European Union Aviation Safety Agency

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HORIZON EUROPE PROJECT – EASA.2022.C29

D-5.4: FINAL REPORT FOR STAKEHOLDERS' CONSULTATIONS AND DISSEMINATION EVENTS

GA COLLISION RISK - INTEROPERABILITY OF ELECTRONIC CONSPICUITY SYSTEMS

An Agency of the European Union

DELIVERABLE NUMBER AND TITLE: Interoperability of electronic conspicuity systems, D-5.4
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SUMMARY

Problem area

Airborne collision risk involving non-commercially exploited small aeroplanes represent a key priority in EASA annual safety review and for the development of safety actions at EU level in the European Plan for Aviation Safety (EPAS). As the see-and-avoid principle only has a detection rate of between 40 and 60 percent, the additional use of electronic conspicuity (e-conspicuity) devices is strongly recommended. Given the diversity of the so-called e-conspicuity devices, these are not always interoperable with each other, meaning that aircraft may or may not be electronically visible to each other. Here the lack of harmonised technical standards addressing the performances of such devices, the data transmission protocols and formats as well as the radiocommunication spectrum usage is a major impediment to their widespread use in Europe. In addition, the requirements set for e-conspicuity of manned aircraft for U-space operations (SERA 6005 (c)) entered into force in 2023 and will have an impact on the possible choices for GA pilots regarding the installation of such devices.

Description of work

The foundation of this study was to maximise the utilisation of existing devices, minimise costs, and encourage widespread voluntary adoption. Initially, the primary technologies were identified and assessed based on network and future viability, costs, user acceptance, transmission characteristics, and development potential. To achieve this, a survey was conducted among General Aviation pilots to determine the most commonly used devices, gather insights on their usage, and understand the requirements of different pilot groups. Two workshops involving experts were held to identify a target system combination from the existing operational devices and to determine the needs and limitations related to interoperability. Technical meetings focusing on mobile communications, transmission paths, and protocols were organised to facilitate and support these efforts. Subsequently, three main case studies were developed to address the implementation of interoperability requirements corresponding to the three primary transmission paths: 1090 MHz, SRD860, and mobile telephony. Additionally, an extra case study emphasised the benefits for other ground users and services, such as Search and Rescue (SAR), Flight Information Service (FIS), training and education organisations, and safety analysis. Drawing from these case studies and the feedback received from manufacturers and developers throughout the project, an action plan for implementation was formulated.

Results and Application

The key findings from the General Aviation survey revealed a significant information gap across all user groups, with 22% of respondents indicating that they do not utilize any e-conspicuity device. Consequently, the primary objective is to establish and sustain communication and guidance for pilots and other interested user groups regarding e-conspicuity, its advantages, and limitations. This communication initiative has already commenced through various presentations and events, including the AERO 2024 trade fair in Friedrichshafen.

The foundation of e-conspicuity in General Aviation will involve a combination of uncertified (preferably license free systems without mandate) and certified systems, such as ADS-B, among others.
The ADS-L protocol is one part to pave the way. This is also reflected in the definition of the target system combination with ADS-B, ADS-L, FLARM, apps using mobile telephony. The intended interoperability can be achieved through multilink transmission paths, a consistent language like ADS-L and, traffic networks. To

accomplish this, several tasks remain to be completed across technical, regulatory, and financial domains. The primary tasks include the complete specification and implementation of the ADS-L protocol (for both SRD860 devices and mobile telephony), defining the data and ensuring data quality for traffic information, planning and testing the necessary ground network, defining pilot benefits (such as airspace clearances and additional information via uplink), fostering a just culture and ensuring accountability for pilots, and addressing financial aspects.

CONTENTS

ABBREVIATIONS

ACRONYM	DESCRIPTION
ACAS-X	Airborne Collision Avoidance System X
ADS-B	Automatic Dependent Surveillance - Broadcast
ADS-L	Automatic Dependent Surveillance – Light
ATC	Air Traffic Control
ANSP	Air Navigation Service Provider
BNK	Bedarfsgerechte Nachtkennzeichnung
BVLOS	Beyond Visual Line of Sight
CAA	Civil Aviation Authority
DFS	Deutsche Flugsicherung GmbH (German ASNP)
DF	Downlink Format
EFR	Enhanced Flight Rules
EPAS	European Plan for Aviation Safety
FIS	Flight Information Service
FLARM	Portable Collision Avoidance System
GDL	Garmin remote-mount broadband transceiver
GNSS	Global Navigation Satellite Service
JARUS	Joint Authorities for Rulemaking of Unmanned Systems
MLAT	Multilateration
NAA	National Aviation Authority
NMEA	National Marine Electronics Association
OGN	Open Glider Network
PLMN	Public Land Mobile Network
SAR	Search and Rescue
SERA	Standardised European Rules of the Air
SIL	Source Integrity Level
SRD	Short Range Device
SDR	Software Defined Radio
TCAS	Traffic Collision Avoidance System
UAS	Unmanned Aircraft System
USB	Universal Serial Bus
USP	Unmanned Traffic Management Service Provider
VFR	Visual Flight Rules

1. Introduction

1.1 Background and structure of the project

Airborne collision risk involving non-commercially used small airplanes represents a key priority in EASA's annual safety review and for the development of safety actions at EU level in the European Plan for Aviation Safety (EPAS). Given the diversity of the so-called e-conspicuity devices, they are mostly not interoperable with each other, meaning that aircraft may or may not be electronically visible to each other. The lack of harmonised technical standards addresses the performances of such devices, the data transmission protocols and formats as well as the radiocommunication spectrum usage preventing their widespread use in Europe. In addition, the requirements set for e-conspicuity of manned aircraft for U-space operations (SERA 6005 (c)) entered into force in 2023 and will have an impact on the possible choices for General Aviation (GA) pilots regarding the installation of such devices.

The aim of the study is to provide a comprehensive roadmap for the development of technical standards, addressing the interoperability of e-conspicuity systems for General Aviation, contributing to the reduction of aircraft collision risks. E-conspicuity is not to be seen as a collision avoidance system; rather, its purpose is to enhance pilots' situational awareness throughout Europe, for all altitudes, while catering to diverse needs within the aviation community. It is important to note that e-conspicuity is not designed to support surveillance services for Air Traffic Control (ATC). Instead, e-conspicuity is meant to supplement Flight Information Service (FIS) and Search and Rescue (SAR) operations by providing extra data.

An online survey was carried out from April 4th, 2023, to May 7th, 2023, targeting end-users (GA pilots) to assess the current usage of e-conspicuity systems, satisfaction levels, and the associated needs and limitations. The substantial participation of over 2,000 individuals underscores the significance of this study for the General Aviation community. One of the primary findings is the lack of end-user information leading to considerable uncertainty regarding the installation, usage, limitations, and potential of existing e-conspicuity systems. Furthermore, the survey highlights that the systems must be made interoperable to obtain a traffic picture that is as complete as possible. Given that the existing e-conspicuity solutions have emerged from different areas of aviation (e.g., powered aviation, glider, hang glider) several incompatible technologies are being used.

Subsequent to the survey, two extensive workshops were conducted bringing together experts from various sectors of General Aviation. The workshops laid the groundwork for the ensuing case studies.

The first workshop focused on presenting survey results, developing potential criteria for interoperability, and deriving system combinations. The identified system combination incorporates ADS-B, ADS-L 4 SRD 860, ADS-L 4 Mobile, FLARM, applications using mobile telephony, and ground-based applications.

In between the workshops several technical meetings were conducted to identify how the different transmission paths can be made interoperable. One outcome was that interoperability can only be attained by integrating the transmission paths, such as through multilink devices and networks. It was also recognized that the existing deployed solutions cannot be simply replaced, and each transmission path possesses specific characteristics, qualities, and constraints. Consequently, they must be individually examined in the subsequent project phases.

The second workshop focused on identifying interoperability levels and deriving needs, constraints, and requirements for implementation. Building logically upon the previous results, the emphasis here is on the 1090 MHz, SRD 860 spectrum, and mobile network transmission paths.

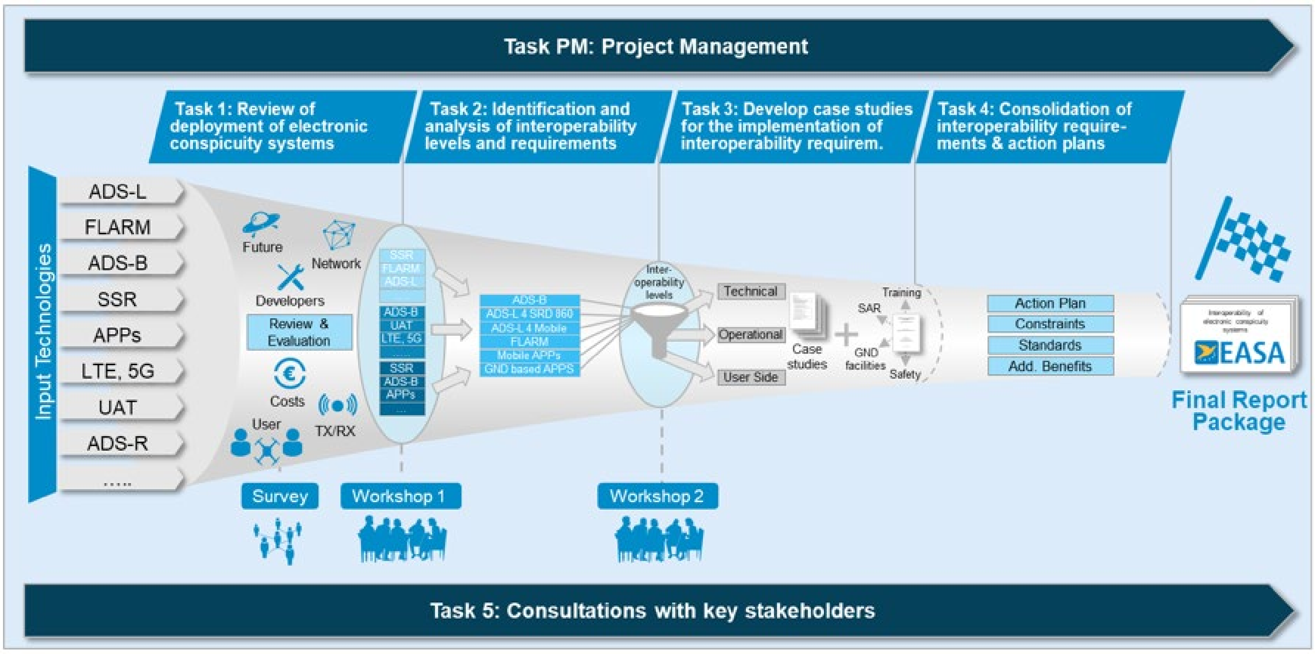
Subsequently, three case studies were developed to offer a comprehensive understanding of the advancements and innovations stemming from the two workshops and the aforementioned technical meetings. Aligned with the workshop approach, the case studies were categorised based on different transmission paths. As a result, three main case studies (Deliverable 3.1) were created, each with a distinct focus on technical, operational, and regulatory feasibility, constraints, and costs. They also take into account the currently deployed e-conspicuity solutions for General Aviation and identify suitable deployment scenarios and the collaborative actions required among various stakeholders, such as users, developers, network providers, and authorities. The first case study centred on 1030/1090 MHz systems, the second on SRD860, and the third on applications using mobile telephony. This framework is easily expandable to include additional and future technologies, such as satellite communication, UAT technology, and forthcoming developments.

