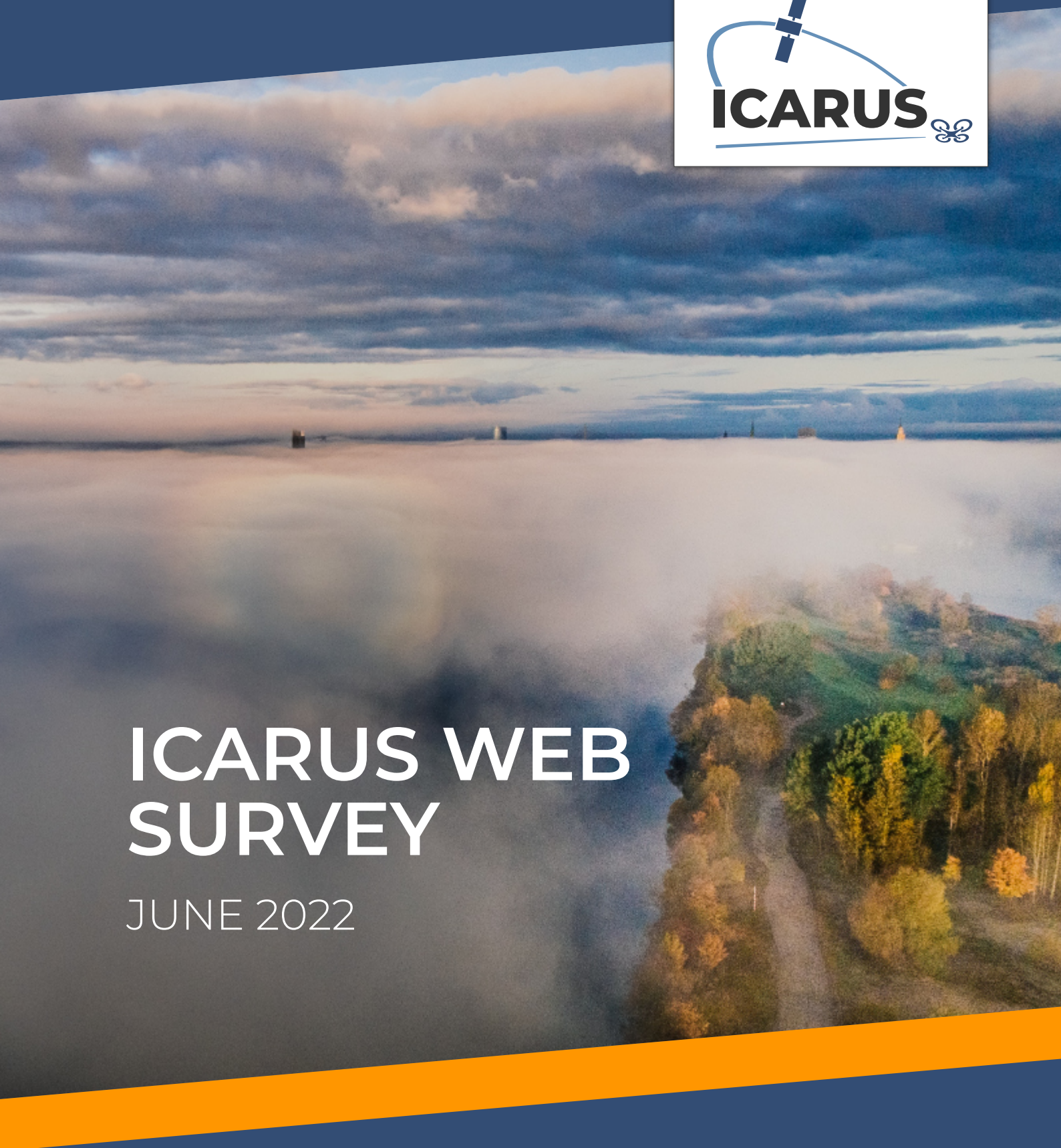
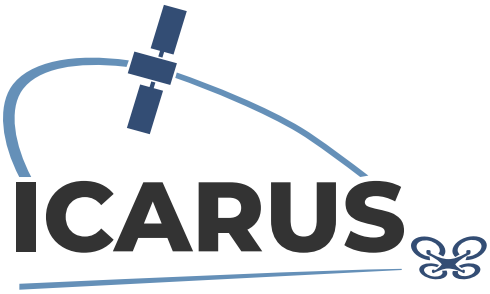
INTEGRATED COMMON ALTITUDE REFERENCE SYSTEM FOR U-SPACE



