HORVÁTH

Deliverable D2: Report of interoperability levels and requirements

Interoperability of e-Conspicuity systems for GA

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Scope of this report

- Analysis of interoperability needs and constraints for deployed e-conspicuity systems and systems/technologies available in the near future
- Definition of interoperability levels associated to this needs considering the different options for data exchange (transmission, protocols, formats)
- Derivation of the necessary requirements for the interoperability levels and implementation
- Identification of main scenario for e-conspicuity
- Report is input for final deliverable and not supposed to be published

List of abbreviations

Abbreviation	Meaning
1090	1090 MHz
ACAS	Airborne collision avoidance system
ADS-B	Automatic dependent surveillance - broadcast
ADS-L	Automatic dependent surveillance - light
ANSP	Air navigation service provider
DMFV	Deutscher Modellflieger Verband
FIS	Flight information service
FLARM	Flight alarm
GNSS	Global navigation satellite system
GPS	Global positioning system
IFR	Instrument flight rules
IoT	Internet of things

Abbreviation	Meaning
MLAT	Multilateration
NAA	National aviation authority
NOTAM	Notice to air men
SERA	Standardised European rules of the air
SIL	Safety integrity level
SRD 860	Short range device 860 frequency band
TABS	Traffic Awareness Beacon System
TCAS	Traffic alert and collision avoidance system
UAT	Universal access transceiver
U-Space	European system to manage unmanned aerial systems
VFR	Visual flight rules

