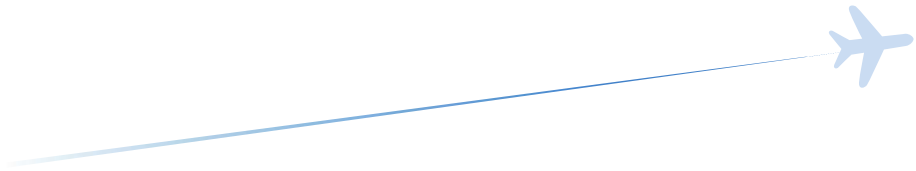

PJ.11-A3 V2 Validation Report

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Authoring & Approval

Authors of the document

Name/Beneficiary	Position/Title	Date
Eva Jošth Adamová/Honeywell	Solution Leader	12/04/2019
André Marques / Airbus	Design engineer	03/06/2019
Benoit Morizet / Airbus	Cockpit Ops engineer	12/04/2019
Marek Šolc / Honeywell	HF expert	15/04/2019
Dariia Averkova / Honeywell	HF expert	15/04/2019
Pavel Klang / Honeywell	Solution Leader	03/06/2019

Reviewers internal to the project

Name/Beneficiary	Position/Title	Date
Eva Jošth Adamová/Honeywell	Solution Leader	23/04/2019
André Marques / Airbus	Design engineer	03/06/2019

Approved for submission to the SJU By - Representatives of beneficiaries involved in the project

Name/Beneficiary	Position/Title	Date
André Marques / Airbus	SESAR Contribution Manager	03/06/2019
Tereza Spalenkova / Honeywell	SESAR Contribution Manager	07/05/2019
Bill Booth /EUROCONTROL	SESAR Contribution Manager	Approved by default

Rejected By - Representatives of beneficiaries involved in the project

Name/Beneficiary	Position/Title	Date

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CAPITO

CAPITO

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Abstract

This document provides Validation report for V2 validation activities in the frame of the solution PJ.11-A3 "ACAS for Commercial Air Transport specific operations - ACAS Xo" included in the SESAR project PJ11 "CAPITO - Collision Avoidance Performance Improvement TechnOlogy". It concludes the results from two validation exercises:

- **Workshop with digital mock-up** performed by Honeywell in fall 2018, in Honeywell facilities. The purpose of the workshop was to assess and validate principles for solution in operation and assess the maximum possible cases with variations on several parameters.
- **Real Time Simulations (RTS)** performed on Airbus integration simulator with V2 candidate prototype developed by project PJ.11-A3, in Airbus facilities with pilots from Airbus from 2018 fall to beginning of 2019. The purpose of these trials was to assess and validate principles for intruder designation, alert triggering, and associated Human Machine Interface principles in case of specific operations, such as parallel approach.

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1 Executive summary

This deliverable is the VALR - Validation Report. It aims at reporting the validation activities performed in V2 in the frame of the solution PJ.11-A3 “ACAS for Commercial Air Transport specific operations - ACAS Xo” included in the SESAR project PJ11 "CAPITO - Collision Avoidance Performance Improvement TechnOlogy".

This report provides results gathered from scenarios used for two validation exercises:

- **Workshop with digital mock-up** performed by Honeywell in 2018 fall, in Honeywell facilities. The purpose of the workshop was to assess and validate principles for solution in operation and assess the maximum possible cases with variations on several parameters.
- **Real Time Simulations (RTS)** performed on Airbus integration simulator with V2 candidate prototype developed by project PJ.11-A3, in Airbus facilities with pilots from Airbus from 2018 fall to beginning of 2019. The purpose of these trials was to assess and validate principles for intruder designation, alert triggering, and associated Human Machine Interface principles in case of specific operations, such as parallel approach.

This document includes:

- The context of the validation,
- The validation results including:
  - Initial objectives coverage (matrix)
  - Confidence that can be given in results
- A detailed view on each validation exercise with a description of the results gathered from validation scenarios (as defined in the VALP):
  - EXE01: Stakeholder workshop
  - EXE02: Real Time Simulations (RTS) on Airbus simulator

From the scope perspective, the validation results and activities captured in this document conform to VALS (Validation Strategy) content apportioned to the PJ.11-A3 solution. The activities were executed using a validation technique suitable for V2 objectives (Real-time Simulation) and, in addition addressed some remained V1 open points through Stakeholder Workshop.

From the performance perspective, results are in line with what was targeted for the solution in VALP. No validation targets were assigned to this solution at SESAR level.

This SESAR solution performed all activities as planned for V2 maturity level, however, some results are not according the expectations. In this context, the conclusions can be split to two parts:

- V2 from technical point of view:
  - ACAS Xo as defined in the ACAS Xa/Xo MOPS is technically feasible since no technical blocking point was observed (pilots were able to perform approaches with ACAS Xo activation), even if some improvements need to be done regarding HMI to comply with pilots’ feedback.

- From European operational point of view, the results don't support achieving V2 maturity:
    - While ACAS Xo system requirements are specified in ACAS Xa/Xo MOPS, **there is no detailed operational definition published for ACAS Xo procedures**, only Concept of operation being currently available.
    - Two use cases (CSPO and DNA) as defined in the ACAS Xa/Xo MOPS are not suitable for current EU airspace.

In this situation validation was performed for the two above mentioned use cases at US airports (as we did not identify any EU airport with suitable operations) using experimental operational scenarios substituting missing detailed operational and procedural definition. Unfortunately, the obtained feedback from pilots was not positive and at this stage it is not possible to clearly distinguish whether and/or to which extent the cause lies in the concept itself or in the considered cockpit/operational procedures.

2 Introduction

2.1 Purpose of the document

This document provides the Validation Report for PJ.11-A3 (ACAS Xo) solution for V2. It describes the results of validation exercises defined in VALPand how they have been conducted and provides a set of relevant conclusions and recommendations.

2.2 Intended readership

The intended audience for this document are PJ.11-A3 solution members, PJ.11 project members and SJU. At a higher programme level, the transversal project such as Content Integration project (PJ.19) which is responsible for coordination and integration of solutions, as well as development of validation strategy with appropriate validation targets, and Validation and Demonstration Engineering project (PJ.22) would make use of this document.

In addition, airspace users as main stakeholders, and standardization bodies, may have an interest in this document too.

2.3 Background

“ACAS” is a generic acronym used by ICAO for the specific line of avionics that is certified to provide decision support to pilots during encounters with other aircraft when there is an imminent risk of collision. ACAS implementation, TCAS II, is mandated for all aircraft with a maximum take-off mass (MTOM) of over 5 700 kg or authorized to carry more than 19 passengers.

Since 2008, the FAA’s TCAS Program Office (PO) initiated a research and development program under RTCA SC-147 of a new approach to collision avoidance – ACAS X. The work is done in cooperation with SJU, under aegis of FAA-SJU Coordination Plan 4.1. ACAS X has several variants which share an underlying common design, but have hardware, surveillance, and collision avoidance logic tailored for different user groups as summarized at the figure below.

User group	Surveillan Technolo
Current TCAS II users (large aircraft)	Active surveill supplemented ADS-B
Users of specific operations (e.g. closely-spaced parallel operations)	Active surveill supplemented ADS-B

Figure 1: ACAS X variants

In SESAR 1, two projects addressed the development of ACAS Xa – SESAR 04.08.01 with focus on logic and SESAR 9.47 focusing on the surveillance aspects. The work undertaken in SESAR 1 now continues in SESAR2020 as solution PJ.11-A1.

Solution PJ.11-A3, addresses a specific function of the ACAS X system, variant ACAS Xo which allows the use of alternative CAS logic for specifically designated traffic while maintaining normal ACAS Xa alerting against all other aircraft. ACAS Xo is a supplement to ACAS Xa to allow special operations such as parallel approaches that would otherwise be likely to trigger ACAS Xa alerts. Both ACAS Xa and Xo have been developed in parallel and share the same standard which was due at the end of 2018. In Europe, EUROCAE WG-75 group was tasked to develop ACAS X MOPS as a joint RTCA/EUROCAE activity.

Within the standardization activities, initial concept of ACAS Xo system was described, initial functional architecture (FAD document) published, potential uses of ACAS Xo identified, and even the testing have been done (ACAS Xo was flight tested in September 2015). From operational and HP point of view, initial human-in-the-loop evaluation has been performed by MITRE in 2015, collecting feedback on ACAS Xo. Outcome of the study is that pilots viewed the ACAS Xo concept favourably. PJ.11-A3 brings first analysis from European perspective.

2.4 Structure of the document

Sections 1 and **2** are introductory sections describing purpose of this document and its background.

Section 3 describes validation context, describes ACAS Xo in general, its mapping on PJ.11-A3 solution and provides traces to EATMA.

Section 4 introduces validation results from solution point of view.

Section 5 provides overall conclusions and recommendations.

Section 6 lists reference documents.

Appendix A and B provide more details on Validation results per exercise.

Appendix C provides maturity assessment of solution.

2.5 Glossary of terms

Term	Definition	Source of the definition
ACAS Xo Mode	An alternative ACAS X logic. Two ACAS Xo modes are included in MOPS document: DNA and CSPO-3000.	MOPS
Designated traffic	A particular traffic that has been designated by the flight crew for a particular ACAS Xo mode.	CONUSE
Un-designation	A process by which either the flight crew or automation removes the designation of traffic for an ACAS Xo alternative logic mode. When traffic is undesignated, it is returned to normal ACAS X operation	CONUSE
Valid traffic	Traffic that meets the criteria, such as data quality requirements, defined for an ACAS Xo mode. Different criteria may be defined for each individual mode.	CONUSE

Table 1: Glossary of terms

2.6 Acronyms and Terminology

Term	Definition
1090ES	1090 MHz Extended Squitter
ACAS	Airborne Collision Avoidance System
ADS-B	Automatic Dependent Surveillance - Broadcast
ATC	Air Traffic Control
ATM	Air Traffic Management
CA/CAS	Collision Avoidance (System)
CDTI	Cockpit Display of Traffic Information
CNS	Communication Navigation and Surveillance
CONOPS	Concept of Operations
CR	Change Request

CSPO	Closely Spaced Parallel Operation
DNA	Designated No Alert
EATMA	European ATM Architecture
E-ATMS	European Air Traffic Management System
FAA	Federal Aviation Administration
HPAR	Human Performance Assessment Report
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
INTEROP	Interoperability Requirements
MOPS	Minimum Operational Performance Standards
MSL	Mean Sea Level
MTOM	Maximum Take-Off Mass
NMAC	Near Mid-Air Collision
NOZ	Normal Operating Zone
NTZ	Non Transgression Zone
KPA	Key Performance Area
OI	Operational Improvement
OPAR	Operational Performance Assessment Report
OSED	Operational Service and Environment Definition
PAR	Performance Assessment Report
PIRM	Programme Information Reference Model
RA	Resolution Advisory
QoS	Quality of Service
SAC	Safety Criteria
SAR	Safety Assessment Report
SecAR	Security Assessment Report
SESAR	Single European Sky ATM Research Programme
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SPR	Safety and Performance Requirements
STM	Surveillance and Tracking Module
SWIM	System Wide Information Model
TA	Traffic Advisory

TCAS	Traffic Collision Avoidance System
TOPA	TCAS Operational Performance Assessment
TRM	Threat Resolution Module
TS	Technical Specification

Table 2: Acronyms and terminology

3 Context of the Validation

3.1 SESAR Solution PJ.11-A3_ACAS for Commercial Air Transport specific operations – ACAS Xo: a summary

SESAR solution under the scope of this Validation Report was ACAS Xo. ACAS Xo is a mode of operation of ACAS X designed for particular operations for which ACAS Xa is unsuitable and might generate an unacceptable number of nuisance alerts (e.g. procedures with reduced separation, such as closely spaced parallel approaches).

ACAS Xo is integrated with ACAS Xa systems, but activation of the ACAS Xo functionality is optional (through dedicated HMI). It provides additional collision avoidance logic modes designed to support closely-spaced flight operations and allows specifically designated traffic to be monitored by an alternative ACAS logic more compatible with the flight operation than the standard ACAS Xa logic. So far, there are two Xo modes defined by EUROCAE/RTCA in MOPS:

1. Closely Spaced Parallel Operations from 4,300ft down to 3,000ft runway separation mode (**CSPO-3000**) which provides designated traffic with modified CAS logic monitoring more appropriate for parallel operations; applicable in both visual and instrument conditions. ACAS Xa protection is maintained on all other cooperative traffic.

2. Designated No Alerts mode (**DNA**) which suppress all alerts and guidance (except during multi-threat encounters) on the specifically designated traffic; requiring flight crew to visually acquire the desired traffic before designating it and then maintaining visual separation from the DNA-designated aircraft. This mode is intended for use in closely-spaced operations on visual conditions, where ACAS Xa alerts would otherwise be a nuisance, ignored, and/or disruptive. DNA mode may be used instead of placing ACAS Xa into TA-only mode, preventing alerts on the designated traffic but still allowing full ACAS Xa protection from all other cooperative traffic. DNA mode is also applicable for parallel runways where separation is below 2500ft.

Additional ACAS Xo modes are expected in the future, however only CSPO-3000 and DNA are defined in ACAS Xa/Xo MOPS published in 2018.

OI step and enablers associated to the solution (~~applicable~~ from EATMA version: PUBLIC DS17b — early 2018 the model was updated in EATMA V13.0 Draft / DS20 Draft) are listed in the table below.

SESAR Solution ID	SESAR Solution Description	Master or Contributing (M or C)	Contribution to the SESAR Solution short description	OI Steps ref. (from EATMA)	Enablers ref. (from EATMA)

PJ.11-A3	ACAS for Commercial Air Transport specific operations - ACAS Xo	M	N/A	CM-0808-o (Collision Avoidance for commercial air transport Adapted to New Separation Modes)	A/C-54a: Enhanced Airborne Collision Avoidance (ACAS) A/C-54b: ACAS adaptation to new separation modes

Table 3: SESAR Solution under Validation

3.2 Summary of the Validation Plan

3.2.1 Validation Plan Purpose

The purpose of validation was to evaluate a solution providing two ACAS Xo modes called DNA and CSPO-3000, allowing specific operations in approach (refer to next chapter for a deeper insight of the solution). The validation activities aimed at evaluating the following items:

- ACAS Xo alerting logics,
- ACAS Xo designation operational acceptability,
- ACAS Xo automatic un-designation operational acceptability,
- ACAS Xo HMI and ACAS Xo algorithm acceptability at human factor perspective,
- the adapted Navigation Display symbology,
- ACAS Xo Safety assessment;

Regarding **operational environment**, ACAS Xo application can be used in airspace of any traffic density, without any additional ground equipment. For CSPO-3000 mode, operational environment is currently limited and cannot be used at high altitudes, above 14 000ft. Both modes of ACAS Xo are applicable during approaches since most of the nuisance RAs occur in this phase of flight, while DNA is not limited only to approaches and could be potentially used for other closely spaced flight operations. Current definition of DNA however limits it application for visual conditions only. CSPO-3000 operation is possible in both visual and instrument conditions.

Regarding **geographical environment**, the scenarios were defined based on the study performed from US scenarios. However, these items had to be rigorously similar in case of potential future European ACAS Xo operation (there is already a need for European Operators frequently serving destinations in the US). As a consequence, identified airport for DNA mode testing was SFO (San Francisco) and airport for CSPO-3000 have been initially picked up from one of European airports with parallel runways.

Validation exercises have been addressed both with workshop using a digital mock-up and with test sessions in a simulator with actual equipment in accordance with project PJ11-A3.

3.2.2 Summary of Validation Objectives and success criteria

The following three validation objectives at solution level were identified at the time of the VALP redaction.

3.2.2.1 OBJ-PJ.11.A3-V2-VALP-001: European ACAS Xo use cases

Objective	Identify potential use cases for the ACAS Xo capability within current and future European operations.

Success Criterion	Identifier
Potential use cases for ACAS Xo capability within current or future European operations identified.	CRT-PJ.11.A3-V2-001-001

3.2.2.2 OBJ-PJ.11.A3-V2-VALP-002: ACAS Xo suitability

Objective	Evaluate the suitability of the current ACAS Xo implementation in Europe.

Success Criterion	Identifier
V1 and V2 operational aspects assessed.	CRT-PJ.11.A3-V2-002-001
HMI aspects assessed including pilots in the loop.	CRT-PJ.11.A3-V2-002-002
ACAS Xo alerting algorithms evaluated.	CRT-PJ.11.A3-V2-002-003

3.2.2.3 OBJ-PJ.11.A3-V2-VALP-003: Potential for tailored European ACAS Xo version

Objective	Identify the benefits potentially achievable by a tailored European ACAS Xo version and define high-level requirements on such a function.

Success Criterion	Identifier
Potentially achievable benefits of tailored European ACAS Xo version identified.	CRT-PJ.11.A3-V2-003-001
High-level requirements on potential European ACAS Xo version defined.	CRT-PJ.11.A3-V2-003-002

3.2.3 Validation Assumptions

No solution-level validation assumptions identified.

Please refer to chapter B.1.4 for exercise-level assumptions on Validation Exercise #02.

3.2.4 Validation Exercises List

[EXE]

Identifier	EXE-PJ.11.A3-V2-VALP-001
Title	Workshop
Description	Stakeholder Workshop was focused mainly on the definition of ACAS Xo operational procedures. The discussion planned to cover two ACAS Xo modes –CSPO-3000 and DNA. A low fidelity digital mock-up of ACAS Xo HMI was developed and presented to the participants to help them define and validate the operating method.
Expected Achievements	Progress with the undefined operational aspects of ACAS Xo, and answer the questions on its applicability in European airspace.
V Phase	V1 / V2
Use Cases	N/A
Validation Technique	Focus Group
KPA/TA Addressed	Safety, Human Performance
Start Date	27/11/2018
End Date	28/11/2018
Validation Coordinator	Honeywell
Validation Platform	N/A
Validation Location	Prague, Czech Republic
Status	<completed>
Dependencies	N/A

[EXE Trace]

Linked Element Type	Identifier
<SESAR Solution>	PJ.11-A3

<Sub-Operating Environment>	N/A
<Validation Objective>	OBJ-PJ.11.A3-V2-VALP-001 OBJ-PJ.11.A3-V2-VALP-002 OBJ-PJ.11.A3-V2-VALP-003

[EXE]

Identifier	EXE-PJ.11.A3-V2-VALP-002
Title	Real-time Simulations on Airbus simulator
Description	Operational evaluation through real-time simulation with pilots in-the-loop. The purpose was to validate principles for ACAS Xo alert triggering/inhibition, and associated Human Machine Interface, for special operations such as parallel approaches that could cause nuisance RA alerts with surrounding traffic without this solution.
Expected Achievements	Pilots operational feedback on the solution, validating operational principles for ACAS Xo
V Phase	V1 / V2
Use Cases	DNA approach at US airport; CSPO-3000 approach at European airport
Validation Technique	Real-time simulation
KPA/TA Addressed	Safety, Human Performance
Start Date	28/01/2019 (28/01/2019 at time of VALP writing)
End Date	22/02/2019 (27/02/2019 at time of VALP writing)
Validation Coordinator	Airbus
Validation Platform	Airbus A320 simulator
Validation Location	Toulouse, France
Status	<completed>
Dependencies	N/A

[EXE Trace]

Linked Element Type	Identifier
<SESAR Solution>	PJ.11-A3

<Sub-Operating Environment>	N/A
<Validation Objective>	OBJ-PJ.11.A3-V2-VALP-001 OBJ-PJ.11.A3-V2-VALP-002

Table 4: Validation Exercise layout

3.3 Deviations

3.3.1 Deviations with respect to the SJU Project Handbook

Use cases from US scenarios

Validation use cases are derived from US scenarios. There are no use cases known in the European environment today. There are parallel runways also at European airports, but the way they are used operationally have not resulted in frequent TCAS nuisance alerts, unlike at several locations in the US. In order to prepare to potential future European ACAS Xo operation, the scenarios should imply a US airport but also an European airport. The latter should be chosen among airports that could be subject to potential nuisance RA if the future traffic demand in Europe would lead to change in operations on parallel runways (finally, picking up an European airport for validation on simulator has not been possible: it will be explained later in this document, refer to following section and to section B.2).

Coexisting V1 and V2 maturity levels

This project was directly introduced at V2 level in SESAR 2020 (not existing in SESAR 1). The maturity level of this SESAR solution currently differs for the system (technical), more mature thanks to standardization activities, and Human Performance (operational) aspects, where some aspects still need to be addressed from V1 perspective. For this reason, validation activities described in this document are covering not only V2, but also missing V1 objectives. This should allow staying in line with Validation Strategy related to the SJU handbook project.

3.3.2 Deviations with respect to the Validation Plan

Compared to the items to evaluate to reach the **overall aim** of the validation activities (as described in chapter 3.2.1), there have been slight deviations for evaluations on simulator (EXE-2). Compared to initial plan during evaluations on simulator (RTS), the following deviations were identified:

- *ACAS Xo alerting logics*; during simulator evaluation, global feedback from pilots was collected on logics rather than detailed timing of alerts, because the perception of timing is uneasy for pilots.
- *ACAS Xo un-designation*; operational acceptability was covered during simulator evaluation based on its automatic behaviour (most common) but manual un-designation was addressed only during discussions,
- *Candidate airports for evaluations*; scenarios were modified in order to include Portland airport instead of Madrid as defined initially in the Validation Plan for CSPO-3000 mode testing. The scenarios were initially planned on Madrid but, when tuning this reference scenario, no alert was triggered because ACAS Xa logics are already lowering nuisance alerts.

Portland airport was rather chosen, because of its configuration suitable with Xo scenarios. Only the airport was modified, the scenario principle was kept unchanged.

- *Airbus simulator configuration*; emulated display was installed in central position.

More details and justifications are given in chapter B.2.

4 SESAR Solution PJ11-A3 Validation Results

4.1 Summary of SESAR Solution PJ11-A3 Validation Results

SESAR Solution Validation Objective ID	SESAR Solution Validation Objective Title	SESAR Solution Success Criterion ID	SESAR Solution Success Criterion	SESAR Solution Validation Results	SESAR Solution Validation Objective Status
OBJ-PJ.11.A3-V2-VALP-001	Identify potential use cases for the ACAS Xo capability within current and future European operations.	CRT-PJ.11.A3-V2-001-001	Potential use cases for ACAS Xo capability within current of future European operations identified.	No use cases for ACAS Xo have been clearly identified for now in Europe, either from discussions with stakeholders or from experimental application into simulator with pilots in the loop. The situation can however change in the future: if the traffic increases, it would lead to the need for increased airport capacity through building additional (parallel) runways aimed for parallel approaches. From ATC point of view, ACAS Xo might then be useful and could help to reduce missed approaches, especially in dense traffic. But it should be considered that ACAS Xa already solves many problems as it reduces drastically the unnecessary alerts.	NOK
OBJ-PJ.11.A3-V2-VALP-002	Evaluate the suitability of the current ACAS Xo implementation in Europe.	CRT-PJ.11.A3-V2-002-001	V1 and V2 operational aspects assessed.	Most operational aspects could be assessed. However, ambiguity regarding the distribution of responsibilities and involvement of ATC into ACAS Xo procedure has been raised in both exercises, and should be further developed.	Partially OK
		CRT-PJ.11.A3-V2-002-	HMI aspects assessed including pilots in the	HMI could be assessed in details thanks to both static evaluation with stakeholder workshop and dynamic evaluation with simulator sessions with pilots in the loop. Although some parts of HMI design are not	Partially OK

		002	loop.	acceptable "as is" (in particular, in terms of workload increase) and would need several improvements, this allowed to collect pertinent remarks and suggestions that would allow further developments to make it acceptable.	
		CRT-PJ.11.A3-V2-002-003	ACAS Xo alerting algorithms evaluated.	ACAS Xo alerting algorithms were evaluated. CSPO-3000 mode did not raised any major issues, but **DNA mode is mainly pointed out as unacceptable** as it removes the TA/RA alerts and then a last safety net with an intruder, with the risk of potential error in the identification/designation.	Partially OK
OBJ-PJ.11.A3-V2-VALP-003	Identify the benefits potentially achievable by a tailored European ACAS Xo version and define high-level requirements on such a function.	CRT-PJ.11.A3-V2-003-001	Potentially achievable benefits of tailored European ACAS Xo version identified.	No benefits for a tailored European ACAS Xo version are identified but, based on feedback received during Stakeholder Workshop, a number of operational open points and recommendations (available in the conclusion section) have been identified in order to be addressed prior ACAS Xo becomes operational in Europe.	~~Partially~~ NOK
		CRT-PJ.11.A3-V2-003-002	High-level requirements on potential European ACAS Xo version defined.	Main high-level requirements have been defined.	

Table 5: Summary of Validation Exercises Results

4.2 Detailed analysis of SESAR Solution Validation Results per Validation objective

4.2.1 OBJ-PJ.11.A3-V2-VALP-001 Results

The solution objective OBJ-PJ.11.A3-V2-VALP-001 was to identify potential use cases for the ACAS Xo capability within current and future European operations.

Identification of potential use cases for ACAS Xo capability in Europe

The activities around identification of potential use cases for ACAS Xo capability in Europe analysis from both exercises showed that:

- In the US the ACAS Xo would very likely decrease the number of cases when ACAS is set to TA-only mode. In the European area, a more conservative environment, TA-only mode usage is not so frequent, and data on such occurrences are not available.
- There are a few airports with parallel runways in Europe (such as Malpensa, Madrid, or Bucharest), but those do not apply parallel approach procedures since there is no such demand in terms of traffic.
- At this moment, ACAS Xo operations could potentially help in Europe in situations which involve military or rescue helicopters based at the civil airport, or general aviation in TMA areas. In such situations, possibility to apply DNA mode on the traffic would be useful to avoid triggering unnecessary RA. However, procedures in this situation have not been designed in the frame of these validation exercises.
- During the simulator validation exercise, the approaches were flown based on currently existing procedures. Specific procedures could not be determined and integrated in flight crews' tasks during concerned operations.
- The feedback from flight crews is that specific procedures are required and moreover, the potential use of the ACAS sub modes should be part of the approach briefing.
- It was noticed that ACAS Xa logics already reduces significantly the unnecessary alerts.

Summary

This **objective OBJ-PJ.11.A3-V2-VALP-001 is not met** as no use cases for ACAS Xo have been clearly identified for now in Europe, either from discussions with stakeholders or from experimental application into simulator with pilots in the loop.

The situation can however change in the future: if the traffic increases, it would lead to the need for increased airport capacity through building additional (parallel) runways aimed for parallel approaches. From ATC point of view, ACAS Xo might then be useful and could help to reduce missed approaches, especially in dense traffic. But it should be considered that ACAS Xa already solves many problems as it significantly reduces the unnecessary alerts.

4.2.2 OBJ-PJ.11.A3-V2-VALP-002 Results

The solution objective was to evaluate the suitability of the current ACAS Xo implementation in Europe.

V1 and V2 operational aspects assessment

The goal of this success criterion was to ensure that identified V1 gaps in validation activities are addressed together with V2 expectations. During HP VALP preparation, following V1 gaps in evidence were identified and decided to be addressed in this V2 validation:

- Normal operating conditions are defined. Where possible initial needs/ requirements relating to the operating methods for normal operating conditions may be identified. (Operating methods cover operations in normal operating conditions.)

- For preliminary operating methods defined, the content has been determined to be clear and non-contradictory by end users. (The content of operating methods is clear and consistent (in V1: non-contradictory).)

- The potential changes to the level of workload/task demands and the preliminary mitigation identified are acceptable (acceptable can be defined based on end-users opinion and good HF practice relating to workload).

- Where possible, initial needs/requirements to support end-users acquisition of a mental model of the automated function are identified. (Human actors can acquire an adequate mental model of the machine and its automated functions.)

The operational aspects analysis from both exercises showed that:

- ACAS Xo would require **regulatory updates** as well as pilot training. Regulations should consider making ACAS Xo training compulsory, regular and recurring. **Responsibility and reporting** policies will need to be clearly thought out. Should the responsibility of removing or reducing the safety net be on the flight crews' shoulders, they will not accept to take the risk.

- It was difficult to assess whether overall **situation awareness** is going to increase or decrease. A lot will depend on the system design and implementation. Situation awareness could increase due to higher confidence in issued RAs (due to smaller number of nuisance RAs). But situation awareness might decrease due to pilots constant monitoring of one target, or in case of loss of out-the-window visual of the target;

- **Normal operating conditions** for ACAS Xo have been defined as Closely Spaced Parallel Runway Operations. Initial needs and issues identified, but **further research and clarification** is needed. Procedure will greatly depend on the particular environment where it is going to be implemented. Many open points remain.

- There was some ambiguity regarding **involvement of ATC** into ACAS Xo procedure. Pilots required ATC to be involved to inform the crew for the parallel traffic **early** in the approach procedure. In real heavy surrounding traffic, flight crews will not be able to identify and designate without ambiguity the right target without ATC help. ATC involvement is then necessary to **perform the designation task**. There is need to:

    - include possible ACAS Xo usage in approach briefing and have information about the mode applicable (DNA or CSPO) on the explicit airport.

    - have prescribed use of ACAS Xo together with tasks and responsibilities of ACAS Xo involved parties (FC and ATC) as well as communication rules within ACAS Xo operations.

- The **amount of time** it took to set up ACAS Xo within the mock-up session was acceptable, but the simulator validation exercise brought this **was not acceptable** with realistic operational environment. In short final approach, workload is high, and flight crews have not sufficient resources to activate the ACAS Xo function. Moreover, it is likely that ACAS Xo will not be frequently used by an individual pilot, which might generate hesitation in activating the function and contribute to higher workload when using ACAS Xo.

- Globally the flight crews activated the ACAS Xo function, but in case of any doubt or in high workload situation, the crew does not activate and tend to ignore the ACAS Xo function. But the safety level remains sufficient with the traditional alerting threshold for TA/RA.

HMI assessment with pilots in the loop

The HMI aspects analysis from both exercises showed that:

- For **target identification**, potential for errors is quite high. Possibility of designating wrong target is quite high with ACAS Xo DNA mode, since visual acquisition is feasible only during good VMC conditions. The flight crew does not have sufficient information to quickly analyze the situation and the right target. However, no mistake due to the function use was observed during the mock-up session, or during the evaluations as flight crews rather ignore the function in tricky situations.

- When **automatic un-designation** of traffic occurred, pilots immediately provided the appropriate reaction to eventual RA. But the information about automatic un-designation should be provided to the FC together with mode acquired. It was observed that HMI feedback is necessary to inform pilots when an automatic un-designation occurs. Automatic un-designation rules (and differences between CSPO and DNA un-designation mechanisms) should be clarified and made more intelligible for pilots: that would ease function acceptability.

