PJ18-02b TRL-6 Contextual Note-6

Deliverable ID:	D3.3
Dissemination Level:	PU
Project Acronym:	PJ18 4DTM
Grant:	734161
Call:	H2020-SESAR-2015-2
Topic:	SESAR.IR-VLD.Wave1-21-2015
Consortium Coordinator:	INDRA
Edition date:	8 DEC 2020
Edition:	00.01.03
Template Edition:	02.00.01

Founding Members
EUROPEAN UNION
EUROCONTROL
SESAR
JOINT UNDERTAKING

Authoring & Approval

Authors of the document

Name/Beneficiary	Position/Title	Date
P Leplae/EUROCONTROL	Solution Leader	10/11/2020

Reviewers internal to the project

Name/Beneficiary	Position/Title	Date
Julian Alonso/INDRA	PJ18 Project Leader	10/11/2020
Hugo Salinas/INDRA	IOP Analysis Team	10/11/2020
Lucio Caminiti/LEONARDO	IOP Analysis Team	10/11/2020
Noud De Lang/EUROCONTROL-MUAC	IOP Analysis Team	10/11/2020
Paul Guérard/DSNA	IOP OPS Group	10/11/2020
Frédéric Picard/Thales	IOP Analysis Team	10/11/2020
Peter Glombiowski/DFS	IOP Analysis Team	10/11/2020
Andrés Grijalba/Enaire	IOP Analysis Team	10/11/2020
Erik Langevi/COOPANS	IOP Analysis Team	10/11/2020
Federico Ferrari/ENAV	IOP Analysis Team	10/11/2020
Dave Lewin/NATS	IOP Analysis Team	10/11/2020

Document History

Edition	Date	Status	Author	Justification
0.3	10 Nov 20	For review	P Leplae	
1.0	18 Nov 20	For approval	P.Leplae	
1.2	23 Nov 20	Revised	P. Leplae	
1.3	8 Dec 2020	Final	P.Leplae	Last SJU comments IOP AT 72 discussion

Copyright Statement

PJ18 4DTM

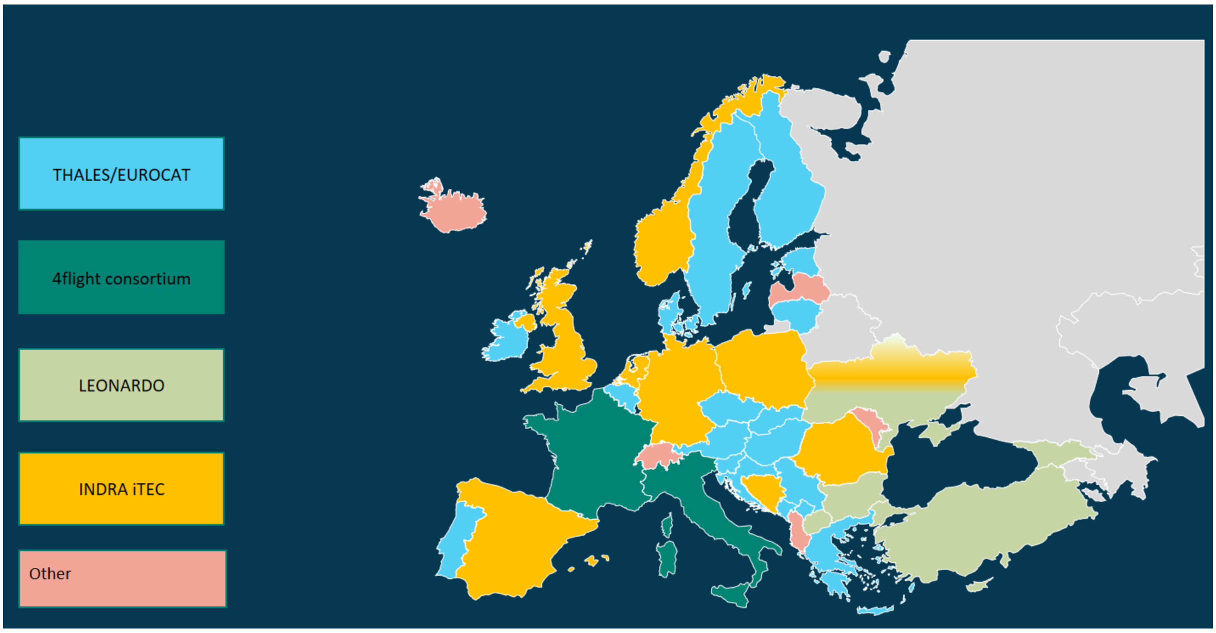
This Solution is part of a project that has received funding from the SESAR Joint Undertaking under grant agreement No 734161 under European Union's Horizon 2020 research and innovation programme.