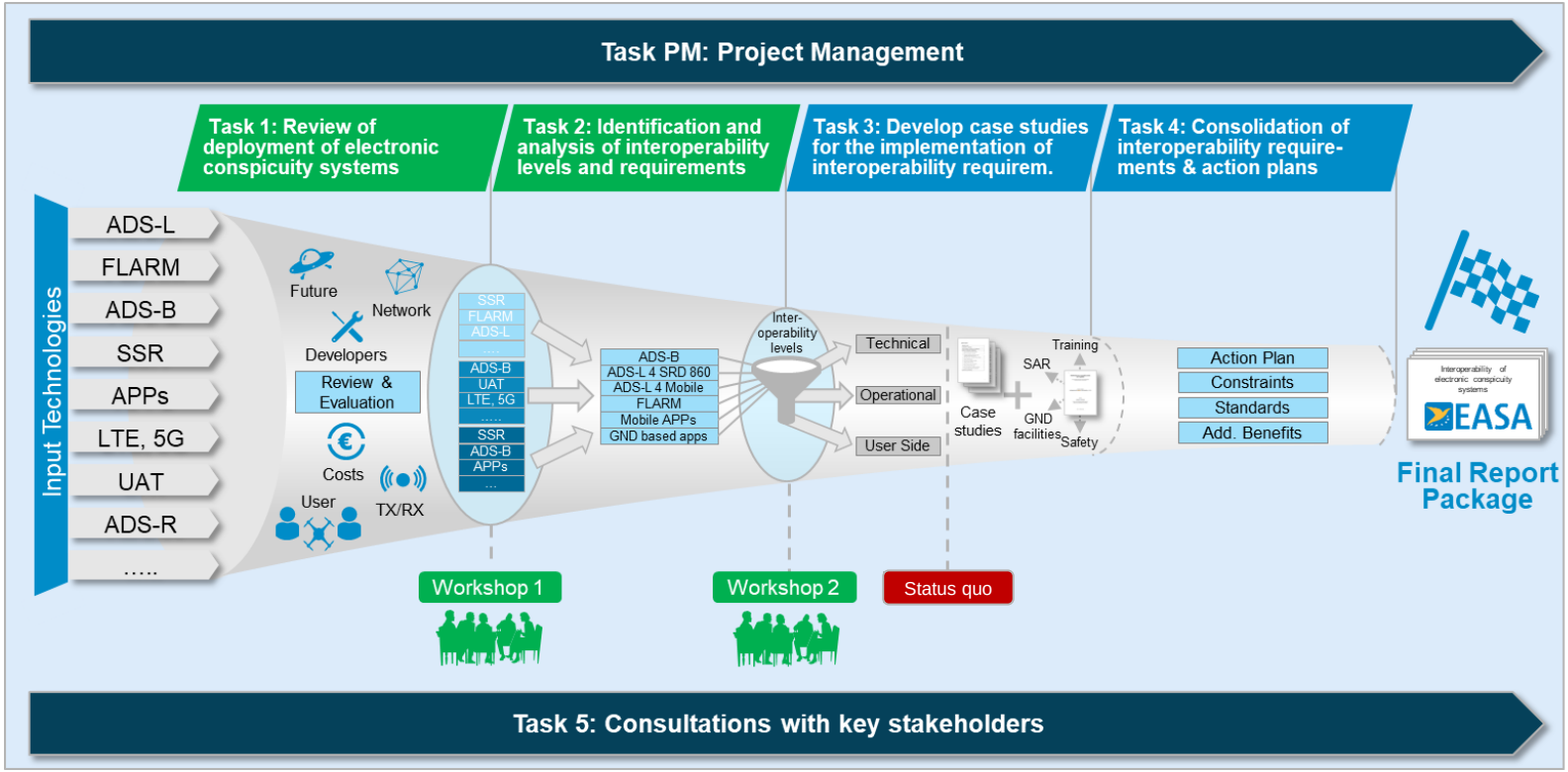
Definitions and Terms

e-Conspicuity: Technology to transmit the own vehicle position to be electronically conspicous to other airspace users (e.g. as mandated in SERA 6005c)

i-Conspicuity: Technology which extends the e-conspicuity with the transmission of additional information, for example weather, used radio frequencies, NOTAMs and airspace data
i-Conspicuity can be understood as „in-flight capability“

The scope of this project are the deployed e-conspicuity solutions. But in the near future the integration of more features, the linkage of different transmission ways and the enabling of relay function will lead this systems into the i-conspicuity environment.

Current project status:
Next Step is to develop the case studies



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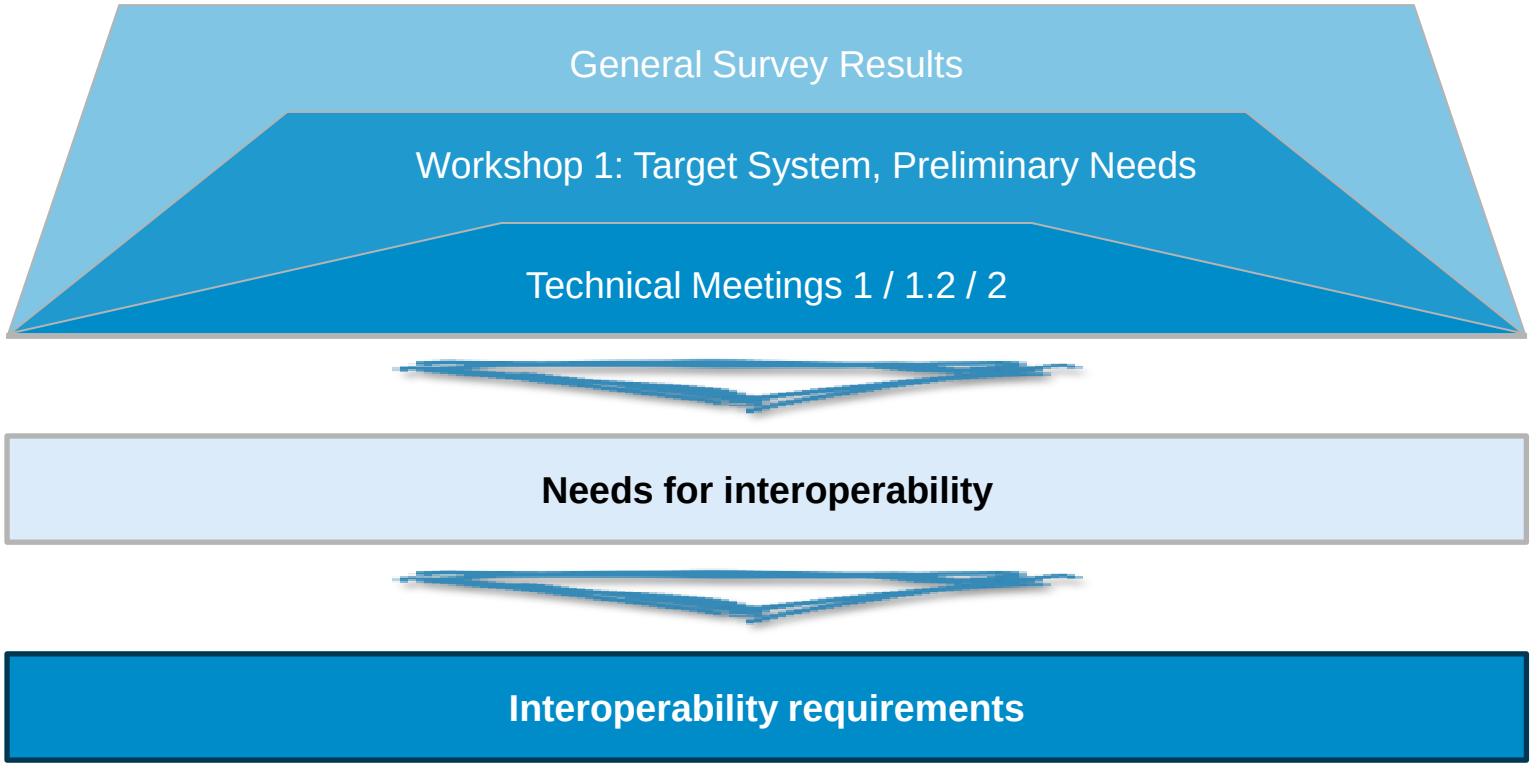
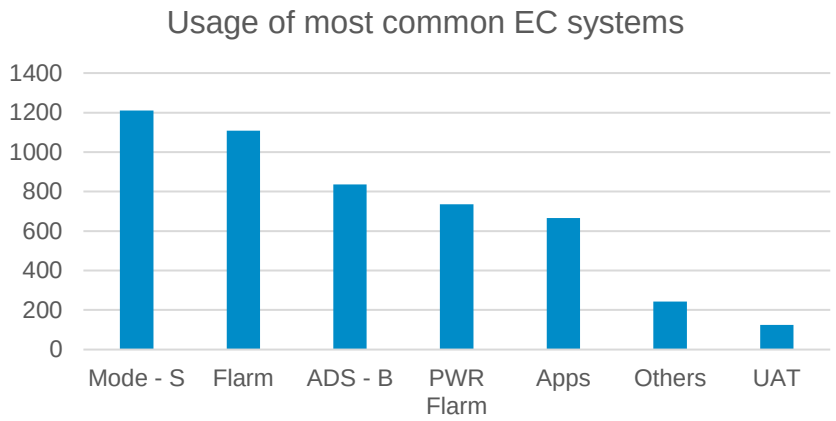
Procedure to derive needs and requirements