- **Target selection** to select the required aircraft as ACAS Xo target was mostly found easy and sufficiently usable. The sequence of steps regarding the target selection and mode selection might be implemented differently in each aircraft ownship type. On simulator, the flight crews were satisfied with the ATSAW selection with traffic selector and found the target selection easy. On the contrary, the flight crews were reluctant for the ACAS Xo activation through MCDU, with more risks to select the wrong aircraft (one occurrence during the evaluation). Next possible mitigation would be an automatic mode selection.

- **Modes activation** was found easy and sufficiently usable during mock-up sessions. No errors were reported or observed. But on simulator, flight crews spend too much time head-down to activate the function, which is not acceptable during this phase of approach. Globally, the HMI (especially through MCDU) was **not mature enough** to allow activation with a correct workload and without impact on safety.

- Participants managed to **manually de-activate** ACAS Xo. Most of them found it easy and sufficiently usable. Some errors were made, but they can be attributed to the low fidelity of the mock-up and fixed scenarios - tailored for particular use case and success flow only. This could not be addressed with simulator.

- For **situation awareness**, HMI labels of selected mode have been found helpful and useful to maintain awareness of the selected mode. However, one of the participants expressed concerns regarding **potential clutter** on navigation display using the current mode labels. Moreover, the flight crews were not always comfortable on simulator with the **wording proposed** for the sub mode selection.

ACAS Xo alerting algorithms evaluated

No alerting in DNA mode was found unacceptable for most of the pilots. Removing the TA/RA alerts as a last safety net with an intruder is not acceptable if a risk of potential error in the identification exists. Even if visual contact shall be maintained with the intruder during DNA mode, crew may track visually an intruder which is not the one that has been designated through the HMI. The delay of CSPO-3000 mode alert is acceptable. The information about automatic un-designation should be provided to the Flight Crews, as already identified in the section above.

Summary

This **objective OBJ-PJ.11.A3-V2-VALP-002 is partially met** as :

- Most **operational aspects could be assessed**. However, ambiguity regarding the distribution of responsibilities and involvement of ATC into ACAS Xo procedure has been raised in both exercises and should be further developed.
- **HMI could be assessed in detail** thanks to both static evaluation with stakeholder workshop and dynamic evaluation with simulator sessions with pilots in the loop. Although HMI design is **not acceptable "as is"** (in particular, in terms of workload increase) and would need several improvements, this allowed to collect pertinent remarks and suggestions that would allow further developments to make it acceptable.
- ACAS Xo **alerting algorithms were evaluated**. CSPO-3000 mode did not raised any major issues, but **DNA mode is mainly pointed out as unacceptable** as it removes the TA/RA alerts and then a last safety net with an intruder, with the risk of potential error in the identification.

For these reasons, current ACAS Xo implementation is not suitable (at least in Europe) and would need further modifications.

4.2.3 OBJ-PJ.11.A3-V2-VALP-003 Results

The objective was to identify the benefits potentially achievable by a tailored European ACAS Xo version and define high-level requirements on such a function.

Identify the benefits potentially achievable by a tailored European ACAS Xo version and define high-level requirements on such a function

There was no need identified for tailored European ACAS Xo version during the exercises. Addressing tailored European ACAS Xo version and its potentially achievable benefits was dependent on PJ.11-A1 EXE-05 (EUROCONTROL exercise). Since initial EUROCONTROL analysis on European future operations did not identify candidate operations, the scope of EXE-05 was changed and did not address European future operations. Instead, a complementary study – ACAS Xa verification in European environment, was performed.

Regarding high-level requirements on potential ACAS Xo version, the main one is linked to assumed minimum equipage for its operation. ACAS Xo ownship is expected to be equipped with Mode S transponder and 1090 ADS-B OUT equipment (which will be the case to meet the US/European mandates), integrated ASA System including CDTI, and any other flight deck systems or displays required to support specific ACAS Xo operations.

Summary

As a summary, in the frame of this VALR, this **objective OBJ-PJ.11.A3-V2-VALP-003 is partially met**. No benefits for a tailored European ACAS Xo version are identified but, based on feedback received during Stakeholder Workshop, a number of operational open points and recommendations (available in the conclusion section) has been identified in order to be addressed prior ACAS Xo becomes operational in Europe.

4.3 Confidence in Validation Results

4.3.1 Limitations of Validation Results

During Stakeholders Workshop (EXE-1), one of the challenges of the exercise was the absence of clear use cases for ACAS Xo in Europe due to the layout of airports and probably infrequent nuisance TCAS alerts (no publicly available data on the frequency of occurrence). Therefore, the participants, all of whom work in the European context, could not base the discussion on solving the problems of today, but rather those of the future.

Some similar limitations were encountered for simulator evaluation with pilots (EXE-2, refer to § B.3.41) in order to define and run realistic scenarios, but they were well integrated by the flight crews and they projected the use of the function in more realistic conditions as well, giving insights on ACAS Xo in busy airspace.

At solution level, global limitation was absence of existing clear use cases for ACAS Xo in Europe, that needed to adapt both exercises to the present reality. But the experience and background of participants of both exercises allowed to integrate this situation and to project discussions and evaluations on the problems of the future.

4.3.1.1 Quality of Validation Results

The results from Stakeholders Workshop (EXE-1) can be considered having high quality since the opinions collected came from a mixture of operational experts from different aviation domains (ATM, pilots, ATCs, Human Factors). Thus, workshop conclusions represent a high-level guidance on further development of the concept and a possibility to extend its use to the European environment.

The simulator evaluation with pilots (EXE-2) accuracy of the results can be considered as intermediate as the function was exposed for a limited flight crew number (2 crews). Nonetheless, the obtained results were quite converging for both crews, and the problems raised were similar. Therefore, we can be confident that the results can be extrapolated to a wider pilot's population.

At solution level, global quality of results is then considered as high, and could be used as guidance for a further development of the ACAS Xo concept in the European environment.

4.3.1.2 Significance of Validation Results

The results from Stakeholders Workshop (EXE-1) cannot be considered conclusive, but only preliminary, since they are based on opinions of participants not placed in a realistic experimental environment. However, considering the current maturity level of the Solution, these results are considered sufficient.

The results from evaluations with pilots on simulator (EXE-2) are operationally significant:

- even if the scenarios were simplified compared to a real airport environment, the exercises were performed with realistic parameters: traffic behavior, communication with ATC (even simplified), approach procedures unchanged
- only counterpoint is that, despite their wide competences, participating flight test pilots did not have operational experience of the tested approach compared with airline pilots that could fly this type of approaches almost daily.

Regarding quality of data:

- evaluation exercise could not obtain a wide sample of data. But all evaluations were performed with professional pilots, so the quality of data is trustworthy.
- there was a limited number of flight crews for the exercise. Nonetheless, as the maturity level of the function is low and the outputs converge, the results are encouraging for further development of the function.

At solution level, global significance of results is operationally significant, as the evaluations with pilots on simulator allowed to collect opinions from a realistic experimental environment and to merge them with the opinions from the Stakeholders Workshop. But they are considered as statistically non-significant due to the limited number of flight crews for the evaluations with pilots exercise. However, considering that the quality of the results is high, and that current maturity level of the Solution is low, these results are considered sufficient.

5 Conclusions and recommendations

5.1 Conclusions

5.1.1 Conclusions on SESAR Solution maturity

From the scope perspective, the validation results and activities captured in this document conform to VALS (Validation Strategy) content apportioned to the PJ.11-A3 solution. The activities were executed using a validation technique suitable for V2 objectives (Real-time Simulation) and, in addition addressed some remained V1 open points through Stakeholder Workshop.

From the performance perspective, results are in line with what was targeted for the solution in VALP. No validation targets were assigned to this solution at SESAR level (Coordinated with project PJ.19).

This SESAR solution performed all activities as planned for V2 maturity level, however, some results are not according the expectations. In this context, the conclusions can be split to two parts:

- V2 from technical point of view:
    - ACAS Xo as defined in the ACAS Xa/Xo MOPS is technically feasible since no technical blocking point was observed (pilots were able to perform approaches with ACAS Xo activation), even if some improvements need to be done regarding HMI to comply with pilots' feedback.
- From European operational point of view, the results don't support achieving V2 maturity:
    - While ACAS Xo system requirements are specified in ACAS Xa/Xo MOPS, **there is no detailed operational definition published for ACAS Xo procedures**, only Concept of operation being currently available.
    - Two use cases (CSPO and DNA) as defined in the ACAS Xa/Xo MOPS are not suitable for current EU airspace.

In this situation validation was performed for the two above mentioned use cases at US airports (as we did not identify any EU airport with suitable operations) using experimental operational scenarios substituting missing detailed operational and procedural definition. Unfortunately, the obtained feedback from pilots was not positive and at this stage it is not possible to clearly distinguish whether and/or to which extent the cause lies in the concept itself or in the considered cockpit/operational procedures.

5.1.2 Conclusions on concept clarification

Discussed key ACAS Xo concept highlights can be summarized as follows:

- **ACAS Xo procedures** - would be very likely airport-specific, designed for particular use case, and well-regulated in SOP. ACAS Xo function use was encouraged by the high rate of unnecessary RA advisories during approach for close runways, where pilots have tendencies

to disregard some alerts. But as the ACAS Xa already reduces drastically the spurious alerts in most cases, the use of the Xo function has been questioned as it could be limited to only few approaches.

- **DNA mode** - brings many questions and concerns (acquiring and maintaining visual contact, displaying information about actual separation, DNA should be very well tested by day and night). Pilots wonder why such a possibility exists to remove TA/RA alerts. Pilots may not accept DNA mode because it removes the TCAS safety net, in case the wrong target is designated.

- **Pilot workload** - using ACAS Xo would depend on the implementation of the system and procedures. An important point obtained during the evaluation is the major difficulty to identify the correct target, especially in crowded environment. With current systems, the risk of identifying the wrong target is too high in crowded environment. Most of the time, in case of doubt, pilots will not use the function. Plus, the added workload for pilots to look head-down during the critical phase of approach is not appropriate.

- **Situation awareness** - is not expected to be significantly different from current situation, but the confidence in issued RAs may increase. In case of automatic un-designation by the function, the crews did not notice that they loss the function. Even if this does not decrease the safety (all TA/RA advisory recovered), pilots expect an HMI feedback.

- **ATC** - The communication would likely be generic information provided to all aircraft regarding the traffic sequence. Sequence may be very dynamic. The pilots considered ATC involvement as mandatory for an efficient and safe use of ACAS Xo. They shall guide the FC for intruder identification.

- **Regulatory updates** - The crews also raised the question of responsibilities during the evaluations. From their point of view, they will never decide to remove a safety net alert. So, if ACAS Xo enters into service, responsibilities shall be clearly defined and attributed to all actors (pilots, controllers and authorities). The crews confirmed that they would only use ACAS Xo sub modes if requested by authorities (at least indicated on approach charts).

- **Intruders designation** - The pilots shall be able to perform the ACAS Xo activation as soon as they identified the target.

As a general conclusion, several results confirm that **the current design is from the conceptual point of view not mature enough for Europe, and shall be further defined.** From operational point of view, the ACAS Xo function benefit in Europe is not obvious.

5.1.3 Conclusions on technical feasibility

Pilots were able to perform approaches with ACAS Xo activation. From this point of view, ACAS Xo function is **technically feasible** since no technical blocking point was observed.

Nevertheless, the current design has been criticized regarding HMI, and **some improvements need to be done** to make it more efficient to use when in high workload situations, as this is the case in approach phase (if not, pilots may disregard the function to focus on other tasks).

5.1.4 Conclusions on performance assessments

Human Performance was the key transversal area addressed by this validation activity. Discussed key ideas regarding the human **performance assessment** can be summarized as follows:

Pilot workload

- An increased workload both for pilot and ATC might be expected due to the need to set up the system (AC designation, mode selection, activation...) during approach when workload is already high.
- Potential decision making on mode selection would increase pilot workload.
- Workload would depend on the adopted flight crew task sharing.
- It is likely that ACAS Xo will not be frequently used by an individual pilot. This lack of consistent practice might contribute to higher workload when using ACAS Xo.

Situation awareness

- The situation awareness is expected to stay the same or slightly increased with DNA mode, since (in contrary with TA-only mode) it still generates RA against other than designated traffic.
- If the system is well designed, the situation awareness has potential to increase.
- However, it is also possible that the overall situation awareness might somewhat decrease due to pilot's constant monitoring of one target, on instruments as well as visually.
- Situation awareness will decrease if you lose the target from the navigation display in CSPO-3000 and lose the target visually in DNA. An immediate action should then be taken.

Potential to human error

- The possibility of designating wrong target is high with ACAS Xo DNA, since visual acquisition before designation is feasible only during good VMC conditions.
- Missing information about the selected mode of ACAS Xo could potentially lead to error. Pilots would expect to have the information about the selected mode.
- The sequence of steps regarding the target selection and mode selection may be implemented differently for each aircraft ownship type. The sequence could flip. Suggestions for default ACAS Xo mode have been raised.
- Due to a workload increased to activate and track visually an intruder (DNA mode), the use of ACAS Xo function might limit safety.

Timeliness of ACAS Xo-related tasks completion

- End user's tasks could be achievable within an acceptable time frame only if the intruders could be designated soon enough (which is not the case with the current design). The amount of time it took to set up ACAS Xo within the mock-up session was acceptable, but was not deemed acceptable during realistic traffic conditions within the simulator sessions.

5.2 Recommendations

5.2.1 Recommendations for next phase

ACAS Xo procedures

- Before going further with ACAS Xo procedures definitions, the need of such function should be investigated by analyzing the frequency of nuisance alerts with ACAS Xa algorithm on the targeted procedure.
- ACAS Xo should be activated before ACAS could issue nuisance alerts.
- ACAS Xo can be activated as soon as flight crew can identify the target.
- Perhaps being established on the localizer and glide should be a requirement for using ACAS Xo, especially for DNA.
- Approach briefing should prepare the pilot for a possible use of ACAS Xo on the approach. Thus, pilot will already know which mode he/she might be using.

DNA mode

- Acquiring and maintaining visual contact is essential, i.e. the mode should be used only in good visual conditions. Conditions such as reduced visibility or use by night brings in more challenges like city lights, water reflections and changed perspective of objects.
- Some pilots would find it beneficial if the information about actual separation was displayed to them, e.g. on a dedicated window on navigation display.
- DNA should be very well tested by day and night. The distance by night is very difficult to estimate correctly.

ATC

- On eligible ACAS Xo procedures, ATC involvement should be investigated (ATC should be involved to determine procedures).
- Use of CPDLC for providing information / instruction about ACAS Xo usage should be investigated.
- ACAS Xo equipage is not expected to be communicated to the ATC.
- ATC might need additional monitoring tool for ACAS Xo.

HMI

- HMI should sufficiently support the pilot with the selection of the target aircraft, mode and awareness of the mode selected.
- The ND design should be amended to reflect pilots needs but new evaluations will be necessary to validate new propositions. In particular,
- MCDU shall not be the primary means of interaction but a back-up means for ACAS Xo otherwise it will not be used. Pilots suggested to improve HMI to have a more direct activation (use of traffic selector coupled with a pop-up menu for instance).

Pilot's workload

- The idea of automated ACAS Xo feature would be welcome. Especially in CSPO, a potential solution could be automatic activation of CSPO mode when established on final against all other aircraft that are established as well.
- Automatic ACAS Xo mode selection based on the distance between runways, if such information can be obtained;

- Preselect the mode when entering the TMA when the workload is still low and select the target aircraft later.

5.2.2 Recommendations for updating ATM Master Plan Level 2

No recommendations.

5.2.3 Recommendations on regulation and standardisation initiatives

ACAS Xo has been standardized together with ACAS Xa in October 2018 (RTCA DO-385/ EUROCAE ED-256).

However, if the need to deploy ACAS Xo in Europe/US is confirmed, before going to V3 maturity process, the following major topics should be addressed:

- A detailed operational procedure with focus on associating controllers in order to help pilots identifying and designating the right aircraft for correct ACAS Xo mode.
- Definition of appropriate cockpit procedures for pilots about the use of ACAS Xo.
- The need to maintain safety net needs to be carefully investigated for each proposed procedure.

These conclusions will be presented to the representatives of RTCA SC-147/EUROCAE WG-75 which are in charge of the ACAS X development.

Pilot training should also be investigated.

- Good understanding of how the system works and what are the possible blunders should support the decision of whether and how the ACAS Xo would be used.
- Responsibility and reporting policies will need to be clearly thought out.
- Regulators should consider making ACAS Xo training compulsory, regular and recurring.
- Ambiguity regarding the distribution of responsibilities and involvement of ATC into ACAS Xo procedure has been raised in both exercises and should be further developed. If ACAS Xo enters into service, responsibilities shall be clearly defined and attributed to all actors (pilots, controllers and authorities).

Moreover, ACAS Xo procedures would be very likely airport-specific, designed for particular use case, and well-regulated in SOP what may require regulatory involvement as well.

6 References

6.1 Applicable Documents

Content Integration

[1] PJ.19 D5.7~~B.04.01 D138~~ EATMA Guidance Material and Report (2018) V11

[2] EATMA Community pages

[3] SESAR ATM Lexicon

Content Development

[4] PJ.19 D2.1 ~~B4.2 D106 Transition~~ Concept of Operations ~~SESAR 2020~~Edition 2017

Performance Management

[5] PJ.19 D4.4~~B.04.01 D108 SESAR 2020 Transition~~ Performance Framework (2018)

[6] PJ.19 D2.4~~B.04.01 D42 SESAR2020 Transition~~ Validation Strategy (2018)

Validation

[7] European Operational Concept Validation Methodology (E-OCVM) - 3.0 [February 2010]

Human Performance

[8] 16.06.05 D 27 HP Reference Material D27

[9] 16.04.02 D04 e-HP Repository - Release note

6.2 Reference Documents

[10] ED-78A GUIDELINES FOR APPROVAL OF THE PROVISION AND USE OF AIR TRAFFIC SERVICES SUPPORTED BY DATA COMMUNICATIONS.[1]

[11] Concept of Use for ACAS Xo, V2R0, February 12, 2015

[12] RTCA DO-385/EUROCAE ED-256, MOPS for ACAS Xa/Xo, October 2018

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Appendix A Validation Exercise #01 Report

This appendix concludes validation report for EXE-PJ.11.A3-V2-VALP-001 (Stakeholder Workshop), an exercise performed by Honeywell.

A.1 Summary of the Validation Exercise #01 Plan

As in the V2 VALP Part I, II, IV project PJ.11-A3.

A.1.1 Validation Exercise description, scope

This exercise is a Stakeholder Workshop focused mainly on the definition of ACAS Xo operational procedures. The discussion will cover two ACAS Xo modes –CSPO-3000 and DNA. A low fidelity l mock-up of ACAS Xo HMI has been developed and presented to the participants to help them define and validate the operating method. The data collected included participant's feedback during the discussions, observation of their interaction with the mock-up and their responses to the questionnaires.

The primary objective of the workshop was to:

- obtain expert feedback on high-level ACAS Xo operational concept as defined so far,
- brainstorm on more detailed operating method and address the operational open points,
- assess the feasibility and potential use cases of ACAS Xo use in European environment,
- obtain feedback on proposed HMI using low fidelity mock-up.

A.1.2 Summary of Validation Exercise #01 Validation Objectives and success criteria

Exercise Validation Objective	Exercise Success criteria
EX1-OBJ-PJ.11.A3-V2-VALP-001 Identify potential use cases for the ACAS Xo capability within current and future European operations.	**EX1-CRT-PJ.11.A3-V2-VALP-001** Potential use cases for ACAS Xo capability within current of future European operations identified.
EX1-OBJ-PJ.11.A3-V2-VALP-002 Assess that FC procedures can be determined and integrated in FC tasks during concerned operations	**EX1-CRT-PJ.11.A3-V2-VALP-002** Normal operating conditions are defined. Where possible initial needs/ requirements relating to the operating methods for normal operating conditions may be identified.
EX1-OBJ-PJ.11.A3-V2-VALP-003 Assess whether the identified operating method is clear and judged as feasible.	**EX1-CRT-PJ.11.A3-V2-VALP-003** If preliminary operating methods are defined the content has been determined to be clear and non-contradictory by end users.
EX1-OBJ-PJ.11.A3-V2-VALP-004 Assess the feasibility and timeliness of ACAS Xo-related tasks completion.	**EX1-CRT-PJ.11.A3-V2-VALP-004** Potential changes to the end users tasks are achievable within an acceptable time frame (acceptable can be defined based on end users opinion and good HF practice)

Exercise Validation Objective	Exercise Success criteria
EX1-OBJ-PJ.11.A3-V2-VALP-005 Identify the impact of ACAS-Xo procedure on FC workload.	**EX1-CRT-PJ.11.A3-V2-VALP-005** The potential changes to the level of workload/task demands and the preliminary mitigation identified are acceptable (acceptable can be defined based on end users opinion and good HF practice relating to workload).
EX1-OBJ-PJ.11.A3-V2-VALP-006 Identify pilots' information needs regarding the mode selection.	**EX1-CRT-PJ.11.A3-V2-VALP-006** Information needs/requirements are identified.
EX1-OBJ-PJ.11.A3-V2-VALP-007 Identify factors that might have an impact on FC situation awareness.	**EX1-CRT-PJ.11.A3-V2-VALP-007** Potential changes to situation awareness & preliminary mitigation are identified and acceptable.
EX1-OBJ-PJ.11.A3-V2-VALP-008 Identify preliminary training needs.	**EX1-CRT-PJ.11.A3-V2-VALP-008** Where possible, initial knowledge, skill and experience requirements are identified.
EX1-OBJ-PJ.11.A3-V2-VALP-009 Identify potential errors and preliminary mitigations regarding the target designation task.	**EX1-CRT-PJ.11.A3-V2-VALP-009** Where possible, potential changes to human error and preliminary mitigation have been identified for consideration by the safety/project team.
EX1-OBJ-PJ.11.A3-V2-VALP-010 Identify potential errors and preliminary mitigations regarding the mode selection.	**EX1-CRT-PJ.11.A3-V2-VALP-010** Where possible, potential changes to human error and preliminary mitigation have been identified for consideration by the safety/project team.
EX1-OBJ-PJ.11.A3-V2-VALP-011 Identify potential errors and preliminary mitigations regarding the mode awareness. .	**EX1-CRT-PJ.11.A3-V2-VALP-011** Where possible, potential changes to human error and preliminary mitigation have been identified for consideration by the safety/project team.
EX1-OBJ-PJ.11.A3-V2-VALP-012 Assess that automatic un-designation is well understood by FC.	**EX1-CRT-PJ.11.A3-V2-VALP-012** Understanding of the technical system's behaviour is consistent with the operator's task demands.
EX1-OBJ-PJ.11.A3-V2-VALP-013 Assess whether information needs of the FC to be able to successfully use ACAS Xo are met with the proposed design.	**EX1-CRT-PJ.11.A3-V2-VALP-013** There is no discrepancy between system-provided information and user-required information.
EX1-OBJ-PJ.11.A3-V2-VALP-014 Identify pilots' information needs regarding the mode awareness.	**EX1-CRT-PJ.11.A3-V2-VALP-014** Information needs/requirements are identified.
EX1-OBJ-PJ.11.A3-V2-VALP-015 Assess the usability of HMI to select the target.	**EX1-CRT-PJ.11.A3-V2-VALP-015** End user experiences integrated interface including any new system components as sufficiently usable.
EX1-OBJ-PJ.11.A3-V2-VALP-016 Assess the usability of HMI to activate the ACAS Xo function.	**EX1-CRT-PJ.11.A3-V2-VALP-016** End user experiences integrated interface including any new system components as sufficiently usable.
EX1-OBJ-PJ.11.A3-V2-VALP-017 Assess the usability of the HMI to undesignate a target.	**EX1-CRT-PJ.11.A3-V2-VALP-017** End user experiences integrated interface including any new system components as sufficiently usable.

Exercise Validation Objective	Exercise Success criteria
EX1-OBJ-PJ.11.A3-V2-VALP-018 Assess if FC alerts needs are met with the current concept.	**EX1-CRT-PJ.11.A3-V2-VALP-018** Where possible initial alarm/alerts needs/requirements are identified.
EX1-OBJ-PJ.11.A3-V2-VALP-019 Identify potentially achievable benefits of tailored European ACAS Xo version.	**EX1-CRT-PJ.11.A3-V2-VALP-019** Potentially achievable benefits of tailored European ACAS Xo version identified.
EX1-OBJ-PJ.11.A3-V2-VALP-020 Define high-level requirements on potential European ACAS Xo version.	**EX1-CRT-PJ.11.A3-V2-VALP-020** High-level requirements on potential European ACAS Xo version defined.

A.1.3 Summary of Validation Exercise #01 Validation scenarios

Validation scenarios were not applicable due to the format of the activity.

A.1.4 Summary of Validation Exercise #01 Validation Assumptions

No exercise-specific assumptions are defined.

A.2 Deviation from the planned activities

The only deviation from planned activity was the date of Workshop execution, which was shifted from October 2018 to November 2018 due to participants unavailability.

A.3 Validation Exercise #01 Results

A.3.1 Summary of Validation Exercise #01 Results

Validation Exercise #01 Validation Objective ID	Validation Exercise #01 Validation Objective Title	Validation Exercise #01 Success Criterion ID	Validation Exercise #01 Success Criterion	Sub-operating environment	Exercise #01 Validation Results	Validation Exercise #01 Validation Objective Status

Validation Exercise #01 Validation Objective ID	Validation Exercise #01 Validation Objective Title	Validation Exercise #01 Success Criterion ID	Validation Exercise #01 Success Criterion	Sub-operating environment	Exercise #01 Validation Results	Validation Exercise #01 Validation Objective Status
EX1-OBJ-PJ.11.A3-V2-VALP-001	Identify potential use cases for the ACAS Xo capability within current and future European operations.	EX1-CRT-PJ.11.A3-V2-VALP-001	Potential use cases for ACAS Xo capability within current of future European operations identified.	En-route & TMA (all complexities)	No use case for ACAS Xo identified now in Europe. At this moment ACAS Xo procedure can help in situations where military or rescue helicopters in the airport want to take off or land. In such situation A/C can use DNA mode and avoid unnecessary RA.	NOK
EX1-OBJ-PJ.11.A3-V2-VALP-002	Assess that FC procedures can be determined and integrated in FC tasks during concerned operations	EX1-CRT-PJ.11.A3-V2-VALP-002	Normal operating conditions are defined. Where possible initial needs/ requirements relating to the operating methods for normal operating conditions may be identified.	En-route & TMA (all complexities)	Normal operating conditions for ACAS Xo have been defined as Closely Spaced Parallel Runway Operations. Initial needs and issues identified. But further research and clarification is needed. Procedure will greatly depend on the particular environment where it is going to be implemented.	OK

Validation Exercise #01 Validation Objective ID	Validation Exercise #01 Validation Objective Title	Validation Exercise #01 Success Criterion ID	Validation Exercise #01 Success Criterion	Sub-operating environment	Exercise #01 Validation Results	Validation Exercise #01 Validation Objective Status
EX1-OBJ-PJ.11.A3-V2-VALP-003	Assess whether the identified operating method is clear and judged as feasible.	EX1-CRT-PJ.11.A3-V2-VALP-003	If preliminary operating methods are defined the content has been determined to be clear and non-contradictory by end users.	En-route & TMA (all complexities)	Even though the questionnaire responses of the majority of participants indicated the discussed operating method to be clear and feasible, the discussion did not show the same perception. Many open points remain. There was some ambiguity regarding the distribution of responsibilities and involvement of ATC into ACAS Xo procedure. Workshop participants expressed uncertainty whether the use of ACAS Xo should be to mandated by regulations.	NOK

Validation Exercise #01 Validation Objective ID	Validation Exercise #01 Validation Objective Title	Validation Exercise #01 Success Criterion ID	Validation Exercise #01 Success Criterion	Sub-operating environment	Exercise #01 Validation Results	Validation Exercise #01 Validation Objective Status
EX1-OBJ-PJ.11.A3-V2-VALP-004	Assess the feasibility and timeliness of ACAS Xo-related tasks completion.	EX1-CRT-PJ.11.A3-V2-VALP-004	Potential changes to the end users tasks are achievable within an acceptable time frame (acceptable can be defined based on end users opinion and good HF practice).	En-route & TMA (all complexities)	Initial results obtained with the mock-up are not conclusive. A lot will depend on the implementation in the specific environment. The acceptable time to spend on setting up ACAS Xo is “as little as possible”. The amount of time it took to set up ACAS Xo within the mock-up session was acceptable.	Partially OK
EX1-OBJ-PJ.11.A3-V2-VALP-005	Identify the impact of ACAS-Xo procedure on FC workload.	EX1-CRT-PJ.11.A3-V2-VALP-005	The potential changes to the level of workload/task demands and the preliminary mitigation identified are acceptable (acceptable can be defined based on end users opinion and good HF practice relating to workload).	En-route & TMA (all complexities)	Pilot workload using ACAS Xo would depend on the implementation of the system and procedures, but an increased workload for both pilot and ATC might be expected. It is likely that ACAS Xo will not be frequently used by an individual pilot. This lack of consistent practice might contribute to higher workload when using ACAS Xo.	OK

Validation Exercise #01 Validation Objective ID	Validation Exercise #01 Validation Objective Title	Validation Exercise #01 Success Criterion ID	Validation Exercise #01 Success Criterion	Sub-operating environment	Exercise #01 Validation Results	Validation Exercise #01 Validation Objective Status
EX1-OBJ-PJ.11.A3-V2-VALP-006	Identify pilots' information needs regarding the mode selection.	EX1-CRT-PJ.11.A3-V2-VALP-006	Information needs/requirements are identified.	En-route & TMA (all complexities)	Participants did not have complete clarity on which mode to select and when. Participants expressed need to {1} include possible ACAS Xo usage in approach briefing and have information about the mode applicable on the explicit airport. {2} have prescribed use of ACAS Xo together with tasks and responsibilities of ACAS Xo involved parties (FC and ATC) as well as communication rules within ACAS Xo operations.	Partially OK

