*]

3.3.1.2 Downlink messages

I4D Downlink Messages			
Version H		Official release	
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
		155	MESSAGE NOT SUPPORTED BY THIS AIRCRAFT
PLANNED SPEED IN THE CRUISE [speed schedule]	158		
REQUEST CLIMB SPEED [speed schedule]	159		
REQUEST DESCENT SPEED [speed schedule]	160		

3.3.2 ADS-C

Table 3 and Table 4 below indicate the types of contracts and associated contents that must be implemented for compliance with REQ-05.06.01-INTEROP-AGDL-0101 in Section 3.1.1.

Messages	Content
ADS Demand Contract	EPP demand, TOA range demand, Speed schedule demand
ADS Periodic Contract	EPP periodic, TOA range periodic, Speed schedule periodic
ADS Event Contract	EPP Change, Flightplan change, Next waypoint in horizon, EPP tolerance, RTA status change, Airspeed change, Ground speed change
ADS Cancel Contract	

Table 1 ADS-C Uplink Messages

Messages	Content
ADS demand report	EPP data, TOA range, Speed schedule
ADS periodic report	EPP data, TOA range, Speed schedule
ADS event report	EPP data, RTA status data
ADS positive acknowledgement	
ADS non compliance notification	
ADS reject notification	

Table 2 ADS-C Downlink Messages

Gap analysis ATN Baseline 2 Revision A against the interim 0.h release on which validation of requirements provided in Section 3 was conducted:

- 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".
    - "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

4 References

4.1 Applicable Documents

[1] Template Toolbox 03.00.00
https://extranet.sesarju.eu/Programme%20Library/SESAR%20Template%20Toolbox.dot

[2] Requirements and V&V Guidelines 03.00.00
https://extranet.sesarju.eu/Programme%20Library/Requirements%20and%20VV%20Guidelines.doc

[3] Templates and Toolbox User Manual 03.00.00
https://extranet.sesarju.eu/Programme%20Library/Templates%20and%20Toolbox%20User%20Manual.doc

[4] EUROCONTROL ATM Lexicon
https://extranet.eurocontrol.int/http://atmlexicon.eurocontrol.int/en/index.php/SESAR

4.2 Reference Documents

[5] ED-78A Guidelines for Approval of the provision and use of Air Traffic Services supported by Data Communications

[6] ICAO “GOLD” – Global Operational Data Link Document 10037

[7] WPB.01 Integrated Roadmap DS15

[8] SESAR 05.06.01 Step 1 OSED – final, Ed 00.01.00, 2016/05/27

[9] SESAR 05.06.01 D84 Fully Validated SPR, Ed 00.04.02, 2016/10/28

[10] SESAR 05.06.04 D34-002 Interoperability Requirements, Ed 00.01.01. 2015/05/07

[11] SESAR 05.05.01 D11 Step 1 TMA Trajectory Management Framework Advanced INTEROP, Ed 00.02.00, 2011/10/24

[12] EUROCAE ED-228A ATN B2 SPR, March 2016

[13] EUROCAE ED-229A ATN B2 Baseline INTEROP, March 2016

[14] EUROCAE ED-230A ATN B2 INTEROP for B1, March 2016

[15] ICAO DOC 9705-AN/956 Ed 2, Manual of Technical Provisions for the Aeronautical Telecommunication Network (ATN), Second Edition.

[16] ICAO DOC 9880-AN/466, Manual on Detailed Technical Specifications for the Aeronautical Telecommunication Network (ATN), using ISO/OSI standards and protocols.

[17] ITU-T X.691 ASN.1 encoding rules: specification of Packet Encoding Rules (PER), November 2008.

[18] ICAO Annex 10 Volume III – Aeronautical Telecommunications, Second edition, July 2007

[19] SESAR 10.01.07 D120 Technical Architecture Description – Cycle 2015, Ed 01.00, 19/01/2016

[20]SESAR 9.49 D02 Consolidated functional airborne architecture, Ed 00.03.00. 21/12/2012

Appendix A Additional considerations

Originally this INTEROP considered two cases for interoperability of Ground-Ground data communication technology; due to uncertainties concerning maturity of this part with respect to SESAR Solution #06, a decision was made to restrict the scope of the solution to single ACC operation, rendering the GND – GND interoperability part redundant, including associated requirements. The part is retained in this appendix, provided on an as-is basis for information and future reference.

A.1 Background to Ground-Ground Interoperability

The technology supporting ground-ground information exchange management is assumed to be SWIM. In line with the recommendation referred to in Chapter 1.1 and inherited from the E-AMAN INTEROP [10].