Context:

After the withdrawal of the European FDP project (eFDP) and the segmentation of the big ATC projects into a Coflight and an iTEC camp in the early 2000's, the major ANSP's involved decided to develop a concept to exchange flight information between their different systems.

Thus, the Flight Object Interoperability (FO-IOP) Concept was developed as a compromise solution towards SingleSky despite the fragmentation.

The diagram below gives an idea of this fragmentation as it is expected in the mid 2020's:



Three ATM industries now build all centres in Europe with solutions each involving different operational concepts and requirements. This can be compared to the situation in US where two main manufacturers share the market, one for Enroute centres, one for Approaches.

FO-IOP concept and validation:

Flight Object Interoperability is a protocol to exchange Flight Data Processing (FDP) information related to planning and tactical actions, as well as trajectory, allowing to eliminate the impact of system boundaries on Controllers work and information.

Developed first through the ICOG consortium involving iTEC and Coflight ANSP's in [2005-2008], it was then, after 2010, intended to be validated in SESAR.

Despite a difficult start during SESAR 1, the project was refocused in 2016 and completed validation activities by 2020 within solution PJ18-02b.

Abstract

This 18-02b TRL6 Contextual note provides SESAR Solution description for industrialisation consideration. It summarizes the activities performed to mature the solution, and provide recommendations for the start of industrialization phase.

Table of Contents

1 Purpose

As the solution 18-02b has completed TRL6 validation, this contextual note provides the reader information about the scope of the solution, a high level assessment of the validation activities, and the status of development work.

It discusses the main outcome of the validation and also provides recommendations for future phases.

2 Improvements in Air Traffic Management (ATM)

Today communications on live traffic between ATC systems relies on OLDI messages. These messages are based on a Coordination point where transfer conditions are defined, and are well suited to most coordination activities. However they are not designed to cover well situations where route amendments are made at a boundary, where the amendments are such that the downstream centre changes, or when controllers would like to negotiate various changes to transfer conditions for instance. A Full OLDI standard partly covers these weaknesses, but its adoption level is low, and it cannot solve all situations, due to the limited information that is exchanged in OLDI messages.

Technology solution PJ18-02b, ATC-ATC Flight Object Interoperability encompasses En-route and TMA environment and provides an exchange mechanism designed to cover all operational situations. This solution is based on a set of data, called the Flight Object that all ATC's involved in a flight share and update. One of the ATS Units is responsible for updating the data on behalf of the others and for publishing the results, normally this is the Unit currently controlling the flight or that will soon control it. The solution defines the rules governing the update of this data for all stakeholders. The main advantage of this model is that it brings together the various time horizons that are involved in a flight: tactical, planning and flow and maintains the consistency between these views.

Thanks to the sharing and management of this information, the solution supports a number of operational use cases requiring the exchange of information between ATS Units:

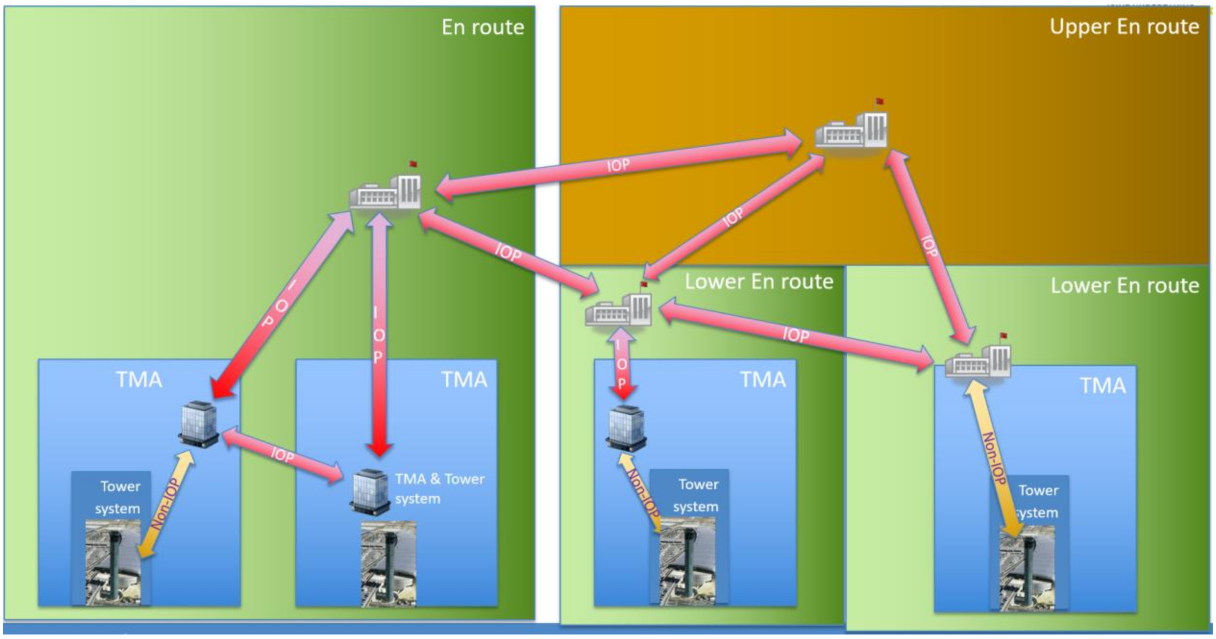
- Coordination and transfer in nominal and non-nominal situations under different release conditions
- Negotiation between different units in relation to a coordination
- Management of SSR codes across units
- Modification and sharing of route and other flight elements
- Sharing of tactical actions
- Airspace management including delegation of airspace, skip and unskip operations
- Distribution of Flight Object to non crossed Units for Situational awareness.
- Non nominal situations including:
  - Coordination of flight with multiple re-entry legs
  - Pointing a flight to an ATS unit outside the Crossed and Control sequence
  - Taking control of a flight at an ATS unit outside the Crossed and Control sequence
  - De-synchronization of Flight Object with local flight plan
- Exchange of Arrival and Departure data including AMAN information