ICARUS WEB SURVEY

JUNE 2022



INTEGRATED COMMON ALTITUDE REFERENCE SYSTEM FOR U-SPACE

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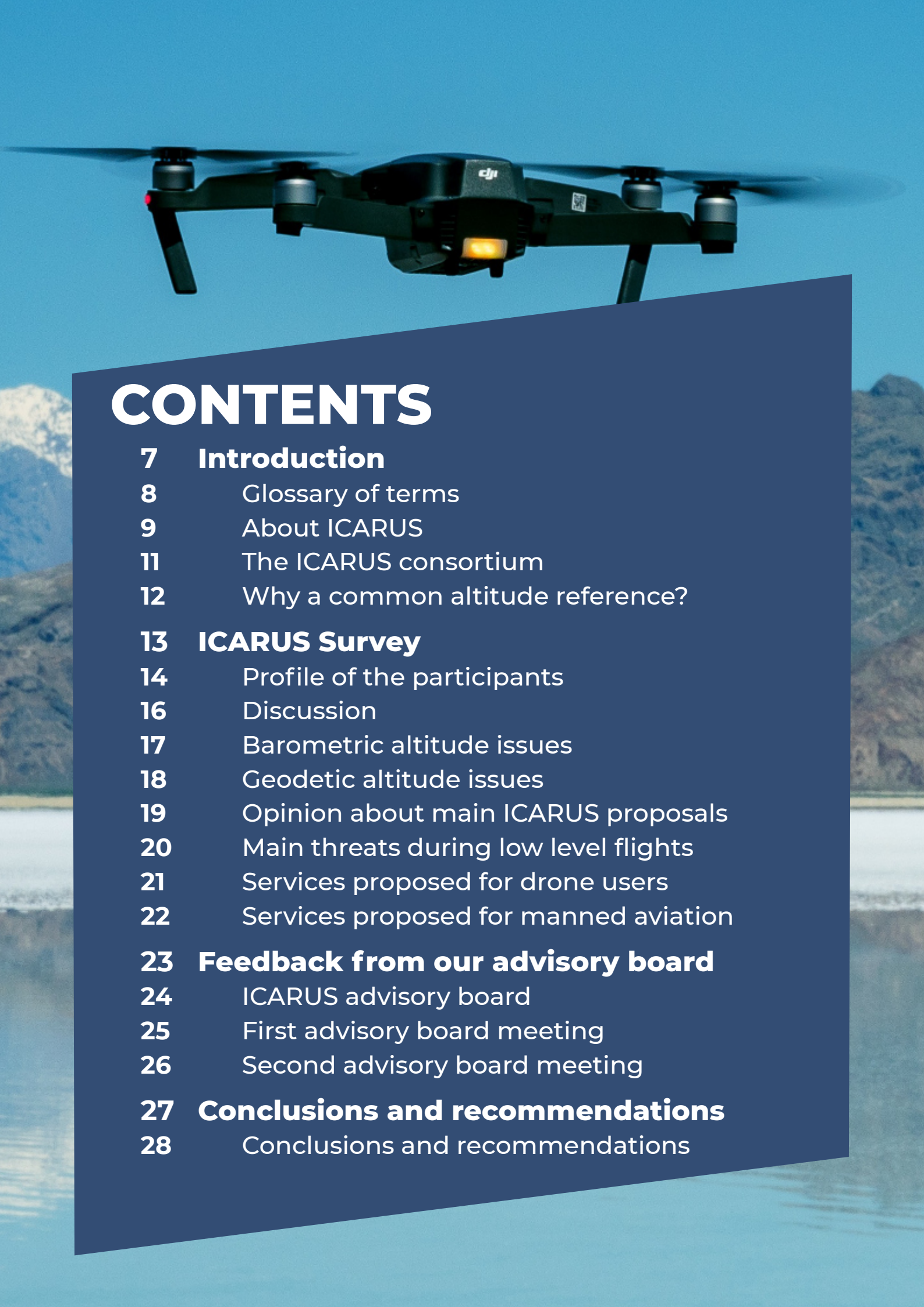
Issue 2.0

This project has received funding from the SESAR Joint Undertaking under the European Union 2020 research and innovation programme under grant agreement No 894593



CONTENTS

ICARUS

INTEGRATED COMMON ALTITUDE REFERENCE SYSTEM FOR U-SPACE

In manned aviation, an aircraft's altitude is determined using various pressure altitude difference measurements. However, since small drones can take off and land almost anywhere, some of these settings aren't as significant in unmanned aircraft flights.