Survey Results – Deployed e-conspicuity systems

- April, 12th to May, 7th
- 2.133 Participants, 93% VFR (1.975), 7% IFR (158)
- 61% (1.300) answered in German, 39% (833) in English
- Most used aircrafts: Single Engine Piston, Glider, Motorglider, Ultralight
- 22% (463) do not use any e-conspicuity system



Survey Results – Identified Needs

- Inform the pilots, clubs, rentals comprehensively about e-conspicuity, as there were a lot of complains about the knowledge gap. In this manner also clearly state the risk of complacency and illusion of complete traffic pictures in certain user groups.
- Enable networking and merging of information from existing systems as this is evaluated as necessary by 94% of the participants
- Enable the air-to-air connection, as it is considered as the most important connection
- Connect the e-conspicuity systems to the ANSP in order to relieve the FIS service (and radio frequencies)
- If there is the possibility of additional information the participants would like to see real-time airspace and airport data, weather and NOTAMs
- The systems should not distract the pilot from his/her tasks.
- Displayed information must be filterable

Target system combination – Setup of systems to be enclosed

Target System Combination
ADS-B
ADS-L 4 SRD 860
ADS-L 4 Mobile
FLARM
Mobile APPs
GND based Apps

Systems to be monitored, but not in focus/scope
RADAR
Mode S
UAT
TCAS II
ACAS

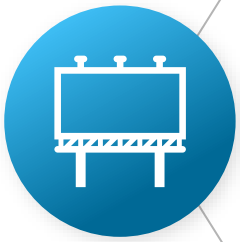
- The target system combination was determined in Workshop 1.
- Mode S will still be considered (as mandated at least 2008 for GA in certain airspaces)

Preliminary needs and constraints for interoperability determined in Workshop 1

- Enabling of Air-Air Connection and network between different systems
- Enabling of network capabilities (via ground systems; ground infrastructure, network and antennas…)
- Frequency usage and congestion
- Certified and non-certified components regarding interchange data (e.g. SIL)
- Solution for position discrepancy (GPS and Radar, MLAT…)
- Interface for different (incompatible) transmission protocols
- Usage and legality of using mobile services in the air, service status in different altitudes
- Enabling security and anonymization of transmissions
- Enabling of cross-border flying and usage of the EC-systems in Non-EU countries