Validation Exercise #01 Validation Objective ID	Validation Exercise #01 Validation Objective Title	Validation Exercise #01 Success Criterion ID	Validation Exercise #01 Success Criterion	Sub-operating environment	Exercise #01 Validation Results	Validation Exercise #01 Validation Objective Status
EX1-OBJ-PJ.11.A3-V2-VALP-007	Identify factors that might have an impact on FC situation awareness.	EX1-CRT-PJ.11.A3-V2-VALP-007	Potential changes to situation awareness & preliminary mitigation are identified and acceptable.	En-route & TMA (all complexities)	It's difficult to assess whether overall situation awareness is going to increase or decrease. A lot will depend on the system design and implementation. Situation awareness could increase: -due to higher confidence in issued RAs (due to smaller number of nuisance RAs). Situation awareness might decrease: -due to pilots constant monitoring of one target; -due to loss of the target from navigation display for CSPO-3000 mode; -due to visual loss of target in DNA mode; Separation information in extra window might help pilots to be aware of situation.	OK

Validation Exercise #01 Validation Objective ID	Validation Exercise #01 Validation Objective Title	Validation Exercise #01 Success Criterion ID	Validation Exercise #01 Success Criterion	Sub-operating environment	Exercise #01 Validation Results	Validation Exercise #01 Validation Objective Status
EX1-OBJ-PJ.11.A3-V2-VALP-008	Identify preliminary training needs.	EX1-CRT-PJ.11.A3-V2-VALP-008	Where possible, initial knowledge, skill and experience requirements are identified.	En-route & TMA (all complexities)	ACAS Xo would require regulatory updates as well as pilot training. Responsibility and reporting policies will need to be clearly thought out. Regulations should consider making ACAS Xo training compulsory, regular and recurring.	OK
EX1-OBJ-PJ.11.A3-V2-VALP-009	Identify potential errors and preliminary mitigations regarding the target designation task.	EX1-CRT-PJ.11.A3-V2-VALP-009	Where possible, potential changes to human error and preliminary mitigation have been identified for consideration by the safety/project team.	En-route & TMA (all complexities)	The possibility of designating wrong target is quite high with ACAS Xo DNA mode, since visual acquisition before designation is feasible only during good VMC conditions.	OK
EX1-OBJ-PJ.11.A3-V2-VALP-011	Identify potential errors and preliminary mitigations regarding the mode awareness.	EX1-CRT-PJ.11.A3-V2-VALP-011	Where possible, potential changes to human error and preliminary mitigation have been identified for consideration by the safety/project team.	En-route & TMA (all complexities)	Potential to human error has been identified, missing information about the selected mode of ACAS Xo could potentially lead to error. Pilots would expect to have the information about the mode selected highlighted in special window on navigation display or, if possible, also in TCAS window.	OK

Validation Exercise #01 Validation Objective ID	Validation Exercise #01 Validation Objective Title	Validation Exercise #01 Success Criterion ID	Validation Exercise #01 Success Criterion	Sub-operating environment	Exercise #01 Validation Results	Validation Exercise #01 Validation Objective Status
EX1-OBJ-PJ.11.A3-V2-VALP-010	Identify potential errors and preliminary mitigations regarding the mode selection task.	EX1-CRT-PJ.11.A3-V2-VALP-010	Where possible, potential changes to human error and preliminary mitigation have been identified for consideration by the safety/project team.	En-route & TMA (all complexities)	A potential for error when selectin the mode does exist. The sequence of steps regarding the target selection and mode selection might be different in each aircraft type. The sequence could flip. Suggestions for a possibility to select as well a default ACAS Xo mode have been made. Next possible mitigation would be an automatic mode selection. During mock-up session, participants have made no errors in mode selection.	OK

Validation Exercise #01 Validation Objective ID	Validation Exercise #01 Validation Objective Title	Validation Exercise #01 Success Criterion ID	Validation Exercise #01 Success Criterion	Sub-operating environment	Exercise #01 Validation Results	Validation Exercise #01 Validation Objective Status
EX1-OBJ-PJ.11.A3-V2-VALP-012	Assess that automatic un-designation is well understood by FC.	EX1-CRT-PJ.11.A3-V2-VALP-012	Understanding of the technical system's behaviour is consistent with the operator's task demands.	En-route & TMA (all complexities)	When automatic un-designation of traffic will occur, pilots will immediately react to (if) RA with no doubt of why this happened. Reasons for automatic un-designation of the ACAS Xo are clear. The algorithm for automatic un-designation needs to be reviewed to make sure that all cases are covered. The system should try to reconnect when automatic un-designation will appear. The information about automatic un-designation should be provided to the FC together with mode acquired.	OK

Validation Exercise #01 Validation Objective ID	Validation Exercise #01 Validation Objective Title	Validation Exercise #01 Success Criterion ID	Validation Exercise #01 Success Criterion	Sub-operating environment	Exercise #01 Validation Results	Validation Exercise #01 Validation Objective Status
EX1-OBJ-PJ.11.A3-V2-VALP-013	Assess whether information needs of the FC to be able to successfully use ACAS Xo are met with the proposed design.	EX1-CRT-PJ.11.A3-V2-VALP-013	There is no discrepancy between system-provided information and user-required information.	En-route & TMA (all complexities)	The displayed information related to ACAS Xo is sufficient to successfully execute ACAS Xo procedure. Proposed symbols and labels have been rated by participants as helpful information elements. Participants expressed positive attitude to the amount and form of presentation of ACAS Xo information within the proposed HMI design. ACAS Xo system should offer only modes that are applicable for intruder and airport. CPDLC messages would be beneficial to communicate with ATC regarding ACAS Xo and could provide direct activation of ACAS Xo functionality.	OK

Validation Exercise #01 Validation Objective ID	Validation Exercise #01 Validation Objective Title	Validation Exercise #01 Success Criterion ID	Validation Exercise #01 Success Criterion	Sub-operating environment	Exercise #01 Validation Results	Validation Exercise #01 Validation Objective Status
EX1-OBJ-PJ.11.A3-V2-VALP-014	Identify pilots' information needs regarding the mode awareness.	EX1-CRT-PJ.11.A3-V2-VALP-014	Information needs/requirements are identified.	En-route & TMA (all complexities)	Provided HMI labels of selected mode have been found helpful and useful to maintain awareness of the selected mode. However, one of the participants expressed concerns regarding potential clutter on navigation display using the current mode labels. Thanks to the labels none of the pilots have lost awareness of the selected mode.	OK
EX1-OBJ-PJ.11.A3-V2-VALP-015	Assess the usability of HMI to select the target.	EX1-CRT-PJ.11.A3-V2-VALP-015	End user experiences integrated interface including any new system components as sufficiently usable.	En-route & TMA (all complexities)	Participants managed to select the required aircraft as ACAS Xo target and most of them found it easy and sufficiently usable. No errors were reported or observed.	OK
EX1-OBJ-PJ.11.A3-V2-VALP-016	Assess the usability of HMI to activate the ACAS Xo function.	EX1-CRT-PJ.11.A3-V2-VALP-016	End user experiences integrated interface including any new system components as sufficiently usable.	En-route & TMA (all complexities)	Participants managed to activate ACAS Xo in the mock-up and found it easy and sufficiently usable. No errors were reported or observed.	OK

Validation Exercise #01 Validation Objective ID	Validation Exercise #01 Validation Objective Title	Validation Exercise #01 Success Criterion ID	Validation Exercise #01 Success Criterion	Sub-operating environment	Exercise #01 Validation Results	Validation Exercise #01 Validation Objective Status
EX1-OBJ-PJ.11.A3-V2-VALP-017	Assess the usability of the HMI to undesignate a target.	EX1-CRT-PJ.11.A3-V2-VALP-017	End user experiences integrated interface including any new system components as sufficiently usable.	En-route & TMA (all complexities)	Participants managed to de-activate ACAS Xo. Most of them found it easy and sufficiently usable. Some errors were made, but they can be attributed to the low fidelity of the mock-up and fixed scenarios - tailored for particular use case and success flow only.	OK
EX1-OBJ-PJ.11.A3-V2-VALP-018	Assess if FC alerts needs are met with the current concept.	EX1-CRT-PJ.11.A3-V2-VALP-018	Where possible initial alarm/alerts needs/requirements are identified.	En-route & TMA (all complexities)	No alerting in DNA mode was found unacceptable for most of the pilots. The delay of CSPO-3000 mode alert is acceptable. The information about automatic un-designation should be provided to the FC.	OK
EX1-OBJ-PJ.11.A3-V2-VALP-019	Identify potentially achievable benefits of tailored European ACAS Xo version.	EX1-CRT-PJ.11.A3-V2-VALP-019	Potentially achievable benefits of tailored European ACAS Xo version identified.	En-route & TMA (all complexities)	There was no need for tailored European ACAS Xo version identified based on the Workshop discussion.	NOK

Validation Exercise #01 Validation Objective ID	Validation Exercise #01 Validation Objective Title	Validation Exercise #01 Success Criterion ID	Validation Exercise #01 Success Criterion	Sub-operating environment	Exercise #01 Validation Results	Validation Exercise #01 Validation Objective Status
EX1-OBJ-PJ.11.A3-V2-VALP-020	Define high-level requirements on potential European ACAS Xo version.	EX1-CRT-PJ.11.A3-V2-VALP-019	High-level requirements on potential European ACAS Xo version defined.	En-route & TMA (all complexities)	ADS-B OUT equipage & related SPI mandate	OK

Table 6: Validation Results for Exercise 1

A.3.2 Analysis of Exercise 1 Results per Validation objective

EX1-OBJ-PJ.11.A3-V2-VALP-001 (Potential use cases for ACAS Xo in Europe)

One workshop session was dedicated to identification of potential use cases for the ACAS Xo capability within current and future European operations. The discussion has been driven by the following set of questions:

- Do you think that the use of ACAS Xo is likely to
  - a] Decrease the number of cases when ACAS is set to TA only mode?
  - b] Increase pilots' compliance with RAs (as a result of not treating them as nuisance alerts)?
- How likely is it that ACAS Xo will reduce the number of unnecessary or counter-productive manoeuvres during the approaches/departures on parallel or closely-spaced parallel runways that could otherwise take place if nuisance RAs are generated?
- How likely is it that the use of Xo operations will reduce the number of missed approaches? (For ATC)
- How likely is it that the use of Xo operations will result in fewer go-arounds? (For ATC)
- What would lead you to use ACAS Xo?
- What conditions would allow the use of ACAS Xo? What conditions wouldn't? (weather, operational environment, etc.)
- Is there anything what can be done different?
- In which way could this procedure work in EU?
- Are there any cases or problems in Europe where ACAS Xo might help to solve them?
- What additional training (knowledge, skills etc.) will the pilots require to fly ACAS Xo procedures? Different for CSPO3000 and DNA?

Workshop participants concurred that while in the US the ACAS Xo would very likely decrease the number of cases when ACAS is set to TA-only mode, in the European, a more conservative environment, TA-only mode usage is not so frequent, and the data on such occurrences is not available.

There are a few airports with parallel runways in Europe (such as Malpensa, Madrid, or Bucharest), but those do not apply parallel approach procedures since there is no such demand in terms of traffic. The situation can however change in the future if the traffic increases, it would lead to the need for increased airport capacity through building additional (parallel) runways aimed for parallel approaches.

Workshop participants noted that in Europe, at this moment, ACAS Xo operations could potentially help in situations which involve military or rescue helicopters based at the civil airport, or general aviation in TMA areas. In such situations, possibility to apply DNA mode on the traffic would be useful to avoid triggering unnecessary RA. From ATC point of view, ACAS Xo might then be useful and could help to reduce missed approaches, especially in dense traffic. In addition, during workshop discussion, several recommendations were captured:

- DNA mode should be used during good visibility and for very specific VMC.
- Conditions such as bad weather or use by night when A/C is not on localizer might be problematic and using of ACAS Xo might be difficult. More detailed analysis would be needed to assess the use of ACAS Xo modes by night.
- ACAS Xo could work only in well-regulated conditions. Especially DNA mode should be very well tested for day & night conditions.
- Responsibility and reporting policies will need to be clearly thought out.
- Regulations should consider making ACAS Xo training compulsory, regular and recurring.

EX1-OBJ-PJ.11.A3-V2-VALP-002 (Operating method and FC procedures)

Operating method has been defined on the FC side as sequence of steps containing

1] identification of ACAS Xo target,

2] selection of ACAS Xo mode,

3] designation of the ACAS Xo target,

4] execution of ACAS Xo (flying with active ACAS Xo mode), and

5] un-designation (automatic, manual).

The sequence of 1] and 2] could potentially be switched depending on the implementation in HMIs of various types of aircraft.

Pilots expressed the need to pre-brief the expected use of ACAS Xo operation in advance of the approach briefing, and to be able to have the information about applicable ACAS Xo modes on the airport and route documentation. The involvement of ATC has been discussed with the conclusion that the communication with ATC would likely be generic information provided to all aircraft regarding the sequence. ATCOs expressed uncertainty about when ATC should provide information as the sequence of aircraft on the approach is very dynamic. To address the need to minimize the risk for the pilots to designate a wrong aircraft, ATC providing a call sign could be a possible mitigation. At

the same time the use of third party call sign in voice communications is a known problem (the use of a call sign of the aircraft that is not participating in controller-pilot voice communication but is being referred to on a common voice frequency might lead to confusion for both controllers and pilots). ATCOs expressed the need to provide the FC with clear information, so it is very likely that ATC would hesitate to give the information to the FC unless he/she is fully confident about the approach sequence. In such a dynamic environment, a further research should be conducted to assess the extent of possible future confusions and to avoid an increase of workload either to FC or ATC.

After the workshop the low-fidelity mock-up session took place. In the mock-up session, pilots were asked to validate the proposed HMI as supportive for the process of above-mentioned task sequence and overall operating method as well.

EX1-OBJ-PJ.11.A3-V2-VALP-003 (Operating method being clear & feasible)

As the preliminary operating methods have been defined, we tried to determine the content to be clear and non-contradictory, and that the identified operating method is clear and judged as feasible. To preliminarily prove the feasibility of the operating method, participants had an opportunity to discuss the designation steps during the workshop session and try particular use cases within low-fidelity mock-up session. Two statements were included in a questionnaire after the mock-up session:

- I find that the identified procedure for the use of ACAS Xo is clear and unambiguous.
- I find the identified ACAS Xo procedure feasible.

Discussion:

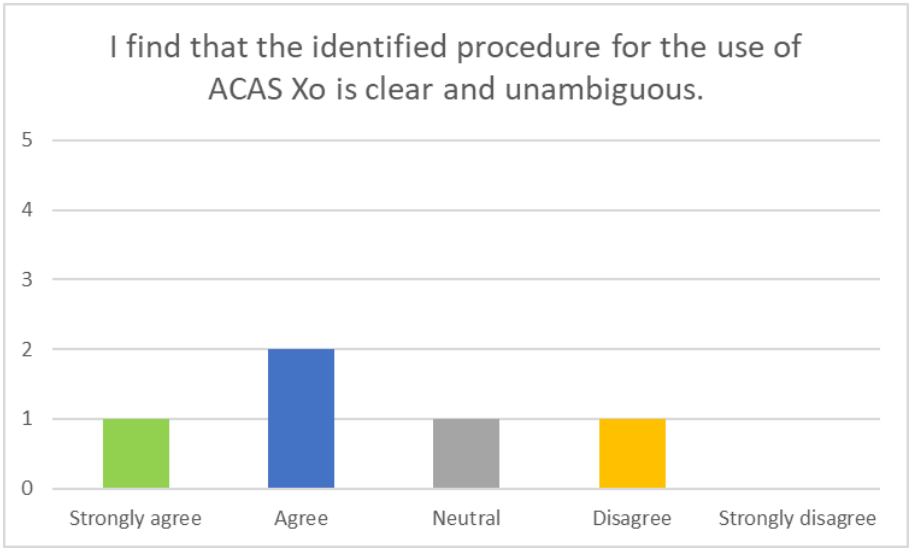
Within the discussion, participants were concerned about the distribution of responsibilities when involving ATC into ACAS Xo process. The mentioned uncertainty has been captured in the following graph (see Graph 1).

Responsibility for the decision to use DNA remains on FC and ATC should be involved in the designation process only by providing the information to the FC in order not to increase ATCs' and FC's workload and avoid the use of 3rd party callsigns (known issue).

Use of D-ATIS or CPDLC could be investigated for this purpose (see EX1-CRT-PJ.11.A3-V2-VALP-013, where we provide some inputs for possible CPDLC use and pilot´s point of view on such a feature).

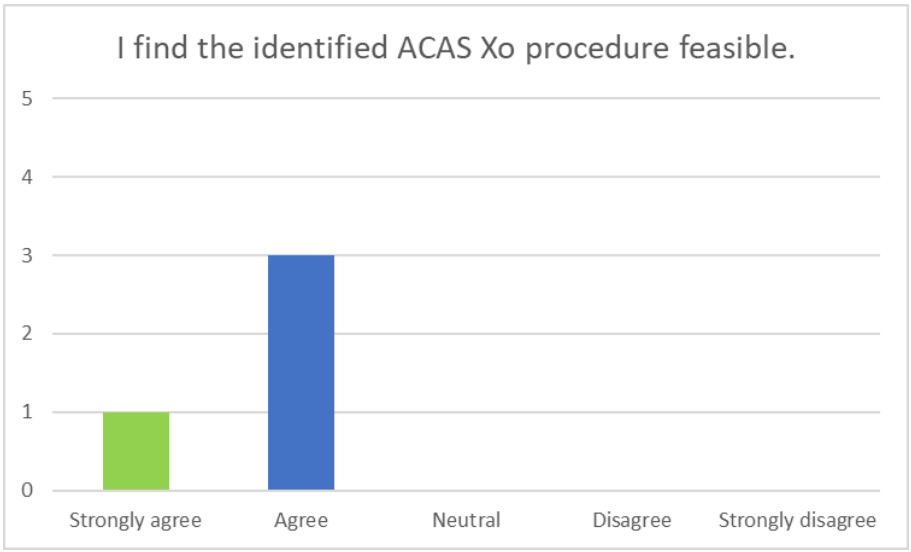
Questionnaire:

3 out of 5 participants expressed positive attitude ("strongly agree" and "agree") to the statement that they find the identified procedure for the use of ACAS Xo clear and unambiguous. 1 out of 5 participants expressed neutral attitude to this statement. 1 out of 5 participants expressed negative attitude ("disagree") with a note that it is not clear whether the use of ACAS Xo is mandatory or not and if the pilot is free to choose the mode:



Graph 1: Operating method being clear & feasible (EX1-OBJ-PJ.11.A3-V2-VALP-003)

4 out of 4 participants expressed positive attitude ("strongly agree" and "agree") to the statement that they find the identified ACAS Xo procedure feasible. 1 participant did not answer:



Graph 2: Operating method being clear & feasible (EX1-OBJ-PJ.11.A3-V2-VALP-003)

EX1-OBJ-PJ.11.A3-V2-VALP-004 (Feasibility & timeliness of ACAS Xo related tasks)

To assess the feasibility and timeliness of ACAS Xo related tasks completion by the workshop participants, following questions were prepared:

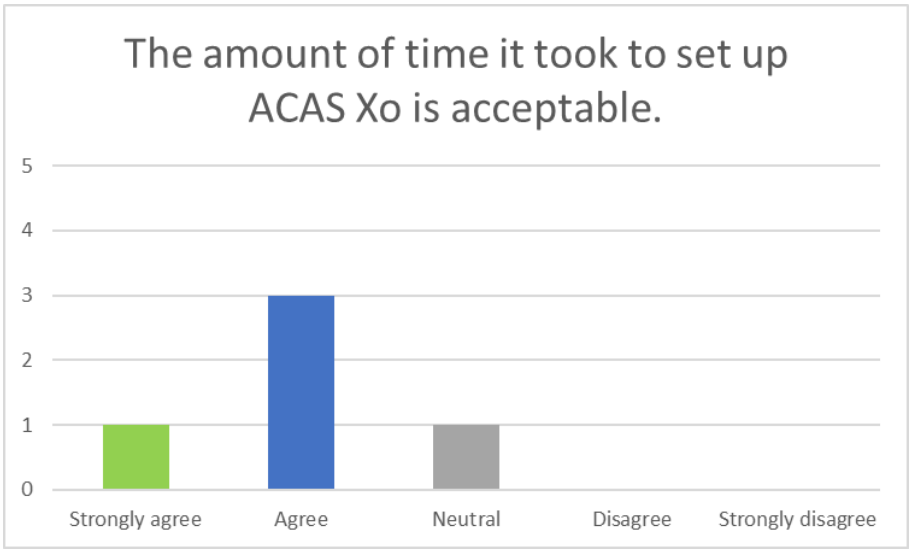
- How much time do you think it is acceptable to spend on setting up ACAS Xo?
- Do you find the amount of time it took to set up ACAS Xo is acceptable? (mock-up questionnaire question to assess the feasibility and timeliness)

Discussion:

During the discussion, participants have stated, that from their point of view the acceptable time to spend on setting up ACAS Xo is "as little as possible". The acceptability of timeliness and feasibility of task completion regarding the ACAS Xo depends on the system implementation. This implementation should consider the usability of ACAS Xo functions in designation process (easy access to option where pilot can preselect the mode and then choose the aircraft is preferable).

Questionnaire:

4 out of 5 participants expressed positive attitude ("strongly agree" and "agree") to the statement that the amount of time it took to set up the ACAS Xo is acceptable. 1 out of 5 participants expressed neutral attitude:



Graph 3: Feasibility & timeliness of ACAS Xo related tasks (EX1-OBJ-PJ.11.A3-V2-VALP-004)

EX1-OBJ-PJ.11.A3-V2-VALP-005 (Impact of ACAS Xo procedure on FC workload)

To identify the impact of ACAS Xo procedure on FC workload within the workshop discussion, the following set of questions was prepared. Questions were asked during each session dedicated to particular step of ACAS Xo designation process:

- What impact do you think ACAS Xo procedure will have on pilots' workload?
- Selection of the target: The workload is likely to stay similar/ decrease/increase. Why?

- Selection of the mode: The workload is likely to stay similar/ decrease/increase. Why?
- Activation of ACAS Xo: The workload is likely to stay similar/ decrease/increase. Why?
- Execution of the procedure: The workload is likely to stay similar/ decrease/increase. Why?
- Manual deactivation of ACAS Xo: The workload is likely to stay similar/ decrease/increase. Why?
- Automatic deactivation of ACAS Xo: The workload is likely to stay similar/ decrease/increase. Why?

After the workshop the low-fidelity mock-up session took place. In this session pilots were asked to validate the proposed HMI to preliminary assess the workload as well.

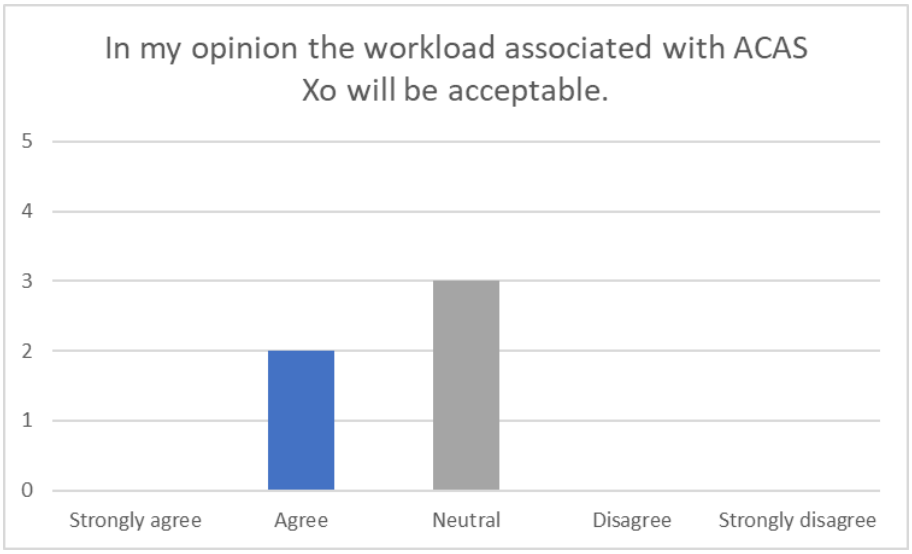
Discussion:

Pilot workload using ACAS Xo would depend on the implementation of the system and procedures, but an increased workload for both pilot and ATC might be expected due to the need to set up the system (AC designation, mode selection, activation...) during approach when workload is already high.

Potential decision making on mode selection would increase pilot workload. Workload would depend on the adopted flight crew task sharing. It is likely that ACAS Xo will not be frequently used by an individual pilot. This lack of consistent practice might contribute to higher workload when using ACAS Xo. The idea of automated ACAS Xo feature would be welcome.

Questionnaire:

2 out of 5 participants expressed positive attitude (“agree”) to the statement that in their opinion, the workload associated with ACAS Xo will be acceptable. 3 out of 5 participants expressed neutral attitude with a note, that it depends on the implementation of ACAS Xo:



Graph 4: Impact of ACAS Xo procedure on FC workload (EX1-OBJ-PJ.11.A3-V2-VALP-005)

EX1-OBJ-PJ.11.A3-V2-VALP-006 (Pilots' information needs)

To identify the information needs regarding the mode selection, the following set of questions was prepared.

- How do you know which mode to select (CSPO300 or DNA)? What do you need to know to decide?

After the mock-up session the following set of statements was assessed through questionnaire:

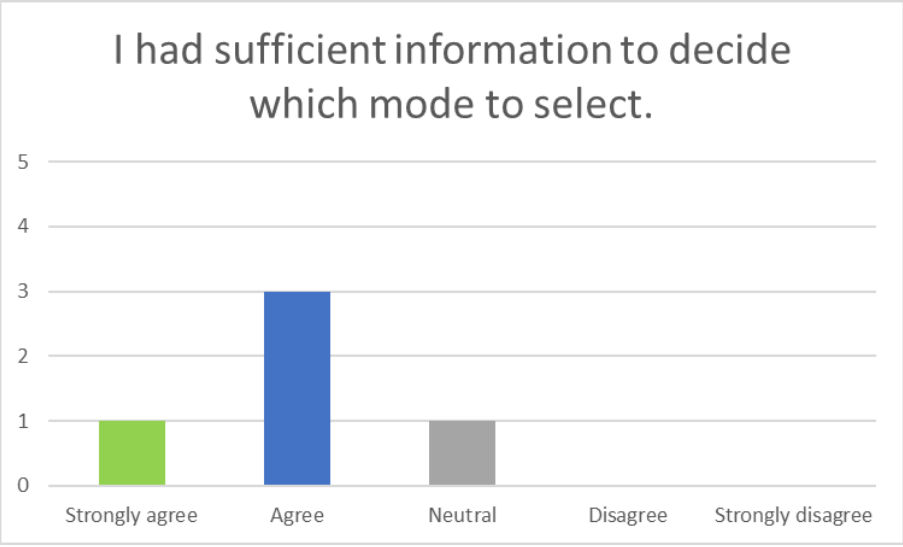
- I had sufficient information to decide which mode to select.
- Did you manage to select the required mode (DNA or CSPO3000)?
- I found it easy to select the required mode.

Discussion:

Participants have stated that it is very probably not very feasible for the pilot to choose the mode without any previous approach briefing. The FC should be able to prepare for the expected approach (FC should make the briefing regarding the use of mode either before the departure or before the approach, participant have stated that it is not possible to select target and then start thinking of what mode to use). The information about expected ACAS Xo mode availability on approach could be provided to the FC in advance via ATIS info or through ATC communication. Together with this, the ACAS Xo system could offer only possible and currently applicable ACAS Xo modes automatically (preselect the mode).

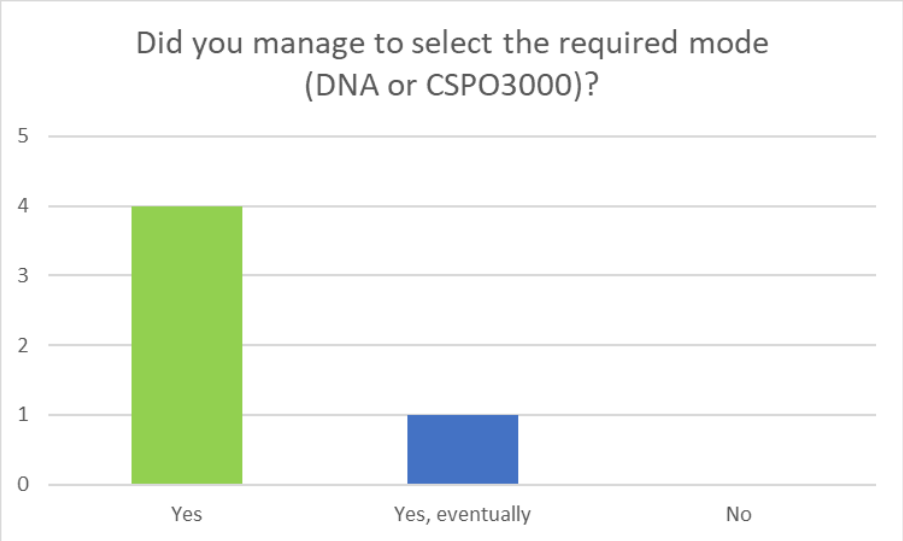
Questionnaire:

4 out of 5 participants expressed positive attitude ("strongly agree" and "agree") to the statement that they had sufficient information to decide which mode to select. 1 participant expressed neutral attitude to this statement:



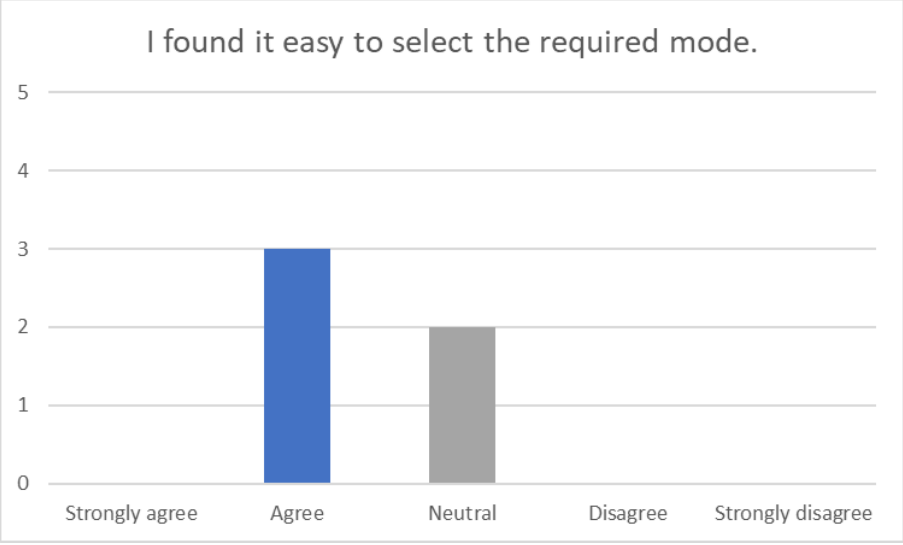
Graph 5: Pilots' information needs (EX1-OBJ-PJ.11.A3-V2-VALP-006)

5 out of 5 participants expressed positive attitude (4 out of 5 participants expressed "yes" and 1 out of 5 participants express "yes, eventually") to the statement that they did manage to select the required mode via mock-up:



Graph 6: Pilots' information needs (EX1-OBJ-PJ.11.A3-V2-VALP-006)

3 out of 5 participants expressed positive attitude (3 out of 5 participants expressed "agree") to the statement that they found it easy to select the required mode. 2 out of 5 participants expressed neutral attitude with a note that participants have experienced difficulities to click on the right spot because of the intended low maturity of mock-up design:



Graph 7: Pilots' information needs (EX1-OBJ-PJ.11.A3-V2-VALP-006)

EX1-OBJ-PJ.11.A3-V2-VALP-007 (Factors impacting FC situation awareness)

To identify factors that might have an impact on FC situation awareness within the workshop discussion, following questions were asked:

- The situation awareness is likely to stay similar/ deteriorate/ improve. Why?