New methods and procedures are therefore needed for large numbers of drones. The EU-funded ICARUS project aims to introduce an innovative solution for common altitude reference inside very low-level airspace. To this end, it will define new U-space services and validate them in real operational environments.

With this approach, the Vertical Conversion Service (VCS) will be embedded in an application programme interface that can be queried by a remote pilot or drone based on the actual positioning of the unmanned aircraft.

To understand the perceived needs of the future users of ICARUS, drone operators and pilots, manned aviation pilots, authorities and other stakeholders, the ICARUS Consortium organised a public web survey on the project website during October and November 2020. The web survey was publicised through social accounts, associations, internet portals and contacts of the beneficiaries and members of the Advisory Board.

The output of the web survey has been used in the Reference Scenario identification task, which is used for the ICARUS Concept Definition.

The present document has been created to share the results of the survey for the benefit of the European aviation community.

To get more information about the project ICARUS, please contact us at:

www.u-spaceicarus.eu
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Follow us:

INTRODUCTION

GLOSSARY OF TERMS

Term	Acronym	Definition
Above ground level	AGL	Altitude (of an aircraft) measured above the terrain.
Beyond visual line of sight (operation)	BVLOS	An operation in which the remote pilot does not maintain direct unaided visual contact with the UAS at all times.
Electronic terrain and obstacle data	eTOD	The digital representation of terrain and obstacles provided as datasets satisfying the requirements of a series of airborne and ground applications.
Flight Level	FL	A surface of constant atmospheric pressure, which is related to a specific pressure datum, 1013.2 hectopascals (hPa), and is separated from other such surfaces by specific pressure intervals.
General Aviation	GA	All civil aviation operations other than scheduled air services and non-scheduled air transport operations for remuneration or hire.
Global navigation satellite system	GNSS	The generic term for satellite navigation systems that provide autonomous geospatial positioning with global coverage using GPS, Galileo and other satellite constellations.
International Civil Aviation Organisation	ICAO	The United Nations Agency responsible for international cooperation in air transport.
Private pilot license	PPL	An aviation license enabling non-commercial flights.
QFE altimeter pressure setting	QFE	The pressure set on the subscale of the altimeter so that the instrument indicates its height above the reference elevation being used (e.g. aerodrome elevation).
QNE altimeter pressure setting	QNE	The pressure altitude measured with reference to 1013.2 hectopascals (hPa) datum.
QNH altimeter pressure setting	QNH	The pressure set on the subscale of the altimeter so that the instrument indicates its height above sea level.
	RGIS	Real-time Geographical Information Service
Unmanned Traffic Management	UTM	A number of functions, services and facilities involved in the management of UAS traffic in a defined airspace.
Small and medium-sized enterprises	SME	Businesses that are smaller in terms of headcount, annual turnover or total balance sheet than an established threshold.
	VALS	Vertical Alert Service
	VCS	Vertical Conversion Service
Very low level	VLL	The airspace below 500 feet (400 feet in some countries) above ground level (AGL).
Visual line of sight (operation)	VLOS	An operation in which the remote pilot maintains direct unaided visual contact with the UAS at all times.

ABOUT ICARUS

Problem statement

Currently there is **no common altitude reference** in manned vs unmanned aviation, or between different drone manufacturers. Traditional methods to determine altitude, and ensure vertical separation, are **based on pressure altitude** while drones and manned aircraft already **use satellite measurements** (GNSS) for navigation purposes.