Summary Technical Meeting 1
Aerial mobile network usage – Key takeaways

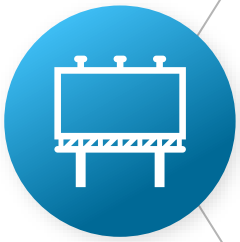
Participants: Thomas Neubauer (Dimetor), Mikael Timsater (Ericsson), Manuel Ruiz (Ericsson), Ralph Schepp (Droniq)



- **Actual available coverage** is up to 300 m altitude, correlated to ground coverage
- **Network connectivity:** between 300 m – 1000 m which is available in some areas, nevertheless the link quality is descending with rising altitude
- **Coverage:** in some countries like Sweden already a coverage up to 3000 m altitude is available due to uptilted antennas (Teracom, state owned company)
- **Requirements for coverage:** for a coverage up to 3000 m and more 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

Summary Technical Meeting 1.2
Aerial mobile network usage – Key takeaways

Participants: Thomas Pöggel (telecommunication expert)

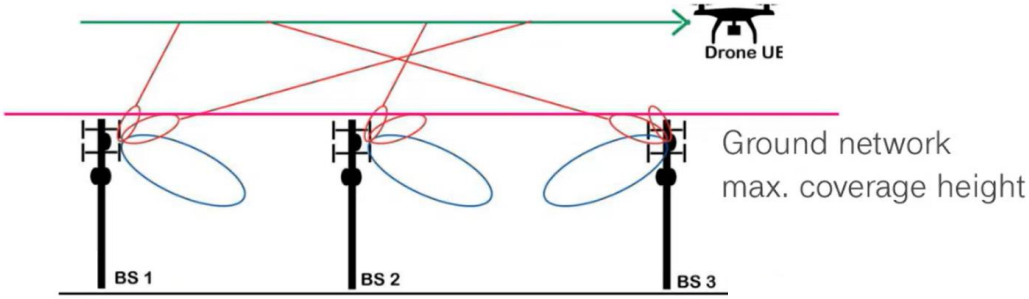


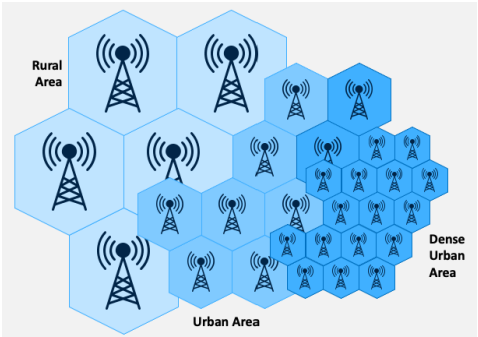
- **Best frequency** for aerial usage is below 1 GHz
- **Reception in aerial use** is varying because of the different frequencies
- **Why do we have coverage in the air?**
  - Through side lobes, interferences and reflections you also have some coverage in the air
  - Providers would like to eliminate this effect (>30-40 m altitude above the antenna is not intended for usage)
- **The lower the frequency** the higher the possibility of ground reflection
- **For aerial usage** a limitation to discrete frequencies is advantageous→ Bandlocking
- **Business Case view**: Influencing the ground network business case will not be accepted
- **Actual network** can be used to certain extend, but it has restrictions

Summary Technical Meeting 1.2
Aerial mobile network usage – Key takeaways

Participants: Thomas Pöggel (telecommunication expert)

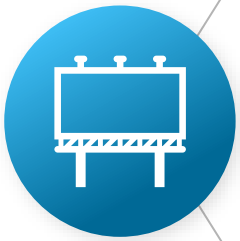
- Handovers between cells that are not network neighbors during a flight can pose a problem because the network is designed to hand over connections to its neighboring cells.
- To address this issue, there is a need to modify the current network service to handle handovers between cells that are not directly adjacent. However, this requires distinguishing between ground-based and aerial users, which the current network cannot do.
- Devices located above the antenna have a stronger signal than those on the ground.