The objective of the case studies was to assess the feasibility, constraints and costs of the proposed interoperability requirements while considering the currently deployed e-conspicuity solutions for General Aviation and identifying the suitable deployment scenarios and the coordination actions required amongst the different stakeholders.

In Deliverable 3.2 the assessment of additional benefits for airspace and ground users through harmonised data exchanges was outlined. This included the availability of additional data for search and rescue operations, the investigation of safety events and trends, as well as the reuse of traffic data for training purposes.

In the subsequent phase, the results from the previous steps were reviewed and consolidated with input from discussions and presentations involving pilots, developers, and manufacturers. Presentations and panel discussions were conducted, and new developments in the hardware and software market were examined. An action plan was then formulated based on the consolidated findings and the identified problem areas.

Figure 1-1 Project approach

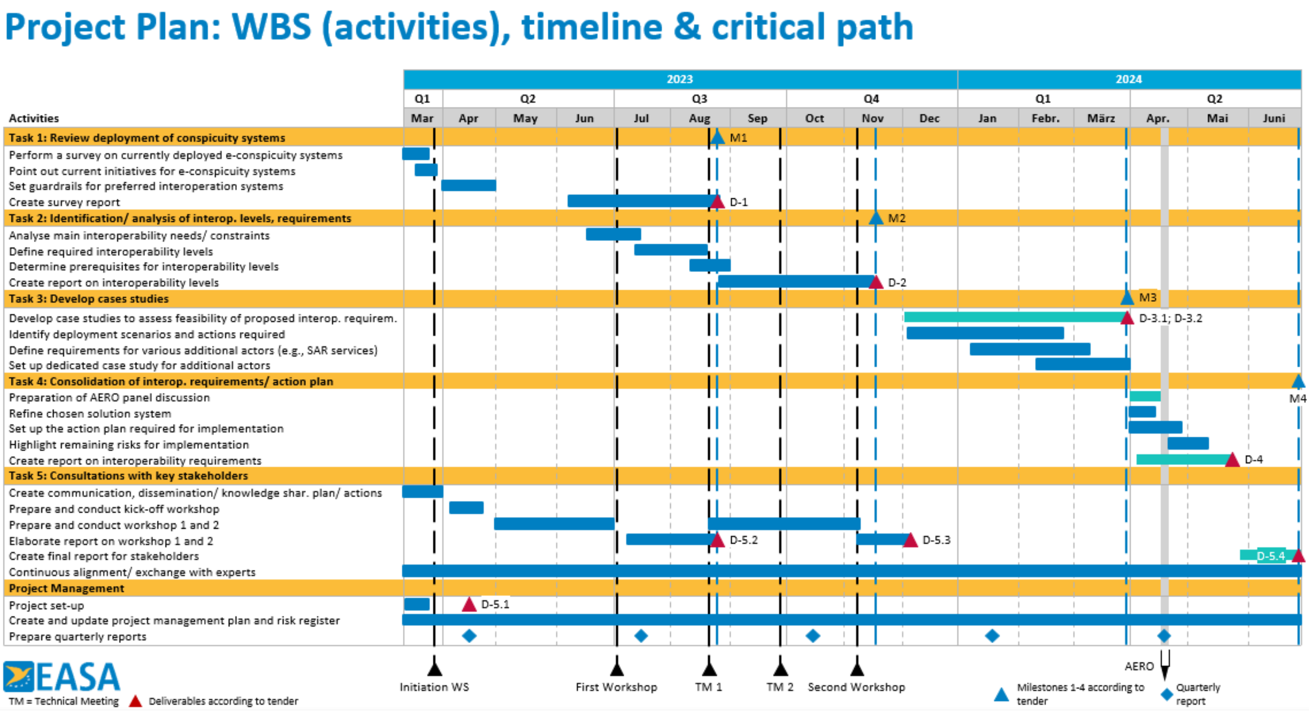


1.2 Scope of this report

This report represents deliverable 'D-5.4' of the Interoperability of e-conspicuity devices for General Aviation project. The work presented here represents the final results of all project deliverables. This includes the General Aviation Survey, the two workshops, technical meetings, case studies, consolidation of results and the action plan. In this document, the reproduction is limited to the essential findings. More detailed information can be found in the individual deliverables that are published on the EASA project website.

1.3 Timeline

Figure 1-2 Project timeline



The project was initiated in March 2023 and completed in June 2024. During this period several milestones were met including carrying out a survey, conducting expert workshops, creating case studies, and consolidating all the project results in a final report as well as presenting these results at a final dissemination event at the EASA headquarter in Cologne.

2. Survey Report

2.1 Overview of results

An online survey for General Aviation end-users was conducted from April 2023 to May 2023. The survey focused on the usage of existing e-conspicuity systems in General Aviation (drones added). It inquired about the usage of e-conspicuity systems, satisfaction levels regarding conspicuity, and current needs and constraints. The survey was distributed through EASA (social media), pilot associations, aircraft owners, and pilots within Europe. It was designed to be anonymous, and participants were able to make multiple selections for both used aircraft and e-conspicuity systems.

A total of 2.133 participants responded to the survey with the most commonly used aircraft being Single Engine Piston, Glider, Motor Glider and Ultralight. Of the respondents 61% (1.300) answered in German and 39% (833) in English. Additionally, 93% of participants follow VFR (1.975), 7% IFR (158). 22% (463) of the participants do not use any e-conspicuity system.

The survey revealed that pilots, aviation clubs, and rentals lack adequate information about e-conspicuity, as indicated by comments highlighting an information deficit. Many users of e-conspicuity systems appear to have limited technical understanding of how their systems operate. Within "closed" user groups, such as glider pilots, the use of group-adapted e-conspicuity systems like FLARM can create a false sense of complete safety. Conversely, user groups like parachute jumpers, paragliders, and wingsuit jumpers, who cannot react to traffic warnings and are unable to install heavy or fixed devices, do not require visibility of other aircraft (as stated in survey comments).

The survey also found that 94% of participants consider networking and correlation of information from existing systems to be necessary, with air-to-air connections being deemed the most important. Additionally, 91% of all participants believe that e-conspicuity systems should be used in all airspaces, and 72% think their use would be beneficial for Flight Information Service, such as providing the status of special airspace. While additional information such as airspace data and weather is seen as advantageous, it should not distract from the pilot's primary tasks. If the opportunity for additional information arises, participants expressed a desire for real-time airspace and airport data, weather updates, and NOTAMs. The safety benefit of using EC systems was rated at 8.7 out of 10.

2.2 Survey analysis

86% of the participants, who are not using an EC system today, would like to use one. 54% of these users would like to have a portable solution.

The main reasons for not using an EC system are indicated as follows:

- Costs (39%)
- Technical issues (20%)
- Not necessary (15%)
- Privacy (4%)

Other reasons (22%) were:

- Lack of information
- No harmonised solution available in EU (equipage, interoperability)
- Not available in rental aircrafts

Figure 2-1 Usage of any EC system

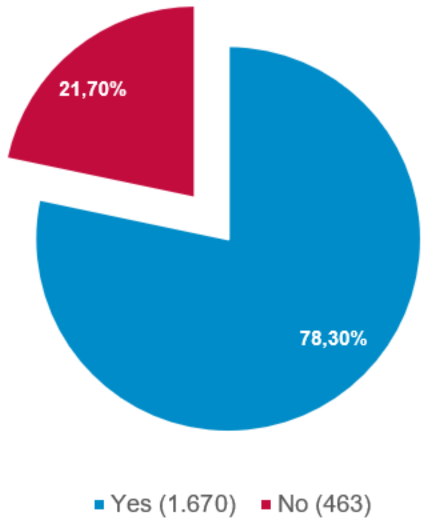
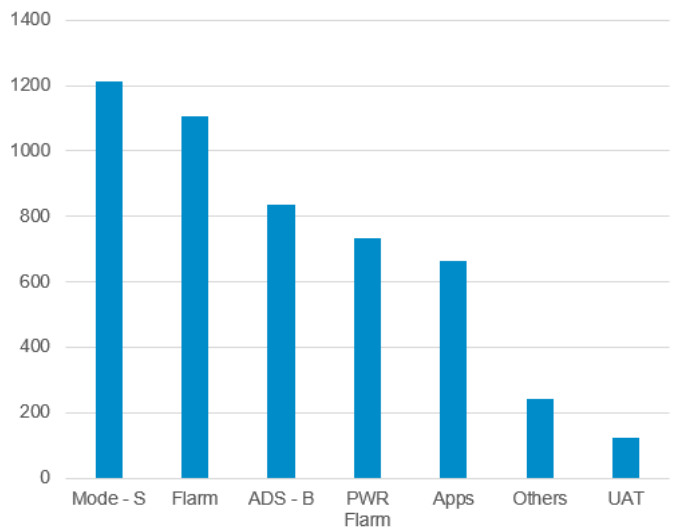


Figure 2-2 Usage of most common EC System



11.5% of all participants think that they can see all traffic and most commonly these are glider pilots.
The following reasons were mentioned for not seeing the entire traffic (with e-conspicuity systems):

- 47% of the participants think that there are still too many aircraft without an e-conspicuity system
- 37% of the participants think that the systems are not networking

The displayed traffic should be able to be filtered according to the specific needs of the respective user group. Most pilots opt to see only the traffic nearby to avoid collisions, while 34% prefer to have visibility of all traffic for strategic planning purposes.