This question was asked during each session dedicated to particular step of ACAS Xo designation process: Selection of the target, Selection of the mode, Activation of ACAS Xo, Execution of the procedure, Manual deactivation of ACAS Xo, Automatic deactivation of ACAS Xo.

Two additional statements on situation awareness were assessed within the questionnaire after the mock-up session:

- In my opinion the situation awareness during the execution of ACAS Xo procedures will be acceptable.
- I think that an extra window with information on designated aircraft would help with my situation awareness concerning designated aircraft.

Discussion:

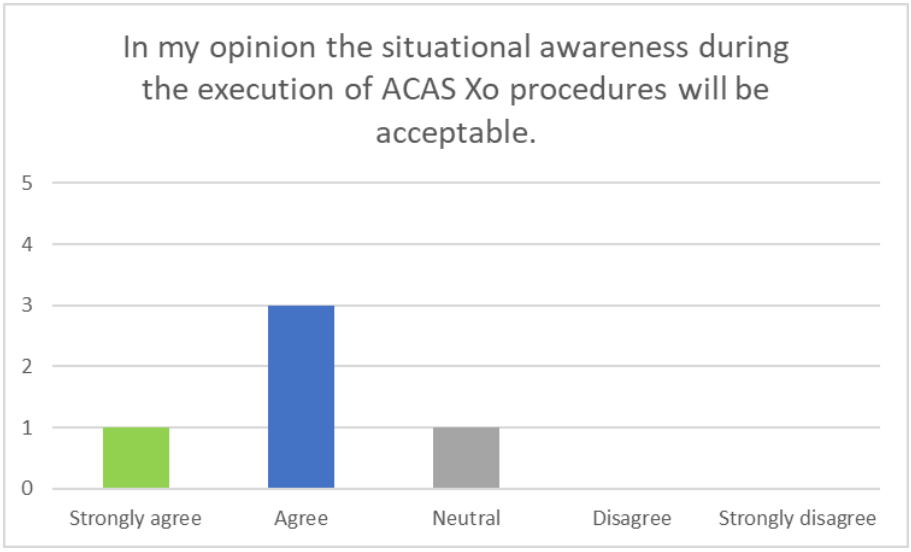
Situation awareness is not expected to be significantly different from current situation, but the confidence in issued RAs may increase (RAs will be less likely perceived as nuisance RAs and, therefore, compliance with them is expected to increase).

The situation awareness is expected to stay the same or slightly increase with DNA mode, since (contrary to TA-only mode) it still generates RA against other than designated traffic. If the system is well designed, the situation awareness has a potential to increase.

However, it is also possible that the overall situation awareness might somewhat decrease due to pilot's constant monitoring of one target, on instruments as well as visually. Situation awareness will decrease if you lose the target from the navigation display in CSPO-3000 and lose the target visually in DNA. An immediate action should then be taken.

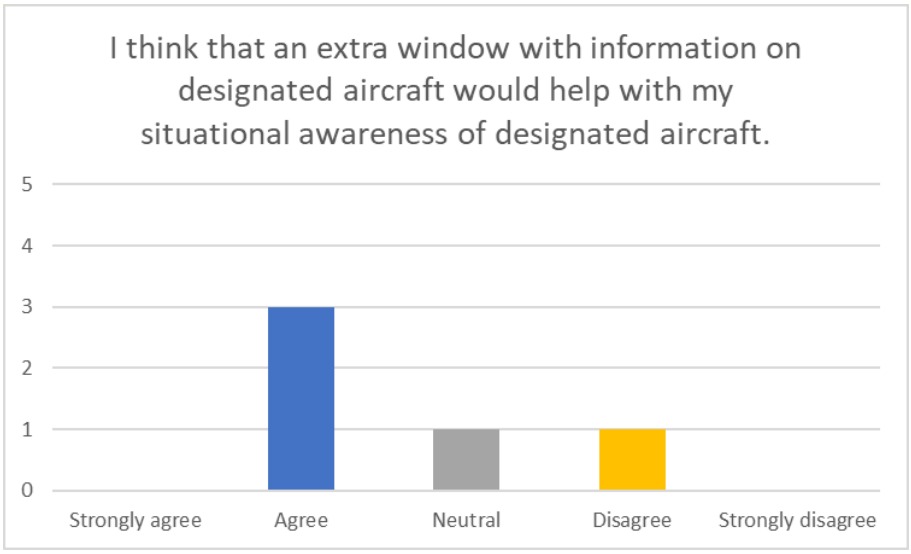
Questionnaire:

4 out of 5 participants expressed positive attitude ("strongly agree" and "agree") to the statement that the situation awareness during the execution of ACAS Xo procedures will be acceptable. 1 out of 5 participants expressed neutral attitude to this statement:



Graph 8: Factors impacting FC situation awareness (EX1-OBJ-PJ.11.A3-V2-VALP-007)

3 out of 5 participants expressed positive attitude ("agree") to the statement, that they think that an extra window with information on designated aircraft would help with their situation awareness of designated aircraft. 1 out of 5 participants expressed neutral attitude. 1 out of 5 participants expressed negative attitude ("disagree") with a note, that if the special window was to be beneficial to the pilot, it has to include valuable additional information which he was missing in the current HMI proposal:



Graph 9: Factors impacting FC situation awareness (EX1-OBJ-PJ.11.A3-V2-VALP-007)

EX1-OBJ-PJ.11.A3-V2-VALP-008 (Preliminary training needs)

To identify preliminary training needs, initial knowledge skills and experience requirements, the following question that has been asked during the workshop discussion:

- What additional training (knowledge, skills etc.) will the pilots require to fly ACAS Xo procedures?

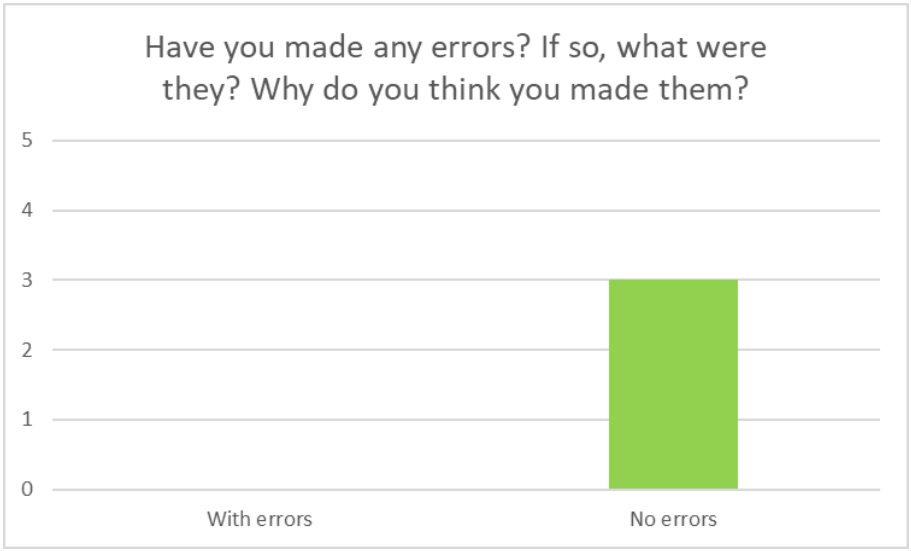
Discussion:

ACAS Xo would require regulatory updates as well as pilot training. Good understanding of how the system works and what the possible system limitations are should support the decision of whether and how the ACAS Xo would be used. Responsibility and reporting policies will need to be clearly thought out. Regulations should consider making ACAS Xo training compulsory, regular and recurring.

EX1-OBJ-PJ.11.A3-V2-VALP-009 (Potential errors regarding target designation task)

After the discussion, the low-fidelity mock-up session took place. During this session pilots were asked to evaluate proposed HMI to assess the potential of a human error within the defined task sequence. Obtained results are applicable also for EX1-OBJ-PJ.11.A3-V2-VALP-010 (Potential errors regarding mode selection) and EX1-OBJ-PJ.11.A3-V2-VALP-011 (Potential errors regarding mode awareness).

3 out of 5 participants stated they made no errors. 2 out of 5 participants did not report making or not making an error. 1 participant suggested different design for mode selection and 1 participant stated, that “fixed scenario” made it impossible to make an error:



Graph 10: Potential errors

To identify potential changes to human error and preliminary mitigations regarding the target designation task, the following questions were asked during the discussion:

- How likely is it that you may choose the wrong ACAS Xo target aircraft?

- Why could you choose the wrong target aircraft? What will happen if you do? Different implications for DNA/ CSPO-3000? How would you recover from this? What is the mitigation?

The probability of selecting the wrong aircraft as the ACAS Xo target does exist and with ACAS Xo DNA is high (higher in airports with dense and mixed traffic where DNA would be most beneficial).

Visual acquisition before designation on the traffic display is only feasible during good VMC conditions, but night time and other conditions impacting visibility make it increasingly difficult.

EX1-OBJ-PJ.11.A3-V2-VALP-010 (Potential errors regarding mode selection)

To identify potential changes to human error and preliminary mitigations regarding the mode selection task, following set of questions were asked during the workshop:

- How likely is it that you may choose the wrong ACAS Xo mode (e.g. CSPO-3000 instead of DNA)?

- Why could you choose the wrong mode? What will happen if you do? How would you recover from this? What is the mitigation?

The potential for making an error when selecting the mode does exist. Mitigation means will depend greatly on the HMI design. The participants of the workshop have experience with different types of aircraft. The sequence of steps to select the target and the mode can differ depending on the aircraft type or different HMI implementation. In some aircraft, the first step would be the selection of a mode, then the designation of an aircraft, but in the other types of aircraft pilot would first select the target and after that he/she select the mode. During the mock-up session, no errors in the mode selection were observed. One participant stated that it would be beneficial to have kind of “default” text alongside one of the two modes indicating which mode is suggested, or pre-selected by the system for particular aircraft during particular operation taking into account traffic validity requirements. Such option might potentially decrease risk of error during mode selection.

EX1-OBJ-PJ.11.A3-V2-VALP-011 (Potential errors regarding mode awareness)

To identify potential changes to human error and preliminary mitigations regarding the mode awareness, following questions were asked during the workshop:

- How likely is it that you will lose the awareness of the mode you selected (CSPO-3000 or DNA) after the activation?

- Why could you lose awareness? What will happen if you do? How would you recover from this? What is the mitigation?

Discussion:

Missing, or insufficiently visible information about the selected mode of ACAS Xo could potentially lead to an error.

Pilots would expect to have the information about the selected mode available. This information could be highlighted in a special window on navigation display or, on a TCAS display, together with other supplementary information to avoid losing awareness of the selected mode(refer to section EX1-OBJ-PJ.11.A3-V2-VALP-007 for more information).

EX1-OBJ-PJ.11.A3-V2-VALP-012 (Automatic un-designation)

We have assessed that automatic un-designation is well understood by FC and that the understanding of the technical system behaviour is consistent with operator´s task demands. To do so, following set of questions was asked during the workshop discussion:

- Can you think of other situations when the automatic de-activation would be preferred?
- How would you react to the automatic de-activation of a target in CSPO3000 mode?
- What information do you need to understand that target is de-activated? Any different for DNA?
- Does a pilot need an alert to be notified of the automatic de-activation? If so, what kind?
- Does a pilot need an indication of the reason for deactivation?

After the workshop discussion, the following set of statements addressing automatic un-designation were included in the questionnaire:

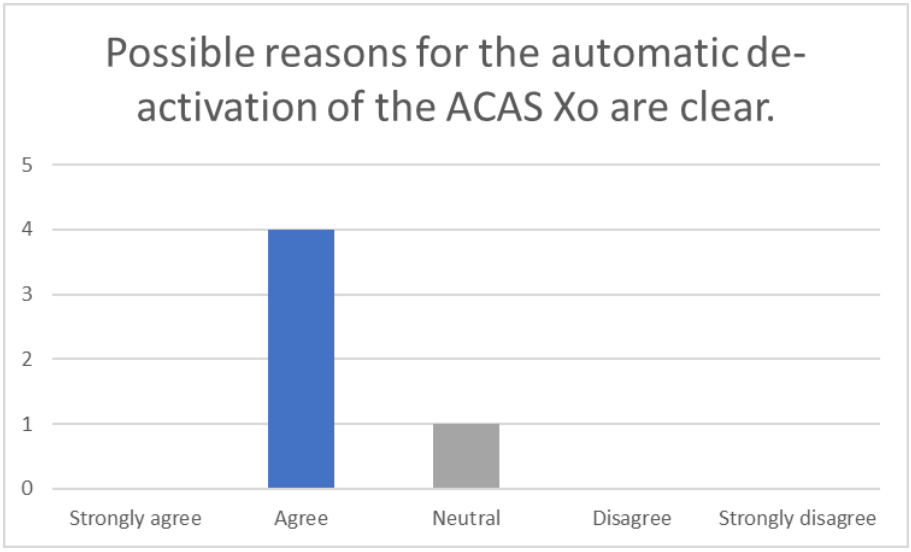
- Possible reasons for the automatic de-activation of the ACAS Xo target aircraft are clear.
- The algorithm for the automatic de-activation of the target does not need any revision.
- When an automatic un-designation occurs for the designated aircraft, I would like to know for which mode the aircraft was designated before.
- The system should try to reconnect when automatic un-designation will appear.
- For how long should the system try to reconnect to the automatically undesignated aircraft?

Discussion:

Understanding of the ACAS Xo behaviour is important to be able to perform ACAS Xo related tasks. When automatic un-designation of traffic occurs, pilots will not search for the reasons for un-designation but will continue to fly the aircraft. If the RA is triggered (not depending if it is due to automatic un-designation of the DNA mode, or not), pilots will react immediately.

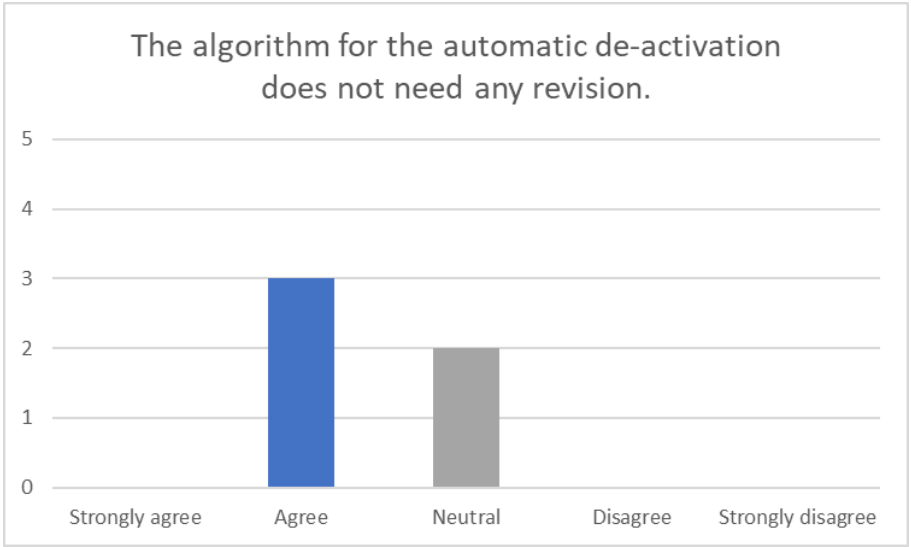
Questionnaire:

4 out of 5 participants expressed positive attitude (“agree”) to the statement that possible reasons for automatic un-designation of the ACAS Xo are clear. 1 out of 5 participants expressed neutral attitude:



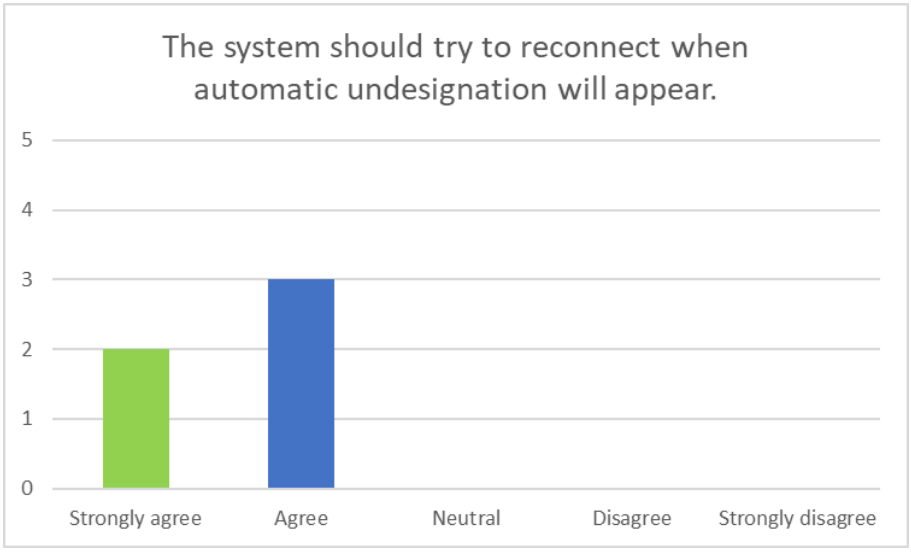
Graph 11: Automatic un-designation (EX1-OBJ-PJ.11.A3-V2-VALP-012)

3 out of 5 participants expressed positive attitude ("agree") to the statement that the algorithm for automatic un-designation does not need any revision. 2 out of 5 participants expressed neutral attitude to this statement with a note, that automatic un-designation needs to be reviewed to make sure that all cases are covered:



Graph 12: Automatic un-designation (EX1-OBJ-PJ.11.A3-V2-VALP-012)

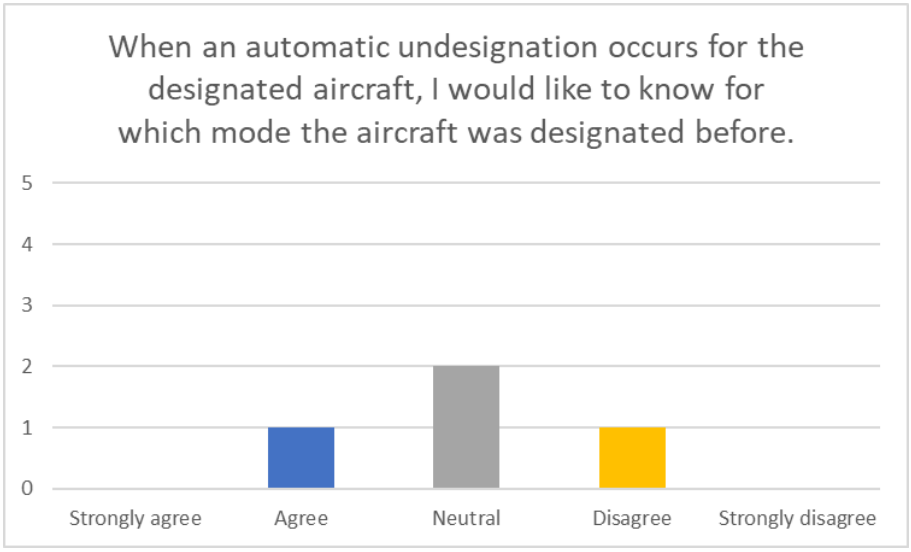
5 out of 5 participants expressed positive attitude ("strongly agree" and "agree") to the statement that the system should try to reconnect when automatic un-designation occurs:



Graph 13: Automatic un-designation (EX1-OBJ-PJ.11.A3-V2-VALP-012)

To have a complete picture about the pilot perception on automatic un-designation reconnection functionality, we have asked a supplementary question about the time that is acceptable for pilot to let the system try to re-establish the lost connection. Participants have stated that the information about automatic un-designation should be provided to the FC as a flashing symbol or visual alert. The acceptable time frame for how long the system should be trying to reconnect has been set to 10 sec at minimum and 60 sec at maximum depending on the position of the aircraft (ownship), phase of the approach and selected mode (the cases for CSPO-3000 and DNA will differ). The displayed countdown (time that has elapsed after the un-designation) in seconds would be beneficial to the pilot. The system should give a message that the connection has been lost. The procedure of how the FC should react should be prescribed in SOPs.

1 out of 4 participants expressed positive attitude (“agree”) to the statement, that they would like to know for which mode was the aircraft designated before automatic un-designation happened. 2 out of 4 participants expressed neutral attitude to this statement. 1 participant disagreed to this statement. 1 participant did not answer. Therefore, it does not appear like this is information that is critical to pilots.



Graph 14: Automatic un-designation (EX1-OBJ-PJ.11.A3-V2-VALP-012)

EX1-OBJ-PJ.11.A3-V2-VALP-013 (Information needs meeting with the proposed design)

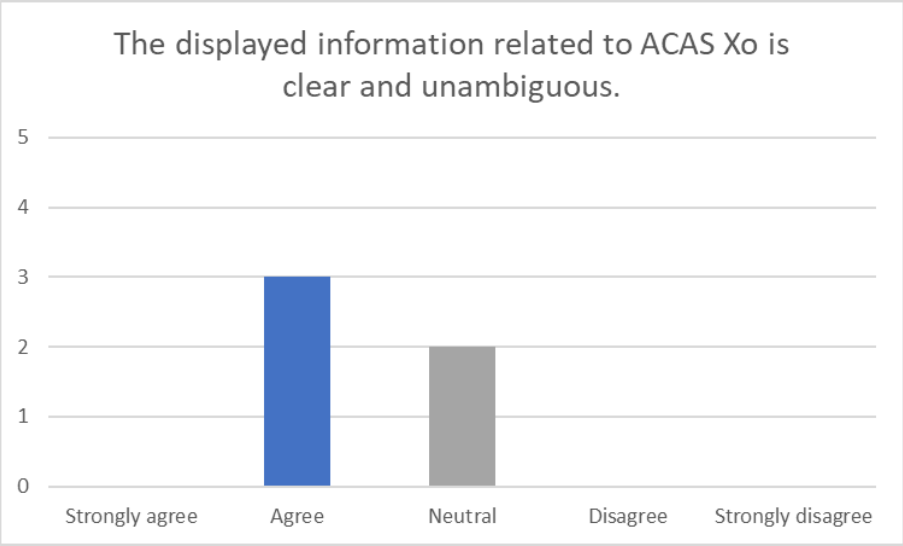
To assess whether information needs of the FC to be able to successfully use ACAS Xo are met with the proposed design, we focused on whether there is no discrepancy between system-provided information and user-required information. To do so, the following set of questions was presented to participants after the mock-up session:

- The displayed information related to ACAS Xo is clear and unambiguous.
- The information on the display is sufficient to successfully execute ACAS Xo procedure.
- Did you need any additional information that was missing from the HMI? If so what was it?
- What information elements on HMI did you find helpful when using ACAS Xo procedures: a) DNA b) CSPO3000?
- Would you change anything about how the ACAS Xo-related information was presented to you?
- How would you like to present currently activated mode on designated symbol in case of CSPO?
- How would you like to present currently activated mode on designated symbol in case of DNA?
- ACAS Xo system should offer only modes that are applicable for particular intruder.
- CPDLC messages would be beneficial to communicate with ATC regarding ACAS Xo.

- CPDLC messages from ATC should provide direct activation of ACAS Xo functionality (highlight intruder, activate mode).

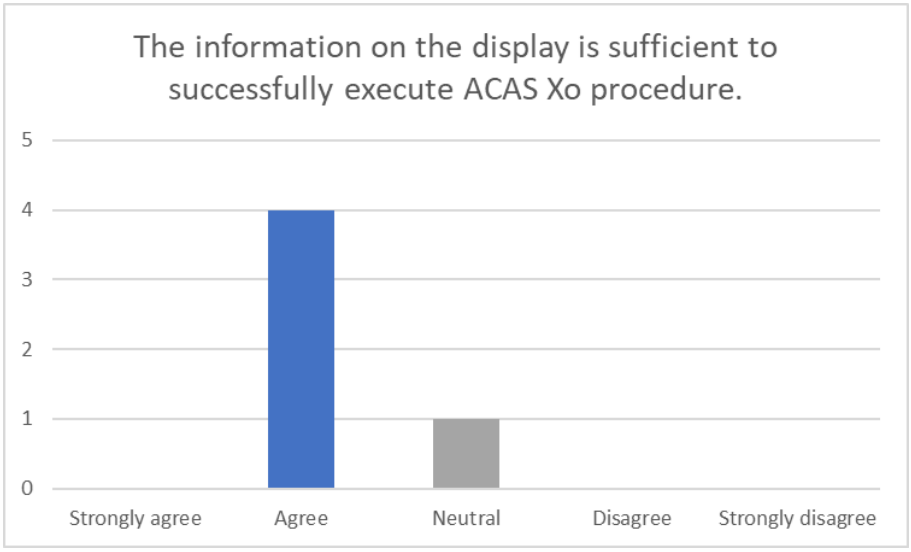
Questionnaire:

3 out of 5 participants expressed positive attitude (“agree”) to the statement that they agree that the displayed information related to ACAS Xo is clear and unambiguous. 2 participants expressed neutral attitude to this statement:



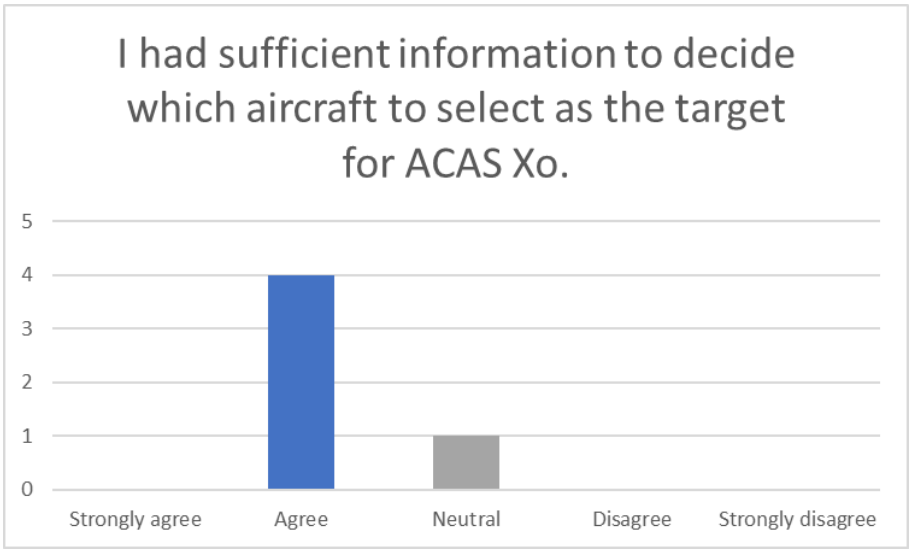
Graph 15: Information needs meeting with the proposed design (EX1-OBJ-PJ.11.A3-V2-VALP-013)

4 out of 5 participants expressed positive attitude (“agree”) to the statement that the information on the display is sufficient to successfully execute ACAS Xo procedure. 1 participant expressed neutral attitude to this statement:



Graph 16: : Information needs meeting with the proposed design (EX1-OBJ-PJ.11.A3-V2-VALP-013)

4 out of 5 participants expressed positive attitude ("agree") to the statement that they had sufficient information to decide which aircraft to select as the target for ACAS Xo. 1 participant expressed neutral attitude to this statement:



Graph 17: Information needs meeting with the proposed design (EX1-OBJ-PJ.11.A3-V2-VALP-013)

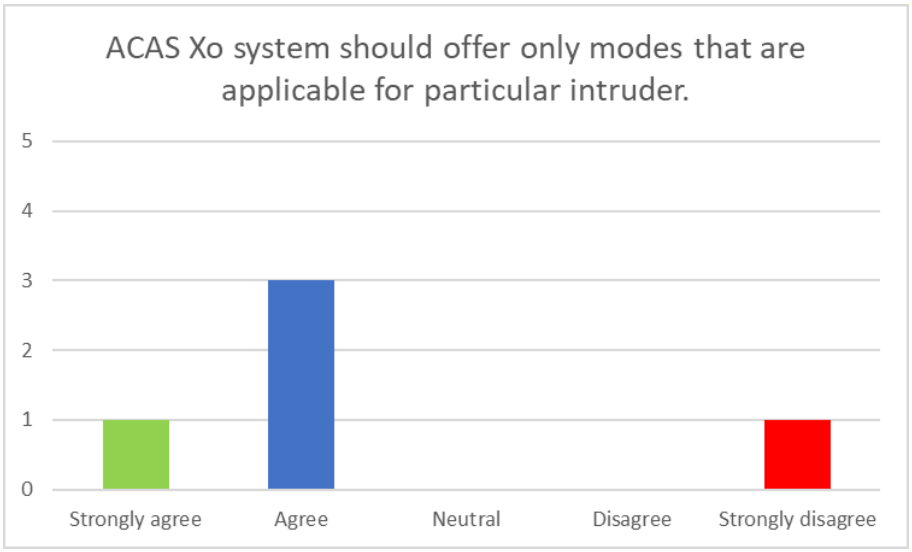
Participants of evaluation also provided feedback on whether they were missing any information or whether they would like to add any additional information to current ACAS Xo HMI. Participants of the evaluation did not miss any information but provided suggestions for possible information to be added, e.g. how close you are coming to the actual separation limits. This piece of information would be helpful mainly for CSPO-3000 mode.

Proposed symbols and labels have been rated by participants as helpful information elements of ACAS Xo HMI design. Other information that has been rated as helpful is the ADS-B data (the call sign, relative altitude and trend) for both modes (DNA and CSPO-3000) consistently.