Summary Technical Meeting 2:
Communication ways for e-conspicuity - Key takeaways

Participants: Junzi Sun (University Delft), Marc Förderer (Air Avionics), Urban Mäder (FLARM), Fynn Klaaßen (Droniq)



- Currently it is possible to transmit ADS-L, it's more difficult to build a receiver (SDR)
- No particular benefit (technically) on using ADS-L for collision avoidance
- The actual benefit is on entering U-Spaces
- Direct communication between ADS-L (SRD860) and ADS-B (1090 MHz) is not possible with current single linked systems. On semantic level there is also a difference between the protocols as ADS-L does not have all information of ADS-B.
- Affordable GPS devices can be installed on Mode-S with extended squitter and SIL0, will meet the requirements of SERA 6005C (U-Space)
- 75%-85% of Mode-S transponders can be equipped or adapted
- Every mobile device, which can be used at home and in the mobile network should also be usable for ADS-L 4 Mobile

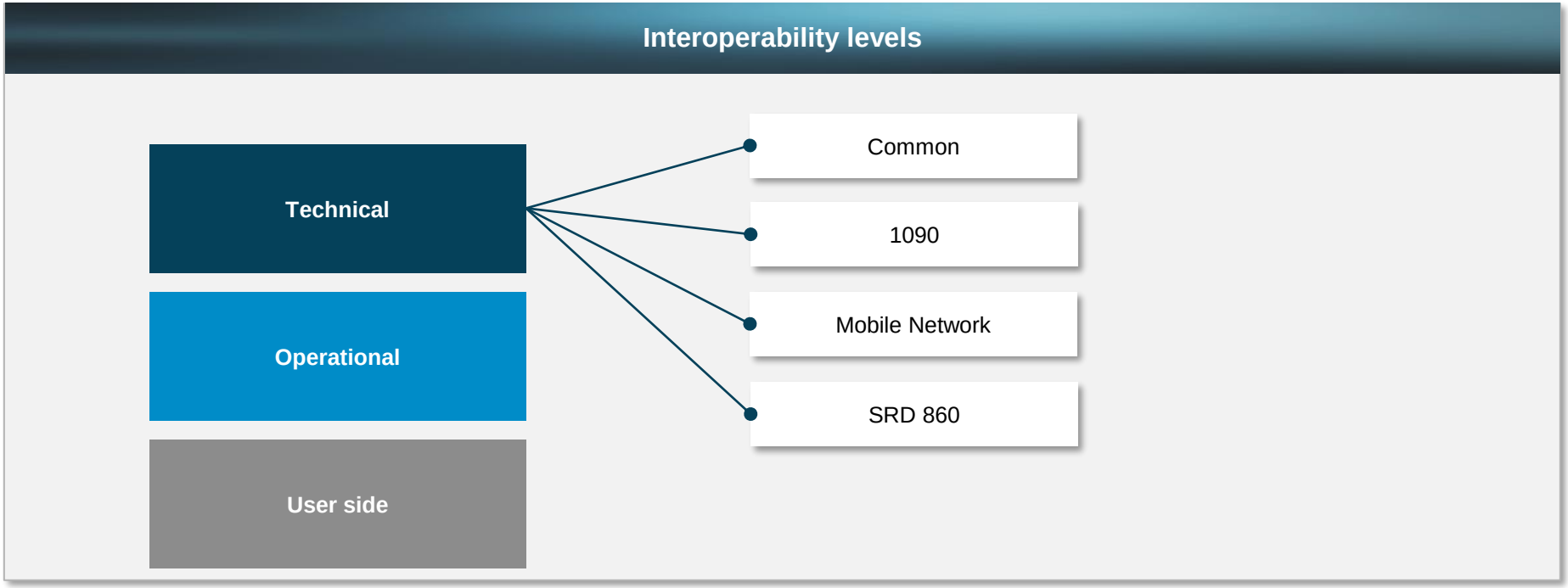
Approach for identification of interoperability levels and requirements

Needs for interoperability of the target system combination, identified with the General Survey, Technical Meetings 1, 1.2 and 2 and in Workshop 1

Derived interoperability levels (to be seen as “categories”)

Requirements derived from interoperability levels to achieve the solution (→ steps on roadmap)

Identified interoperability levels



Technical needs – Common (1/2)

- Use of current installed hardware
- Open protocols, no fees or charges
- Determine the limits of e-conspicuity (e.g. aerobatics, high climb/descend rates…)
- Minimize obscuration in all transmission ways
- Future proof (interfaces for future features and transmission ways, e.g. Sat-Com)