This technology solution has been found to have the potential to provide the following benefits:

- Reduce Air Traffic Controller workload associated to coordination and transfer
- Enable more efficient flight operations and 4D profiles thanks to seamless coordination
- Support all separation processes near FIR boundaries, for instance extend the scope of tactical tools to flight remaining in the vicinity of the boundaries
- Enable route revisions across multiple FIR's

- Sharing of clearances in advance by downstream Unit
- Better estimates thanks to the sharing of all tactical and planning orders will enable better flow management and improved AMAN performances.
- Support dynamic sectorization and flexible airspace management

The solution describes exchanges between upper airspace and lower airspace centres as well as exchange between Approach centres and Enroute centres above and can support various configuration of centre configurations as shown below:



3 Operational Improvement Steps (OIs) & Enablers [DS21]

The technological solution has matured the following Operational Improvements and enablers

Note: Main focus was on operational use cases that are needed to deploy the two operational improvements from the ATM Master Plan as shown below. This focus should be considered when defining a deployment scope for FO IOP by operational stakeholders. This focus should be considered as well when defining the scope for the revised FO IOP standard Eurocae ED133.

3.1 POI's

POI-0016-IS	Basic IOP for G/G data sharing between En-Route ATC centres	Sharing of consistent flight data (including trajectory) and same view of the flight between all involved en-route ATC units. Including enhanced electronic negotiation features for seamless coordination, transfer and dialogue through instant data sharing
POI-0050-IS	Basic IOP for G/G data sharing between En-Route and TMA ATC centres	Sharing of consistent flight data (including trajectory) and same view of the flight between all involved en-route and TMA ATC units. Including enhanced electronic negotiation features for seamless coordination, transfer and dialogue through instant data sharing. Extension of POI-0016-IS to ENR-TMA interface

3.2 Enablers

ER-ATC-160a[1]	ATC to ATC Flight Data Exchange for En-Route Basic-IOP using the Flight Object	Implement ground-ground flight data exchange between En-Route ATC units through the use of Flight Object services based on a revised Flight Object EUROCAE Ed.133 specification, in order to support exchange of flight data at a functional level covering at least all current implementations of the OLDI standard for coordination and transfer. This shall include functionalities supporting negotiation between neighbouring units.

[1] CR 5035 (DS21) in progress to add missing links to EATMA elements

APP-ATC-177[2]	ATC to ATC Flight Data Exchange in a TMA environment	Implement ground-ground flight data exchange between ATC units in a TMA environment, through the use of Flight Object services based on a revised Flight Object, in order to support exchange of flight data at a functional level covering at least all current implementations of the OLDI standard for coordination and transfer. This shall include functionalities supporting negotiation between neighboring units.
ER-ATC-176[3]	FO Recovery mechanisms and failure scenario	Support for loss of IOP nodes full functionality in various configuration, resilience to failure cases and recovery of Flight Object after node failure.
SVC-035	Update the Flight Object Services for Basic- IOP with more precise interface definitions	Provision of the Flight Object services for Basic-IOP including ATC Flight Object Control and Shared Flight Object service interfaces

Other enablers linked to the solution were not further developed within the solution:

ATC-STD-01[4]	Ground-Ground flight data exchange	EUROCAE WG 59 Flight object ATSU/ATSU and ATSU/NM: update of ED-133 rev A Flight Object Interoperability Specifications (FOIS) to align with Blue Profile.
SWIM-APS-05a	Provision and Consumption of Flight Object Sharing services	Provision and Consumption of Flight Object Sharing services (In line with AIRM and ISRM) covering: - Flight Object Creation, Distribution, Cancellation, Update and Reception - Airport DPI contribution to the FO Stakeholders involved in FO Sharing - ANSPs Civil and Military, Network Manager, Airport Operators Civil and Military, Airspace Users (FOC and WOC)
SWIM-INFR-01a	High Criticality SWIM Services infrastructure Support and Connectivity.	Provision of the additional functionality needed by the individual Stakeholder to support their SWIM applications in the provision/consumption of High Criticality SWIM Service.