What is ICARUS

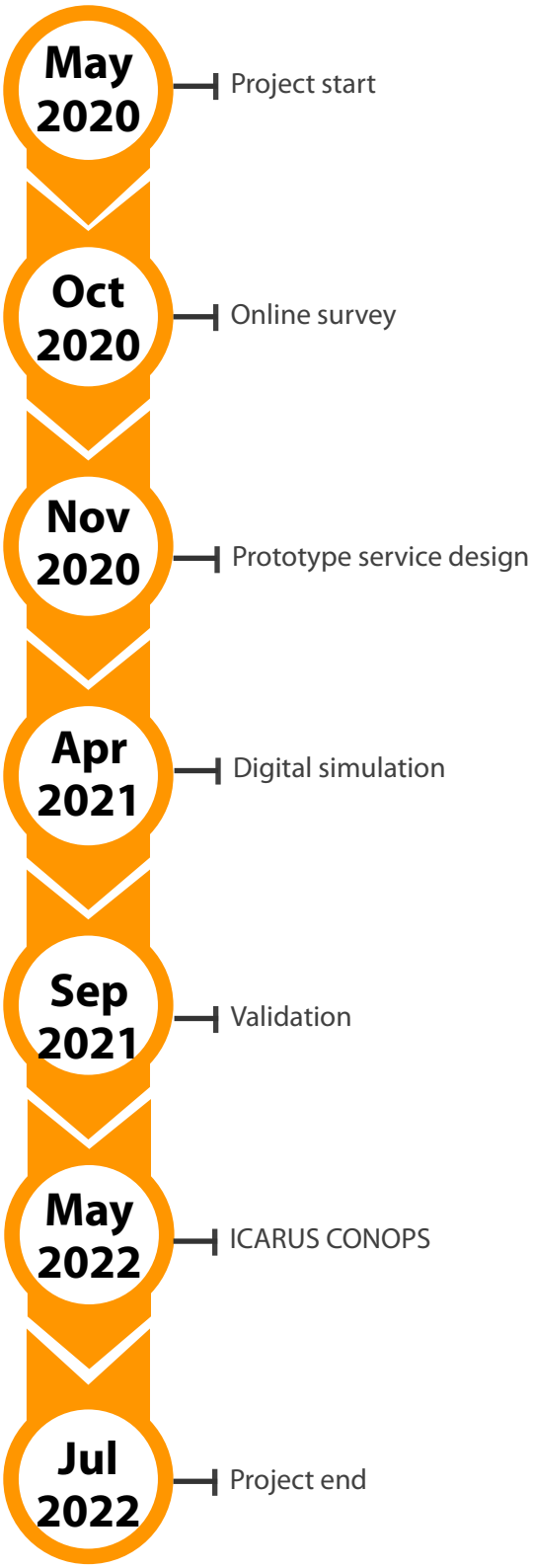
ICARUS are innovative **U-space services** providing its users accurate **height estimation** and **altitude translation** (geometric to/from barometric) for UAS and General Aviation during both the strategic and tactical phases of the flight. Pilots may use the ICARUS service to obtain the terrain profile and known ground obstacles, keeping a common altitude reference as well as augmenting the"level of confidence" on the vertical position.

ICARUS benefits

The U-space service that ICARUS will develop and validate can be **used by drone and manned aviation** to obtain their current altitude, using a Common Altitude Reference, as well as distance from the ground or known obstacles.

This innovative service will increase the **safety of operations**, boosting long distance (BVLOS) operations, increasing the **capacity of congested low level airspace** and further the **integration of drones** with traditional manned aviation.

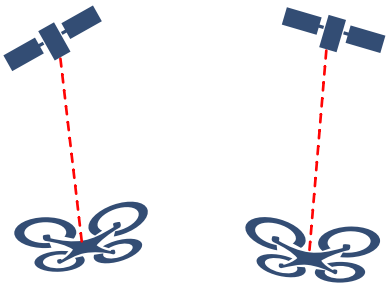
Project timeline



ICARUS addresses the Application area 2: Common altitude reference of the SESAR 2020 Exploratory Research 4 (ER4) call (H2020-SESAR-2019-2)