Technical needs – Common (2/2)

- Open up new capabilities to display threats and traffic (e.g. model flying)
- Transmission and display of active radio frequency for reception
- System redundancy
- Setup supporting ground network

Derived requirements from Technical Needs Common (1/2)

Requirements

Technical

- 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)

Operational

- Setup update/upgrade programs for existing hardware
- Mandate free updates
- Initiate an evaluation group for setting up ground network (interfaces, locations, costs…)

User Side

- Setup communication program about e-conspicuity, limits, techniques for all user groups

Derived requirements from Technical Needs Common (2/2)

Requirements

Technical

- Put ground-based apps (e.g. FlyDMFV) into operation with connection to traffic network
- Setup interfaces to certified equipment (e.g. ACAS)

Operational

- Permanently watch out and enable integration of uprising technologies (e.g. Mode N, UAT-Frequencies, Satellite usage…)

User Side

Technical Needs 1090 User

- Enable visibility and positioning of Mode-S Users for e-conspicuity
- Avoid (excessive) additional load on 1090, do not disturb TCAS/ACAS Systems
- Enable traffic information about SRD 860 and Mobile Network User

Derived requirements from Technical Needs 1090 User

Requirements

Technical

- 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)
- Setup service to collect and verify identifiers and deal with amount of identifiers

Operational

- 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
- Recheck TABS Usage
- Setup technical evaluation group to investigate the additional 1090-load
- Ensure clarity that it is a “situation awareness support”
- Analyse effect and effort to deal with non-certified transponders

User Side

- Supplement equipment to e-conspicuity functionality

Technical Needs - Mobile Network

- Stabilize the network availability and reliability in the air, optimize usage of the mobile network in the current stage of expansion
- Minimize interferences and disturbances of ground network
- Clarify the usable altitude and speed ranges
- Optimize the reception in aircraft and for utilization without airframes
- Check user and provider contracts for aerial usage with e-conspicuity

Derived requirements from Technical Needs Mobile Network (1/2)

Requirements

Technical

- Define recommendations and specifications for mobile devices in terms of e-conspicuity
- 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 Standardization for ADS-L4Mobile
- Define a minimum standard for the aerial usage

Operational

- Clarify responsibility for implementation of U-Space (not focus of this project)
- Ensure contracts with providers to foresee aerial use
- Define cost/budget for setting up network and operate it

User Side

- Stop background apps on mobile devices
- Analyse impact of additional App for pilot

Derived requirements from Technical Needs Mobile Network (2/2)

Requirements

Technical

- Define communication volume (bytes/sec) upstream/downstream (also for ADS-L uplink)
- Address cross-border traffic (roaming)
- Ensure availability of the network
- Scan existing IoT solutions
- Define minimum requirements towards apps
- Define technical infrastructure (e.g. owner of servers)

Operational

User Side

Technical Needs - SRD 860

- Implementation of ADS-L in SRD 860 equipment
- Enable direct communication (Air-Air) with ADS-L
- Use and upgrade of existing equipment for target system combination
- Optimized reception and enlarged range

Derived requirements from Technical Needs SRD 860

Requirements

Technical

- Finish ADS-L specification, 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

Operational

- Incorporate model flying, ground vehicles, starting and landing sites and airborne hazards

User Side

- Install and use external antennas
- Enable participants to use devices (training material)

Needs - Operational

- Enable connection to ANSP and the usage of e-conspicuity data also for airspace utilization (e.g. SIL Handling)
- Enforce “just culture” principles, no chasing of pilots by being conspicuous
- Avoid spoofing (of) signals
- Minimum standard of e-conspicuity data and transfer way
- Put Ground Based Apps (like FlyDMFV) into operation

Derived requirements from Operational Needs

Requirements

Technical

- Enable encryption
- Setup interface for e-conspicuity data for ANSP
- Authentication
- Flexibility of protocol to evolve is required
- Integration of model flying site (“geo zone”) → hazard areas

Operational

- Mandate data fusion and sharing
- Enable usage of e-conspicuity data by ANSP (Airspace and FIS)
- 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)

User Side

- Use Ground Based Apps iso paper-logs (e.g. model flying)
- Always switch on transponder / ADS-B (as prescribed)
- Inform about U-Space
- Integrate ADS-L in training (commit manufacturers to provide right training material)
- Ensure TCAS information is not interfered or made less important.