[2] CR 5034 (DS21) to update missing links to EATMA elements

[3] CR 5036 (DS21) to update missing links to EATMA elements

[4] CR 4974 (DS21) to remove NM from definition of ATC-STD-01 and update availability date

		This enabler addresses the need for each stakeholder to provide the necessary additional functionality to address the messaging protocol, security, resilience, and other SWIM Profile related aspects for the provision/consumption/ exchanging of these High Criticality types of SWIM Services with other stakeholders, by means of Internet Protocol (IP) connectivity via in-common IP network(s).

4 Background and validation process

This solution is building upon SESAR Solution 28, named iIOP, which has allowed to mature the SWIM Blue Profile on which solution 18-02b is built.

During SESAR 1, in order to mature Solution 28, the following validation exercises were run:

- VP-022, run in [Nov 2013 - Feb 2014] has run a series of use cases illustrating IOP basic mechanisms and coordination exchanges through IOP. The outcome of the exercise was not good and none of the use cases could be considered as successfully validated
- VP-711, run in [Dec 2014 – Nov 2015] was attempting to run the same series of use cases as VP-022 but only between FDMP and FDC. The use cases were partially validated during this exercise. The validation results were satisfactory when testing two IOP Units but were much degraded when the tests were grouping three IOP Units.
- VP-841, run in July 2016 was validating SKIP and POINT Use Cases successfully.

Solution PJ18-02b is the continuation of this solution. It has been structured through a list of Use Cases for which we distinguished nominal and non-nominal situations. The validation scope was defined in relation to these Use Cases with the following apportionment between the three validation exercises:

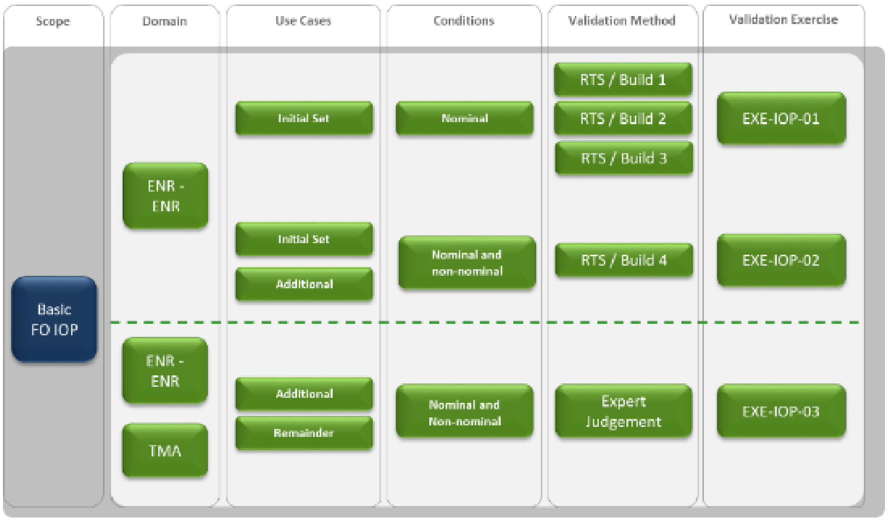


Figure 1: PJ18-02b validation exercises scope

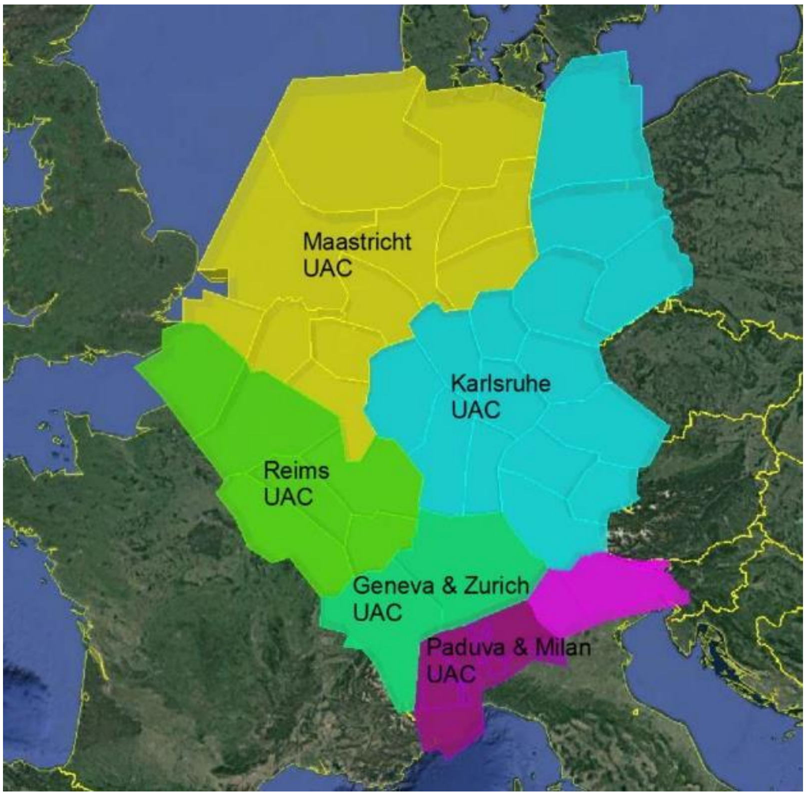
The following validation exercises were run as shown on the Figure above:

- EXE-IOP-1, run in April 2019: this test was considered successful but 4 main issues were identified:
    - Interconnection amongst systems: make the systems less critical, more flexible in accepting shared data
    - Vertical constraints management: principle differences between iTEC and Coflight approach

- Different route expansion rules outside the IOP area in Coflight and iTEC
- Expanded Route information issues

- A re-run of EXE-IOP-1 on factory platforms, which successfully proved the corrections of the four issues above, was organized in November 2019.

- EXE-IOP-2 was run in May 2020, with a system more able to cope with non-nominal cases. A test was successfully run with more than 200 flights and 4 systems interconnected with the same airspace and configuration as for EXE-IOP-1, shown here:



Maastricht UAC was handled by a MUAC test system in Maastricht

Karlsruhe UAC was handled by a DFS test platform in Langen

Paduva and Milan UAC were handled by an ENAV test platform in Roma

Reims, Geneva and Zurich UAC were handled by a DSNA test platform in Toulouse

The issues found during EXE-IOP-2 could not be analysed exhaustively due to limitations of the platforms in the COVID context. The analysis done on a relevant selection of issues has shown that all seen problems were linked to Software bugs, and no new design issue was identified, besides the ones already identified during technical meetings (see chapter 6)

- EXE-IOP-3 consisted of expert judgement sessions that were organized during 2020.

Originally it was planned to perform a very large-scale demonstration in a live traffic environment on the FO IOP solution within the SESAR 2020 Wave 1. An associated VLD project PJ27 IOPVLD was planned during the early project definition phase in 2016 and 2017. Unfortunately, in summer 2017 the SESAR Programme Committee decided to terminate PJ27 due to manpower resource issues and to assign high priority on solution PJ18-02b. Consequently, similar large-scale demonstrations and verifications with live traffic therefore needs to be exercised during the industrialisation and deployment phases.

5 Results and performance achievements

5.1 Validation results

The following figure provides an overview of the status of the validation objectives at the end of solution 18-02b, by looking at the 21 Use Cases validated through platform validation:

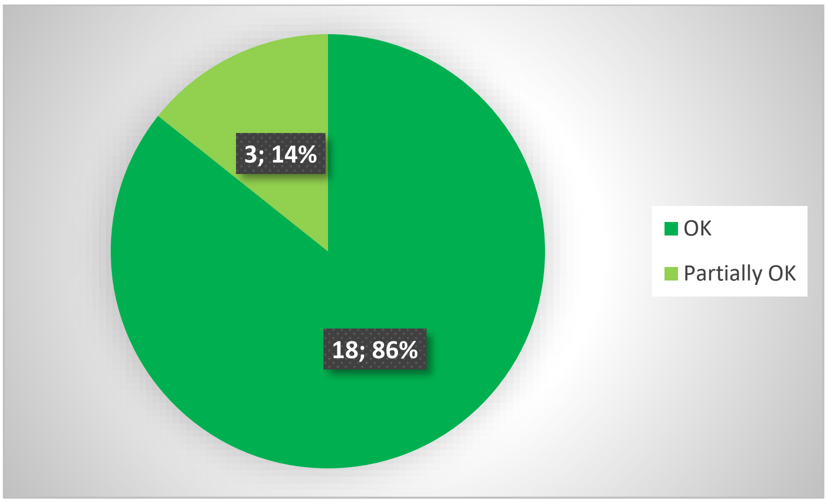


Figure 2: Validation status per use Case

In addition 37 use cases have been validated by expert judgement. The validation plan has established that because the 21 use cases above were the most significant ones we can consider sufficient to validate the 37 others through this process.

Expert judgement process looks at a given Use Case by checking how all the steps will be implemented in the ICD and checking that all experts can understand how the use case will work. The Use Case or the associated requirements and ICD are corrected if need be until a satisfactory outcome.

The prototype validation in the two exercises EXE-IOP-1 and EXE-IOP-2 has allowed some level of assurance that the solution is mature, by exercising more than 200 flights extracted from a random day of traffic in the busiest area of Europe (See map above).