Figure 2-3 Traffic to be displayed

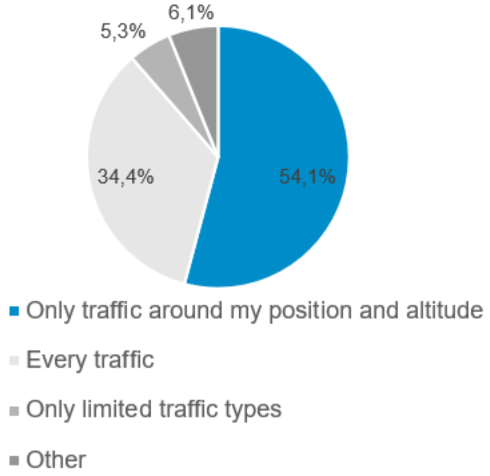
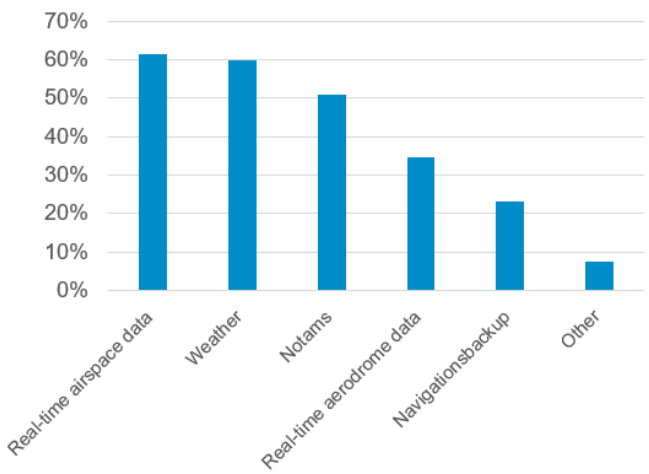
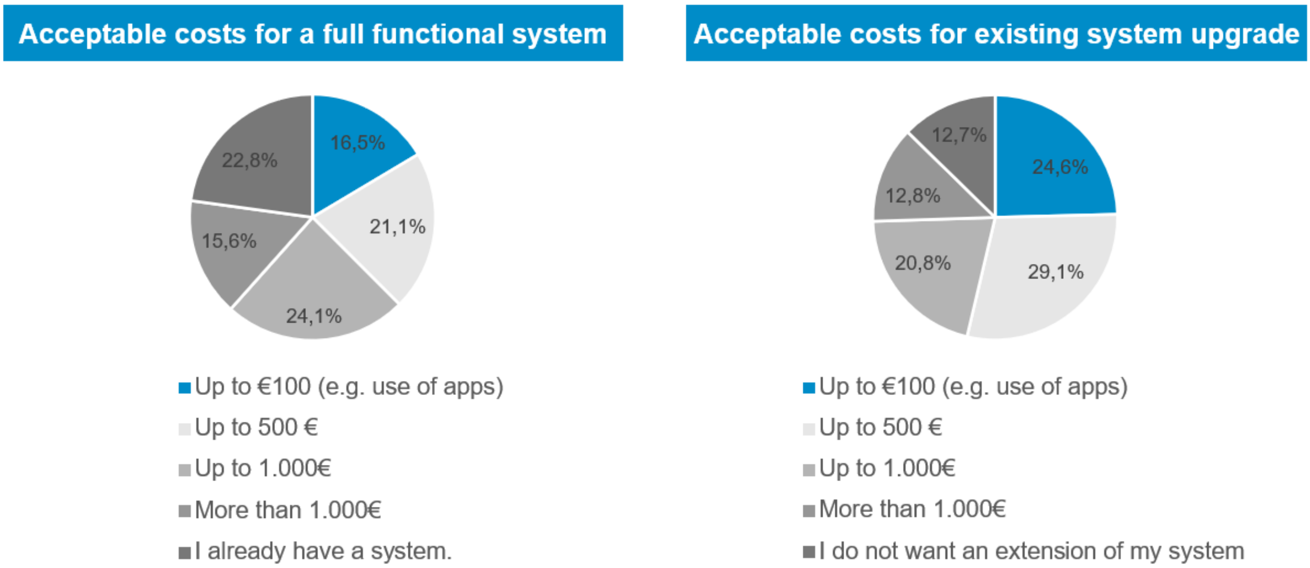


Figure 2-4 Desired additional uplink information



User satisfaction regarding e-conspicuity is low when using Mode-C and Mode-S transponders. Mode C is not further mentioned in this report as the system is rarely used and has been replaced by newer systems (Mode-S and ADS-B). Certain user groups are mandated to use Mode-S devices for specified airspaces, while the use of FLARM systems, apps, and in most cases ADS-B is voluntary.
The satisfaction with the used device rises with newer systems, network ability, and a wide distribution within the respondent group.

Figure 2-5 Acceptable costs for users



The survey revealed that users are willing to pay a premium to acquire a new system or upgrade their existing one. This emphasizes the importance of this topic for users, as even those who already possess a system are prepared to make a significant financial investment to enhance safety.

The entire survey report can be found here on the EASA website: [PowerPoint Presentation (europa.eu)]

3. Workshop Reports

3.1 Workshop 1

In the beginning of July 2023, the first workshop took place with experts from EASA and the GA community, developers, and manufacturers. The workshop was centered around the following objectives:

- to review existing and deployed e-conspicuity-systems
- to define criteria for e-conspicuity-system combinations
- to assemble and evaluate e-conspicuity-system combinations

At first, the results of the general survey were presented to the participants. The survey results are described extensively in the survey report and in the previous chapter.
After the survey, several position papers were presented including the papers from EHPU (European Hang Gliding and Paragliding Union) and EMFU (European Model Flying Union). EHPU mentions in their paper several risks, one of the is that paragliders fly very close to each other which makes the use of e-conspicuity systems crucial for them. The EMFU does not want the use of U-Space to limit them in their rights and they propose that with the use of ground-based apps, indicating the used model flying site electronically in a traffic network like UTM, there is a good solution for that issue.
The introduction of further initiatives and cooperations included the presentation of ADS-L which scales much better than ADS-B, has more flexible payload information with user needs in mind and uses timestamps. Next to ADS-L, there was a brief presentation of FLARM, the SafeSky project, UAT/ADS-B ground station projects in Finland and Norway, LDACS (L-band Digital Aeronautical Communications System) and the DMFV (Deutscher Modellflieger Verband) ground-based app.
In order to identify a final target system combination to be evaluated in the further stages of the study, extensive discussions with all workshop participants took place. To define the system combination several criteria were evaluated. These evaluation criteria included factors such as scalability, user acceptance, infrastructure and several more. The goal for the system combination was led by the results of the survey. First, the users/pilots want to see each other. Second, the user requirement is an air-to-air device. Out of these criteria and requirements, the final target system combination was derived as follows:

- ADS-B
- ADS-L4SRD860, ADS-L4Mobile
- FLARM
- Mobile apps
- GND based apps

Additionally, the systems that are not in the focus of the study but still under investigation were defined as follows:

- RADAR
- Mode S
- UAT
- TCAS II
- ACAS

ACAS X was not taken into consideration as the timeline for development is 2025/2026 and actual large rollout is expected earliest in 10 years. As the final point on the agenda the needs and constraints for interoperability were discussed with all the participants. Crucial points that were identified included for example the enablement of air-to-air connection and a network between different systems, the enablement of network capabilities or the frequency usage and congestion. Out of this discussion several questions arose that need to be clarified in the upcoming technical meetings. These included for example "What happens with ADS-L when ending up in GNSS denied airspace (without GNSS reference, with interferences or while spoofing)?", "How does the merging of double signals work?" – these and further questions were discussed in more detail in the technical meetings described in the next chapter.
The results of the first workshop laid the basis for the further development of the study.
The presentation of workshop 1 can be found here: Workshop 1 Documentation

3.2 Technical meetings

Between the first and second workshop several technical meetings were conducted. One focus area was the aerial mobile network usage, the other was communication ways for e-conspicuity. The key takeaways from each meeting are listed below.

Technical Meeting 1 – Aerial mobile network usage:

- Actual available coverage is up to 300m altitude, correlated to ground coverage
- Network connectivity: between 300m – 1.000m which is available in some areas, nevertheless the link quality is descending with rising altitude and speed.
- Coverage: in some countries like Sweden already a coverage up to 3.000m altitude has been demonstrated due to uptilted antennas (Teracom, state owned company)
- Requirements for coverage: for a coverage up to 3.000m and more a specific infrastructure is necessary
- Usage: no dedicated devices are needed; the usage of smartphones is possible
- External and good antennas: for better and unobstructed connectivity in the aircraft
- Data volume: e-conspicuity needs a very small amount of transmitted data

Technical Meeting 1.2 – Aerial mobile network usage:

- Mobile network infrastructure was never built to be used in the air. The actual usability is based on unwanted coverage in the air (e.g., by reflections)
- Low flying aircraft using mobile devices do have a noticeable influence on the ground network
- Two measures are necessary if the use of mobile networks is intended:
    - Enhance the reception quality on board (e.g. by the means of outside antennas)
    - Focus on low frequencies (that work best in the air) in terms of range and connection
- In terms of the intended aerial usage of mobile networks, providers in Europe should be consulted to see what can be done technically. In cooperation with them the impact to the ground network shall be limited

- The number of air users compared to users on the ground will not fulfil the business case for operators to change the network for aerial usage
- When leaving the coverage area of a network cell while flying the mobile device receives a lot more ground stations. The change from one network cell to another is a very special feature (intelligent prediction of the next used cell). Air usage restricts this prediction with negative impact to the network
- The ground network was created to cover vehicle speeds up to 300km/h for ground movements. Faster aircrafts will exceed this easily

Technical Meeting 2 – Communication ways for e-conspicuity:

- Currently it is possible to transmit ADS-L, it is though more difficult to build a receiver (SDR)
- No particular benefit (technically) on using ADS-L for collision avoidance was seen at the time of this meeting with ADS-L specification #1 published (regarding additional information in protocol, uplink availability, usage of airspaces, etc.)
- The actual benefit is on entering U-Spaces
- Direct communication between ADS-L (SRD860) and ADS-B (1090 MHz) is not possible, even not on semantic level, because ADS-L does not have all information of ADS-B and vice versa
- Affordable GPS devices can be installed on Mode-S with extended squitter and SIL0, this will meet the requirements of SERA 6005C (U-Space)
- 75%-85% of existing Mode-S transponders can be adapted
- Every mobile device, which can be used at home and in the mobile network should also be usable for ADS-L 4 Mobile

The technical meetings successfully laid the basis for the development of the target picture which was presented and discussed in the second workshop.