Participants have been asked if they would change anything about how the ACAS Xo-related information has been presented. Participants expressed positive attitude to the amount and form of presentation of ACAS Xo information within the proposed HMI design. One of the suggestions was to add e.g. indication for automatic designation. A special window with an actual separation (that has been presented as a possible part of ACAS Xo design) has been rated as possibly helpful as well.

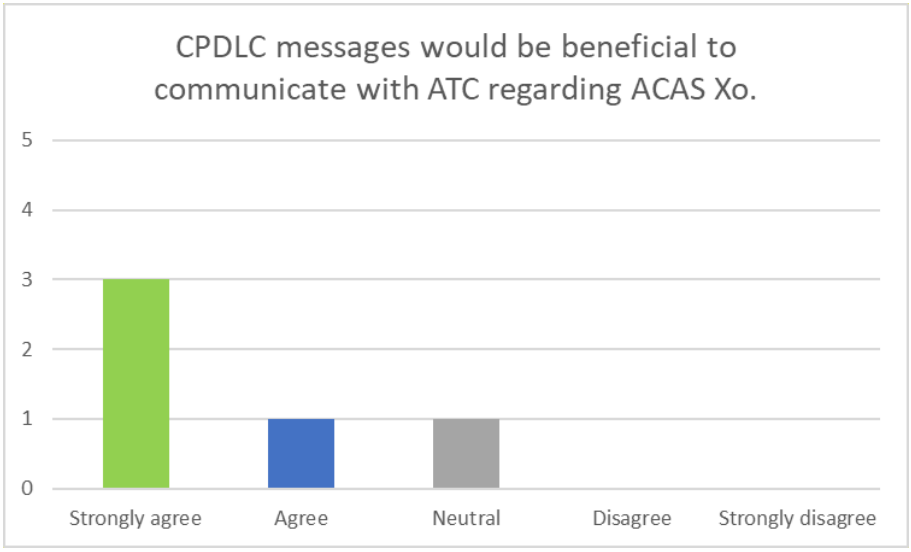
Participants have been asked how they would like currently activated mode to be presented in case of CSPO-3000 and DNA. For both modes, the most suitable and understandable presentation is the label with written abbreviation of mode (i.e. “DNA” for DNA and “CSPO” for CSPO-3000) placed near the traffic symbol of designated aircraft.

4 out of 5 participants expressed positive attitude (“strongly agree” and “agree”) to the statement that ACAS Xo system should offer only modes that are applicable for particular intruder. 1 out of 5 participants expressed negative attitude to this statement and added a note, that the system should not only offer modes applicable for particular intruder but also for the particular airport:



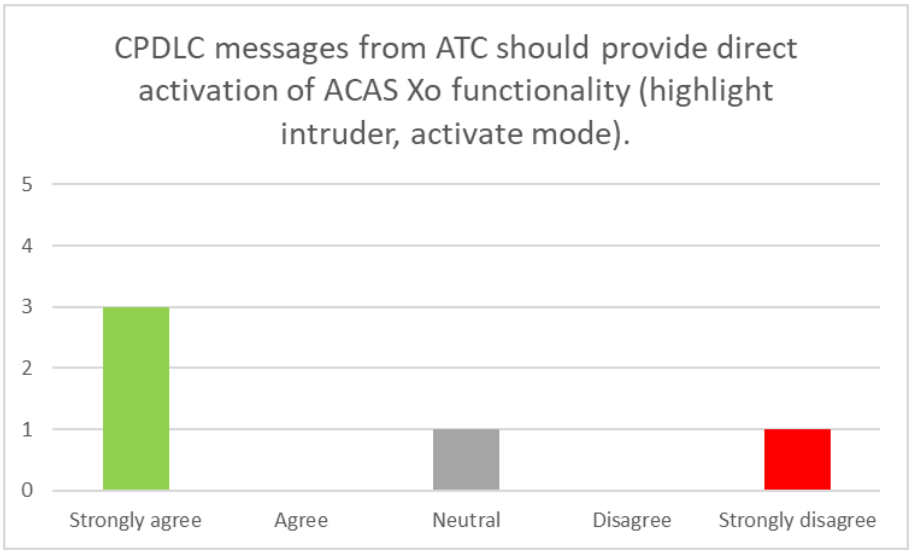
Graph 18: Information needs meeting with the proposed design (EX1-OBJ-PJ.11.A3-V2-VALP-013)

4 out of 5 participants expressed positive attitude (“strongly agree” and “agree”) to the statement, that CPDLC messages would be beneficial to communicate with ATC regarding ACAS Xo. 1 out of 5 participants expressed neutral attitude to this statement:



Graph 19: Information needs meeting with the proposed design (EX1-OBJ-PJ.11.A3-V2-VALP-013)

3 out of 5 participants expressed positive attitude ("strongly agree") to the statement, that CPDLC messages from ATC should provide direct activation of ACAS Xo functionality (highlight intruder, activate mode). 1 out of 5 participants expressed neutral attitude to this statement. 1 out of 5 participants expressed negative attitude to this statement ("strongly disagree") with a note that this possible feature has been rejected at the design stage of ACAS Xo:



Graph 20: Information needs meeting with the proposed design (EX1-OBJ-PJ.11.A3-V2-VALP-013)

EX1-OBJ-PJ.11.A3-V2-VALP-014 (Information needs regarding mode awareness)

To identify the information needs regarding the mode awareness, following set of questions was included in the mock-up questionnaire:

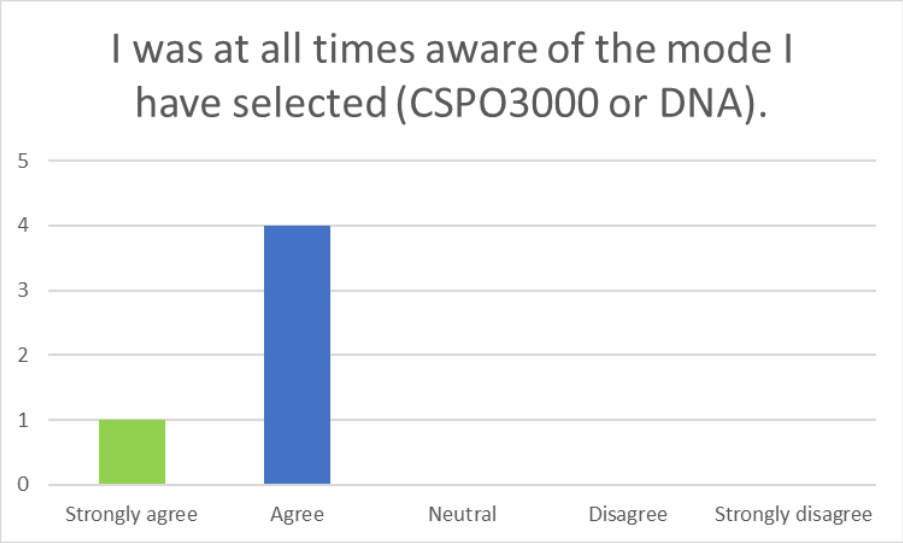
- I was at all times aware of the mode I have selected (CSPO-3000 or DNA).
- Have you lost awareness of the selected mode? If so, why do you think it happened? If you haven't, what do you think helped you maintain it?

Questionnaire:

Participants have stated that the provided labels of selected mode have been helpful, as it was an unknown display for most of them, the labels have been found useful to maintain awareness of the selected mode.

None of the 5 participants have lost awareness of the selected mode. The proposed HMI had information label showing the mode selected. This label has been rated as helpful and useful by 2 participants. 1 participant expressed worries about the potential clutter in navigation display regarding the label.

5 out of 5 participants expressed positive attitude ("strongly agree" and "agree") to the statement that they were all times aware of the mode they have selected:



Graph 21: Information needs regarding mode awareness (EX1-OBJ-PJ.11.A3-V2-VALP-014)

EX1-OBJ-PJ.11.A3-V2-VALP-015 (Usability of HMI to select the target)

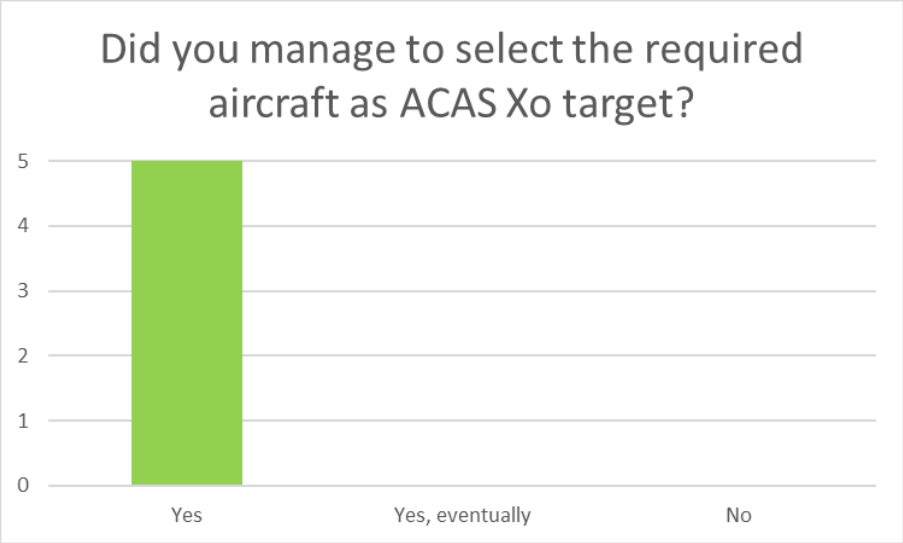
To assess the usability of HMI to select the target, prepared mock-up was used. After the mock-up session pilots were asked to answer the following set of questions in questionnaire:

- Did you manage to select the required aircraft as ACAS Xo target?

- I found it easy to select the aircraft as the ACAS Xo target on the HMI.
- Have you made any errors? If so, what were they? Why do you think you made them?

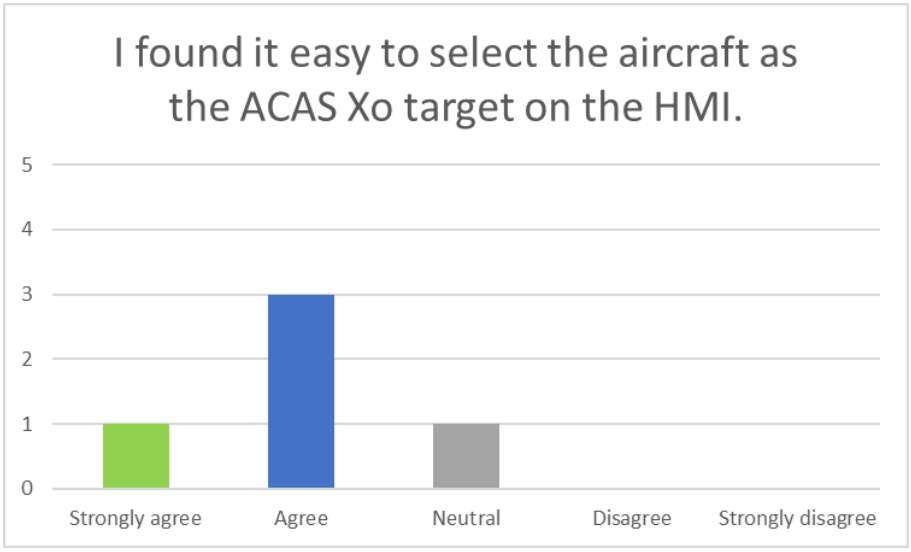
Questionnaire:

5 out of 5 participants did manage to select the required aircraft as ACAS Xo target within current mock-up:



Graph 22: Usability of HMI to select the target (EX1-OBJ-PJ.11.A3-V2-VALP-015)

4 out of 5 participants expressed positive atitude ("strongly agree" and "agree") to the statement, that they found it easy to select the aircraft as ACAS Xo target on the HMI. 1 participant expressed neutral attitude.



Graph 23: Usability of HMI to select the target (EX1-OBJ-PJ.11.A3-V2-VALP-015)

5 out of 5 participants made no errors. Participants have experienced selection of target within mock-up as sufficiently usable.

EX1-OBJ-PJ.11.A3-V2-VALP-016 (Usability of HMI to activate the ACAS Xo function)

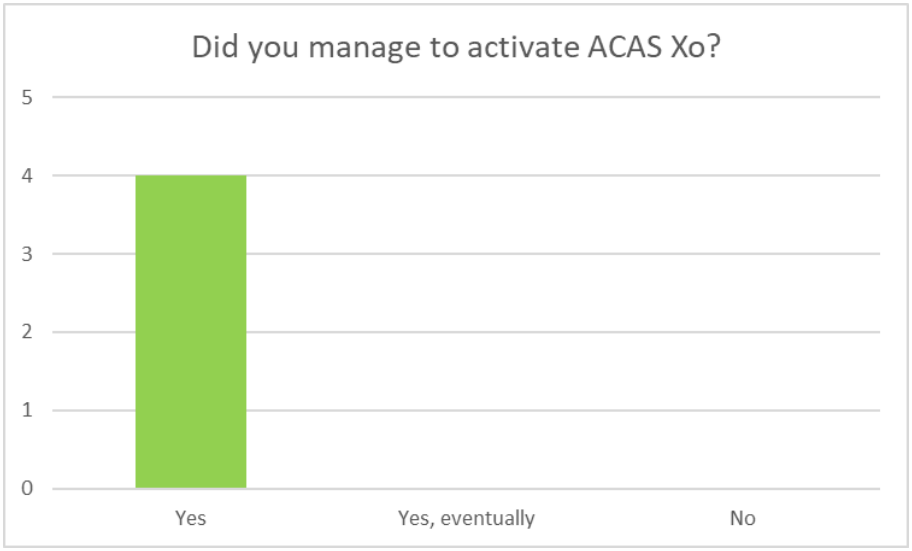
To assess the usability of HMI to activate the ACAS Xo function we have prepared the mock-up. After the mock-up session pilots were asked to answer the following set of questions:

- Did you manage to activate ACAS Xo?
- Do you find it easy to activate ACAS Xo?
- Have you made any errors? If so, what were they? Why do you think you made them?
- Do you find the symbol for designated aircraft understandable? If not, what is your suggestion?
- Do you think the symbol of designated aircraft could interfere with other aircraft symbols? With which symbols and why?
- would you prefer final pilot's consent for manual designation? (i.e. Do you really want to activate this mode? Yes/No)
- Should the activation of CSPO-3000 mode be done automatically?
- Would you prefer final pilot's consent for automatic designation? (i.e. Do you really want to activate this mode? Yes/No)
- Do you think that automatic designation is beneficial? Why?

- Do you think that automatic designation is acceptable for both modes (DNA, CSPO)?

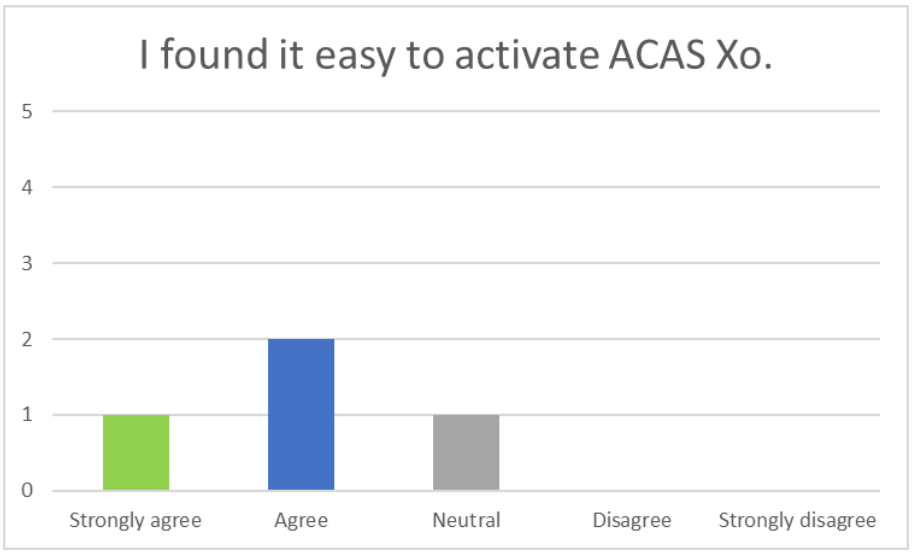
Questionnaire:

4 out of 4 participants did manage to activate the ACAS Xo function:



Graph 24: Usability of HMI to activate the ACAS Xo function (EX1-OBJ-PJ.11.A3-V2-VALP-016)

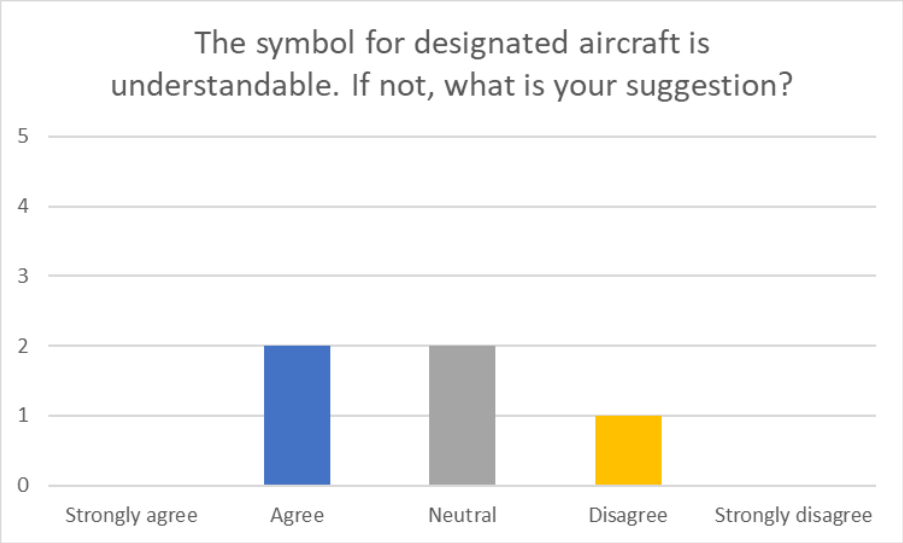
3 out of 4 participants expressed positive attitude ("strongly agree" and "agree") to the statement that they found it easy to activate the ACAS Xo. 1 participant expressed neutral attitude to this statement:



Graph 25: Usability of HMI to activate the ACAS Xo function (EX1-OBJ-PJ.11.A3-V2-VALP-016)

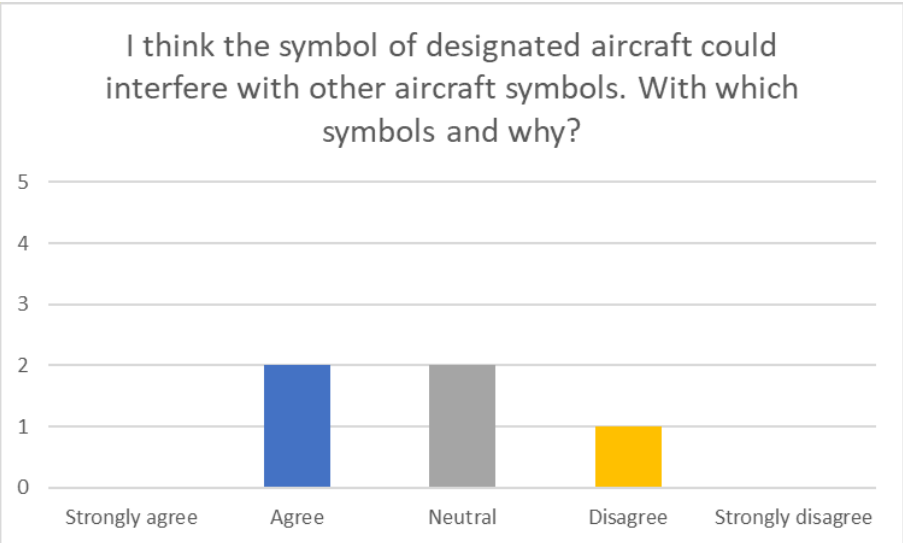
5 out of 5 participants have made no errors. Participants have experienced activation of ACAS Xo function within mockup as sufficiently usable.

2 out of 5 participants expressed positive attitude (“agree”) to the statement, that the designated aircraft symbol is understandable. 2 out of 5 participants expressed neutral attitude. 1 out of 5 participants expressed negative attitude (“disagree”) with a note, that for CSPO the symbol should be combined with traditional TCAS symbols:



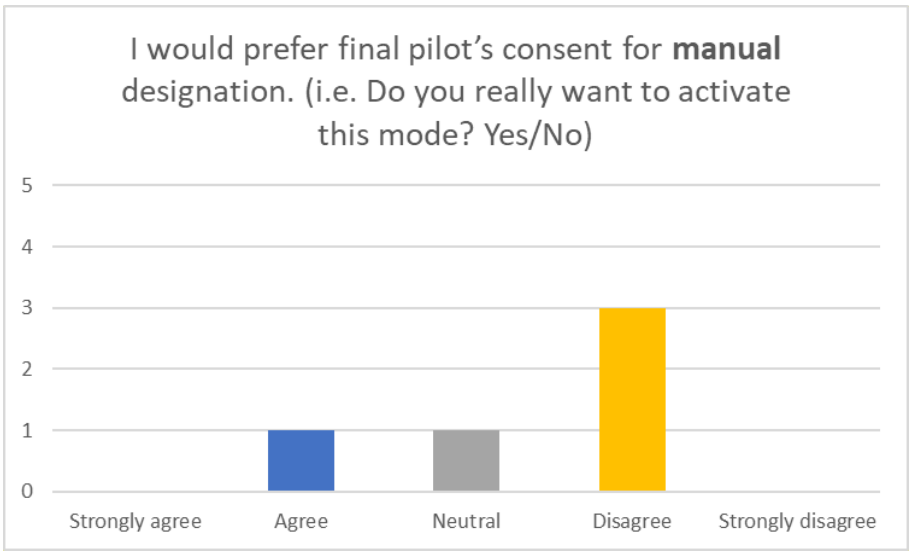
Graph 26: Usability of HMI to activate the ACAS Xo function (EX1-OBJ-PJ.11.A3-V2-VALP-016)

2 out of 5 participants expressed positive attitude (“agree”) to the statement, that they think the symbol of designated aircraft could interfere with other aircraft symbols. 2 out of 5 participants expressed neutral attitude. 1 out of 5 participants expressed negative attitude (“disagree”):



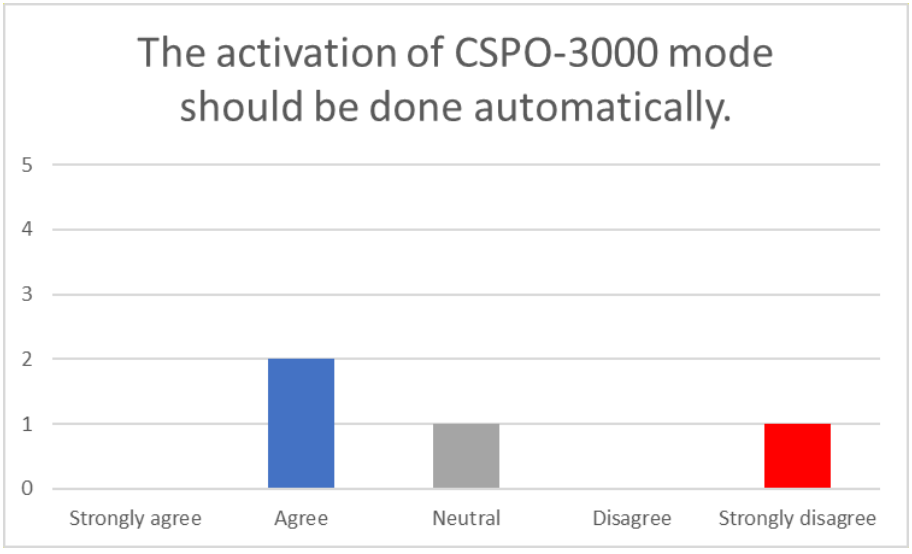
Graph 27: Usability of HMI to activate the ACAS Xo function (EX1-OBJ-PJ.11.A3-V2-VALP-016)

3 out of 5 participants expressed negative attitude (“disagree”) to the statement, that if they would prefer final pilot’s consent for manual designation with a note, that it should be rather easy way to designate and un-designate (one click). 1 out of 5 participants expressed neutral attitude to this statement. 1 out of 5 participants expressed positive attitude (“agree”) to this statement:



Graph 28: Usability of HMI to activate the ACAS Xo function (EX1-OBJ-PJ.11.A3-V2-VALP-016)

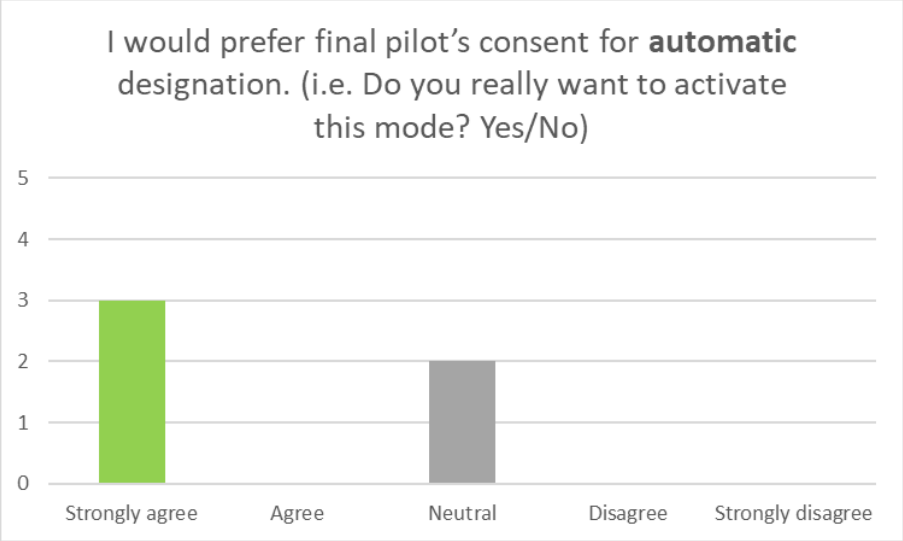
2 out of 5 participants expressed positive attitude (“agree”) to the statement, that the activation of CSPO-3000 mode should be done automatically. 1 out of 5 participants expressed neutral attitude to this statement. 1 out of 5 participants expressed negative attitude (“strongly disagree”) to this statement with a note that it is difficult to say without studying operational cases, but it should be possible for both modes:



Graph 29: Usability of HMI to activate the ACAS Xo function (EX1-OBJ-PJ.11.A3-V2-VALP-016)

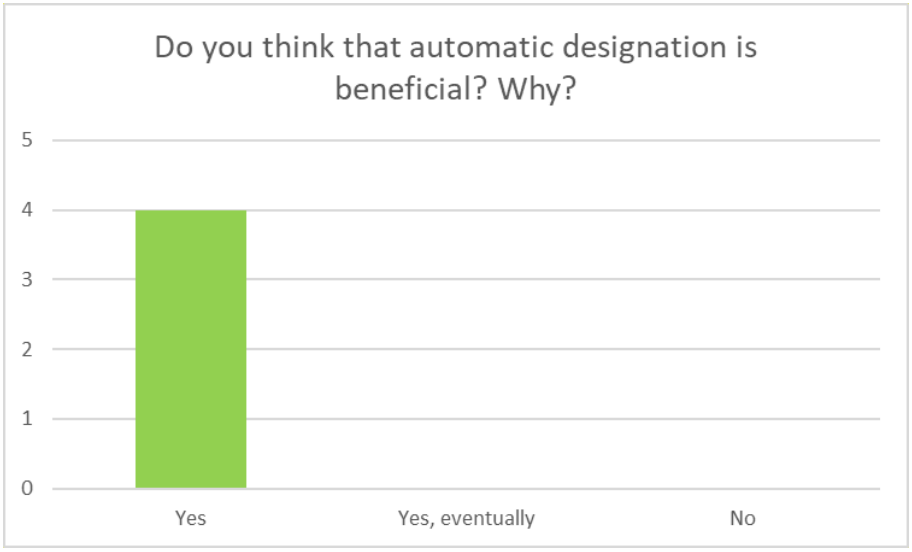
When we have asked participants what they think could be the trigger for this automatic designation in CSPO-3000 mode, they proposed that the trigger could be the aircraft being established in LOC or ILS. Participants also expressed that simulations are needed to decide.

3 out of 5 participants expressed positive attitude ("strongly agree") to the statement, that they would prefer final pilot's consent for automatic designation. 2 out of 5 participants expressed neutral attitude to this statement:



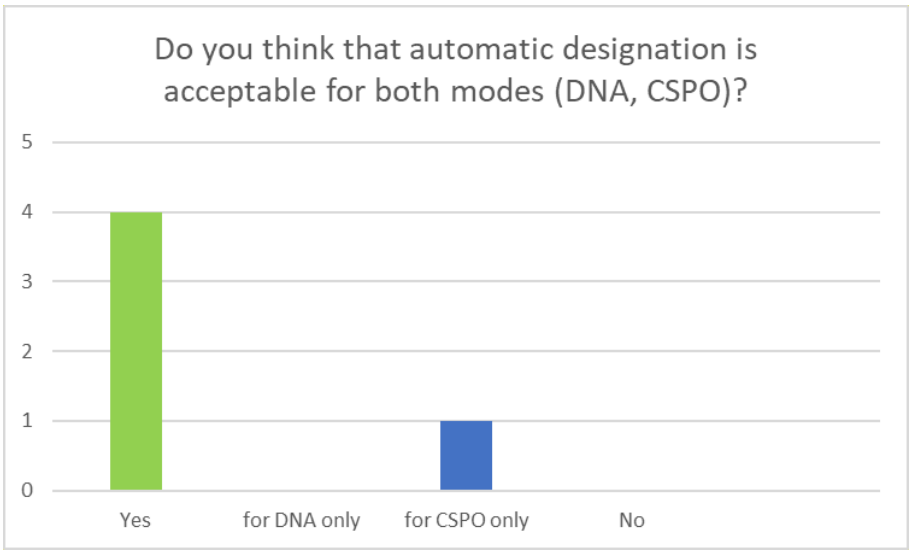
Graph 30: Usability of HMI to activate the ACAS Xo function (EX1-OBJ-PJ.11.A3-V2-VALP-016)

4 out of 4 participants expressed positive attitude ("yes") to the statement, that the automatic designation is beneficial:



Graph 31: Usability of HMI to activate the ACAS Xo function (EX1-OBJ-PJ.11.A3-V2-VALP-016)

4 out of 5 participants expressed ("yes") that they think the automatic designation is acceptable for both modes. 1 out of 5 participants expressed that the automatic designation is acceptable for CSPO--3000 mode only:



Graph 32: Usability of HMI to activate the ACAS Xo function (EX1-OBJ-PJ.11.A3-V2-VALP-016)

EX1-OBJ-PJ.11.A3-V2-VALP-017 (Usability of HMI to undesignated the target)

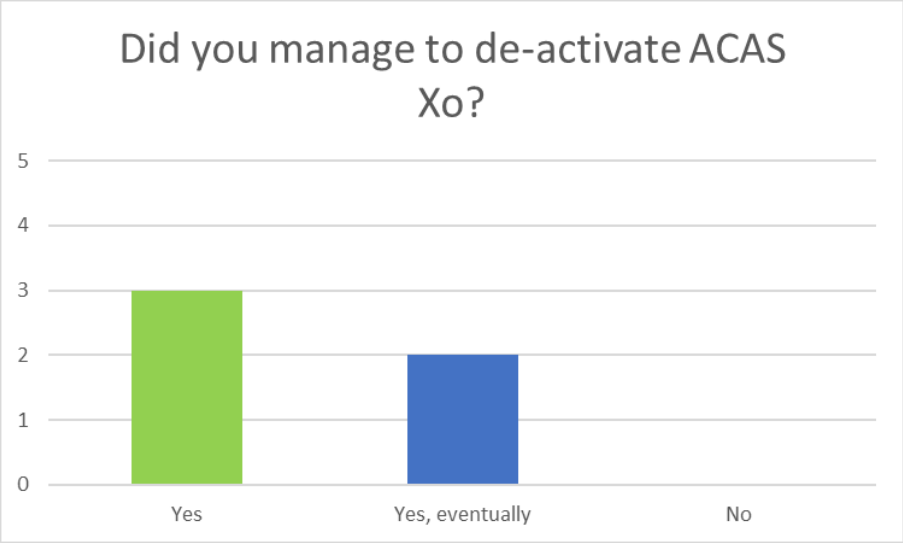
To assess the usability of the HMI to un-designate the target, the mock-up was used. After the mock-up session, pilots were asked to answer the following questions::

Did you manage to de-activate ACAS Xo?