The stability of the platforms during the exercise was very good and there was very few crashes observed. The majority of validation runs were executed in a configuration of just 2 system platforms and a subset of validation runs was executed with 3 and 4 system platforms. The 3 and 4 platform configurations typically allowed uncovering more technical issues than the 2 platform configuration and this means that, to be representative, all testing done in the upcoming industrialization phases should include testing with more than two system instances.

There are differences between the behaviour of IOP between cross vendor platforms (eg KUAC-REIM), same vendor platforms (eg KUAC-MUAC) and between identical FDP's(eg REIM-LIPU), with increasing reliability across the three types of links. However this difference was decreased between EXE-IOP-1 and EXE-IOP-2 as we had worked between both exercises to solve the incompatibilities between different FDP's.

5.2 Operational assessment

The testing have reserved some time slots to unscripted tests when controllers could use the system freely, with the limitation that they could only exercise use cases in the scope of the exercise.

The feedback from controllers were that when working well, IOP had potential to increase the efficiency of controllers working next to an FIR boundary, and to reduce safety hazards by enhancing the situation awareness.

Given that the platform only had in some cases partial integration of IOP in the overall ATC system, one can expect even better benefits when deploying IOP in full within ATC systems

5.3 Overall assessment

With IOP, because actions that used to be local in current systems now have repercussions on their neighbours, the IOP software is very critical as there are more interdependencies between systems, with the potential for one ACC to modify data in an other ACC.

The IOP design provides protections to ensure that the ACC controlling the flight has complete priority, but these mechanisms will need to be checked thoroughly and be allocated a high Software Assurance Level.

As all IOP partners share a trajectory covering the whole IOP area, and must each take turn to compute this trajectory, the design of the IOP solution was improved in order to increase the resilience in case of differences between the various implementation of trajectory prediction. For instance the following mechanisms are foreseen:

- Normally the list of crossed centres, which is key to drive the distribution of information, is based on the IOP trajectory, but we have added specific mechanisms to use to make corrections when some partners are aware of errors

- When large discrepancies are detected between IOP information and local systems, the system desynchronizes his view from the IOP information in a managed way. While desynchronized there are still some basic mechanisms in place to ensure that essential interoperability mechanisms are still in place.

The elements above are key to a safe deployment of IOP and were only partially validated on the IOP test platforms.

During the preparation of testing phases, a lot of time was spent in order to build a consistent data set merging the data from ENAV, DSNA, MUAC and DFS. The process was very time consuming and this reinforces the need for a common management of the AIM data. This aspect was not part of the validation and work was done in solution 18-02b1 to define the requirements for a common distribution scheme.

However, the feasibility of implementing such a service has not been validated on platform although it is a highly critical aspect of IOP.

5.4 Safety assessment

The IOP safety assessment (operational level- see annex in INTEROP, and technical level- see annex in TS) allowed to analyse the various IOP failures, assess their operational effects and identify the corresponding operational hazards and severity.

For a significant number of IOP failures, adequate mitigations have been specified as safety requirements on the IOP design in order to either prevent failure occurrence or to limit their operational effect (to a severity not higher than MAC-SC4b[5] with IM[6]<=10).

However, the risk mitigation related to the following categories of IOP failures need to be addressed in a different manner:

- A set of IOP errors or corruptions: as their worst still credible effect might display a severity MAC-SC3[7] (operational hazards Hz#02: Late tactical conflict detection due to uncoordinated flight at horizontal ATSU boundary and Hz#04: Wrong correlation with potential for erroneous coordination or late tactical conflict detection), an adequate software assurance shall apply to IOP;

- The Loss of IOP at multiple SI involves an operational effect of severity MAC SC4b with impact modification factor IM=20; that requires adequate mitigation at IOP network level in order to minimize frequency of that occurrence

Due to the safety critical nature of IOP, it is expected that the IOP should be implemented with the appropriate Software Assurance Level. This could be achieved by implementing a level of redundancy in the IOP architecture and requiring that some key modules of IOP are developed under SWAL 3.

These prescriptions may be added in the ED-133 standard in the form of recommendations or guidance material.