3.3 Workshop 2

The second workshop took place in the beginning of November 2023. The following guardrails were set up for this workshop to have a clear structure for the discussions:

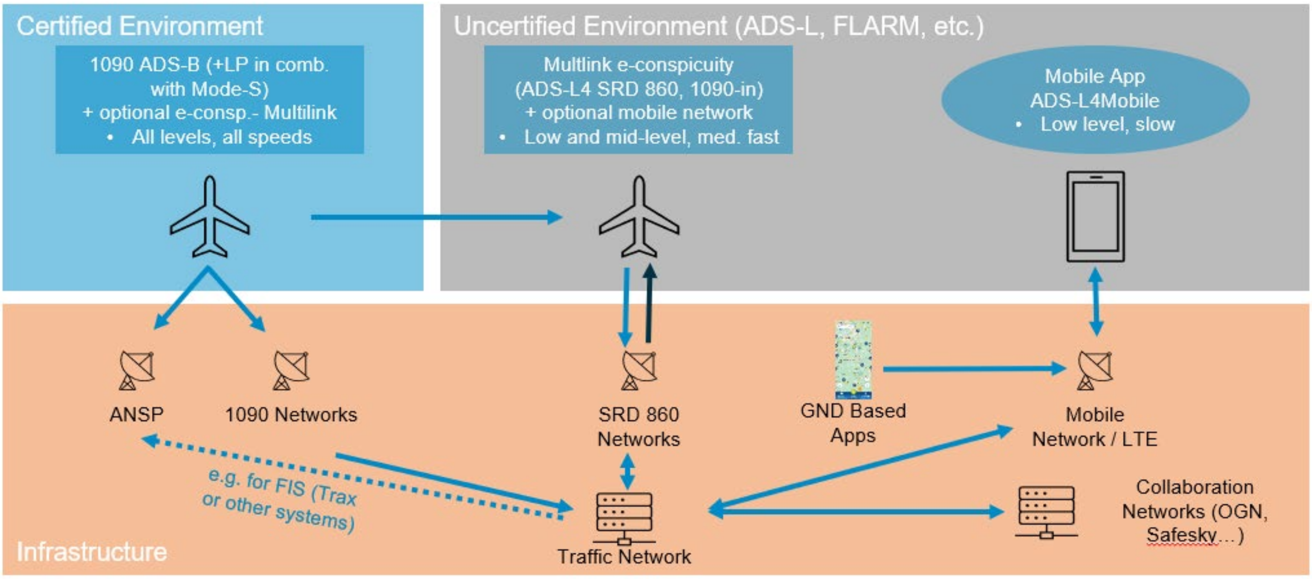
- the topic is e-conspicuity not air traffic control
- the focus is the target system combination from the first workshop (ADS-B, ADS-L4SRD860, ADS-L4Mobile, FLARM, Mobile apps, GND based apps)
- there will be no evaluation of single systems

The workshop had the following objectives:

- to collect and compile the main needs for interoperability
- to identify and specify the interoperability levels
- to derive the necessary requirements

After a brief recap of the project progress, survey results, selected target system combination and the needs and constraints for interoperability from workshop 1, the results of the technical meetings were presented to the participants. Based on these results the target picture for the near future was created:

➡ **Figure 3-1** Future iConspicuity view



This target picture (in a preliminary version) was discussed extensively with the workshop participants. It shows the combination of certified and uncertified equipment supported by a ground infrastructure. In the certified environment an upgrade from existing Mode-S transponders to ADS-B was discussed, supplemented by the addition of low power ADS-B devices to systems that cannot be upgraded. This works for all speeds and levels and might be supplemented by an additional e-conspicuity device to display traffic. In the uncertified environment multilink systems are used as they combine the reception of data from certified devices and the transmission and reception of different protocols (e.g., ADS-L) on SRD860 frequencies and mobile network. This approach is suitable for low to medium altitudes and medium to fast speeds. For low-level and slow-flying aircraft, as well as for pilots unable to carry a fixed device, the use of mobile apps may serve as a viable solution. Additionally, it can function as a complementary solution for other combinations.

In the ground infrastructure section, the need of a traffic network is shown combined with SRD860 and 1090 networks. This traffic network is also connected to collaborative networks feeding traffic information from other sources and to the mobile network. Ground based apps, like the FlyDMFV app for the integration of traffic data from model airplane pilots complete the picture.

The inclusion of the 1090 uplink is currently not depicted in the target picture due to uncertainties regarding its consideration of uncertified devices (although it may encompass information from uncertified devices). EASA has confirmed plans to address this issue with ATM stakeholders in research projects.
Additionally, certain limitations were discussed such as the unspecified hosting of traffic network systems, the requirement for only credible mobile applications to participate in the ADS-L ecosystem, and the ongoing research into methods for real-time authorisation of devices.

To derive the interoperability levels, needs and constraints the three clusters “Technical”, “Operational” and “User” were established. The “Technical” cluster was further divided into “Aerial Mobile Network Usage”, “1090”, and “SRD860”. The most crucial needs, constraints, and unresolved issues for each cluster and subcluster were openly discussed with the workshop participants, leading to the following conclusions:

<u>Technical – Common Requirements:</u>

- Maximum use of current installed hardware

- Enable ADS-L
- Evaluate max possible reception measures (e.g. ext. antennas)
- Develop multilink devices, which include existing hardware
- Enable connection to peripheral equipment (radio, altimeter, etc.) to integrate this information into transmission (e.g. actual used frequency to reach the pilot)
- Setup update/ upgrade programs for existing hardware
- Mandate free updates
- Initiate an evaluation group for setting up ground network (interfaces, locations, costs…)
- Setup communication program about e-conspicuity, limits, techniques for all user groups

<u>Technical – 1090:</u>

- Enable upgrade of existing Mode-S Transponders to ADS-B (connection with certified and non-certified positioning source)
- Develop affordable GNSS sources for upgrades (preferably as e-conspicuity Multilink device with GNSS interface)
- Encourage an exemption permit for those with older, not upgradeable Mode-S transponders in EASA member states for usage of an additional low power device
- Due to ETSO and ICAO SARP dependencies it is difficult to support low power devices which are not ETSO certified. Technically it is possible to use low power ADS-B devices but an approval from every single EASA state is needed
- Recheck TABS Usage
- Setup technical evaluation group to investigate the additional 1090-load, avoid any disturbance of TCAS and ATM surveillance systems
- Ensure clarity that it is a “situation awareness support”
- Analyse effect and effort to deal with non-certified transponders
- Supplement equipment to e-conspicuity functionality

<u>Technical – SRD860:</u>

- Finish ADS-L specification (at the date of workshop 2), define integration and payload
- Enable relay communication on O-Band (air-air and ground-air)
- Encourage hardware manufacturers (integration of ADS-L, upgrades, exchanges…)
- Integrate optional mobile connection
- Incorporate model flying, ground vehicles, starting and landing sites and airborne hazards
- Install and use external antennas
- Enable participants to use devices (training material)
- EASA presented benefits and additional features of ADS-L at AERO 2024. The implementation of ADS-L in SRD 860 devices is seen as a good opportunity

<u>Technical – Aerial Mobile Network Usage:</u>

- Define recommendations and specifications for mobile devices in terms of e-conspicuity, a minimum standard for the aerial usage and communication volume and minimum requirements towards apps
- Check UE (User Equipment/ modem) based features for more stable aerial use of mobile network (i.e. „band locking“ to most suitable frequency bands to prevent UE from trying to hop across frequencies)
- Design external devices (like 5G/LTE WLAN Router) with specific external antennas for usage in aircrafts
- Initialize studies and tests for stable aerial usage together with European network providers (Script with realistic data streams)
- Setup Specification for ADS-L4Mobile
- Address cross-border traffic (roaming)

- Ensure availability of the network
- Scan existing IoT solutions
- Define technical infrastructure (e.g. owner of servers)
- Ensure contracts with providers to foresee aerial use
- Define cost/budget for setting up network and operate it
- Analyse impact of additional App for pilot
- For the U-Space it is conceivable to have an entity who will be the app provider/developer and who will be obliged through mandate of SERA
- The e-conspicuity data must be shared to ensure the conspicuity of the users. Beyond U-Space there is no clear definition yet. Service providers and app developers should be encouraged to share the data as in U-Space

Operational:

- Enable encryption and authentication
- Setup interface for e-conspicuity data for ANSP
- Enable usage of e-conspicuity data by ANSP (Airspace and FIS)
- Flexibility of protocol to evolve is required
- Mandate data fusion and sharing
- Integration of model flying site ("geo zone") → hazard areas
- No punishment by being conspicuous and making small individual mistakes (just culture) Encourage NAAs to join → get "Acceptance Declaration"
- Define minimum requirements for data quality (all transfer ways, latency…)
- Avoid duplicate identifications
- Enable conformity management; pilots to be obliged to have their devices up-to-date
- Interconnection and prioritisation of systems (Best system broadcasts on ground & air)
- Inform about U-Space
- Integrate ADS-L in training (commit manufacturers to provide right training material)
- Ensure TCAS information is not interfered or displayed in a less important way

User:

- Inform about e-conspicuity and it's limits
- Make clear that see and avoid is still of paramount importance
- The project should stay as close as possible to existing standards
- Enable anonymization in protocols
- Define recommendations for usage (HMI, warnings, utilization without airframes (e.g. Hang gliders…)
- Prioritization of information, transparency which mode is currently used
- Simple to use, simple to understand, enabling fast decisions → reduce complexity (e.g. "Connected" indication regardless of link)
- Differentiate interfaces between "reliable" TCAS and other systems
- Enable support programs (exchange of hardware, supported new devices)
- Setup training programs and material for users
- Be open for changes, new features, installation changes (e.g. outside antennas…)
- Train system usage for interfaces/systems after installation
- Be compatible with existing cockpit solutions e.g. audio

During the project, the requirements and needs have changed and were supplemented. This will be described in the further project steps.

The presentation of workshop 2 can be found here: https://www.easa.europa.eu/en/downloads/139413/en

4. D-3.1: Case Studies

4.1 Case studies transmission paths

The three case studies examined the transmission paths 1090 MHz, SRD 860, and mobile networks in terms of their interoperability in e-conspicuity. Within each case study, the interoperability requirements determined in the second workshop were assessed for feasibility, constraints, and costs. It is essential to emphasise that in all considerations, e-conspicuity is intended to enhance the situational awareness of pilots and is not intended for surveillance to support ATC.

The individual transmission paths are not directly compatible due to the use of different protocols. Therefore, the only way to achieve interoperability is to optimize the utilization of the individual paths (e.g., through the use of external antennas) and connect them using a common language, such as ADS-L, within a traffic network and through combined (Multilink) devices.

Transitioning from existing Mode-S transponders to ADS-B offers a clear pathway to significantly enhance visibility and traffic awareness. This transition focuses on upgrading existing devices to transmit their precise positions via ADS-B, rather than introducing new 1090 MHz users. Typically, this upgrade involves the installation of a GNSS source, such as e-conspicuity systems with a GNSS interface, onto existing hardware. Additionally, exploring alternative solutions such as supported exchange programs and the introduction of low-power ADS-B options should be considered.

Integrating 1090 traffic data into traffic networks would support aircraft utilizing different transmission paths, such as the ADS-L protocol, as the current transmission and reception of ADS-L on 1090 MHz is unfeasible due to complex hardware changes required by licensing and approval requirements. Receiver stations can be established using a combination of professional and community resources, enabling the precise localization of Mode-S transponders via MLAT, especially for aircraft that cannot be updated or should not be updated due to technical feasibility and cost considerations.