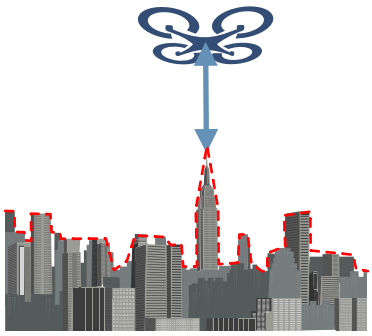
Technical objectives

1



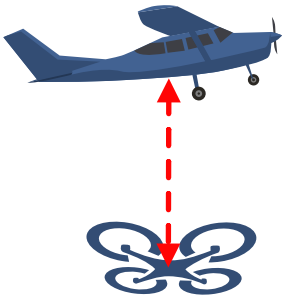
UAS Common altitude reference

2

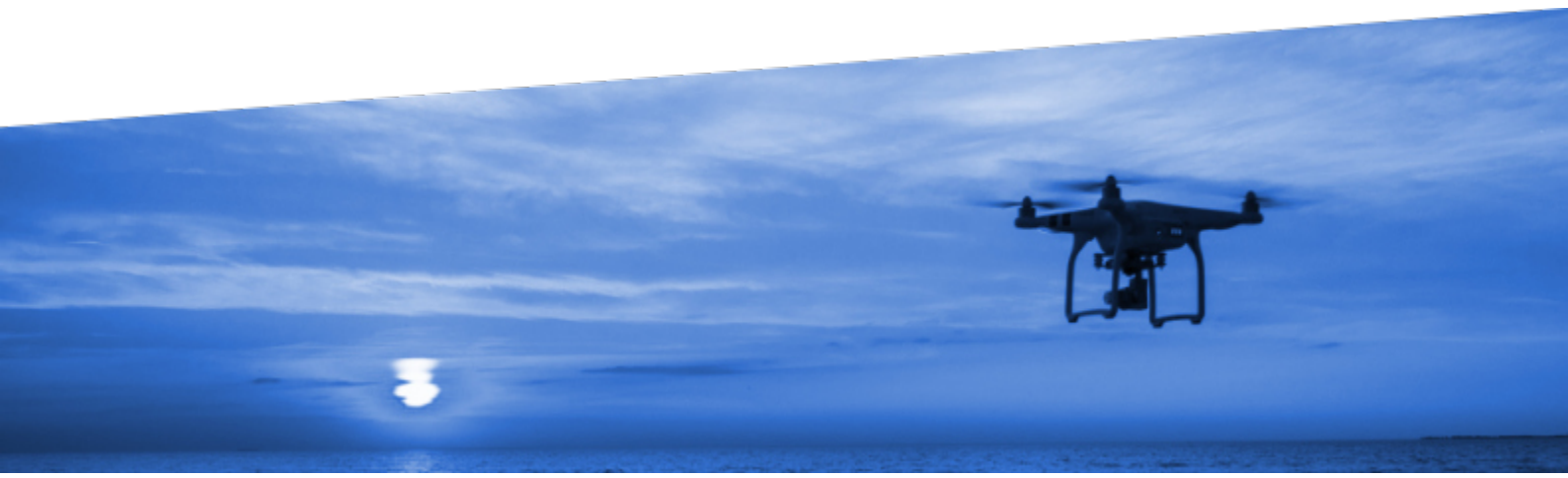


Ground obstacle awareness

3



Barometric to geodetic translation



THE ICARUS CONSORTIUM

e-Geos

e-GEOS is a leading international player in the Earth Observation and Geo-Spatial Information business. offering a unique portfolio of application services and has acquired leading position within the European Copernicus Program

DiCEA – Sapienza

DICEA, the Department of Civil, Constructional and Environmental Engineering at Sapienza, ensures scientific excellence and quality education in all branches of civil and environmental engineering, architectural design and urban planning

Droneradar

Founded in 2015 by the co-creator of PansaUTM. Developer of Droneradar mobile application, used in Poland by more than 500 000 users. Co-author and co-developer of Data Driven SORA platform. Droneradar is involved in many European VLD and R&D projects.

Eurocontrol

Eurocontrol is a pan-European, civil-military organisation dedicated to supporting European aviation

EuroUSC España

EuroUSC España is an aviation safety consulting company, specialized in Unmanned Aerial Systems (UAS) and Remotely Piloted Aircraft Systems (RPAS). Our services cover the entire workflow of a successful UAS operation

EuroUSC Italia

A consultancy company covering all domains relevant for the civil UAS industry and drones flying under GAT rules. A leading expert in standardisation, regulation, safety assessment and Education on RPAS safety and security

Politecnico di Milano

An Italian technical university, offering courses in engineering, architecture and design. The Department of Civil and Environmental Engineering (DICA) covers many disciplines, also including Geodesy and Geomatics

Telespazio

One of Europe's leaders and world's main players in satellite solutions and services providing also new innovative business solutions for remotely piloted aircraft and supporting the design of the new U-Space platform. Telespazio has its HQ in Rome, Italy, includes e-GEOS, operates worldwide through a wide network of space centres and teleports.

TopView

An Italian Engineering SME offering drones and IoT based systems tailored for industry and service providers to enhance their processes. TopView has joined several U-space projects as partner and advisory board member

WHY A COMMON ALTITUDE REFERENCE?