Did you find it easy to de-activate ACAS Xo?

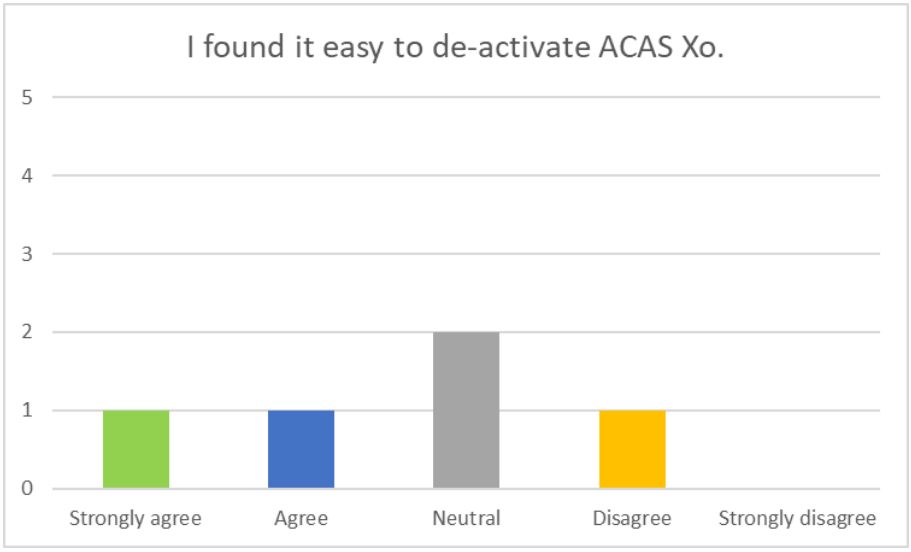
Questionnaire:

4 out of 4 participants did manage (“yes” and “yes, eventually”) to de-activate ACAS Xo.



Graph 33: Usability of HMI to undesignated the target (EX1-OBJ-PJ.11.A3-V2-VALP-017)

2 out of 5 participants expressed positive attitude (“strongly agree” and “agree”) to the statement that they found it easy to de-acitvate ACAS Xo. 2 out of 5 participants expressed neutral attitude to this statement. 1 out of 5 participants expressed negative attitude (“disagree”) to this statement. Analysis of the answers show, that the reason for neutral and negative attitude in this case were not based on the feasibility of operation (de-activation use case) but it is more HMI design-related(participant experienced difficulities to click on the right spot because of the low maturity of the mock-up design). Furhter analysis showed that pilots also expressed concerns about deactivation when experiencing turbulence :



Graph 34: Usability of HMI to undesignated the target (EX1-OBJ-PJ.11.A3-V2-VALP-017)

EX1-OBJ-PJ.11.A3-V2-VALP-018 (Alerts needs meeting with the current concept)

To assess if FC alert needs are met with the current concept and to identify initial needs and requirements, following set of questions were raised during the discussion:

- Do you find it acceptable that you are not alerted about the target aircraft in your proximity when DNA mode is selected?
- Do you find it acceptable that in CSPO3000 mode you receive an alert for the target aircraft later than normally?

After the workshop discussion, during mock-up session, the following statements were assessed addressing other possible alert needs were included in the questionnaire:

- I would like to be informed when designated aircraft is in my (even mode-adjusted) proximity area.
- I would like to be informed if someone designates me. How?

Discussion:

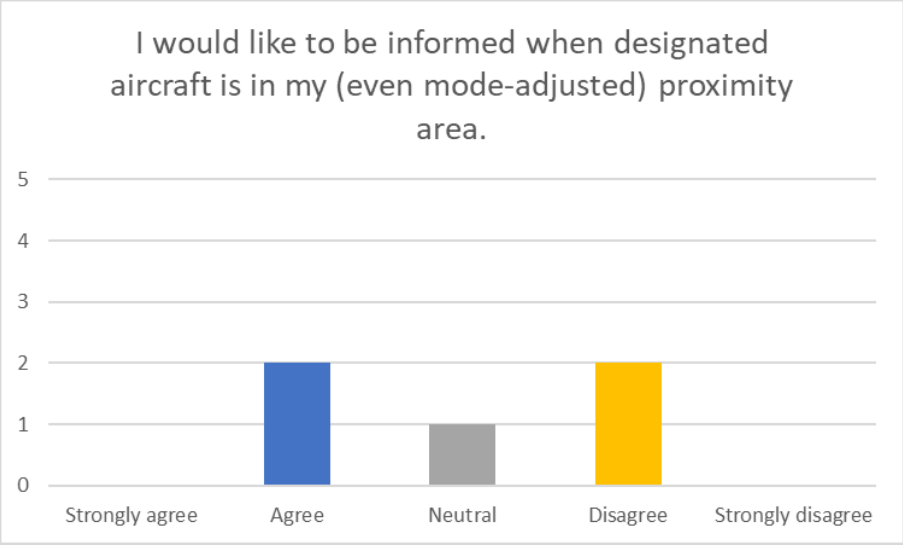
DNA mode brings many questions and concerns assuming there will be no alerts when traffic is designated for DNA mode. The philosophy of DNA mode with no alerts is unacceptable for most of the pilots, all the more when the aircraft (ownship) is not yet established on localizer.

Pilots feel like as if the safety net has been completely removed, pilots are not used to visual self-separation. The DNA “no alert” philosophy could be the reason for most of the workshop participants for not accepting of ACAS Xo DNA as an operational concept.

Regarding the delay of CSPO-3000 mode alert, this situation is accepted by most of the pilots as a part of design.

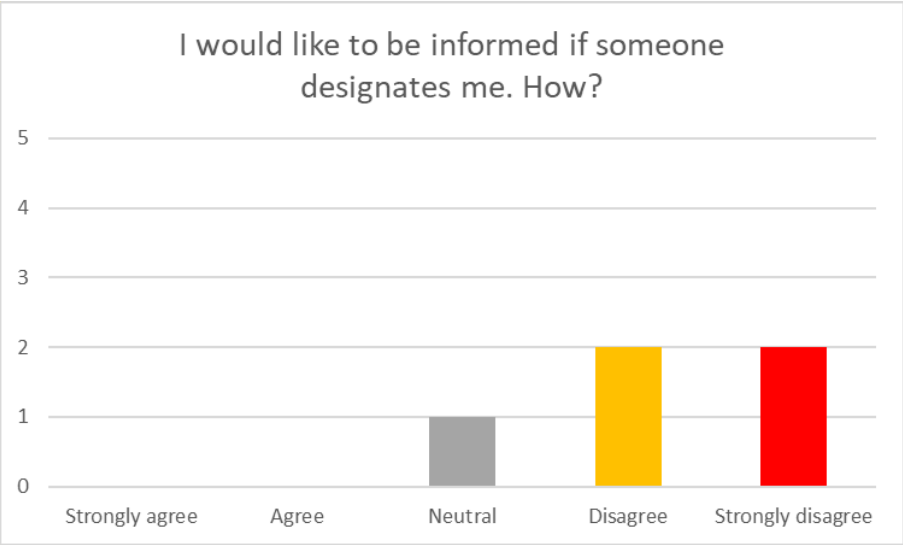
Questionnaire:

2 out of 5 participants expressed positie atitude (“agree”) to the statement, that they would like to be informed when designated aircraft is in their (even mode-adjusted) proximity area. 1 participant expressed neutral attitude to this statement. 2 out of 5 participants expressed negative atittude to this statement with a note that it would be beneficial to have this information even beyond proximity area of ownhsip:



Graph 35: Alerts needs meeting with the current concept (EX1-OBJ-PJ.11.A3-V2-VALP-018)

4 out of 5 participant expressed negative atitude (“strongly disagree” and “disagree”) to the statement, that they would like to be informed if someone designates them with a note that it is likely that such an information causes confusion and information overload. 1 participant expressed neutral attitude to this statement:



Graph 36: Alerts needs meeting with the current concept (EX1-OBJ-PJ.11.A3-V2-VALP-018)

To have a complete picture about the pilot perception on alerting when automatic un-designation reconnection will occur we have asked a supplementary question about how the procedure of re-establishing lost connection could look like. Participants have stated that the information about automatic un-designation should be provided to the FC as a visual alert (possibly a flashing symbol). The countdown in seconds measuring time from automatic un-designation until reconnection or time that has elapsed after the un-designation, would be beneficial to the pilot. The system should give a message that the connection has been lost.

EX1-OBJ-PJ.11.A3-V2-VALP-019 (Potentially achievable benefits of tailored European ACAS Xo version)

Objective addressing tailored European ACAS Xo version and its potentially achievable benefits was dependent on PJ.11-A1 EXE-05 (EUROCONTROL exercise) which was originally supposed to check the compatibility of the ACAS X logic module with some European future operations in order to decide whether the use of ACAS Xo is needed for any of these operations. The outcome of this exercise was planned to be used as an input for this objective. Since initial EUROCONTROL analysis on European future operations did not identify candidate operations, the scope of EXE-05 was changed and did not address European future operations. Instead, a complementary study – ACAS Xa verification in European environment, was performed.

During the workshop, no need for tailored European ACAS Xo was explicitly stated.

EX1-OBJ-PJ.11.A3-V2-VALP-020 (High-level requirements on potential European ACAS Xo version)

This objective, due to justification provided above in EX1-OBJ-PJ.11.A3-V2-VALP-019, does not provide high-level requirements on European ACAS Xo version rather than overall ACAS Xo operation in European airspace.

The main requirement is linked to assumed minimum equipage for its operation. According to ACAS Xo CONUSE [[11]], ACAS Xo ownship is expected to be equipped with Mode S transponder, integrated ASA System including CDTI, and any other flight deck systems or displays required to support specific ACAS Xo operations.

Minimum equipage of the target includes: Mode S transponder and 1090 ADS-B OUT equipment meeting the US/European mandates.

While FAA has mandated that aircraft operating in most controlled U.S. airspace be equipped for ADS-B OUT by January 1st 2020, EASA mandated June 7th 2020 for European skies, but there is some risk that European mandate will be postponed to 2024.

Based on feedback received during Stakeholder Workshop, a number of operational open points and recommendations (available in the conclusion section) should be addressed prior ACAS Xo becomes operational in Europe.

A.3.3 Unexpected Behaviours/Results

No unexpected behaviours/results were observed during Stakeholder Workshop.

A.3.4 Confidence in Results of Validation Exercise 1

1. Level of significance/limitations of Validation Exercise Results

The validation exercise aimed to collect information to define ACAS Xo operating method in European airspace, where no such procedure is currently utilized. The exercise was conducted in the form of a Stakeholder Workshop; thus the results are based on opinions of participating operational experts.

The participants were supported with visuals to help them answer questions regarding the definition of the procedure. Pilots were asked to interact with a low-fidelity digital mock up to support their decision making on the possible use of ACAS Xo and issues associated with it.

One of the challenges of the exercise was the absence of clear use cases for ACAS Xo in Europe due to the layout of airports and probably infrequent nuisance TCAS alerts (no publicly available data on the frequency of occurrence). Therefore, the participants, all of whom work in the European context, could not base the discussion on solving the problems of today, but rather those of the future.

2. Quality of Validation Exercises Results

Overall, the results can be considered having high quality since the opinions collected came from a mixture of operational experts from different aviation domains (ATM, pilots, ATCs, Human Factors). Thus, both airborne and ground aspects were considered (See the table below). 10 experts participated in the discussion and 5 of them (4 pilots) – in the mock-up session.

Workshop conclusions represent a high-level guidance on further development of the concept and a possibility to extend its use to the European environment.

#	Participated as	Current rating/ licenses	Total hours	Hours on aircraft type	Current Aircraft Type	Discussion	Mock-up session
1	ACAS expert, PJ.11-A3 solution						
2	ACAS expert, pilot, PJ.11-A3 solution	Private pilot, Commercial, Instrument rating, ATP, Instructor	3700	250	C-525		
3	Pilot	Instrument rating, ATP, Instructor	3500	500	B-737		

4	Pilot	Commercial, Instrument rating, ATP	> 12000	12000	Airbus FBW		
5	Pilot	Commercial, ATP	17200	4000	Falcon 900 EX		
6	ATC						
7	ATC						
8	Pilot	Commercial, Instrument rating, ATP	9000 +	500	DHC 6		
9	Pilot	Commercial, Instrument rating	10000	1000	A-320		
10	HP expert, PJ.11-A3 solution						

3. Significance of Validation Exercises Results

Workshop results cannot be considered conclusive, but only preliminary, since they are based on opinions of participants not placed in a realistic experimental environment. However, considering the current maturity level of the Solution, these results are considered sufficient.

A.3.5 Conclusions

1. Conclusions on concept clarification

Discussions were conducted based on the foreseen flow of the usage of ACAS Xo function in both modes: CSPO-3000 and DNA. There was a lot of overlap between the two modes in terms of their usage and potential issues both for flight crew and ATC. Discussed key ACAS Xo **concept** highlights can be summarized as follows:

- **ACAS Xo procedures** - would be very likely airport-specific, designed for particular use case, and well-regulated in SOP
- **DNA mode** - brings many questions and concerns (acquiring and maintaining visual contact, displaying information about actual separation, DNA should be very well tested by day and night)
- **Pilot workload** - using ACAS Xo would depend on the implementation of the system and procedures
- **Situation awareness** - is not expected to be significantly different from current situation, but the confidence in issued RAs may increase

- **ATC** - The communication would likely be a generic information provided to all aircraft regarding the traffic sequence. Sequence may be very dynamic
- ACAS Xo would require **regulatory** updates as well as pilot **training**

2. Conclusions on technical feasibility

Discussed key concept highlights regarding the **technical feasibility** suggestions can be summarized as follows:

ACAS Xo procedures

- Would be very likely airport-specific, designed for particular use case, and well-regulated in SOP
- Approach briefing should prepare the pilot for a possible use of ACAS Xo on the approach. Thus, pilot will already know which mode he/she might be using

DNA mode brings many questions and concerns.

- For DNA acquiring and maintaining visual contact is essential, i.e. the mode should be used only in good visual conditions. Conditions such as reduced visibility or use by night brings in more challenges like city lights, water reflections and changed perspective of objects.
- DNA should be very well tested by day and night. It is very difficult to estimate correctly the distance by night.

3. Conclusions on performance assessments

Human Performance was the key transversal area addressed by this validation activity. Discussed key ideas regarding the human **performance assessment** can be summarized as follows:

Pilot workload

- An increased workload both for pilot and ATC might be expected due to the need to set up the system (AC designation, mode selection, activation…) during approach when workload is already high.
- Potential decision making on mode selection would increase pilot workload.
- Workload would depend on the adopted flight crew task sharing.
- It is likely that ACAS Xo will not be frequently used by an individual pilot. This lack of consistent practice might contribute to higher workload when using ACAS Xo.

Situation awareness

- The situation awareness is expected to stay the same or slightly increased with DNA mode, since (in contrary with TA-only mode) it still generates RA against other than designated traffic.
- If the system is well designed, the situation awareness has potential to increase.
- However, it is also possible that the overall situation awareness might somewhat decrease due to pilot's constant monitoring of one target, on instruments as well as visually.
- Situation awareness will decrease if you lose the target from the navigation display in CSPO-3000 and lose the target visually in DNA. An immediate action should then be taken.

Potential to human error:

- The possibility of designating wrong target is high with ACAS Xo DNA, since visual acquisition before designation is feasible only during good VMC conditions.
- Missing information about the selected mode of ACAS Xo could potentially lead to error. Pilots would expect to have the information about the selected mode.
- The sequence of steps regarding the target selection and mode selection is different in each aircraft type. The sequence could flip. Suggestions for default ACAS Xo mode have been raised.

Timeliness of ACAS Xo-related tasks completion

- End user's tasks are achievable within an acceptable time frame. The acceptable time to spend on setting up ACAS Xo is "as little as possible". The amount of time it took to set up ACAS Xo within the mock-up session was acceptable.

A.3.6 Recommendations

ACAS Xo procedures

- ACAS Xo should be activated before ACAS could issue nuisance alerts.
- ACAS Xo can be activated as soon as flight crew can identify the target.
- Perhaps being established on the localizer and glide should be a requirement for using ACAS Xo, especially for DNA.
- Approach briefing should prepare the pilot for a possible use of ACAS Xo on the approach. Thus, pilot will already know which mode he/she might be using.

DNA mode

- Acquiring and maintaining visual contact is essential, i.e. the mode should be used only in good visual conditions. Conditions such as reduced visibility or use by night brings in more challenges like city lights, water reflections and changed perspective of objects.
- Some pilots would find it beneficial if the information about actual separation was displayed to them, e.g. on a dedicated window on navigation display (not in the standard).
- DNA should be very well tested by day and night. The distance by night is very difficult to estimate correctly.

ATC

- Use of ATIS or CPDLC for providing information / instruction about ACAS Xo usage should be investigated.
- ACAS Xo equipage is not expected to be communicated to the ATC.
- ATC might need additional monitoring tool for ACAS Xo.

HMI

- HMI should sufficiently support the pilot with the selection of the target aircraft, mode and awareness of the mode selected.

Suggestion to manage pilot's **workload**:

- The idea of automated ACAS Xo feature would be welcome. Especially in CSPO, a potential solution could be automatic activation of CSPO mode when established on final against all other aircraft that are established as well.
- Automatic ACAS Xo mode selection based on the distance between runways, if such information can be obtained;
- preselect the mode when entering the TMA when the workload is still low and select the target aircraft later.

Appendix B Validation Exercise #02 Report

This appendix concludes validation report for EXE-PJ.11.A3-V2-VALP-002 (Simulator Evaluation with pilots in-the-loop), an exercise performed by Airbus.

B.1 Summary of the Validation Exercise #02 Plan

B.1.1 Validation Exercise description, scope

Validation Exercise #02 consisted in a Real Time Simulation (RTS) to assess prototype and OI solutions, covering objectives defined in chapter 3.2.2.

Real Time Simulations (RTS) was performed with V2 candidate prototypes developed by project PJ.11A-03. These trials took place in Airbus facilities, on realistic integration simulator, involving professional pilots from Airbus.

The purpose of these trials was to validate ACAS Xo principles for alert triggering/inhibition, and associated Human Machine Interface, for the two existing ACAS Xo modes: DNA and CSPO-3000. Pilots' participation allowed getting representative operational feedback on the solution.

B.1.2 Summary of Validation Exercise #02 Validation Objectives and success criteria

Exercise Validation Objective	Exercise Success criteria
EX2-OBJ-PJ.11.A3-V2-VALP-001 Assess that FC procedures can be determined and integrated in FC tasks during concerned operations	**EX2-CRT-PJ.11.A3-V2-VALP-001** V2. Operating methods are found to cover identified normal operating conditions.
	EX2-CRT-PJ.11.A3-V2-VALP-002 V1. Normal operating conditions are defined. Where possible initial needs/ requirements relating to the operating methods for normal operating conditions may be identified.
EX2-OBJ-PJ.11.A3-V2-VALP-003 Confirm ATC involvement is not necessary to perform the designation task.	**EX2-CRT-PJ.11.A3-V2-VALP-004** V2. Tasks are effectively achieved.
EX2-OBJ-PJ.11.A3-V2-VALP-004 Assess that FC has sufficient spare mental resources to activate the ACAS Xo function during the approach phase.	**EX2-CRT-PJ.11.A3-V2-VALP-006** V2. Level of workload within acceptable limits ('acceptable limits' to be defined with regard to the tool used for the assessment).
EX2-OBJ-PJ.11.A3-V2-VALP-005 Assess that FC has sufficient spare resources to analyse the situation and designate the right aircraft.	**EX2-CRT-PJ.11.A3-V2-VALP-006** V2. Potential for errors is within acceptable limits, taking into account error type & operational/safety impact.
EX2-OBJ-PJ.11.A3-V2-VALP-008 Assess that FC workload stay in acceptable limits when performing ACAS-Xo related tasks.	**EX2-CRT-PJ.11.A3-V2-VALP-009** V2. Level of workload within acceptable limits ('acceptable limits' to be defined with regard to the tool used for the assessment).

EX2-OBJ-PJ.11.A3-V2-VALP-002 Assess that FC has sufficient information to be aware of the need to activate the appropriate ACAS Xo function in specific locations.	**EX2-CRT-PJ.11.A3-V2-VALP-003** V1. If preliminary operating methods are defined the content has been determined to be clear and non-contradictory by end users.
EX2-OBJ-PJ.11.A3-V2-VALP-006 Assess that FC has sufficient information to quickly analyse the situation and identify the right target, even in non-visual conditions.	**EX2-CRT-PJ.11.A3-V2-VALP-007** V2. Tasks are effectively achieved
EX2-OBJ-PJ.11.A3-V2-VALP-007 Assess that FC has sufficient information to quickly analyse the situation and identify the right target, even in busy airspace.	**EX2-CRT-PJ.11.A3-V2-VALP-003** V2. Tasks are effectively achieved.
EX2-OBJ-PJ.11.A3-V2-VALP-009 Assess that automatic undesignation is well understood by FC.	**EX2-CRT-PJ.11.A3-V2-VALP-010** V2. Understanding of the technical system's behaviour is consistent with the operator's task demands.
EX2-OBJ-PJ.11.A3-V2-VALP-010 Assess that FC is well aware of designation limitations and do not struggle with non-ADS-B paired aircraft.	**EX2-CRT-PJ.11.A3-V2-VALP-011** V1. Where possible, initial needs/requirements to support end-users acquisition of a mental model of the automated function are identified.
EX2-OBJ-PJ.11.A3-V2-VALP-011 Assess the usability of HMI to select the target.	**EX2-CRT-PJ.11.A3-V2-VALP-012** V2. End user experiences integrated interface including any new system components as sufficiently usable.
EX2-OBJ-PJ.11.A3-V2-VALP-012 Assess the usability of HMI to activate the ACAS Xo function.	**EX2-CRT-PJ.11.A3-V2-VALP-013** V2. End user experiences integrated interface including any new system components as sufficiently usable.
EX2-OBJ-PJ.11.A3-V2-VALP-013 Assess the usability of the HMI to undesignate a target.	**EX2-CRT-PJ.11.A3-V2-VALP-014** V2. End user experiences integrated interface including any new system components as sufficiently usable.
EX2-OBJ-PJ.11.A3-V2-VALP-014 Assess the automatic undesignation feedback is sufficient to be detected by the FC.	**EX2-CRT-PJ.11.A3-V2-VALP-015** V2. Team is able to perceive and interpret task relevant information and anticipate future events/actions.

B.1.3 Summary of Validation Exercise #02 Validation scenarios

Reference scenarios

Reference Scenario 1: Simultaneous Close Parallel approaches on KSFO RWY 28L/R

The ownship is flying the LDA PRM 28R approach, while another traffic is flying the ILS PRM 28L approach.

Concurrent traffic conducts a conventional ILS approach respecting published altitudes and intercepts the glide path at waypoint HEMAN and at 3100ft alt.

The ownship is established on descent from waypoint ANETE at 7000ft and down to runway threshold. It is important that the ownship respects the altitude restrictions in order to respect any crossing restrictions and to avoid wake turbulences from the concurrent traffic. The ownship shall remain on the LDA until waypoint DARNE. Ownship shall acquire and report visual contact on the

concurrent traffic as soon as practical and before passing waypoint DARNE. it shall not overtake the concurrent traffic.

After DARNE, the ownship shall manoeuver manually to land. During this visual segment, pilots are responsible for collision and wake avoidance.

As per FAA recommendation, in order to avoid any nuisance TCAS alert during a parallel approach, flight crew may activate the "TA only" TCAS modes, which converts any RA into a TA. Flight crew has to be aware that in that case all RAs are inhibited.

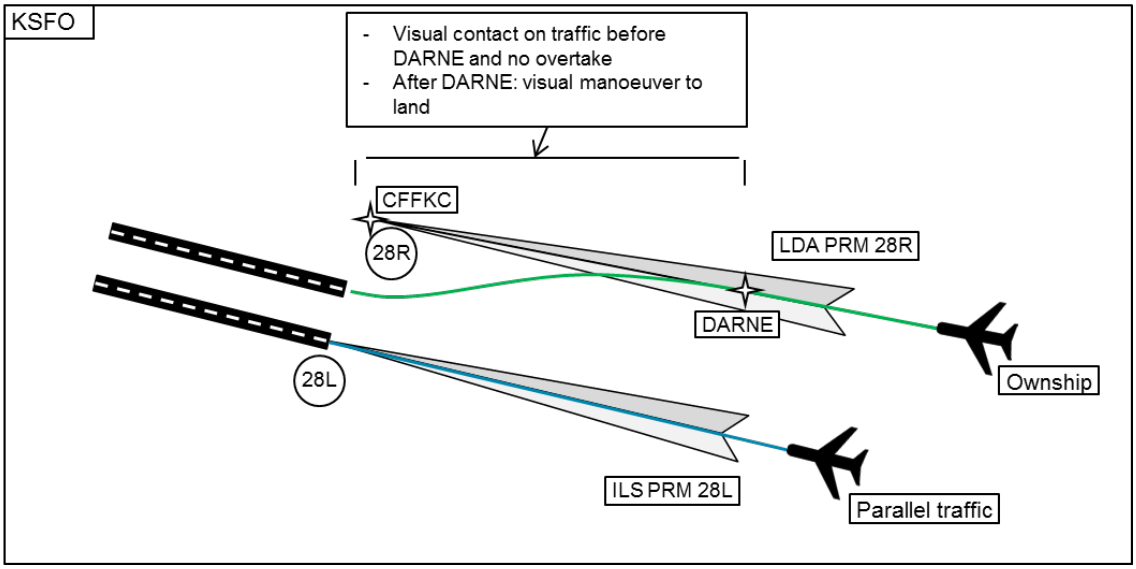


Figure 2: Simultaneous Close Parallel approaches on KSFO RWY 28L/R

Reference Scenario 2: Simultaneous Independent Parallel approaches on KPDX RWY 10L/R

The ownship is flying from the south and perform a DIR TO HAIRN followed by the ILS 10R approach.

Concurrent traffic is flying the radial R220 followed by the ILS 10L approach from waypoint TRYAL.

As these are independent approaches, no particular procedure is applied regarding parallel operations. However, the proximity of both traffic during the approach and in particular during the convergence of concurrent traffic toward its respective localizer may trigger unnecessary TCAS alerts.

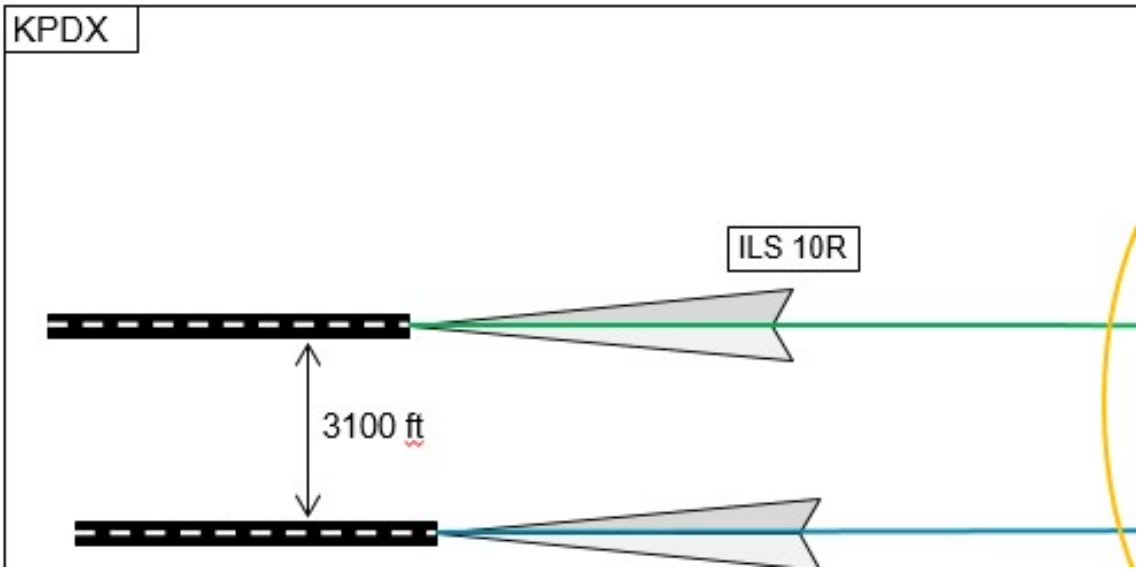


Figure 3: Simultaneous Independent Parallel approaches on KPDX RWY 10L/R

Solution scenarios

Solution Scenario 1: Simultaneous Close Parallel approaches on KSFO RWY 28L/R with DNA

The ownship and the concurrent traffic are flying the standard PRM approaches as described in the reference scenario #1.