---

[5] A situation where an imminent infringement coming from a planned conflict that should have been resolved by Traffic planning & Synchronization was prevented by tactical conflict management

[6] IM is the Impact Modification factor to take account of additional information regarding the operational effect of the hazard, in particular related to the number of aircraft exposed to the operational hazard. See more detail here below

[7] MAC-SC3= A situation where an imminent collision was prevented by ATC Collision prevention

6 Recommendations and Additional activities

6.1 Recommendations

- An alternative solution to build the Flight Object is studied by a subset of partners to simplify and de-risk their deployment. The impact on other partners' implementation is still under technical evaluation
- There are questions on the scalability of the solution up to the whole ECAC area. Additional verification activities including large scale demonstration with live traffic will be needed to secure the deployment to the whole ECAC area. (See also Remark in Page 14)
- The lack of common strategy between NM and IOP implementers need to be addressed. IOP will be deployed in parallel with FF-ICE/1 and FF-ICE/2 and the method to manage the difference of scope (geographical and temporal) between IOP world and FF-ICE world need to be addressed.
- There are a number of questions remaining open at the end of validation. These questions were earmarked to be solved within the ED-133 Rev A standard. A working structure should be maintained to support the standard drafting work in order to continue the collaborative work.

6.2 Detailed recommendations

6.2.1 Additional Validation activities

The various processes designed to handle non-nominal or abnormal situations have only been partially tested on platforms.

We recommend to devote some time to the platform validation of these features.

The testing platform was composed of four En-route FDP's in charge of upper airspace centres. There was no system available to control flight in lower airspace so we had to limit the traffic sample in order to avoid these airspaces. This limited the representativeness of the tests.

We recommend to extend IOP testing to a fuller configuration including the lower airspace.

This would also have the benefit of testing the combination of IOP and OLDI connections for one system.

The testing done in SESAR was using an environment that may not be representative (see remark in 5.2). When future systems are developed with new FDP versions, it will be necessary to re-test the IOP functionalities with neighbouring systems:

- At least a complete testing campaign will be needed when the versions of iTEC and Coflight that are designed to be deployed with IOP are fully developed.

IOP testing may create a lot of constraints on deployment as any stakeholder may have to be involved in multiple IOP testing. We should study a process to facilitate the testing and the certification of the IOP systems before we move to deployment.

As the scope of solution 18-02b only covered the first step of IOP deployment, (so-called Basic IOP), it will also be necessary to perform further validation in order to support future deployment of TBO enabled system relying on Full IOP. In particular, future ATM concepts planned for deployments in 2035+ should be assessed and the related IOP Use Cases studied and validated. There is also a need to perform performance assessment of the quality of an ECAC wide trajectory that would be supporting IOP when it is fully deployed.

6.2.2 Additional technical work

6.2.2.1 TS completion

The requirements work in the OPS and TECH teams was using a data base where all work to be done was gathered and managed through trouble tickets:

- We recommend to continue using this system, that has proven very efficient in managing collaborative work.
- Some of the tickets will still be open at the end of SESAR. They have been tagged as having to be handled “after SESAR”. It is essential that this activity is not stopped so that the work can be properly concluded.

6.2.2.2 UC#0403 - FO Stabilization

6.2.2.2.1 Purpose

Once a new FO is distributed, all IOP Systems (System Instances or SI’s) receive it and evaluate it. If needed, they are going to request updates in the FO to adapt it to their local view. Without a given priority, various FDC could make a request on FOs that are not stable, that is, they are still being processed by upstream systems. This situation could create a flow and overlap of changes in the FO leading to an instability period.

The purpose of this topic is to ensure the stability of the FO content in the situation explained here above.

6.2.2.2.2 What has been done so far

Two solutions have been proposed by the industries to cover this need. The descriptions of the proposed solutions are recorded in trouble ticket #1174. One solution proposes a mechanism where the FDC shall wait for confirmation of its immediate upstream system. The other solution proposes a mechanism putting in place a Stabilisation period (All FDC’s notify local view being updated) and a Stabilisation sequence (Priority to FDC close to the flight).

The first one was considered as not valid for deployment by some, and the second one as too complex to solve an issue that was not observed during validation by others. So it was agreed that further analysis is required on this subject to find the right balance. Given the time left before the end of the project it was decided to postpone the finalization of this topic to the standardization activities.

6.2.2.2.3 Risks

The risk not finding a proper solution for the standardisation is considered low for two reasons:

1. Solutions exist.
2. It was reported that no Operational instability has been observed during the EXE-01 and EXE-02.

6.2.2.2.4 Recommendation

With the need to ensure scalability of IOP deployment this topic should be further studied and formalised during the standardization process.

6.2.2.3 UC#0404 – De-synchronisation and Re-synchronisation

6.2.2.3.1 Purpose

The purpose of this UC is to demonstrate the mechanism of "Coordination Failsafe Mode" that is activated by a system detecting a misalignment between the local view and the FO, but remaining capable to perform actions on the FO. For information it is also defined a "Severe Desynchronisation Mode" used when a system detects a complete misalignment, is completely desynchronized and is not able to perform any actions on the FO. This last mode is partially covered by UC#0401 and assessment of corresponding non-validated requirements are given in the non-validated Requirements assessment table present in the TS Appendix G.

6.2.2.3.2 What has been done

The UC#0404 has been completely described after an in-depth revision from the TECH group, each operational step has been attended and effectively translated into data exchanges and updates contemplated by the TECH requirements in the TS and the ICD. This Use Case has been validated by expert judgement.