Traditional aviation

Traditionally in manned aviation, the acknowledged method of determining the altitude of an aircraft was based on pressure altitude difference measurements referred with respect to to a common datum and using the ICAO standard atmosphere (ISA).

The barometric altitude references **do not provide true heights**, just approximations of height based on the fact that atmospheric pressure decreases with altitude (albeit in a somewhat irregular way).

Within this model, different references are used to define different common altitude references that are used at various stages of the flight, based on the type of flight (visual or instrumental) and the airspace being flown.

Thus, we have three main references, For low level flights there are **QNH** (altitude above sea level) and **QFE** (altitude above airfield elevation) and for high level flights, **QNE** (altitude based on an ideal standard pressure). This complex model has been used since 1928, so it has become an acquired behaviour for manned pilots all around the world.

Even though barometric altimeters do not provide real heights, as long as this system is **followed by all pilots in a consistent way** (i.e. using properly calibrated barometers and selecting the appropriate barometric setting at each point) it provides a common reference to ensure adequate vertical separation. In other words, two different pilots flying near each other will both receive inaccurate height readings, but at least they will use the same wrong values. On the other hand, barometric altitude is not really adequate to ensure vertical separation with obstacles on the ground.

Unmanned aviation

Unmanned Aviation superimposes new challenges. Since a small drone may take off and land almost from everywhere the concept of QFE is not relevant. Also, UAS fly usually between (or even below) certain obstacles on the ground. Finally, Urban Air Mobility (UAM) scenarios have the potential to involve flight densities that are unknown to manned aviation.

For these reasons, a new Common Altitude Reference paradigm such as the one promoted by ICARUS for unnamed aviation is required.

ICARUS SURVEY

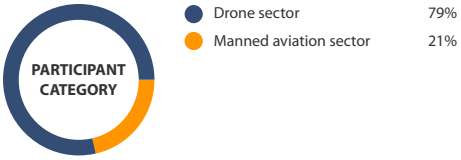
PROFILE OF THE PARTICIPANTS

To understand the perceived needs of the future users of ICARUS including drone operators and pilots, manned aviation pilots, authorities and other stakeholders, the ICARUS Consortium organised a public web survey on the project website during October and November 2020.

The web survey was publicised through social accounts, associations, internet portals and contacts of the beneficiaries and members of the Advisory Board.

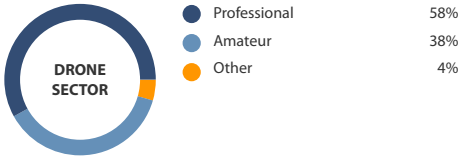
The web survey was conducted in an absolutely anonymous way. The only personal information that was recorded was a broad categorisation of the person participating in the survey.

Of the 173 participants, 136 (79%) were from the drone sector and 37 (21%) from the aviation sector.

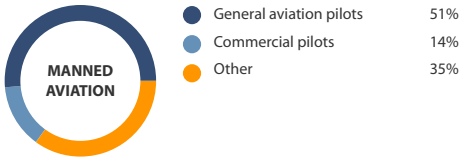


Based on their initial answer the participants were presented a slightly different version of the questionnaire.

Inside the drone sector group almost 60% of the participants described themselves as professional operators or pilots.



In what respects to the manned aviation sector group, around half of the participants identified as General Aviation pilots (almost all of them as holders of a PPL license). For that reason, the answers received from the manned aviation sector might not be completely representative of the sector as a whole, but in any case indicate that manned aviation is not particularly concerned at this time with the issue of a new Common Altitude Reference.



The low response from the traditional aviation sector might be an indication of the perceived low priority of this issue for this sector

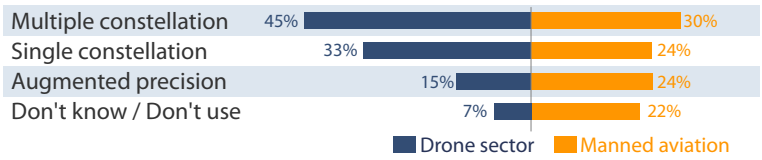
Use of satellite positioning technologies

Participants were asked about their use of GNSS devices for navigation and localisation.

Almost all participants from the drone sector (93%) and a great majority of the participants from manned aviation (78%) use GNSS.