SRD860 devices enjoy widespread popularity within General Aviation, as they are used as permanent cockpit installations as well as mobile devices, such as those used by paragliders. Operating on a specific frequency, they possess a limited range and support both air-to-air and air-to-ground communication. Leveraging existing and emerging SRD860 technology for the implementation of ADS-L represents the optimal and most straightforward path to achieving interoperability through this new protocol. Existing systems can undergo upgrades and retrofits up to a certain age. While the integration of various technologies and frequencies within the SRD860 band facilitates the technical realisation of transmission, reception, and relay operations, it also presents some technical hurdles.

First and foremost, it is crucial to finalize the specification for the ADS-L protocol for SRD860 and to commence the development of the ADS-L4Mobile specification. These steps are essential in laying the groundwork for creating devices tailored for General Aviation. From a financial perspective, SRD860 devices do not incur registration or authorization costs and involve minimal licensing fees. The upgrade to ADS-L is a cost-effective option, although the full range of new functionalities offered by ADS-L will only be accessible to new devices.

Mobile network data services function as shared resources and are susceptible to overload. Lower airspace coverage by mobile networks is not an intended feature, as the primary user is ground-based and relies on unintentional reflections for network coverage. However, this may not be the case for modern 5G or a dedicated LTE network for aviation.

Mobile network operators are cautious about airborne users due to unintended neighborship relations between network cells. Discussions during the second workshop highlighted uncertainties regarding the reliability of mobile networks as a transmission pathway for e-conspicuity messaging, contradicting assertions made by service partners such as SafeSky, which advocate for mobile network-based solutions. Considerations regarding performance parameters for seamless connectivity are of utmost importance.

While enabling mobile network usage onboard an aircraft or by airspace users would significantly enhance e-conspicuity situational awareness, accessing a broader spectrum of traffic information sources is currently unavailable to users. The success of such a solution depends on the simultaneous establishment of a server infrastructure for e-conspicuity message communication and rebroadcasting to connected users.

Mandating the development of an ADS-L4MOBILE specification to incentivize manufacturers to invest in hardware or retrofit solutions for e-conspicuity message transmission is crucial. Additionally, EASA will assess the costs associated with developing, installing, and maintaining a suitable server infrastructure.

In contrast to air-to-air broadcasting communication employed by e-conspicuity device users, communication via mobile networks or internet connection relies on a centralized data platform with the following functions:

a. Receiving e-conspicuity messages and other air traffic information sources
b. Processing (Correlation) and filtering messages based on user location and time stamps
c. Rebroadcasting messages through multiple communication paths, such as mobile networks

Without an appropriate ground infrastructure and continuous system monitoring, the mobile network communication pathway offers no advantages for e-conspicuity message transmission.

4.2 Influence from unmanned aviation

Electronic conspicuity has been a critical requirement for unmanned aerial systems (UAS) from day one, as per aviation regulations, UAS are mandated to give right of way to manned aviation. In u-space airspace operations, the visibility of air traffic is comprehensively regulated, with clear requirements and responsibilities.

Compliance with this law during UAS missions beyond visual line of sight (BVLOS) necessitates the presence of electronic situational awareness, as the UAS pilot is unable to fulfil the see-and-avoid mandate.

Receiver stations for all common e-conspicuity systems along the UAS flight path are essential for populating a situational awareness map system for the UAS pilot. In the drone industry, companies already provide service packages for drone operators, which include receiver stations, transmission of received data, and the calculation of situational awareness visualisations. These enable the drone pilot to give right of way to manned aviation within their operational area, such as becoming aware of an approaching rescue helicopter. However, it is important to note that this may not cover all manned aviation, for instance, aircraft equipped with Mode-S transponders (see case study 1090MHz).

The European Aviation Safety Agency (EASA) is responsible for regulating the use of drones in the EU and has established a regulatory framework for Remote ID, which mandates the majority of drones to be equipped with a Remote ID system (same as FAA/US).

Remote ID is designed to enhance the safety, security, and accountability of drone operations, particularly in areas where drones may be operating near other aircraft or in sensitive locations. This system enables drones to transmit identification and location information, which can be received by other airspace participants, including authorities, pilots, and the public. It has been mandatory for many UAS operation categories since January 2024 and is currently being integrated by leading manufacturers.

From a purely technical point of view, the Direct (Broadcast) Remote ID and Network Remote ID systems functions as follows:

Direct (Broadcast) Remote ID:
In this method, the unmanned aircraft broadcasts its identification, location, and other relevant information using WIFI or Bluetooth. Nearby receivers, including other aircraft and ground stations, can pick up these signals to obtain information about the UAS. While effective for supporting operations in the direct vicinity of the receivers (i.e., VLOS), the inherent range limitation of WIFI or Bluetooth broadcast technology makes it unsuitable for supporting long-range operations (i.e., BVLOS).

Network Remote ID:
With Network Remote ID, the identification and location data of UAS are transmitted to the UAS operators through a network. A third-party service collects and disseminates Remote ID information via the Internet. Authorised parties, such as air traffic control, law enforcement, and other stakeholders, can access this information through the network.

Network Remote ID is mandatory for the upcoming EU airspaces known as U-space, where manned and unmanned traffic will be integrated. It may also be suitable for supporting BVLOS operations outside U-space airspace. The acquisition and sharing of Network Remote ID may be facilitated by dedicated service providers through their specific technical means and infrastructure (e.g., mobile network/centralized database). In U-space, Network Remote ID can be directly acquired by the USSP through their own infrastructure (e.g., antennas) and transmitting means provided to their operators.

The Network Remote ID traffic messages can be integrated into the network systems mentioned in the case studies using the ADS-L protocol. This also means for EASA that data exchange/format and protocol mapping needs to be aligned between the Network Remote ID and e-conspicuity.

Focus groups within the unmanned aviation industry, such as the Joint Authorities for Rulemaking of Unmanned Systems (JARUS), have been dedicated to digital information sharing for years. JARUS recently published a whitepaper aimed at outlining the impact of automation and digital information sharing on all aspects of aviation safety.

In summary, the whitepaper emphasises that digitalisation, the sharing of digital information, and e-conspicuity can enable safe flight operations, particularly with high levels of automation. Electronic conspicuity will facilitate cooperation among aircraft for safe separation.

EASA's approach to ADS-L specification and its efforts to harmonize with other protocols and existing data models, such as Network ID, are becoming crucial enablers of safe and fair airspace sharing between manned and unmanned aviation without airspace segregation.

4.3 Identification of suitable deployment scenarios & user matching

To identify suitable deployment scenarios, various categories of solutions are proposed to facilitate a comprehensive and widespread dissemination of e-conspicuity systems and to offer suggestions and guidance to all user groups. The categories are primarily differentiated based on mobility, certification, and financial considerations. The project survey has revealed a significant interest in improvement and a willingness to invest. The intended user group clustering is already supported in the ADS-L protocol. However, there are plans to expand these clusters in the future, for example, to include the identification of hazard zones for ground-based applications such as model flying sites, as well as take-off and landing sites for hang gliders.

4.3.1 Certified e-Conspicuity solution

The certified solution will be a fully integrated system, consolidating all three transmission paths, the core unit, communication, and display components into a single device from a single manufacturer. The display will present traffic information, support navigation, provide additional data such as weather, and may also serve for planning purposes. Since this device will be permanently installed in the aircraft and potentially linked to other aircraft systems, it necessitates certification and regular compliance and performance evaluations.

The primary advantage of this solution is the seamless integration of the entire unit into the cockpit environment, primarily to demonstrate a high level of safety. The individual transmission paths are meticulously coordinated, and the reception is optimized to meet the specific operational needs of the aircraft. The traffic data, along with additional information, flight planning, and aircraft parameters, is displayed on a single system with a well-adapted human-machine interface.

The primary drawback of this solution is clearly its cost. The development, coordination, approval, and installation of such a system represent a significant undertaking. Additionally, recurrent inspections and fees add to the financial burden.

Given these characteristics, this system solution is only viable for larger and more expensive airplanes and helicopters.

4.3.2 Uncertified e-conspicuity solution

The uncertified solution will consist of a device or a combination of devices that integrate the various transmission paths described in the case studies. The core device gathers traffic data from the different receiving units and processes it for display. The display can be provided by the manufacturer or even a user's mobile phone/tablet. The transmission paths utilised here should encompass transmission and reception on SRD860 and reception of ADS-B. This combination may be complemented by the mobile transmission path. Ideally, all three options can be integrated into one transceiver connected to external antennas. This upgrade could also be made available for existing e-conspicuity systems if the appropriate interfaces are accessible. The installation is managed as a standard or minor change without requiring certification.

The primary advantages of this solution include the visualisation of all received traffic, direct air-to-air transmission, affordability, and the usage of existing equipment.

The main disadvantage of this solution lies in the combination of different parts (core device, communication box, display) and the required interfaces. All components must be consistently updated to compatible versions, potentially leading to a higher failure rate compared to integrated systems. Moreover, there is a greater likelihood that design and software errors may be the source of malfunctions and instabilities.

4.3.3 Portable e-conspicuity solution

The portable solution is primarily designed to accommodate users who prefer not to invest significantly in an e-conspicuity device or are unable to install a device (e.g., no fuselage). It is likely to comprise a mobile, app-based solution utilising an existing mobile phone. The costs will be limited to the application fees (one-time purchase and/or recurring costs) and potentially a cradle for securing the device in the cockpit. Furthermore, solutions with external antennas for reception optimisation could slightly increase the costs. In a mobile-app solution, various sources of e-conspicuity may be made available if supported by the ground-side server system. The ADS-L4Mobile protocol will facilitate the realisation of this provision, including additional information (e.g., weather). Since the device is not permanently installed in the aircraft, no certification or modification is necessary.

The advantages include the low entry costs and the use of well-known, proprietary equipment. Additionally, this solution's portability allows for use across multiple aircraft, meeting the needs of paragliders and hang-gliders without a fixed airframe for device installation. Easy updates and upgrades are achievable via internet access on the ground, and pilots can even practice usage at home.

The disadvantage of this solution lies in its reliance on a single transmission path with inherent weaknesses (e.g., dependence on speed, altitude, network condition). It lacks direct transmission and reception of other transmission paths, as detailed in the mobile network case study. Furthermore, this solution is not currently compatible with display in commercial aircraft.

This solution is suitable for paragliders, hang-gliders, and slow-flying aircraft, and it can complement already installed devices for other users. However, if this system is the sole one used, there is no visibility to pure 1090MHz users (mostly commercial aviation) due to the absence of a rebroadcast system for ADS-L on 1090.

4.3.4 Specific solutions

Some user groups will still require more specific or specialised e-conspicuity solutions. For instance, hot air balloons may use a portable combined unit with a radio and an ADS-B capable transponder, potentially supplemented by a low-level e-conspicuity solution. In this context, weight and power consumption play a minor role.