6.2.2.3.3 Risks

There is a risk inherent to the Expert Judgement validation that has been performed for this UC that deserved to be prototyped and validated in real time with controller acting on the flights while one of the systems concerned by the flight desynchronized.

The UC#0404 and the TS cover the FDC/FDMP requirements signaling that an SI has entered/exited a degraded mode and the capability to support update of coordination data in specific circumstances. However, they do not cover requirements describing the behavior of the other Sis when an SI has entered a degraded mode. This implies a risk linked to the behaviour of the non-desynchronized systems.

6.2.2.3.4 Recommendations

It is recommended to further develop the specification mainly on the expected behavior of the non-desynchronized systems.

It is recommended to further validate the complete mechanism before deployment with a particular focus on the behavior of the non-synchronized system.

6.2.3 Other activities towards deployment

Since March 2020, the team work has been hampered by the effect of COVID:

- In some cases the impossibility to travel made it more difficult to continue the work, especially regarding testing and live analysis. For instance due to the lack of industry support, some trace files were lost, making it impossible to investigate the issues arisen during the corresponding test period.

- Some partners were putting staff on furlough, so we had no or limited effort from these partners for many months. This is one reason why some tickets were left open and had to be postponed to after SESAR.

- The decision of some partners to withdraw from the IOP Foundation project has changed the context of the activity, with no clear path to deployment after SESAR work.

- The removal of IOP from the CP1 proposed regulation has removed a big incentive to the IOP endorsement.

Despite these changes, it is important to plan common validation & verification activities among IOP partners and to build a common deployment roadmap.

6.3 CBA

Some partners subject their decision to deploy IOP to a positive CBA, however this may prove challenging without any hypothesis on neighbours' deployment.

In the context of ATM, ANSP's are allowed to recuperate their investments in system modernization through user charges increase provided that they can show that the benefits to the AU will outweigh the corresponding increase in their unit rate. However an isolated ANSP deploying IOP will not provide any benefit, so at a minimum, the CBA's would have to be performed by clusters of neighbouring ANSP's.

As long as IOP was part of CP1, it was included in the overall EU wide CP1 CBA as an enabler for other ATM functions.

Without this, it may be necessary to provide an EU wide CBA in order to justify a global deployment decision. However, the benefits will have to be assessed considering that the CP1 ATM functions have already been implemented.

An IOP CBA was developed at the end of the project and is included in the TS.

7 Actors impacted by the SESAR Solution

The actors impacted by this solution are Tactical and Planning controllers.

To a lesser extent FMP are also impacted

The impact of the solution is higher for the controllers in charge of sectors next to the boundary of other IOP partners, as this allows to use the IOP coordination and transfer mechanisms.

Other controllers are also impacted as they benefit from better predictions of incoming traffic as the traffic still flies in the upstream centre.

FMP are impacted because they benefit from better trajectory predictions, thus more accurate traffic counts.

8 Impact on Aircraft System

No impact on aircraft systems

9 Impact on Ground Systems

Ground systems are heavily impacted by IOP as they need to implement the following:

- Connection to PENS network
- Implementation of Blue SWIM layer
- Development of IOP layer connected or integrated to their FDP and interfacing the SWIM layer
- Modification of the FDP in order to be able to synchronize the local flight plans with the Flight Objects
- Modification of the environment data handling in order to be able to manage a central distribution of AIM data covering the whole IOP area
- Coordination of AIM acquisition process with all other IOP stakeholders
- Test and validation system modified in order to support IOP testing with other IOP partners
- Acquisition of MET data covering the whole IOP area

10 Regulatory Framework Considerations

IOP was part of the proposed PCP AF#5.6.2.

However due to the delay in implementation plans, it has been decided to remove IOP from the CP1 proposed definition. This decision must be approved at the end of 2020.

We expect that IOP be part of a future Common Project when standardization is complete and a deployment roadmap is agreed among partners.

11 Standardization Framework Considerations

The SESAR IOP work was initially based on the ED-133 standard published in 2009.

During SESAR 1, many issues were identified with this standard, and new specifications documents have been developed in SESAR 1 and then this solution.

The outcome of PJ18-02b should be used to produce a new revision of the standard.

A draft of this revision has already been produced in February 2020 and provided to EUROCAE.

We plan to take the outcome of PJ18-02b, once the TRL-6 maturity is confirmed and continue to work on this material to produce a revision of the standard in 2021. (ED-133 Rev A).

This activity is however subject to the agreement of all partners on a deployment roadmap.

12 Solution Data pack

The Solution Data Pack contains:

- D3.3.070-18-02b-TRL-6 INTEROP
- D3.3.080-18-02b-TRL-6 TS/IRS
- D3.3.060-18-02b-TRL-6 TVALR