Needs - User side

- All user groups need clear information and backgrounds
- Affordable solutions with free updates and no yearly fees
- Support programs, hardware swapping programs
- A positive safety gain is indispensable (Human Machine Interfaces)
- Anonymization

Derived requirements from user needs

Requirements

Technical

- Enable anonymization in protocols
- Define recommendations for usage (HMI, warnings, utilization without airframes (e.g. Hang gliders…)
- Differentiate interfaces between “reliable” TCAS and other systems

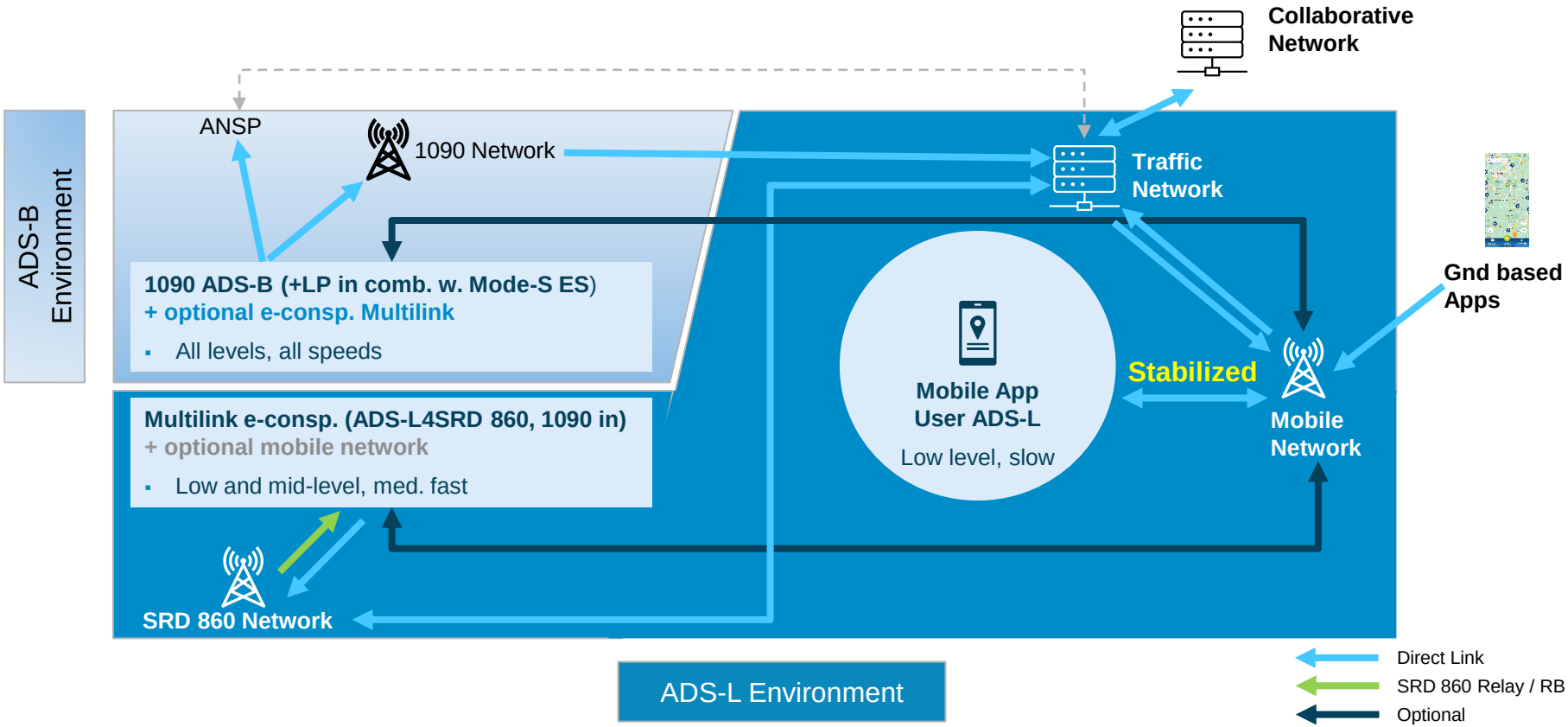
Operational

- Enable support programs (exchange of hardware, supported new devices)
- Setup training programs and material for users