Other groups, such as parachutists, skydivers, wingsuit pilots, and model pilots, are advised to use a ground-based app to mark the area of their operation. They can activate their designated area before takeoff and deactivate it after landing. The FlyDMFV app demonstrates this principle. Similarly, the take-off and landing fields of hang gliders and paragliders will be integrated as a special aircraft category in the ADS-L protocol.

For UAS operations Remote ID and Network Remote ID are provided in use cases where they must be made conspicuous. As there is no coordinated standard for the transmission, the protocol will most probably be ADS-L, enabling the integration of these aircraft into traffic messages.

In conclusion, it is important to note that all solutions and partial solutions should maintain the option to connect to additional transmission technologies, such as UAT technology, satellite communication, and others.

5. D-3.2: Case Study Additional Benefits

5.1 Use of large data sets for General Aviation

The use of large data sets in General Aviation offers several benefits. The interoperability among diverse systems and transmission paths enables a more comprehensive real-time traffic overview. The storage of this data can facilitate the initiation and coordination of rescue operations for lost aircraft. Furthermore, large data sets enhance prediction accuracy, aid in identifying hotspots (such as airspace boundaries or popular gliding routes) and mitigate aircraft congestion during flight planning.

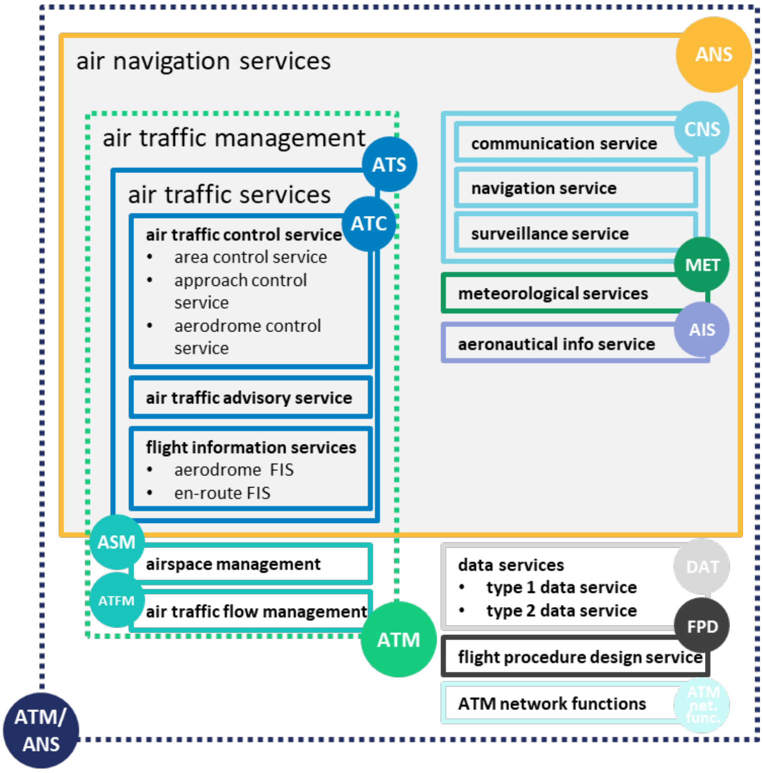
Various types of data serve distinct purposes. Real-time data is crucial for services like ANS, ATS, and SAR, while safety analysis and trend investigation benefit from the storage of data over extended periods. Therefore, traffic networks should be set up with interoperable e-conspicuity systems that can also record data over longer durations to facilitate both applications.

For data exchange, uniform formats (e.g., ADS-B) transmitted via 1090 MHz, SRD 860, and mobile networks are optimal. Software interfaces can connect existing receiver networks (e.g., OGN for FLARM, ADS-B). While mobile networks may lack historical data storage, they enhance situational awareness. Access to storage system data should include data visualization and interfaces for other stakeholders, such as ADS-L/FLARM layers for air traffic controllers.

5.2 Air Navigation Services

Air Navigation Services (ANS) as defined by EASA are mainly Air Traffic Management (ATM) services, Communication, Navigation and Surveillance services (CNS) and Search and Rescue Services. Additionally, meteorological services for air navigation and aeronautical information services are included in this definition (Article 2(4) of Regulation (EC) No 549/2004).

Figure 5-1 Air Navigation Services



ANS are primarily provided within controlled airspaces, requiring air traffic control clearance for access. ANS facilitate the safe and efficient use of airspace structures. The minimum equipment required for most services today typically includes a VHF radio and a transponder. These services are generally administered by an Air Navigation Service Provider (ANSP). In uncontrolled airspaces, Air Navigation Services are not necessary, but Flight Information Services are provided.

Among the uncontrolled airspaces there are controlled airspaces, that do not need a clearance for VFR flights, for example airspace E. Usually there is a growing demand for air navigation services to the IFR traffic because it can happen that VFR traffic encounters IFR traffic.

The current solution attempt for mixed IFR/VFR traffic zones are TMZ/RMZ airspaces to make all VFR traffic visible to the ANSP and being able to contact the VFR traffic via two-way radio communication. This segregation limits the airspace use to users equipped with transponders.

To enhance the management of IFR/VFR mixed traffic situations, the e-conspicuity of VFR airspace users without transponders to the ANSP could be facilitated by real-time data availability from a ground-based e-conspicuity receiver system data centre. This would involve the transmission of ADS-L messages over alternative communication paths to the data centre and could potentially render the transponder as a minimum equipment redundant.

5.3 Air Traffic Services

Air Traffic Services (ATS) encompass a variety of services designed to ensure the safe, orderly, and efficient flow of air traffic within controlled airspace.

The primary air traffic service relevant to General Aviation operating under visual flight rules (VFR) is the flight information service (FIS). Currently, the core component of FIS is traffic advisory, which provides pilots with guidance on surrounding air traffic. It is advisory in nature and assists pilots in maintaining situational awareness, although it does not involve instructions or clearances from air traffic control. This service relies on primary and secondary radar surveillance data as well as flight plans, and it can also be provided to aircraft without transponders.

However, this also means that the FIS controller has limited visibility of electronically less conspicuous traffic compared to a pilot using an interoperable e-conspicuity system. Conversely, the controller can accurately detect traffic using Mode S (basic, without transmission of position data) due to the secondary radar, which may not be visible to another pilot due to their equipment. The entire spectrum of traffic transmitting messages on SRD860, or mobile network systems remains undetectable to the controller, except for aircraft large enough to be targeted by primary radar.

Incorporating traffic data from currently unsupported e-conspicuity systems such as SRD860 systems and others into surveillance systems would significantly enhance traffic advisory capabilities. While it is possible that non-transponder equipped aircraft/airspace users could also receive the service, the inclusion of e-conspicuity data would greatly improve traffic advisory. However, this may also lead to increased workload for FIS specialists, particularly in high-density traffic areas, such as glider and paraglider hotspots. Conversely, it could be that participants may no longer feel the need to use the FIS if they have a fully interoperable e-conspicuity system on board.

Air Traffic Services will face the challenge of managing the increasing volume of traffic advisories to FIS users, as the current service relies on one-to-one VHF radio communication.

Enabling the centralised ground-based network data centre to access the most relevant e-conspicuity system data/ADS-L message content could potentially change the future of long-distance flight planning and FIS interaction with General Aviation users operating under visual flight rules, by enhancing the availability of long-distance planning data information.

5.4 Search and Rescue services

Search And Rescue (SAR) operations follow international standards. A systematic approach has been e.g., issued by the U.S. Coast Guard. In this approach there are five SAR stages for an incident:

Awareness,
Initial Actions,
Planning,
Operations and
Conclusions.

Any system or data analysis that can help reduce location uncertainties during the awareness stage will significantly enhance the efficiency and success of SAR planning and operations.

The availability of data from on-board e-conspicuity systems of the missing aircraft, stored and accessible within a reasonable timeframe during the SAR operation planning stage, can have a profound impact on the process of gathering additional information before activating, mobilising, and assigning SAR resources.

The collection and storage of e-conspicuity system data via ground-based receiver networks can become highly significant. This assumption is based on the experience of SAR incident controllers, where primary radar data analysis of the search object has proven to be extremely helpful in reducing location uncertainties in several SAR incidents.

Quick access to historical data is crucial for minimising the search area, reducing further harm, and lowering operational costs. Access to historical e-conspicuity/traffic data may also prove valuable during the conclusion phase, offering insights for learning from further analysed data for future incidents.

Another valid information source is the IGC logs of FLARM equipped aircraft, which automatically store encounters with the missing aircraft (if also FLARM-equipped) when in close proximity. Accessing this information requires copying the data from the FLARM receivers to an SD card and conducting the necessary analysis.

The planned relay function between interoperable e-conspicuity systems (see Deliverable D3.1) is designed to transmit traffic data from all processed sources on the aircraft via the ground network and store it in a storage network. This approach ensures data availability even if the distressed aircraft no longer receives signals from ground stations but remains in contact with other aircraft.

5.5 Safety analysis/ use of data for incident investigation and safety trends

Aviation safety is significantly improved through comprehensive incident investigation, which analyses contributing factors to prevent future incidents and drive enhancements. Investigating safety-related incidents, such as air proximity hazards, is greatly facilitated by reliable traffic data from diverse sources, enabling detailed reconstruction of dangerous situations. Historic e-conspicuity data presents a valuable opportunity in this regard.

In commercial aviation, particularly with large airlines, a mandated safety management system is established to process accidents and incidents and implement measures for future prevention. The utilization of flight data aids in more accurate incident reconstruction, contributing to the maintenance of a consistently high safety standard over decades. Insights gained are integrated into countermeasures and pilot training.

In General Aviation, comprehensive evaluations are frequently hindered by data limitations, as well as a lack of access to professionally trained personnel and financial resources. Nevertheless, an improvement in data availability and the simple, readily accessible use of e-conspicuity data could result in substantial enhancements and streamlining of safety analyses, along with the implementation of corresponding countermeasures.

For instance, the Aircraft Proximity Evaluation Group (APEG) is established in Germany, comprising a substantial number of aviation experts, often including controllers and pilots. APEG's primary objective is to analyse reports of aircraft proximity incidents within the airspace of the Federal Republic of Germany. The lack of comprehensive data often hinders precise analyses. Implementing the aforementioned measures could significantly enhance the thoroughness of case clarifications.

Therefore, the demands are similar as for SAR operation:

- Interfaces to all relevant e-conspicuity receiver station systems/networks as feeding systems to data storage. Interfaces mean data exchange with the existing systems for traffic data, best case all in the same protocol (e.g., ADS-L)
- Traffic data storage server infrastructure as storage place
- User interface to access/visualise data for analysis
- Export functionality to existing professional incident analysis tools

The easier the data can be accessed and evaluated without expert knowledge, the more it will be used, especially for the reflection of everyday situations where it would not have been expected to use it beforehand.