When the flight crew of the ownship has the traffic in sight, it shall designate it with ACAS Xo and activate the DNA mode. Any potential TCAS alert regarding this traffic is then inhibited.

Pursuing of the approach procedure remains unchanged.

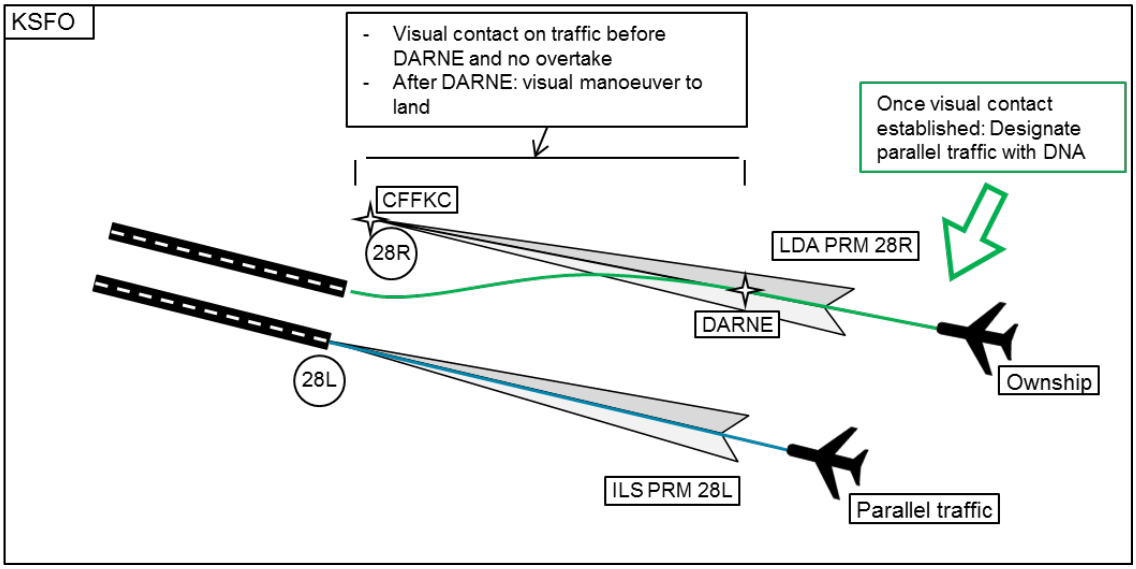


Figure 4: Simultaneous Close Parallel approaches on KSFO RWY 28L/R with DNA

Solution Scenario 2: Multithreat TCAS alert during Simultaneous Close Parallel approaches on KSFO RWY 28L/R with DNA

The ownship and the concurrent traffic are flying the standard PRM approaches as described in the reference scenario #1.

When the flight crew of the ownship has the traffic in sight, it shall designate it with ACAS Xo and activate the DNA mode. Any potential TCAS alert regarding this traffic is then inhibited.

Pursuing of the approach procedure remains unchanged.

During the approach, while the concurrent traffic is designated with DNA, another intruder triggers a TCAS RA onboard the ownship. Any inhibited alert on the concurrent parallel traffic is then uninhibited. The ownship's flight crew should then see two threatening traffics and react as indicated by the TCAS resolution advisory.

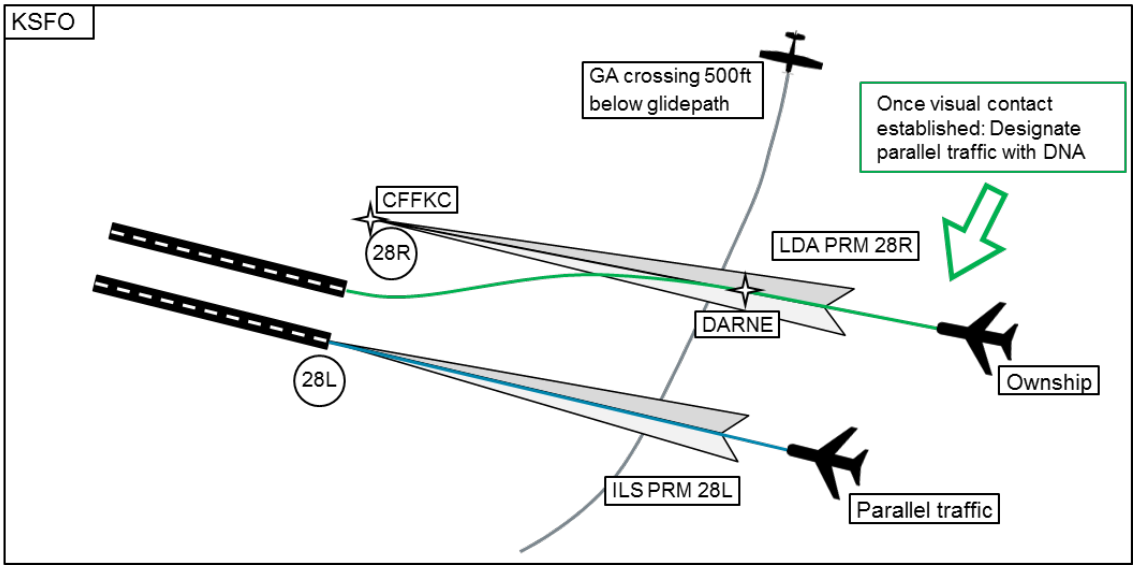


Figure 5: Multithreat TCAS alert during Simultaneous Close Parallel approaches on KSFO RWY 28L/R with DNA

Solution Scenario 3: Voluntary undesignation of DNA traffic during Simultaneous Close Parallel approaches on KSFO RWY 28L/R

The ownship and the concurrent traffic are flying the standard PRM approaches as described in the reference scenario #1.

When the flight crew of the ownship has the traffic in sight, it shall designate it with ACAS Xo and activate the DNA mode. Any potential TCAS alert regarding this traffic is then inhibited.

Pursuing of the approach procedure remains unchanged.

During the approach, while the concurrent traffic is designated with DNA, a visibility degradation leads the ownship's flight crew to lose the visual contact with the concurrent traffic. Prerequisites for DNA and PRM approach being not met anymore, flight crew shall deactivate DNA for the designated traffic, inform the ATC and possibly go around.

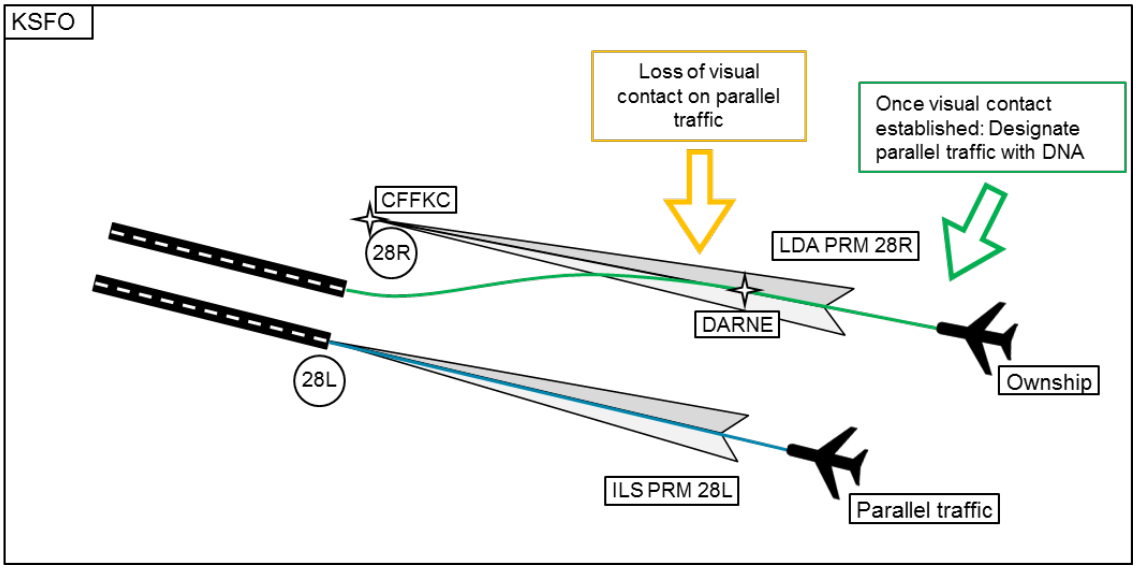


Figure 6: Voluntary undesignation of DNA traffic during Simultaneous Close Parallel approaches on KSFO RWY 28L/R

Solution Scenario 4: Simultaneous Independent Parallel approaches on KPDX RWY 10L/R with CSPO-3000

The ownship and the concurrent traffic are flying the same approaches as described in the reference scenario #2.

In this scenario, the flight crew of the ownship shall designate the concurrent traffic with ACAS Xo and activate the CSPO-3000 mode as soon as needed in order to avoid potential nuisance TCAS advisories.

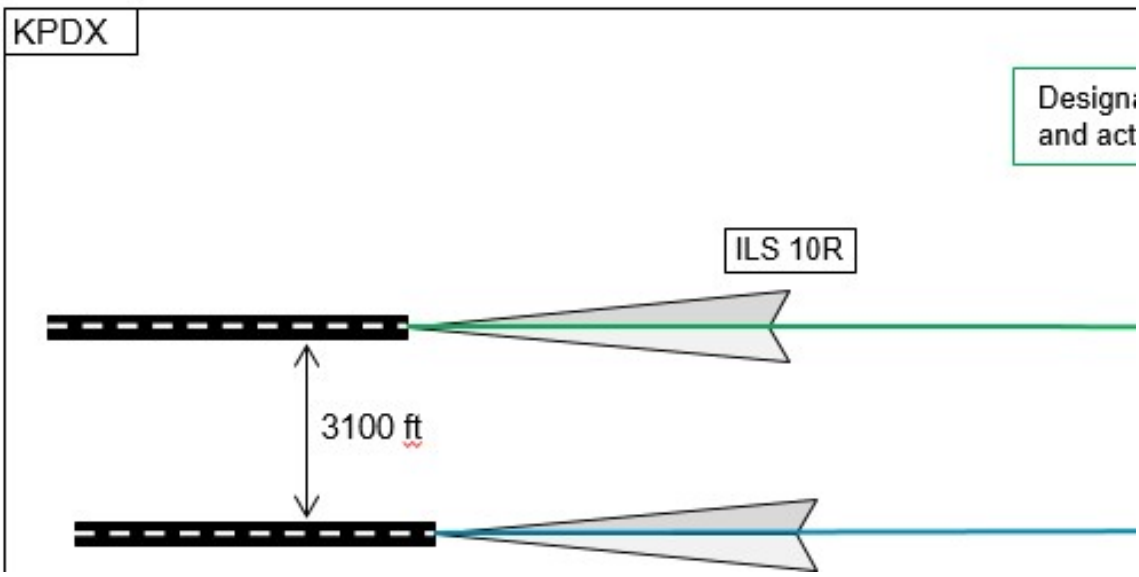


Figure 7: Simultaneous Independent Parallel approaches on KPDX RWY 10L/R with CSPO-3000.

Solution Scenario 5: Simultaneous Independent Parallel approaches on KPDX RWY 10L/R with CSPO-3000 and traffic deviation

The ownship and the concurrent traffic are flying the same approaches as described in the reference scenario #2.

In this scenario, the flight crew of the ownship shall designate the concurrent traffic with ACAS Xo and activate the CSPO-3000 mode (Figure 7~~Figure 7~~) as soon as needed in order to avoid potential nuisance TCAS advisories.

Once established on their respective final axes the ownship is protected against nuisance TCAS alerts. However in this scenario the concurrent traffic deviates sharply from RWY 10L localizer towards 10R (see Figure 8). This should trigger a TCAS resolution advisory onboard the ownship, demonstrating that while reducing the rate of nuisance TCAS alerts, CSPO-3000 is still protecting against real collision threats.

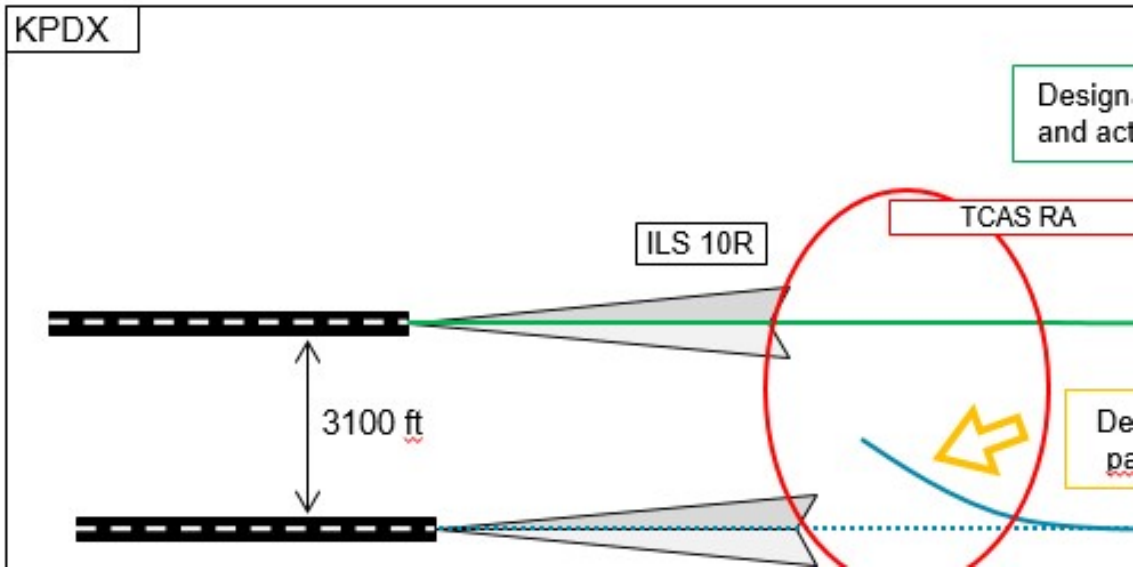


Figure 8: Simultaneous Independent Parallel approaches on KPDX RWY 10L/R with CSPO-3000

B.1.4 Summary of Validation Exercise #02 Validation Assumptions

At solution level, no-specific assumptions were defined, but the following ones were identified at exercise #02 level:

Identifier	Title	Type of Assumption	Description	Justification	Flight Phase	KPA Impacted	Source	Value(s)	Owner	Impact on Assessment
	Surroundi	Aircraft	All	The ACAS	TMA	SAF	Expert	Real		Med.

	ng traffic	equipage	surrounding traffic are TCAS/ADS-B out equipped	Xo prototype is useable with hybrid traffic only.		HP	opinion	situation tends to a hybrid traffic only environment (DO-260B mandate).		
	Existing operation	Procedure in place	Existing parallel approach procedures are unchanged.	The use of ACAS Xo is supposed to be transparent for ATC.	TMA	SAF HP	Standardisation	Refer to real situation		High

Table 7: Validation Exercise Assumptions

B.2 Deviation from the planned activities

Scenario airport different from planned one for CSPO-3000

Madrid (LEMD) runways were too close to the upper limit of separation for CSPO usability: 4290 feet, whereas CSPO is not useful for runways separated more than 4300 feet. The issue was that our scenarios on Madrid (LEMD), run in a realistic way based on the officially published operation procedures in charts, were never leading to a traffic alert (TA) because ACAS Xa mode was already filtering smartly the alerts. In order to keep the objective of using a European airport for our exercise, other potential compatible commercial airports in Europe (Bucharest, Romania for instance) have been checked but it was never possible to reach traffic alerts with a realistic approach and ACAS Xa logics. Instead of tuning excessively the procedures in order to ”force” alert triggering (that would not have been acceptable for flight crews), it has been decided to pick up another airport outside Europe. Portland (KPDX) has been chosen for its CSPO-appropriate parallel runways configuration, the fact that it is a representative international commercial airport, and because we had 3D data already available for better visual rendering to the flight crew’s eyes.

There was no major impact on the scenario, only the destination airport has changed. Scenario has been updated (refer to chapter B.1.3). However, **there was no impact on results** as the updated scenarios allowed to expose CSPO-3000 correctly during pilots’ evaluation.

LSC display emulation installation

As explained in the Validation Plan / Availability Note, a screen emulation of the Navigation Display (ND) called LSC (Lightweight Simulation in Cockpit) was needed in order to be able to display the ACAS Xo new symbology. It would have been too complex and costly to implement a software modification of the real cockpit displays (EIS : Electronic Instruments System). LSC is provided on flat LCD display with same size and resolution than real ND displays, and is realistic enough to be used in place of them. However:

- some minor graphical elements (labels) were not realistic enough after exposure of LSC to pilots during pre-validation tests;
- Display of surrounding traffic has small but perceptible latency (1 to 2 seconds, because of time needed to collect and decode input data from instrumentation bay)

Facing those issues, LSC was installed in central position instead of covering the real displays. Real EIS were used for approach phase, intruders' identification and selection (designation) then the LSC screen was used to confirm ACAS Xo mode activation through HMI feedback. **That did not impact the evaluation scope or results**: feedback from pilots regarding HMI has been gathered either from real or emulated screen, as they have been put aware of this deviation during briefing of the session.

As an illustration, the LSC installation described here above can be seen in Figure 9: LSC installation in the simulator cockpit for Validation Exercise #02.

Figure 9: LSC installation in the simulator cockpit for Validation Exercise #02

ACAS Xo alerting time

There was an issue in the VALP indicating that the exercise #02 will cover the assessment of decision making time when a RA occurs is decreased. The evaluation on simulator did not aim at checking the detailed timing of alerting second by second, but focused on global feedback from pilots regarding triggering of alerts.

Intruders manual un-designation

Due to organisation constraints and timing to ensure a relevant exposition of ACAS Xo features in a same simulator session (5 hours including pilots briefing and de-briefing), some planned scenarios

could not be run. In particular, the solution scenario "Voluntary un-designation" initially planned in the VALP at KSFO RWY 28L/R was not evaluated in order to prioritize the automatic un-designation feature exposition, which is the main case that will be encountered by pilots.

This **slightly impacts the EX2-OBJ-PJ.11.A3-V2-VALP-013** "Assess the usability of the HMI to un-designate a target" objective in a real time simulation perspective, but this mechanism has been presented during briefing and did not returned any negative comments from pilots. Plus, **this objective has been addressed** during Validation Exercise #01 workshop with **EX1-OBJ-PJ.11.A3-V2-VALP-017**.

Limited number of sessions on simulator

Due to Airbus simulator lack of availability at the time of the evaluations, the number of sessions had to be revised and decreased. The evaluations were performed with two crews instead of four to five initially planned. Nonetheless, the obtained results are converging and the restricted number of crews had no major impact on the results considering the maturity level of the solution.

B.3 Validation Exercise #02 Results

B.3.1 Summary of Validation Exercise #02 Results

Validation Exercise #02 Validation Objective ID	Validation Exercise #02 Success Criterion Validation Exercise #02 Validation Objective Title	Exercise #02 Validation Results	Validation Exercise #02 Validation Objective Status
EX2-OBJ-PJ.11.A3-V2-VALP-001 Assess that FC procedures can be determined and integrated in FC tasks during concerned operations	**EX2-CRT-PJ.11.A3-V2-VALP-001** V2. Operating methods are found to cover identified normal operating conditions. **EX2-CRT-PJ.11.A3-V2-VALP-002** V1. Normal operating conditions are defined. Where possible initial needs/ requirements relating to the operating methods for normal operating conditions may be identified.	ACAS Xo function cannot be used by Flight Crew in normal operation conditions, with existing on-board approach procedures. **Specific approach procedures are mandatory** and the ACAS Xo system adapted to those procedures. Moreover, separately from the expected criteria, pilots have raised an Issue of responsibility. If Flight Crew decides to reduce thresholds or activate DNA mode, it is unclear who is responsible in case of incident. Flight Crews will be reluctant to take the risk if they remain responsible	NOK
EX2-OBJ-PJ.11.A3-V2-VALP-002 Assess that FC has sufficient	**EX2-CRT-PJ.11.A3-V2-VALP-003** V1. If preliminary operating methods are defined the	Indication of ACAS Xo use shall be indicated on Airport charts (e.g. "Consider reducing TCAS thresholds on	NOK

information to be aware of the need to activate the appropriate ACAS Xo function in specific locations.	content has been determined to be clear and non-contradictory by end users.	parallel aircraft") From participants' point of view, the added value of ACAS Xo is almost null, considering that Authorities tends to remove the TA only recommendation. If ACAS Xo sub-mode activation is not proposed for the crew during briefing, or in airport charts, flights crews will be reluctant to remove the TA and RA alerts as the last safety net	
EX2-OBJ-PJ.11.A3-V2-VALP-003 Assess if the crew can identify and designate the right target without ATC involvement.	**EX2-CRT-PJ.11.A3-V2-VALP-004** V2. Tasks are effectively achieved.	ACAS Xo function use requires ATC to be involved to inform the crew for the parallel traffic early in the approach procedure (based on flight ID rather than callsign). In real heavy surrounding traffic, flight crews will not be able to identify and designate the right target without ATC support.	NOK
EX2-OBJ-PJ.11.A3-V2-VALP-004 Assess that FC has sufficient spare mental resources to activate the ACAS Xo function during the approach phase.	**EX2-CRT-PJ.11.A3-V2-VALP-006** V2. Level of workload within acceptable limits ('acceptable limits' to be defined with regard to the tool used for the assessment).	With the 5NM activation limit implemented in the current design, the workload added to activate the function in short final approach is not acceptable, because at this stage of the approach, the workload is already very high.	NOK
EX2-OBJ-PJ.11.A3-V2-VALP-005 Assess that FC has sufficient spare resources to analyse the situation and designate the right aircraft.	**EX2-CRT-PJ.11.A3-V2-VALP-006** V2. Potential for errors is within acceptable limits, taking into account error type & operational/safety impact.	Globally the flight crews activated the ACAS Xo function. In case of any doubt or unacceptable workload induced by ACAS Xo activation, the crew gave up the task and did not activate the ACAS Xo function. The safety level then remained sufficient with the traditional alerting threshold for TA/RA.	OK
EX2-OBJ-PJ.11.A3-V2-VALP-006 Assess that FC has sufficient information to quickly analyse the situation and identify the right target, even in non-visual conditions.	**EX2-CRT-PJ.11.A3-V2-VALP-007** V2. Tasks are effectively achieved	Not possible to conclude because of technical limitations. The scenarios in non-visual conditions were not played during the sessions	N/A
EX2-OBJ-PJ.11.A3-V2-VALP-	**EX2-CRT-PJ.11.A3-V2-VALP-003**	The flight crew did not have sufficient information to quickly analyse the	NOK

007 Assess that FC has sufficient information to quickly analyse the situation and identify the right target, even in busy airspace.	V2. Tasks are effectively achieved.	situation and the right target. However, no mistake due to the function use was observed during the evaluations as flight crews rather ignore the function in tricky situations.	
EX2-OBJ-PJ.11.A3-V2-VALP-008 Assess that FC workload stay in acceptable limits when performing ACAS-Xo related tasks.	**EX2-CRT-PJ.11.A3-V2-VALP-009** V2. Level of workload within acceptable limits ('acceptable limits' to be defined with regard to the tool used for the assessment).	In any case, the workload is increased. For identification phase, it remains at acceptable level as long as the airspace traffic is light. In heavy environment, it is supposed that the FC will not search for the target without ATC involvement. Moreover, with the current design (5NM limitation for activation), the ACAS Xo activation step is increasing workload to an unacceptable level for a short final approach phase..	NOK
EX2-OBJ-PJ.11.A3-V2-VALP-009 Assess that automatic undesignation is well understood by FC.	**EX2-CRT-PJ.11.A3-V2-VALP-010** V2. Understanding of the technical system's behaviour is consistent with the operator's task demands.	When automatic undesignations occurred, Flight Crews never directly understood the reason behind. Flight Crews spends time trying to analyze the reason which increases their workload. It is recommended to improve this design, as it may impact the acceptability of the function otherwise.	NOK
EX2-OBJ-PJ.11.A3-V2-VALP-010 Assess that FC is well aware of designation limitations and do not struggle with non-ADS-B paired aircraft.	**EX2-CRT-PJ.11.A3-V2-VALP-011** V1. Where possible, initial needs/requirements to support end-users acquisition of a mental model of the automated function are identified.	Not addressed during exercise due to technical limitations	N/A
EX2-OBJ-PJ.11.A3-V2-VALP-011 Assess the usability of HMI to select the target.	**EX2-CRT-PJ.11.A3-V2-VALP-012** V2. End user experiences integrated interface including any new system components as sufficiently usable.	The usability of HMI to select the target has been validated during the evaluation – the principle to select the target on ND is validated. But the target selection through MCDU is not accepted as a primary means (traffic selector is preferred).	OK
EX2-OBJ-PJ.11.A3-V2-VALP-012 Assess the usability of HMI to activate the ACAS Xo	**EX2-CRT-PJ.11.A3-V2-VALP-013** V2. End user experiences integrated interface including any new system components as	Globally, participants spent too much time head down to activate ACAS Xo functions. This is not acceptable in approach. There were too many steps (with latency) to access the ACAS Xo	NOK

function.	sufficiently usable.	menu. Flight Crews were not comfortable with the wording proposed for the sub mode selection.	
EX2-OBJ-PJ.11.A3-V2-VALP-013 Assess the usability of the HMI to un-designate a target.	**EX2-CRT-PJ.11.A3-V2-VALP-014** V2. End user experiences integrated interface including any new system components as sufficiently usable.	**Not assessed (refer to §B.2 for more details)**	N/A
EX2-OBJ-PJ.11.A3-V2-VALP-014 Assess the automatic un-designation feedback is sufficient to be detected by the FC.	**EX2-CRT-PJ.11.A3-V2-VALP-015** V2. Team is able to perceive and interpret task relevant information and anticipate future events/actions.	The current design regarding HMI feedback is not sufficient for crew to notice automatic un-designation.	NOK

Table 8: Validation Results for Exercise 1

B.3.2 Analysis of Exercise 2 Results per Validation objective

EX2-OBJ-PJ.11.A3-V2-VALP-001 Results

Objective description: The aim of EX2-OBJ-PJ.11.A3-V2-VALP-001 is to assess that FC procedures can be determined and integrated in FC tasks during concerned operations.

Benefit description: there is no pre-defined procedure about the way to activate ACAS Xo. It appears that the time to activate the ACAS Xo function is depending on the approach procedure. Without a precise on-board procedure, FC may be confused, which could in turn, negatively impact human performance and safety.

Expected evidences:

EX2-CRT-PJ.11.A3-V2-VALP-001 Operating methods are found to cover identified normal operating conditions.

EX2-CRT-PJ.11.A3-V2-VALP-002 V1. Normal operating conditions are defined. Where possible, initial needs/requirements relating to the operating methods for normal operating conditions may be identified.

During the validation exercise, no specific procedure for ACAS Xo use was proposed for all scenarios. The approaches were flown based on current procedures.

The ACAS Xo use was systematically questioned during the exercise. The questions addressed the following topics: need to use the function, the aircraft to be identified as target, the ACAS mode to be selected or even when to activate it.

The feedback from FC is that specific procedures are needed and moreover, the potential use of the ACAS sub-modes should be part of the approach briefing. For example in case of DNA approach: “Potential activation of DNA function with parallel traffic to be expected", or "If loss of visual contact, warn ATC" should be available for the concerned approaches.

Concerning the designation phase, according to FCs it should start as soon as possible when the target is identified in order to be consistent with current “TA only” activation performed at the beginning of the approach. Today, this early setting is not possible due to the proposed design (there is a maximal distance between ownship and target aircraft for the function activation limitation).

For the scenarios where the ACAS Xo function was expected to be activated, a responsibility issue was raised by the crews. If the FC decides to activate DNA mode or to reduce alerting thresholds, the responsibility of removing or reducing the safety net remains on the FC shoulders and they are not willing to take the risk. Unless the function activation possibility is clearly identified in procedures.

Conclusion: *EX2-CRT-PJ.11.A3-V2-VALP-001 and EX2-CRT-PJ.11.A3-V2-VALP-002 not satisfied.* ACAS Xo function cannot be used by Flight Crew in normal operation conditions, with existing on-board approach procedures. Specific approach procedures are mandatory and the ACAS Xo system adapted to those procedures.

Moreover, separately from the expected criteria, pilots have raised an Issue of responsibility. If Flight Crew decides to reduce thresholds or activate DNA mode, it is unclear who is responsible in case of incident. Flight Crews will be reluctant to take the risk if they remain responsible.

EX2-OBJ-PJ.11.A3-V2-VALP-002 Results

Objective description: assess that FC has sufficient information to be aware of the need to activate the appropriate ACAS Xo function in specific locations.

Expected evidence: EX2-CRT-PJ.11.A3-V2-VALP-003 If preliminary operating methods are defined the content has been determined to be clear and non-contradictory by end users.

Currently special procedures are rarely used, so the flight crew may not recognize the need to activate the related ACAS Xo function. This may generate undesired ACAS X RAs, leading to a negative impact on efficiency, capacity and environment.

During the evaluation exercise, the pilots have clearly challenged the utility of ACAS Xo function. They considered that there is no added value as Authorities tends to remove the TA only recommendation. Inhibit TA and RA alerts is the last protection and should not be inhibited.

Unless indicated on Airport charts (e.g. "Consider reducing TCAS thresholds on parallel aircraft") pilots will not activate the function

Conclusion: *EX2-CRT-PJ.11.A3-V2-VALP-003 not satisfied* If ACAS Xo sub-mode activation is not proposed for the crew during briefing, or in airport charts, flights crews will be reluctant to remove the TA and RA alerts as the last safety net.

EX2-OBJ-PJ.11.A3-V2-VALP-003 Results

Objective description: the aim of EX2-OBJ-PJ.11.A3-V2-VALP-003 is to assess if the crew can identify and designate the right target without ATC involvement, with the use of available on-board systems.

Expected evidence: EX2-CRT-PJ.11.A3-V2-VALP-004 - Tasks are effectively achieved.

During the evaluation exercise, flight crews were flying in a quite light traffic. The callsign was not given by ATC and flight crews were able to identify and designate the right traffic, but only after spending time to analyze the surrounding traffic.

However, participants considered that in a busy airspace it would be nearly impossible to identify the target aircraft in advance without ATC involvement.

Indeed the flight crews want to set-up the aircraft for approach as soon as possible, and only the ATC has the global information of surrounding traffic and strategy for approach. So the participating pilots required to have ATC indication on parallel traffic as soon as possible based on flight ID rather than callsign.