Complementary technology considered as Legacy Environment is assumed to be a P2P protocol such as OLDI or B2B due to their widespread use in contemporary (pre-SWIM) operations.

Concerning the ground-ground part, it is important to note that the solution is not yet considered fully validated. The validations captured in this INTEROP and the associated SPR [9], modelled the system as depicted in Figure 2 and Figure 3 from the operational perspective and concluded that the concept returns acceptable parameters for the operational domain, that is, what concerns controller workload, method acceptability, situational awareness and coordination needs.

In the technical domain however, assumptions had to be made specifically in the following areas:

- The operation of the respective SWIM services to achieve proper sharing of information across FIR borders
- The operation and suitability of the OLDI network to achieve proper sharing of information across FIR borders, and in particular the required level of performance.
- The procedures to provide an ATSU located in a FIR upstream, with arrival management information required for the concept, particularly the sharing of the expected STAR / RWY combination.
- The procedural and technical framework of ADS-C contract operation, specifically:
    - The acceptability of multiple ADS-C contracts to share EPP with ATSU_CONTROL and ATSU_DEST and its effect on the performance of 4DTRAD service
    - Procedures and rules for contract management in case of multiple ADS-C contracts
    - The sharing of EPP information in the ground domain in case of single ADS-C contract or when for any reason, ATSU_DEST and its AMAN cannot obtain EPP directly.

These assumptions were made simply because the maturity level of the concerned elements (such as SWIM services for Arrival Management, CTA and i4D, 4DTRAD and its use of ADS-C EPP and OLDI at FIR border), was too low at the time of the drafting of the validation scenarios to contribute any meaningful value to the production of interoperability requirements. The resulting generic requirements are well captured in the SPR [9] in:

- REQ-05.06.01-Step 1SPR IT3-SAF1.0065
- REQ-05.06.01-Step 1SPR IT3-SAF1.0090

- REQ-05.06.01-Step 1SPR IT3-SAF1.0111

However it is recommended and in fact necessary, to revisit their impact on interoperability with ADS-C, OLDI and SWIM technologies at a later opportunity when maturity and technical circumstances permit to do so, so that definite interoperability requirements can be developed.

A.2 Interoperability Requirements on Ground-Ground Data Communication

Identifier	REQ-05.06.01-INTEROP-GGDC-0101
Requirement	Ground system of all participating ATSU and other involved ground based stakeholders, shall implement a function to manage and synchronize trajectories in up to 4 dimensions with multiple partners, including non-activated flights.
Title	Ground trajectory synchronization capability
Status	<Validated>
Rationale	To be able to manage and synchronize disparate instances of trajectories in different states of synchronization with one another, among all ground based stakeholders. Includes eventual dissemination of the synchronized resultant trajectory to relevant stakeholders.
Category	<Interoperability>
Validation Method	<Real Time Simulation>
Verification Method	<Test>

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0014	<Full>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0015	<Full>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0019	<Full>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0020	<Full>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0021	<Full>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0030	<Full>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0062	<Full>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0063	<Full>
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A
<ALLOCATED_TO>	<Functional block>	Ground-Ground Data Communications	N/A

Identifier	REQ-05.06.01-INTEROP-GGDC-0102
Requirement	When a need for revision of an air-ground synchronized trajectory is identified in any affected ATSU that is not ATSU_CTRL, the respective ATSU will use ground – ground trajectory management and synchronization function to propose to the ATSU_CTRL for uplink the changes required to synchronise/re-synchronise the affected portion(s) of the air/ground trajectories (e.g. in the form of a request for route uplink).
Title	Ground initiated trajectory revision outside ATSU_CTRL
Status	<Validated>
Rationale	CPDLC route uplinks are only allowed in ATSU_CTRL. When changes to the airborne trajectory/route outside ATSU_CTRL are identified as needed, the request for a route uplink needs to be sent to ATSU_CTRL for actioning. *Note: This requirement generalizes SWIM object access privileges to any network architecture, see SWIM IOP role designations FDMP, FDC, FDU.*
Category	<Interoperability>
Validation Method	<Real Time Simulation>
Verification Method	<Test>

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0020	<Full>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0111	<Full>
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A
<ALLOCATED_TO>	<Functional block>	Ground-Ground Data Communications	N/A