It should be noted also that GNSS devices in manned aviation are more advanced that those used by the drone sector.

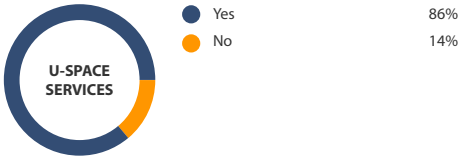
SATELLITE POSITIONING TECHNOLOGIES



GNSS devices are ubiquitous in both manned and unmanned aviation

Use of U-space services

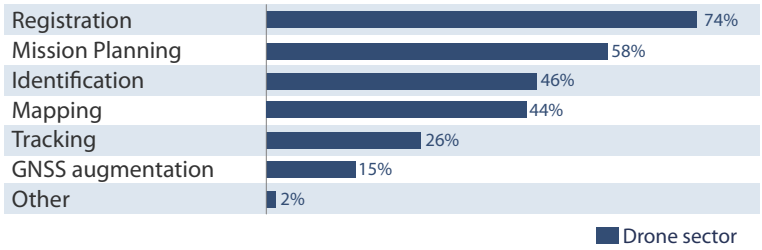
Almost all the participants (86%) from the drone sector have already used at least one U-space service.



The most used service is Registration (74%), followed by Mission Planning (58%), Identification (46%) and Mapping (44%).

It is also relevant that, in average, each user has used 2.3 services.

U-SPACE SERVICES



Both professional and amateur drone pilots and operators are already using several U-space services

DISCUSSION

In addition to responding to the closed-ended questions provided in the questionnaire, participants were encouraged to supplement them with additional comments.

These comments have provided important insights about the reaction of the aviation community towards the ICARUS proposals.

We have selected the most significant comments provided by the participants in the survey, both positive and negative, because we believe that an issue of the importance of the Common Altitude Reference warrants an open discussion that includes both the arguments in favour as the arguments against our proposed solution.

To ensure transparency, these comments have not been edited in any way. Only clear typos have been corrected.

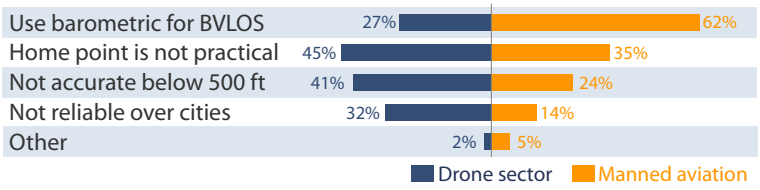
This is a comment in favour.

This is a comment against.

BAROMETRIC ALTITUDE ISSUES

Participants were asked to select the most important issues regarding the use of barometric altitude.

ISSUES RELATED TO BAROMETRIC ALTITUDE



For drone users, the most important problem is the use of the take-off location (Home point) is not practical for many flight scenarios (45% of participants), followed by the inaccuracy of barometric altitudes in VLL airspace (41%) and the lack of reliability of barometric altitude in low level flights over cities (32%).

For manned aviation users, a clear majority (62%) indicated that drone pilots should use barometric altitude for VLOS flights.

The problems of barometric accuracy in low level flights were given much less importance by manned aviation pilots, maybe because they are less affected by them.

Considering barometric pressures can vary, I think reliance on barometric pressures for height above ground, and/or sea, level is "*guesstimation*".

The use of satellites to establish height above ground level, has to be more accurate in all cases: VLOS, EVLOS and BVLOS.

Drones should use QNH for every operation.

Drone operators are usually not aware of regional QNH.

Certification of new equipment to be installed in the aircraft will be very costly due to safety requirements, it will be much cheaper solution in the big picture to adjust drone technology to current manned aviation standards.

General Aviation has very good experience flying on QNH. Pilot Apps on tablets and fixed installed GPS-units in the cockpit already provide the actual height over terrain in almost all GA-cockpits.

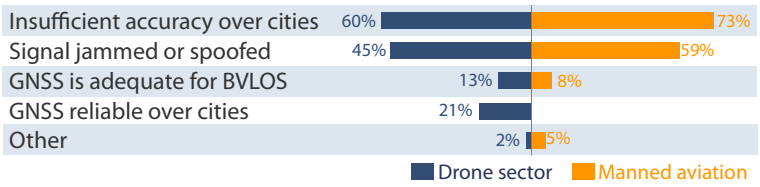
Barometric altimetry needs correct altimeter setting to be meaningful.