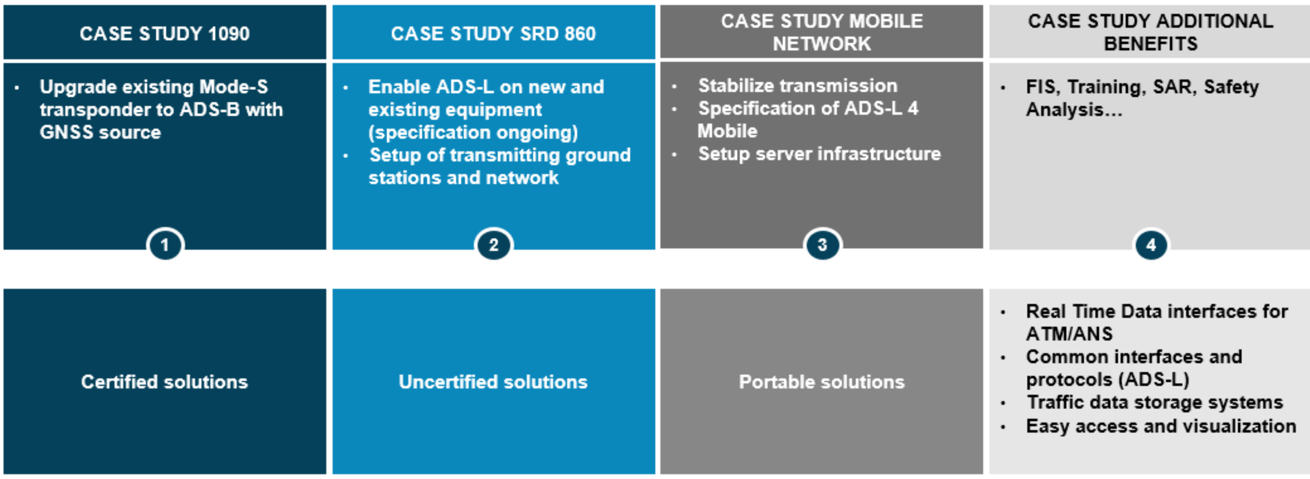
The benefits of rapid investigations are directly linked to the ease of use. The safety culture among General Aviation pilots could improve significantly.

5.6 Re-Use of data for training

The analysis of training-related data primarily contributes to the development of valuable training scenarios based on real-life observations. This includes high-risk potential situations or flight incident/accident-related events such as air proximity events.

Gaining access to real-life traffic data from a data lake could potentially become an integral aspect of our future error culture within the General Aviation training environment.

Figure 5-2 Case studies – Main tasks and suggested systems



6. Implementation of interoperability solutions and the related action plan

6.1 Introduction and background

In Deliverable 3.1, three case studies were presented and evaluated, focusing on the main transmission paths for e-conspicuity (1090 MHz, SRD 860, and mobile network). The evaluation was based on the feasibility of the proposed interoperability requirements for e-conspicuity, as derived in workshop two. Additionally, three deployment scenarios were identified to enable implementation for all aviation participants while maximizing the use of existing equipment. The influence of unmanned aviation on developments in the field of e-conspicuity was also examined.

In Deliverable 3.2, the assessment of additional benefits for airspace and ground users through harmonized data exchanges was outlined. This included the availability of additional (stored) traffic data for search and rescue operations, the investigation of safety-related events and safety trends, as well as the reuse of stored traffic data for training purposes.

One focus of the results and the most important point on the action plan is to inform the General Aviation community about the topic and to raise awareness of e-conspicuity. The AERO Exhibition 2024 in Friedrichshafen was selected as the starting point for this crucial initiative. During the event, Horváth and Droniq delivered presentations and hosted panel discussions with the participation of EASA members and various experts and stakeholders.

Additionally, numerous discussions were initiated with manufacturers of hardware and software for e-conspicuity, leading to deliberations on new developments. This included the availability of information on specification two of the ADS-L4SRD860 protocol, as well as hardware and software advancements integrating the ADS-L protocol. Apart from the trade fair event, there have also been advancements in the UAT and Mode N areas, as described in the following chapter.

6.2 Actual e-conspicuity progress

6.2.1 I-conspicuity developments

At AERO 2024, new hardware and software developments were presented, integrating the interoperability requirements described and developed during the project. This integration has led to an enhanced and more comprehensive traffic situation overview. These developments bring together various transmission paths, integrate the ADS-L protocol, simplify the installation and commissioning of an e-conspicuity system, and have the potential to alleviate frequency congestion. These advancements apply to both on-board transmitters and receivers, ground stations, and conspicuity devices for unmanned aircraft.

The showcased developments serve as evidence that the interoperability requirements and solution approaches identified in the workshops, technical meetings, and case studies are being actively implemented in the industry. The integration of ADS-L and the consolidation of various transmission paths demonstrate that the proposed solutions are on the right path and can be further strengthened. The consolidation document (Deliverable 4) provides detailed examples of hardware and software developments.

Developments in e-conspicuity have also taken place apart from the AERO trade fair.

One example is the SafeSky app, which has been previously introduced for the mobile transmission channel in workshops and technical meetings. One challenge associated with its usage is the reliability and consistent usability of the mobile phone connection at varying altitudes and higher speeds. ADAC Luftrettung has now opted for a trial phase to integrate the SafeSky app in rescue helicopters. To facilitate this, the navigation tablets will be modified, equipped with the app, and a mobile router approved for commercial aviation will be installed in the respective helicopters.

It is important to note that this solution may not be representative for General Aviation due to the high cost of the WI-FI router (over €50.000). However, the trial will yield valuable data regarding the feasibility of implementing such an e-conspicuity app in a professional environment.

Several initiatives are currently underway in the field of UAT transmission technology in Europe. This area was of secondary importance in the workshops and further discussions of the project due to the challenge of allocating the required transmission frequency in different parts of Europe, as these are also in military use for TACAN systems. In the USA, UAT transmission is extensively used in conjunction with ADS-B on 1090MHz, with numerous transmitters available for General Aviation. A significant advantage of this technology is its capability to transmit additional information alongside traffic and conspicuity data, such as weather, airspace, and airfield data. This data is transmitted in FIS-B format, which has now been integrated into the ADS-L protocol.

Several European countries, including the UK, Finland, Norway, and the Netherlands, are in the process of establishing a UAT network with ground-based transmitting and receiving stations. However, the independent actions of individual countries do not facilitate the widespread introduction of UAT technology across Europe.

In workshop two, the developments related to Mode N were presented. Mode N serves as a ground-based positioning system that has the potential to complement or even substitute GNSS systems. A significant advantage of this system is its robust protection against spoofing, attributed to the robust ground-based transmitters. This feature renders the system highly appealing for both military and civilian applications. The implementation of Mode N could facilitate to free up the frequencies used by DME and TACAN systems in Europe, thereby enabling the use of the 978MHz frequency for UAT. The project is presently receiving support from a team of experts at DFS, with an ongoing test phase. Additionally, the Mode N technology will have the capability to transmit small amounts of data. It is imperative to actively monitor this development to ensure that the opportunity to utilize the UAT frequency is not overlooked.

6.2.2 Issue 2 of ADS-L4SRD860

The development of Issue 1 of ADS-L4SRD860 was finalized at the end of 2022 and has been publicly released by EASA. This version pertains to the "surveillance" part, aligning with SERA.6005(c) compliance.

Issue 2 of the protocol specification has been submitted to EASA for review. This version largely completes the development of the protocol for the SRD860 transmission path. Publication is expected to take place in the next few months. Further protocol development will be pursued once a certain level of market acceptance and adaptation has been achieved.

Currently, no transmitters with ADS-L are operational in the SRD860 band, despite the availability of the first new devices with ADS-L and the ADS-L update for FLARM devices.

From a technical perspective, transmission in the O-band now incorporates a high data rate (HDR) channel. This enhancement enables the transmission of up to 10 individual aircraft positions in a single traffic report. Additionally, error correction and a security procedure have been integrated into the protocol, although the practical sufficiency of these integrations remains to be determined. The transmission of FIS-B services, analogous to UAT technology, has also been included, along with the transmission of Remote ID. The incorporation of Remote ID into the ADS-L protocol presents a significant improvement in the very short range of Remote ID.

6.2.3 Implementation issues

To support the i-conspicuity concept and the ADS-L protocol, EASA and Eurocontrol have established the following key points of agreement:
The main objectives are the reduction of mid-air collisions by enhancing the pilot's situational awareness to assist in avoidance of collision and/or mitigation of other airborne hazards. It is understood that there are several systems for e-conspicuity on the market, but the diversity of technological solutions has resulted in a lack of interoperability in terms of communication protocol (language) and means of communication (link). It is also understood that the solutions will not serve as collision avoidance systems, nor as surveillance tools in support of ATC. The chosen solution shall also serve as means making manned aviation conspicuous if flying in the U-Space airspace and not being under Air Traffic Control service. It is also very important to respect the different needs of the different user groups in General Aviation for the successful introduction of interoperable solutions.

In the view of EASA and Eurocontrol, the solution for pilot awareness should operate independently of ground networks. Therefore, a direct link is deemed necessary. However, the comprehensive functionality envisioned in the case studies (D3.1 and D3.2) and workshops can only be realized with network support. Utilizing solutions in the mobile sector is unfeasible without network connectivity. Consequently, there is a need to clarify the necessity and feasibility of a traffic network, as demonstrated in Workshop 2, and to initiate an assessment of the financial, logistical, and technical requirements.

Outside of U-space airspace, the adoption of e-conspicuity technology is voluntary, and its usage must not prompt investigations based solely on conspicuity. The enabling technologies identified include ADS-B 1090MHz, ADS-B UAT (978MHz), SRD 860, and Mobile Telecom (with restrictions for UAT frequency use). Contrary to the initial expectation of rapid U-Space development and expansion, the current assumption is that initially, there will only be isolated U-space airspaces in highly frequented airspaces, where the heightened air risk needs to be mitigated.

Another area for further research involves enhancing the Flight Information Service (FIS) and Search and Rescue capabilities without mandating modifications to current ATM/ANS principles or operational practices. These areas are shown in Deliverable 3.2 (additional case studies).

6.3 Action plan

The action plan presented in Deliverable 3.1 and Deliverable 4 outlined recommendations for EASA, encompassing general actions from workshops and surveys as well as those from analysing the different transmission paths. Key steps include establishing a clear communication on e-conspicuity's merits and limitations and incorporating user feedback into the solution structuring. This step already started very successfully at the AERO 2024 trade in Friedrichshafen. Communication with users and manufacturers was established, the topic of e-conspicuity was explained in detail in presentations and panel discussions and discussed publicly with various experts. Questions from users and spectators were addressed extensively. This communication should be continued through publications in the media, instructional videos, webinars and lectures in clubs and associations to achieve an understanding of the technology and its necessity among users.