Identifier	REQ-05.06.01-INTEROP-GGDC-0103
Requirement	Having received a route uplink request from another ATSU, ATSU_CTRL shall assess the proposal for impact on own operations in conjunction to flight execution. If the impact is considered acceptable, ATSU_CTRL shall adjust its ground trajectory accordingly, resynchronize with aircraft if needed and use the ground based management and synchronization function to inform all involved partners. Otherwise, ATSU_CTRL shall reject the request.
Title	Ground initiated trajectory revision within ATSU_CTRL
Status	<Validated>
Rationale	Amendments to the trajectory agreed between two ATSUs will routinely be of interest to third ATSUs downstream of aircraft position. When the amendment cannot be implemented directly, it is envisaged for coordination to take place as per contemporary operations.
Category	<Interoperability>
Validation Method	<Real Time Simulation>
Verification Method	<Test>

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0014	<Full>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0026	<Full>
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A
<ALLOCATED_TO>	<Functional block>	Ground-Ground Data Communications	N/A

Identifier	REQ-05.06.01-INTEROP-GGDC-0104
Requirement	ATSU_DEST shall communicate arrival management constraints to ATSU_CTRL in such a manner so that ATSU_CTRL can unequivocally interpret the constraint information regardless of what sequence implementation method is being used. *Note: SESAR Extended AMAN [SESAR Solution #05] OSED (D15) covers this requirement as IE-5.6.4-0032-0032)*
Title	Provision of AM information to ATSU_CTRL
Status	<Validated>
Rationale	In a SWIM environment solution E-AMAN provides Arrival Management Information that carries all supplementary AMAN sequence information that is needed. It is encouraged to include the CTA value within this information element. In legacy environment, ATSU_DEST through ground-ground data communication shall either provide all items of information that may be needed in ATSU_CTRL (that is, MF point, CTA, TTL/G, and/or speed advisory), OR LoA will be used to describe how a CTA is to be interpreted as TTL/G, including the respective delay sharing strategy, and all ATSU_INTER shall implement that logic.
Category	<Interoperability>
Validation Method	<Real Time Simulation>
Verification Method	<Test>

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0034	<Full>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0040	<Full>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0042	<Full>
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A
<ALLOCATED_TO>	<Functional block>	Ground-Ground Data Communications	N/A

Identifier	REQ-05.06.01-INTEROP-GGDC-0105
Requirement	Having received a CTA constraint from ATSU_DEST, ATSU_CTRL shall provide to ATSU_DEST any 'agreed information' on the status of implementation of the CTA. *Note: SESAR Extended AMAN [SESAR Solution #05] SPR/INTEROP (D16) covers this requirement.*
Title	Semantic acknowledgement of CTA to AMAN by ATSU_CTRL.
Status	<Validated>
Rationale	AMAN may require information on whether a CTA was assigned or not, for internal purposes.
Category	<Interoperability>
Validation Method	<Real Time Simulation>
Verification Method	<Test>

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0036	<Full>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0075	<Full>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0076	<Full>
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A
<ALLOCATED_TO>	<Functional block>	Ground-Ground Data Communications	N/A

Identifier	REQ-05.06.01-INTEROP-GGDC-0106
Requirement	ATSU_CTRL shall inform all affected ATSUs (downstream along the trajectory including ATSU_DEST) when a CTA status of a flight has changed.
Title	Propagate CTA status
Status	<Validated>
Rationale	Knowledge that an inbound aircraft is presently operating on a CTA is vital for sector planning in all downstream units.
Category	<Interoperability>
Validation Method	<Real Time Simulation>
Verification Method	<Test>

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0034	<Full>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0036	<Full>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0075	<Full>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0076	<Full>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0085	<Full>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0116	<Full>
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A
<ALLOCATED_TO>	<Functional block>	Ground-Ground Data Communications	N/A

Identifier	REQ-05.06.01-INTEROP-GGDC-0107
Requirement	ATSU_DEST shall continually calculate the current value of TTL/G associated to an aircraft operating on CTA and make this – and any other relevant arrival information - available upstream when/if required (e.g. CTA cancel).

	Note: The appropriate delay sharing strategy shall be taken into account, either at AMAN or at ATSU level.
Title	Maintain TTL/G background info to CTA flights
Status	<Validated>
Rationale	Information about the underlying delay to be absorbed is required for the executive ATCO to make an informed decision concerning a flight operating on a CTA.
Category	<Interoperability>
Validation Method	<Real Time Simulation>
Verification Method	<Test>

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0093	<Full>
<SATISFIES>	<ATMS Requirement>	REQ-05.06.01-Step 1SPR IT3-SAF1.0100	<Full>
<APPLIES TO>	<Operational Focus Area>	OFA04.01.02	N/A
<ALLOCATED TO>	<Functional block>	Ground-Ground Data Communications	N/A

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