User Side

- Inform about e-conspicuity and it´s limits
- Be open for changes, new features, installation changes (e.g. outside antennas…)
- Train system usage for interfaces/systems after installation
- Stay close to existing standards for indications (use of colours – avoid red)
- Transparency which mode is currently used
- Prioritization of information
- Be compatible with existing cockpit solutions e.g. audio
- Simple to use, simple to understand, enabling fast decisions → reduce complexity (e.g. “Connected” indication regardless of link)
- Make clear that see and avoid is still important

Identified main scenario



Summary and conclusion 1/4

- Interoperability needs and constraints for deployed e-conspicuity systems have been analysed by means of the results of the General Survey, Workshop 1 and several technical meetings
- As key technologies **ADS-B, ADS-L, FLARM, Mobile** and **Ground Based Apps** are designated
- The interoperability levels “Technical”, “Operational” and “User Side” were identified
- The associated needs have been collected and in discussion with participants of Workshop 2 the corresponding requirements for interoperability and implementation were determined
- The main scenario was set in dependence of these inputs. This scenario will require the usage of **multilink devices** (different transmission ways), as single solutions will not lead to a noticeable improvement
- In this scenario the introduction of **ADS-L as open protocol** and without charges will have a key role
- To achieve the relay functionality (air-gnd-air) a **supporting ground network must be set up. The air-air relay function** with ADS-L should be setup for **O-Band frequencies.**

Summary and conclusion 2/4

- One major common requirement is the spread of **simplified**, but **comprehensive information** for all user groups about e-conspicuity including goal (See and Avoid - support), limits and requirements
- **Support programs** for new/exchange hardware must be **initiated** and maximize the use of existing installations (devices and equipment, e.g. audio). Upgrades of single solutions to multilink devices should be encouraged
- For the technical interoperability level, a division into four parts **(common, 1090 (MHz), SRD 860 and Mobile)** was made
- In all transmission ways obscuration must be minimized with **external antennas** and **external devices** (as far as practical for user)
- Suppliers should be encouraged to develop multilink devices and **hardware upgrades** for existing hardware, also including the ADS-L protocol
- Therefore, the specification of the **ADS-L protocol** has to be finished for **SRD 860** and **mobile usage**. The protocol must be kept flexible for evolving and payload

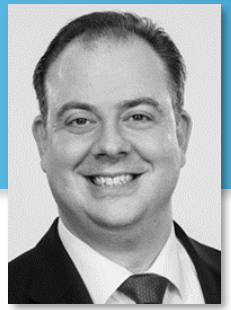
Summary and conclusion 3/4

- All existing Mode-S transponders should be upgraded to **ADS-B** out with certified or non-certified GNSS sources. The additional load to the 1090 MHz frequency band is negligible
- The use of low power ADS-B out devices in addition to existing Mode-S transponders, which cannot be modified, should be considered (e.g. by exemption permits). In this context the usage of **TABS** and **TABS-modes** should be investigated
- The meaningful usage of **mobile network** in the current stage is **limited** to low and slow users, but it can act as complementary transmission way for all users under certain conditions (multilink)
- To **stabilize** the transmission quality, external antennas and devices (e.g. 5G/4G router) should be used. The frequency range may be limited by **bandlocking feature**. This feature will reduce the impact to the ground network, but more extensive testing and a Pan-European coordination with the providers is required. The satellite-based transmission way has to be observed for further usage, as it will also reduce the influence on the ground network.
- Transmitted **data volume must be kept as small as possible** (e.g. no further apps running)
- Further development of the **aerial mobile usage** must be based on clear specifications of transferred data and necessary quality, agreement with **mobile providers** and definition of technical infrastructure (e.g. owner of servers)

Summary and conclusion 4/4

- **Model flying** (on model airfields or outside), **hang gliding starting** and **landing sites**, **parachute areas** and similar hazards must be **integrated** in the traffic network (e.g. by FlyDMFV App) to allow strategic avoidance
- The **safety gain** must be kept **positive**, therefore **training** and information material must be provided and disturbance of the users from flying tasks must be avoided (e.g. optimize human machine interface, stay close to existing standards)
- **Authentication, anonymization** and **encryption** must be integrated in the devices and protocols
- **ANSPs** should **use** the **e-conspicuity data** for releasing FIS service and frequencies, the interfaces for this have to be defined
- **Punishment** of pilots **must not happen** due to making small individual mistakes and being conspicuous (just culture). The NAAs must be encouraged to set an acceptance declaration
- Users must keep their devices autonomously **up to date**

Contacts



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