Urgent tasks include the finalisation of ADS-L specifications for a fast manufacturer implementation and defining network infrastructure requirements. Initiating work on the ADS-L4Mobile specification is particularly crucial, as it has not yet commenced despite the publication of Issue 2 for ADS-L4SRD860. Additionally, proposed studies on mobile network usage and 1090MHz band load, along with efforts to encourage National Aviation Authorities (NAAs) to endorse e-conspicuity solutions and ensure pilot protection, are highlighted. Emphasis is also placed on human-machine interface optimisation, training, and financial considerations, including support programs for hardware upgrades, to achieve widespread acceptance.

The possibility of using UAT for conspicuity in U-Space was also addressed in SERA 6005c. Therefore, it is essential to provide more detailed proof of its availability, as the use of UAT could be highly beneficial in drone and General Aviation use cases. Some European countries have already established test environments or even larger test areas for UAT. However, the primary challenge for the widespread adoption of UAT in Europe lies in frequency availability, particularly concerning the frequencies 978MHz and 979MHz, as there are very few operational military TACAN systems still using these frequencies. Even though the estimated timescale for this enforcement is around 5 years in the best-case scenario, efforts should be made to free up the required frequencies. The UAT spectrum was initially planned in 2002 in connection with the development of the DO-282. As a result, only co-channel (978MHz) and adjacent-channel (979MHz) DME/TACAN stations need to be taken into consideration. The selectivity of the UAT receiver and the pulse interference performance ensure that all other DME/TACAN channels have no impact on the UAT performance.

In this context, it is essential to provide a clearer definition of the strategy for the desired solutions. Deliverable 3.1 examined the three primary transmission paths in case studies. To fully leverage the potential of the end devices, it is crucial to consider the combination of transmission paths. However, this necessitates a network with appropriate storage structures, especially for the connection of mobile radio and for transmitting information from the ground to the aircraft. These storage structures are also vital, particularly for the additional benefits of Search and Rescue (SAR), incident analysis, and training (see Deliverable 3.2). In some discussions with EASA however the direction was taken to initially enable air-to-air communication only. However, this would prevent decisive (purchasing) arguments (additional benefits through weather, airport, and airspace data, for example).

Furthermore, it is crucial to precisely define the additional benefits beyond traffic information and communicate them clearly to potential users. For instance, the allowance for the use of controlled airspace, typically reserved for Mode-S transponders, serves as a compelling argument to incentivize users to either install new hardware or upgrade existing hardware.

Moreover, it is imperative to initiate further research aimed at establishing the necessary networks for developing the required ground structures. Test scenarios should also be created at suitable airfields to assess the interaction of the technologies, the network, and the mobile network. These scenarios can also facilitate productive discussions with mobile phone providers based on measurement series.

EASA attracted attention at the AERO trade fair with its ADS-L coalition and i-conspicuity declaration. The ADS-L coalition is intended to persuade manufacturers to integrate the ADS-L protocol which is mostly successful (see AERO's influence). The i-conspicuity declaration is intended to ensure that an aviation participant cannot be penalised by the NAAs simply because it is conspicuous. This move has already been initiated by the FAA and should also be established in Europe.

6.4 Issues not resolved and remaining risks for implementation

Numerous areas in the development of solutions remain open, presenting unresolved challenges and risks. Unlike the second version of the ADS-L4SRD860 specification, the specification for ADS-L4Mobile has not yet commenced, nor has a consortium or team been designated to initiate its creation. It is imperative to expedite these efforts, as the mobile radio domain is integral to the overall system.

While most users understand the significance of interoperable e-conspicuity systems or can be easily educated about them, ADS-L is not a protocol that has been eagerly anticipated, as it arrives a few years too late. Many users have already committed to a specific e-conspicuity device, and the motivation to expand or switch to ADS-L must be cultivated through compelling benefits. Potential users need to be presented with additional information and advantages, such as the ability to utilize controlled airspaces outside of U-Spaces. Without this, there is a risk of failure due to lack of acceptance. The ADS-L protocol cannot simply serve as a substitute for existing solutions; it must provide tangible added value, and the usability of U-Space using the ADS-L protocol alone is insufficient. Manufacturers will only develop and release new devices and upgrades when there are clearly defined specifications and standards.

Regarding UAT, some organizations (such as IAOPA) and individual countries are establishing test scenarios and areas for UAT within Europe, viewing the UAT solution as more viable for i-conspicuity than integrating ADS-L. The widespread use of UAT in Europe is pending approval due to frequency assignments of (military) TACAN systems. There is a consensus that using UAT in Europe is technically feasible, as outlined in RTCA DO-282C. Both UAT and ADS-L are approved for conspicuity in U-Space, and since UAT is already in use, the simultaneous development of ADS-L and UAT creates confusion among potential users and complicates the widespread adoption of ADS-L. Countries like England (not an EASA member state) will favour UAT over ADS-L, despite a significant portion of the ADS-L transmission technology being developed by PilotAware, which is predominantly used in the United Kingdom. It would therefore be advisable to keep an open mind about UAT technology and investigate its feasibility in Europe in more detail.

The current plans to integrate ADS-L are limited to Europe. However, for widespread acceptance, it is crucial that a system used in Europe is also compatible for use outside of Europe. Since this study pertains to EASA member states, it is necessary to take an even smaller-scale approach here (example: United Kingdom). For instance, the FAA is called upon to collaborate with manufacturers, pilots, industry groups and other stakeholders to identify a low-cost voluntary solution for conspicuity, which could potentially be ADS-L. If ADS-L is introduced across Europe, it is important to ensure that its usability outside of Europe is also guaranteed.

To date, the research and strategies related to i-conspicuity have focused on integrating the necessary networks. An intelligent i-conspicuity network, encompassing users across all the relevant transmission channels (with additional channels, such as satellite connections, to be included in the future), necessitates a network structure capable of compiling, verifying, filtering, and transmitting information. Additionally, network information from sources like OGN and SafeSky networks must be incorporated. Ultimately, the costs and cost units can only be established once the required network structure has been clearly defined.

Another crucial aspect is the launch of funding programs to support the acquisition of new hardware and software, as well as upgrades for clubs and individual pilots. However, no specific initiatives have been introduced in this area yet. This also applies to the creation of corresponding traffic networks.

Additionally, an unresolved issue concerns the availability and usability of FLARM SRD frequencies within the next decade. The ITU (International Telecommunication Union) has published statements from the WRC (World Radiocommunication Conference) 2023 that indicate plans to use the neighbouring frequencies of FLARM by mobile radio. In such a case this could be a "blocking" in the receivers. However, this problem was recognised and solved by the (original) FLARM manufacturer years ago and the devices are robust against blocking. Other manufacturers may have to change their device architectures. The next WRC is scheduled for 2027, and even if the use of the aforementioned neighbouring frequencies by FLARM is decided at that time, the decision must still be ratified by the ETSI (European Telecommunications Standards Institute) and the Member States. This timeline extends beyond the 10-year limit. Nonetheless, it is imperative to clearly address the technical and legal aspects, considering that FLARM technology is a fundamental component of ADS-L.

7. Overall Conclusion

The risk of collision with non-commercial small aircraft is a key priority in the EASA Annual Safety Review and for the development of safety measures at EU level in the European Plan for Aviation Safety (EPAS). Given that the "see and avoid" principle has a detection rate of only 40 to 60 percent, the additional use of e-conspicuity devices is strongly recommended. Furthermore, the requirements for e-conspicuity of manned aircraft for unmanned space operations (SERA 6005 (c)) came into effect in 2023 and will impact the potential choices for General Aviation pilots regarding the installation of such devices. The existing diversity of deployed e-conspicuity devices leads to interoperability challenges, potentially resulting in aircraft being electronically visible or invisible to each other. The absence of harmonised technical standards for the performance of these devices, data transmission protocols and formats, and the usage of the radio frequency spectrum poses a significant barrier to their widespread adoption in Europe.

This study aimed to maximise the use of existing equipment, minimise costs, and promote widespread voluntary adoption. To achieve this, the primary technologies were initially identified and assessed based on network and future viability, cost, user acceptance, transmission characteristics, and development potential. A survey was conducted among General Aviation pilots to determine the most commonly used equipment, experiences with its usage, and the requirements of different pilot groups. In an initial workshop, all experts and participants were briefed on the project approach. Two expert workshops were conducted to select a target system combination from the existing devices in use and to identify interoperability needs and constraints. Technical meetings in the areas of mobile communications, transmission paths, and protocols were held to facilitate and support this identification process. Subsequently, three main case studies were developed to implement the interoperability requirements corresponding to the three main transmission paths: 1090 MHz, SRD860, and mobile telephony. An additional case study highlighted the benefits for other ground users and entities such as Search and Rescue (SAR), Flight Information Service (FIS), training and education organisations, and safety analysis. An action plan for implementation was then formulated based on these case studies and the insights gained from ongoing communication with manufacturers and developers throughout the project.

The primary findings from the General Aviation survey revealed a significant information gap across all user groups, with 22% of respondents indicating non-use of any e-conspicuity device. Consequently, the primary objective is to establish and sustain communication and education for pilots and user groups regarding e-conspicuity, its advantages, and limitations. This initiative has already commenced through various presentations and events, including the AERO 2024 trade show in Friedrichshafen, Germany. The foundation of i-conspicuity in General Aviation will involve the integration of non-certified (license-free systems without mandate) and certified systems, with the ADS-L protocol playing a key role in this process. This approach is also reflected in the definition of the target system combination involving ADS-B, ADS-L, FLARM, mobile, and ground-based applications. The intended interoperability will be facilitated through multilink transmission paths, a common language such as ADS-L, and traffic networks. To achieve this several technical, regulatory, and financial tasks still need to be completed.

The primary objectives outlined in the action plan include the comprehensive specification and implementation of the ADS-L protocol (in both the SRD860 frequency band and mobile radio), the precise definition of data and data quality for traffic situation data, the planning and testing of the necessary ground network, the establishment of clear benefits for pilots (such as airspace clearances and additional information via uplink), the promotion of a just culture and assurance of impunity for pilots who are electronically conspicuous, and the clarification of funding. The integration of ADS-L into new and existing devices has been increasingly emphasised, as evidenced by its presentation at the AERO 2024 trade show. Successful demonstrations of its integration into existing systems have been conducted, and the process of acquiring corresponding software upgrades has commenced. In the area of UAT various organisations and country-specific activities have taken place to introduce UAT for test purposes or on a broader scale. Despite being a secondary consideration in the project, the potential of UAT should be closely monitored, particularly since the use of the UAT frequency in Europe has not been definitively resolved.

The detailed results of the individual project steps are published on the EASA project website.

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