Conclusion: *Criteria EX2-CRT-PJ.11.A3-V2-VALP-004 not satisfied.* ACAS Xo function use requires ATC to be involved to inform the crew for the parallel traffic early in the approach procedure (based on flight ID rather than callsign). In real heavy surrounding traffic, flight crews will not be able to identify and designate the right target without ATC support.

EX2-OBJ-PJ.11.A3-V2-VALP-004 Results

Objective description: the aim of EX2-OBJ-PJ.11.A3-V2-VALP-004 is to assess that FC has sufficient spare mental resources to activate the ACAS Xo function during the approach phase.

Benefit description: the designation task occurring during a high workload phase, flight crew may not have the time to activate the function. This may generate undesired ACAS X RAs, leading to a negative impact on efficiency, capacity and environment.

Expected evidence: EX2-CRT-PJ.11.A3-V2-VALP-005 V2. Level of workload within acceptable limits ('acceptable limits' to be defined with regard to the tool used for the assessment).

For almost all scenarios with ACAS Xo use, we observed that flight crews tend to select the traffic early in the approach phase. They tried to anticipate as much as possible to configure all parameters for the approach prior to entering the critical phase of the approach.

With the current 5NM limitation to activate ACAS Xo, flight crews cannot manage their workload properly during the approach since the function is unavailable if the distance between ownship and target aircraft is greater than 5NM. So, the crew had to wait the very last moment to activate the ACAS Xo function. At this stage of the approach, the workload is already very high. This observation is also emphasized by the fact that during the sessions, the flight crews were not asked to perform all tasks related to approach (e.g. checklist), so, in real environment the workload impact would have been even worse.

Conclusion: *Criteria EX2-CRT-PJ.11.A3-V2-VALP-005 not satisfied.* With the 5NM activation limit implemented in the current design, the workload added to activate the function in short final approach is not acceptable, because at this stage of the approach, the workload is already very high.

EX2-OBJ-PJ.11.A3-V2-VALP-005 Results

Objective description: the aim of EX2-OBJ-PJ.11.A3-V2-VALP-005 is to assess that FC has sufficient spare resources to analyse the situation and designate the right aircraft.

Benefit description: the designation task occurring during a high workload phase, flight crew may not have the time to activate the function. This may generate undesired ACAS X RAs, leading to a negative impact on efficiency, capacity and environment.

Expected evidence: EX2-CRT-PJ.11.A3-V2-VALP-006 V2. Potential for errors is within acceptable limits, taking into account error type & operational/safety impact.

During the validation exercise, two scenarios were flown without ACAS Xo activation on purpose. The other scenarios aimed at evaluating the use of ACAS Xo function.

Globally the flight crews activated the ACAS Xo function.

We observed that in case of any doubt during the approach, the flight crews ignored ACAS Xo activation rather than losing time for activation and kept the traditional ACAS protection. In this case, the risk to get nuisance alerts is higher but this is the current alerting that is safe.

Conclusion: *Criteria EX2-CRT-PJ.11.A3-V2-VALP-006 satisfied.* Globally the flight crews activated the ACAS Xo function. In case of any doubt or unacceptable workload induced by ACAS Xo activation, the crew gave up the task and did not activate the ACAS Xo function. The safety level then remained sufficient with the traditional alerting threshold for TA/RA.

EX2-OBJ-PJ.11.A3-V2-VALP-006 Results

Objective description: the aim of EX2-OBJ-PJ.11.A3-V2-VALP-006 is to assess that FC has sufficient information to quickly analyse the situation and identify the right target, even in non-visual conditions.

Benefit description: in non-visual conditions, the time to manually identify the right target may be important, which may increase flight crew workload and decrease situation awareness. This in turn may have a negative impact on safety.

Expected evidence: EX2-CRT-PJ.11.A3-V2-VALP-007 V2. Tasks are effectively achieved

This objective was not assessed during the evaluation exercise. The scenarios in non-visual conditions were not played during the sessions.

EX2-OBJ-PJ.11.A3-V2-VALP-007 Results

Objective description: the aim of EX2-OBJ-PJ.11.A3-V2-VALP-007 is to assess that FC has sufficient information to quickly analyse the situation and identify the right target, even in busy airspace.

Expected evidence: EX2-CRT-PJ.11.A3-V2-VALP-008 V2. Tasks are effectively achieved

In a busy airspace, the time to manually identify the right target may be important, which may increase flight crew workload and decrease situation awareness. This in turn could have a negative impact on safety.

During the evaluation, the surrounding traffic was not representative of real aircraft vicinity, so the objective is not fully assessed in busy airspace. Nonetheless, some trends were observed during evaluations. The flight crews tend to ignore ACAS Xo in case they had any doubt about the target aircraft, or in case of a workload peak.

In case of any uncertainty, the flight crews prefer to keep the traditional protection with the risk of having nuisance alerts. This choice remains safe in any case.

Conclusion: *Criteria EX2-CRT-PJ.11.A3-V2-VALP-008 V2 not satisfied.* The flight crew did not have sufficient information to quickly analyse the situation and the right target. However, no mistake due to the function use was observed during the evaluations as flight crews rather ignore the function in tricky situations.

EX2-OBJ-PJ.11.A3-V2-VALP-008 Results

Objective description: the aim of EX2-OBJ-PJ.11.A3-V2-VALP-008 is to assess that FC workload stays in acceptable limits when performing ACAS-Xo related tasks.

Benefit description: identification and manual selection of a target aircraft (and further occasionally monitoring of a CDTI screen) during the approach could lead to the increase in WL. This in turn may have negative impact on safety.

Expected evidence: EX2-CRT-PJ.11.A3-V2-VALP-009 V2. Level of workload within acceptable limits ('acceptable limits' to be defined with regard to the tool used for the assessment).

During the validation exercise, the flight crew were not requested to perform all the usual approach actions (e.g. checklist), and the airspace was simplified compared to approaches on KSFO or KPDX airports. Despite this rough assumption, an increase of the workload was systematically observed.

In light traffic environment, the identification phase added workload remains acceptable and well integrated with operations. In heavy environment, the workload will remain at an acceptable level supposing that the flight crew will not search for the target without ATC involvement.

We also observed that flight crew spends time to look for the target early during the approach phase but at this stage, ACAS Xo is not available (target aircraft out of the ACAS Xo activation range). At the end, ACAS Xo may not be necessary (because the target aircraft will have sufficient distance). This led to an increase workload for unnecessary tasks.

Concerning the activation of the ACAS Xo function, both flight crews considered that the workload is too high, because it requires head-down time during high complex and overloaded phase for pilots.

Conclusion: *Criteria EX2-CRT-PJ.11.A3-V2-VALP-009 V2 partially satisfied.* In any case, the workload is increased. For identification phase, it remains at acceptable level as long as the airspace traffic is

light. In heavy environment, it is supposed that the FC will not search for the target without ATC involvement. Moreover, with the current design (5NM limitation for activation), the ACAS Xo activation step is increasing workload to an unacceptable level for a short final approach phase.

EX2-OBJ-PJ.11.A3-V2-VALP-009 Results

Objective description: the aim of EX2-OBJ-PJ.11.A3-V2-VALP-009 is to assess that automatic un-designation is well understood by FC.

Benefit description: in case of automatic un-designation, flight crew may not understand the reason of the un-designation. This would lead to a worse acceptability of the function. This in turn could have a negative impact on efficiency, capacity and environment.

Expected evidence: EX2-CRT-PJ.11.A3-V2-VALP-010 V2. Understanding of the technical system's behavior is consistent with the operator's task demands.

The different automatic un-designation criteria for both ACAS Xo modes were presented to the flight crews prior to the evaluation exercise.

For CSPO-3000 operation, an automatic designation below 900ft directly followed by a TA alert was observed. The flight crew was not able to understand why the CSPO function was de-activated below 900ft (no feedback, as detailed in §0 below), and why a TA alert occurred at this specific point of the procedure with the parallel aircraft.

For DNA operation, during the evaluation briefing, both flight crews questioned the current 50ft AGL for DNA sub-mode automatic un-designation.

Below 900ft the RA alerts are inhibited and only TA alert remains. This is clear as no coordinated manoeuver is possible due to ground proximity.

But below 50ft, the aircraft is almost on ground and no maneuver is possible so they questioned the rationale of this condition. MOPS indicates that this requirement automatically un-designates traffic when descending through 50 feet AGL to the "on ground" altitude because below this altitude, all traffic is regarded as on ground. But this applies only to DNA and not to CSPO.

Conclusion:. *Criteria EX2-CRT-PJ.11.A3-V2-VALP-010 V2 not satisfied.* When automatic un-designations occurred, Flight Crews never directly understood the reason behind. Flight Crews spends time trying to analyze the reason which increases their workload. At the end, it really impacts the acceptability of the function (Automatic un-designation rules should be clarified and made more intelligible for pilots)

EX2-OBJ-PJ.11.A3-V2-VALP-010 Results

Objective description: the aim of EX2-OBJ-PJ.11.A3-V2-VALP-011 is to assess that FC is well aware of designation limitations and do not struggle with non-ADS-B paired aircraft.

Expected evidence: EX2-CRT-PJ.11.A3-V2-VALP-011 V1. Where possible, initial needs/requirements to support end-users acquisition of a mental model of the automated function are identified.

Not addressed during exercise due to technical limitations.

EX2-OBJ-PJ.11.A3-V2-VALP-011 Results

Objective description: the aim of EX2-OBJ-PJ.11.A3-V2-VALP-011 is to assess the usability of HMI to select the target.

Benefit description: the selection of the target may take time, in case of bad HMI design, which may increase flight crew workload in consequence. This in turn would have a negative impact on safety.

Expected evidence: EX2-CRT-PJ.11.A3-V2-VALP-012 V2. End user experiences integrated interface including any new system components as sufficiently usable.

The traffic selection sequence was presented to the flight crews before the exercise.

The flight crews were satisfied with the ATSAW selection with traffic selector and found the target selection easy. They confirmed the need of direct selection from the CDTI. The selection through a traffic list on MCDU presents more risks to select the wrong aircraft (one occurrence during the evaluation).

Conclusion: *Criteria EX2-CRT-PJ.11.A3-V2-VALP-012 V2 satisfied.* The usability of HMI to select the target has been validated during the evaluation – the principle to select the target on ND is validated. But the target selection through MCDU is not accepted as a primary means (traffic selector is preferred).

EX2-OBJ-PJ.11.A3-V2-VALP-012 Results

Objective description: the aim of EX2-OBJ-PJ.11.A3-V2-VALP-012 is to assess the usability of HMI to activate the ACAS Xo function.

Benefit description: the activation of the ACAS Xo function may take time, in case of bad HMI design, which may increase flight crew workload in consequence. This in turn would have a negative impact on safety.

Expected evidence: EX2-CRT-PJ.11.A3-V2-VALP-013 End user experiences integrated interface including any new system components as sufficiently usable.

On the contrary of the target selection through traffic selector that was found satisfying, the flight crews were reluctant for the ACAS Xo activation through MCDU.

They spend too much time head-down to activate the function. This head-down time is not acceptable during this phase of approach. Moreover the flight crews found that there are too much steps required to access ACAS Xo function: several pages on MCDU with latency to enter each page.

In addition, on ACAS Xo menu, the flight crews were not comfortable with the wording proposed for the sub mode selection. For every scenario with ACAS Xo activation required, they ask for the mode selection each time. Based on previous observation, the use of MCDU to activate ACAS Xo function

and modes is not appropriate to be done with an acceptable workload and without impacting the safety.

Conclusion : *Criteria EX2-CRT-PJ.11.A3-V2-VALP-013 not satisfied.* Globally, participants spent too much time head down to activate ACAS Xo functions. This is not acceptable in approach. There were too many steps (with latency) to access the ACAS Xo menu. Flight Crews were not comfortable with the wording proposed for the sub mode selection.

EX2-OBJ-PJ.11.A3-V2-VALP-013 Results

Objective description: the aim of EX2-OBJ-PJ.11.A3-V2-VALP-013 is to assess the usability of the HMI to undesignate a target.

Benefit description: manual undesignation of ACAS Xo target may take time, in case of bad HMI design, which may increase flight crew workload in consequence. This in turn would have a negative impact on safety.

Expected evidence: EX2-CRT-PJ.11.A3-V2-VALP-014 End user experiences integrated interface including any new system components as sufficiently usable.

This objective was not assessed during the evaluation. It was not included in the presented scenarios.

EX2-OBJ-PJ.11.A3-V2-VALP-014 Results

Objective description: the aim of EX2-OBJ-PJ.11.A3-V2-VALP-014 is to assess the automatic undesignation feedback is sufficient to be detected by the FC.

Benefit description: in case of automatic undesignation, the undesignation may be not noticed by the flight crew, which will have a negative impact on situation awareness. This in turn may have an impact on safety.

Expected evidence: EX2-CRT-PJ.11.A3-V2-VALP-015 Team is able to perceive and interpret task relevant information and anticipate future events/actions.

During the exercises, the proposed scenarios did not aim at evaluating the automatic un-designation. Nonetheless, two automatic un-designations were observed with TCAS TA Alerts following the un-designation. At this point, analysis from recorded data showed that both un-designation and TA alert are linked to intruders “positions jumps” due to the traffic generator tool.

Even if the simulation context was not fully representative of a final solution and automatic un-designation was not fully tested, the observations lead to think that an HMI feedback is necessary to inform pilots when an automatic un-designation occurs.

Conclusion: *Criteria EX2-CRT-PJ.11.A3-V2-VALP-015 not satisfied.* The current design regarding HMI feedback is not sufficient for crew to notice automatic un-designation.

B.3.3 Unexpected Behaviours/Results

There were no unexpected results because pilots' feedback confirmed the difficulty to develop an operational concept about ACAS Xo system.

B.3.4 Confidence in Results of Validation Exercise 2

1. Level of significance/limitations of Validation Exercise Results

The validation exercise addressed airborne aspects of ACAS Xo function during operation on chosen airports and aimed at providing a realistic environment allowing pilots to perform approach procedures using ACAS Xo function and interacting with it in a realistic manner.

However, some technical limitations occurred during the validation exercise that might have negatively impacted overall representativeness of the simulation. The external view resolution (projection of the outside environment) was limited; the traffic visual acquisition (in case of DNA) was difficult. Also the traffic was not representative of an environment in which parallel approach are needed (light traffic), and ATC communications were not performed by a real ATC.

The ACAS Xo function feedback (active mode displayed on selected target) was display on a dedicated tablet representing a Navigation Display (refer to section B.2 for more details). This dedicated display did not impact the evaluation negatively considering the maturity level of the solution at the time of the evaluation.

These limitations were well integrated by the flight crews and they projected the use of the function in more realistic conditions as well. These limitations were well integrated by participants. They were able to project themselves using such function in a real environment, giving insights on ACAS Xo in busy airspace.

Results are considered as significant despite some technical limitations.

2. Quality of Validation Exercises Results

The accuracy of the results can be considered as intermediate as the function was exposed for a limited flight crew number (2 crews). Nonetheless, the obtained results were quite converging for both crews, and the problems raised were similar. Therefore, we can be confident that the results can be extrapolated to a wider pilot's population.

So, the quality is good despite the low number of pilots.

3. Significance of Validation Exercises Results

During the evaluation exercise we could not obtain a wide sample of data. Therefore, the results significance is not valid. However, all evaluations were performed with professional pilots, so the quality of data is trustworthy.

Even if the scenarios were simplified compared to a real airport environment, the exercises were performed with realistic parameters: traffic behavior, communication with ATC (even simplified), approach procedures unchanged. Considering the realism of the simulation, the operational significance of the results is validated.

The results obtained are not operationally significant due to the limited number of flight crews for the exercise. Nonetheless, as the maturity level of the function is low and the converging outputs, the results are encouraging for further development of the function.

Finally, the participants were flight test and training pilots. Despite their wide competences, they did not had operational experience of the tested approach compared with airline pilots that fly this type of approaches almost daily.

B.3.5 Conclusions

1. Conclusions on concept clarification

- The crews raised the question of responsibilities during the evaluations. From their point of view, they will never decide to remove a safety net alert. So, if ACAS Xo enters into service, responsibilities shall be clearly defined and attributed to all actors (pilots, controllers and authorities). The crews confirmed that they would only use ACAS Xo sub modes if requested by authorities (at least indicated on approach charts). Therefore, in case ACAS Xo is further developed, SOP shall be clearly defined to include its use for concerned airport and/or approach.

- ACAS Xo function use was encouraged by the high rate of unnecessary RA advisories during approach for close runways, where pilots have tendencies to disregard some alerts. In order to avoid unexpected RA advisories, authorities used to recommend switching to TA mode only in case of known nearby traffic. This suggestion seems not to be used anymore, so the use of the function has been questioned.

- The second main output for ACAS Xo function evaluation remains in the utility of ACAS Xo sub mode. Pilots wonder why such a possibility exists to remove TA/RA alerts. Pilots will not accept DNA mode because it removes the TCAS safety net.

- Another important point obtained during the evaluation is the major difficulty to identify the correct target, especially in crowded environment. With current systems, the risk of identifying the wrong target is too high in crowded environment. Most of the time, in case of doubt, pilots will not use the function. The pilots consider ATC involvement as mandatory for an efficient and safe use of ACAS Xo. They shall guide the FC for intruder identification.

- During the validation exercise, the crews identified several showstoppers in terms of design for the ACAS Xo use to perform operations.

    - The current design of the ACAS Xo function inhibits the function activation if distance between ownship and target aircraft is greater than 5NM. This condition avoids the function activation as soon as the crew identifies the target. The pilots shall be able to perform the ACAS Xo activation as soon as they identified the target.

    - The ACAS Xo function activation with current design is not adapted to the pilots tasks at this moment of the approach. The added workload for pilots to look head-down during a critical phase is not appropriate. MCDU shall not be the primary means of interaction but a back-up means for ACAS Xo otherwise it will not be used.

- In case of un-designation of the function, the crews did not notice that they loss the function. Even if this does not decrease the safety (all TA/RA advisory recovered), pilots expect an HMI feedback. In addition, the automatic un-designation rules should be clarified and made intelligible for pilots.

As a general conclusion, several results confirm that the current design is not mature enough, and shall be further modified. From operational point of view, the ACAS Xo function benefit is not obvious.

2. Conclusions on technical feasibility

During evaluation pilots were able to perform approaches with ACAS Xo activation. From this point of view, ACAS Xo function is technically feasible since no technical blocking point was observed. Nevertheless, the current design has been criticized and the amount of data in the frame of this exercise is not sufficient to conclude on technical feasibility for ACAS Xo function, but data from exercise 1 will help to complete them.

3. Conclusions on performance assessments

During the evaluation exercise, it was neither proved nor disproved that ACAS Xo function brings clear and reliable benefits for CSPO or DNA approaches.

The safety during approach is not increased compared with the reference approach where the ACAS Xo function is not activated. More over due to an improved workload, the use of ACAS Xo function might limit safety.

B.3.6 Recommendations

- Transmit results to Working Group EUROCAE WG-75, that was tasked to develop ACAS X MOPS as a joint RTCA/EUROCAE activity.
- Before going further with ACAS Xo, the need of such function should be investigated by analyzing the frequency of nuisance alerts with ACAS Xa algorithm.
- Design of the ACAS Xo function shall be modified to allow pilots to perform activation as soon as they identified the target.
- On eligible procedures, ATC involvement should be investigated.
- The ND design should be amended to reflect pilots' needs but new evaluations will be necessary to validate new propositions.

Appendix C ACAS Xo Workshop Notes

Following document summarizing the main outcomes and conclusions of the Workshop was prepared and distributed to Workshop participants for their acknowledgement.

Date: Nov 26-27 2018

Location: Honeywell, Prague

Scope and Objectives

The workshop was organised within the scope of PJ.11-A3 activities focusing on the conceptual, operational and, above all, human performance aspects.

The main objectives of ACAS Xo Workshop were to:

- obtain expert feedback on high-level ACAS Xo operational concept as defined so far;
- brainstorm on more detailed operating method and address the operational open points;
- assess the feasibility of ACAS Xo procedures and potential use cases for the European environment;
- obtain feedback on the proposed HMI design.

Workshop participants consisted of safety experts, pilots and ATC based in Europe with knowledge of European airspace operations and European ATM.

Background

ACAS Xo is a product of FAA's TCAS Program Office (PO) initiative under RTCA SC-147 which introduced new approach to collision avoidance, known as ACAS X. The research was done in cooperation with SESAR Joint Undertaking, undear eagis of FAA-SJU Coordination Plan 4.1.

ACAS X has several variants. While ACAS Xa provides the same functionality as TCAS II, ACAS Xo is an optional feature of ACAS Xa, which allows use of alternative collision avoidance logic for specifically designated traffic while maintaining normal ACAS Xa alerting against all other aircraft. ACAS Xo is a supplement to ACAS Xa to allow special operations such as closely-spaced approaches that would otherwise be likely to trigger ACAS Xa alerts.

Both ACAS Xa and Xo were developed in parallel and share the same standard published in October 2018 (RTCA DO-385/EUROCAE ED-256). The standard currently defines two operational modes of ACAS Xo:

- Closely Spaced Parallel Operations down to 3,000ft runway separation mode **(CSPO-3000)** which provides designated traffic with modified collision avoidance logic monitoring, more appropriate for parallel operations; applicable in both visual and instrument conditions. ACAS Xa protection is maintained on all other cooperative traffic.
- Designated No Alerts mode (**DNA**) which suppress all alerts and guidance (except during multi-threat encounters) on designated traffic; requiring flight crew to visually acquire the

desired traffic before designating it and then maintaining visual separation from the DNA-designated aircraft. This mode is intended for use in closely-spaced operations in visual conditions, where ACAS Xa alerts would otherwise be a nuisance, ignored, and/or disruptive. DNA mode may be used instead of placing ACAS Xa into TA-only mode, preventing alerts against designated traffic but still allowing full ACAS Xa protection from all other cooperative traffic.

More modes can be potentially added in the future. Both defined modes are currently rather tailored for US operations where closely-spaced parallel runway operations are more common. Goal of ACAS Xo workshop was to obtain feedback on ACAS Xo from European perspective.

Outcomes

Human Performance discussions were conducted based on the foreseen flow of the usage of ACAS Xo function in both modes: CSPO-3000 and DNA. There was a lot of overlap between the two modes in terms of their usage and potential issues both for flight crew and ATC.

Key ideas among workshop participants about ACAS Xo operations can be summarized as follows:

- **ACAS Xo procedures** would be very likely airport-specific, designed for particular use case, and well-regulated in SOP, but in general:
  - ACAS Xo should be activated before ACAS could issue nuisance alerts.
  - ACAS Xo can be activated as soon as flight crew can identify the target.
  - Perhaps being established on the localizer and glide should be a requirement for using ACAS Xo, especially for DNA.
  - Approach briefing should prepare the pilot for a possible use of ACAS Xo on the approach. Thus, pilot will already know which mode he/she might be using.
- **DNA mode** brings many questions and concerns. Expert opinion:
  - Confirms that for DNA, acquiring and maintaining visual contact is essential, i.e. the mode should be used only in good visual conditions. Conditions such as reduced visibility or use by night brings in more challenges like city lights, water reflections and changed perspective of objects.
  - Some pilots would find it beneficial if the information about actual separation was displayed to them, e.g. on a traffic information display (not in the standard).
  - DNA should be very well tested by day and night. The distance by night is very difficult to estimate correctly.
- **Pilot workload** using ACAS Xo would depend on the implementation of the system and procedures, but
  - An increased workload for both pilot and ATC might be expected due to the need to set up the system (AC designation, mode selection, activation...) during approach when workload is already high.
  - Potential decision making on mode selection would increase pilot workload.
  - Workload would depend on the adopted flight crew task sharing.
  - It is likely that ACAS Xo will not be frequently used by an individual pilot. This lack of consistent practice might contribute to higher workload when using ACAS Xo.

- The idea of automated ACAS Xo feature would be welcome.

- **Situation awareness** is not expected to be significantly different from current situation, but the confidence in issued RAs may increase (RAs will be less likely to be perceived as nuisance RAs and, therefore, compliance with them is expected to increase).
  - The situation awareness is expected to stay the same or slightly increased with DNA mode, since (in contrary with TA-only mode) it still generates RA against other than designated traffic.
  - If the system is well designed, the situation awareness has potential to increase.
  - However, it is also possible that the overall situation awareness might somewhat decrease due to pilot's constant monitoring of one target, on instruments as well as visually.
  - Situational awareness will decrease if you lose the target from the traffic display in CSPO-3000 and lose the target visually in DNA. An immediate action should then be taken.
- **ATC** does not want an added responsibility. The communication would likely be a generic information provided to all aircraft regarding the sequence. There is a need to minimize the risk for the pilots to designate a wrong a/c. ATC providing a call sign could be a possible mitigation. At the same time the use of third party call sign is a known problem.
  - Use of ATIS or CPDLC for this purpose could be investigated.
  - ACAS Xo equipage is not expected to be communicated to the ATC.
  - ATC might need additional monitoring tool.
- ACAS Xo would require **regulatory updates** as well as **pilot training.**
  - Good understanding of how the system works and what are the possible blunders should support the decision of whether and how the ACAS Xo would be used.
  - Responsibility and reporting policies will need to be clearly thought out.
  - Regulations should consider making ACAS Xo training compulsory, regular and recurring.

High-level workshop conclusions

ACAS Xo solution would provide certain benefits to pilots, especially when flying in DNA mode, which is an improvement compared to pilots switching TCAS into TA-only mode. Pilots would at least still maintain the protection against other traffic. Nevertheless, workshop participants concurred that while in US the ACAS Xo would very likely decrease the number of cases when ACAS is set to TA-only mode, in the European, a more conservative environment, TA-only mode usage is not so frequent, and the data on such occurrences is not available.

European pilots are much more used to following the RAs compared to the US pilots, which can be explained by much fewer nuisance RAs occurring in European airspace. This leads to a general concern about modifying, or even partially removing this safety net – especially during approach phase which is the most demanding in terms of workload. From ATC point of view, ACAS Xo might be useful and could help to reduce missed approaches, especially in dense traffic.

In Europe, at this moment, ACAS Xo operations could potentially help in situations which involve military or rescue helicopters based at the civil airport, or general aviation in TMA areas. In such situations, possibility to apply DNA mode on the traffic would be useful to avoid triggering unnecessary RA. Other than that, Europe does not seem to have a clear use case to justify the use of

ACAS Xo. However, in future, increasing traffic, busy airports, especially those with parallel runways, might require pilots to have such a system.

Appendix D SESAR Solution Maturity Assessment

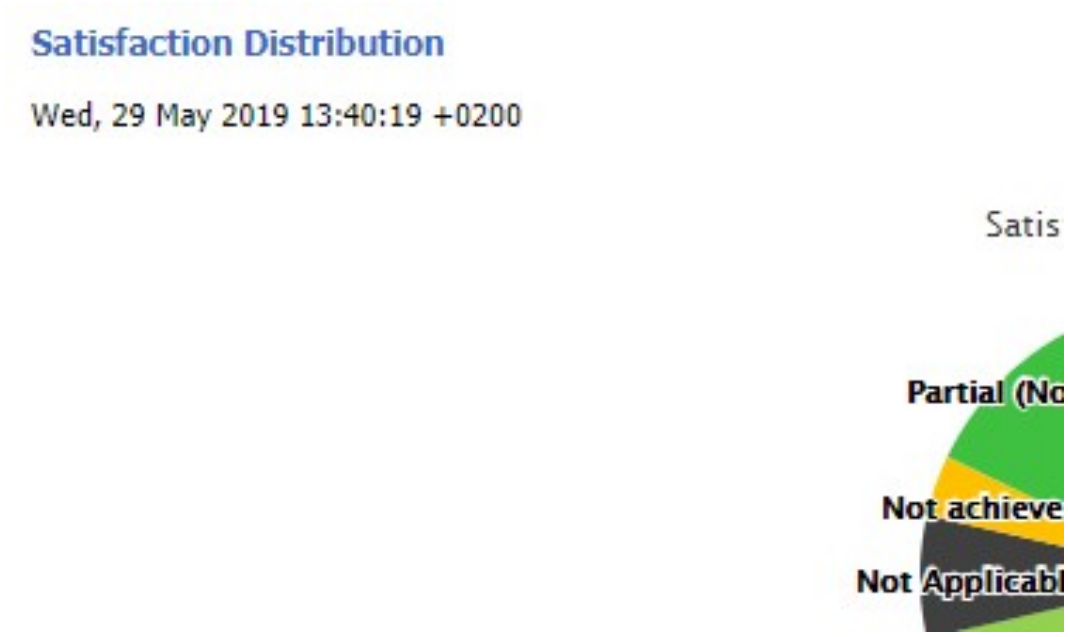


Figure 10: Satisfaction Distribution after the VALR finalization

Figure 11: Assessed Maturity per thread

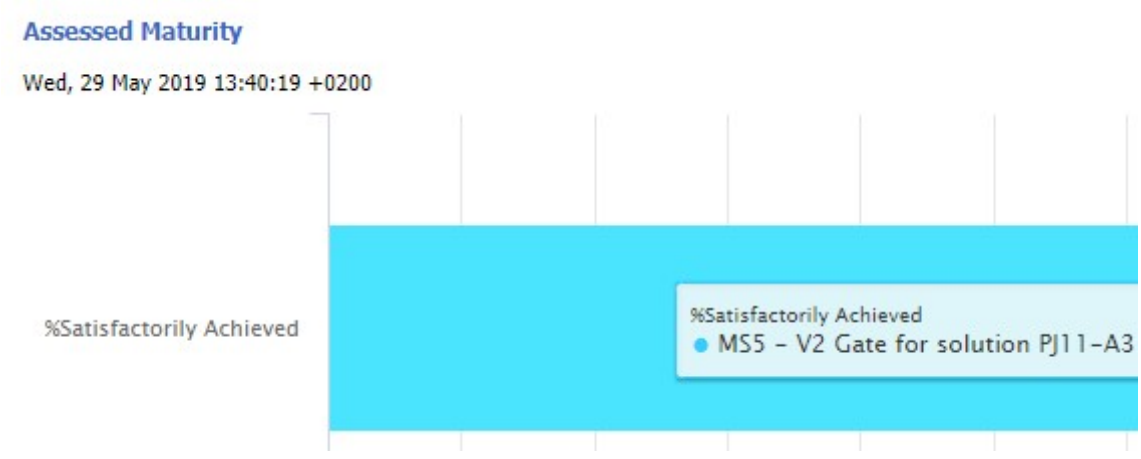


Figure 12: Assessed Maturity

PJ.11-A3 Maturity Assessment Criteria

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