GEODETIC ALTITUDE ISSUES

Similarly, users were asked about the main issues affecting the use of geodetic altitude methods. In this case there were less dispersion in the answers between manned and unmanned users.

For both of them, the most important issue is the insufficient accuracy of geodetic altitude measurements over cities, followed by the threat of GNSS signals being jammed or spoofed although the answers were more negative for manned aviation users than for unmanned aviation users.

ISSUES RELATED TO GEODETIC ALTITUDE



5G positioning, odometry and new GNSS capabilities will provide precision altitude sources in cities.

We still need to know if GNSS is reliable during flight (mainly in BVLOS)

Standard GNSS is useless at determining altitude for any aircraft

Satellite based navigation is prone to system malfunctions. Pressure altitude measurements is completely independent

GNSS positioning precision varies with changing conditions (weather, obstructions, radio noise)

Manned aviation underestimate the problems of barometric altitude and overestimate those of geodetic altitude

OPINION ABOUT MAIN ICARUS PROPOSALS

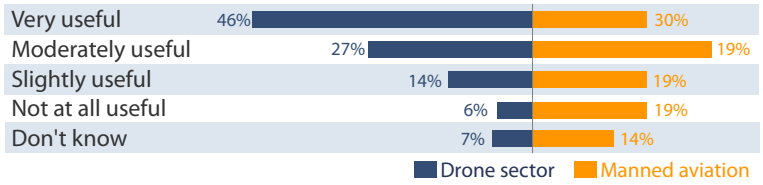
Altitude Translation Service

Participants were asked to rate the usefulness of the proposed ICARUS Altitude Translation Service.

The response from drone users was substantially positive with 73% of them considering it very useful or moderately useful and only 6% considering it not useful at all.

Manned aviation users were less in favour. Only half of them consider it very or moderately useful and 19% not useful at all.

ALTITUDE TRANSLATION SERVICE

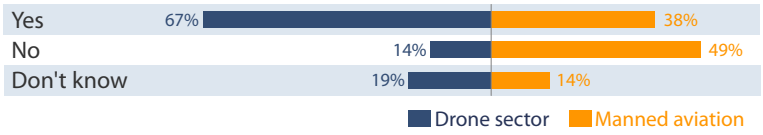


Geodetic Altitude Mandatory Zone

Participants were also asked about the proposed establishment of Geodetic Altitude Mandatory Zones.

As in the previous case, drone users were much more in favour (67%) than manned aviation users (38%).

GEODETIC ALTITUDE MANDATORY ZONE

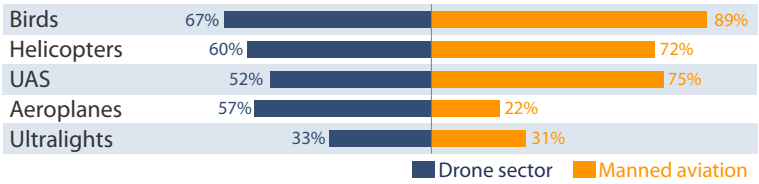


Why should GA suffer from additional limitations (GAMZ) just because drone industry is not willing to restrict their operations?

Even considering the very limited information provided by the questionnaire, the drone sector welcomes the planned results of the ICARUS project while manned aviation will require much more convincing.

MAIN THREATS DURING LOW LEVEL FLIGHTS

FLYING THREATS

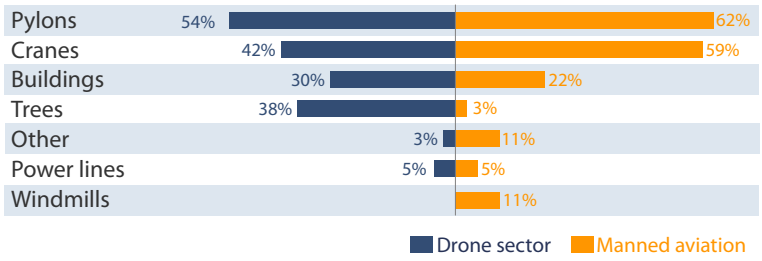


To understand the real threats involved in low level flights, the survey asked about the most important categories of threats experienced personally by the users both in relation with ground obstacles and unexpected conflicting traffic.

As can be seen on the two resulting diagrams summarising the responses, these categories are very similar for both groups.

The only significant difference is that drone users are more affected by trees on the ground –probably because they fly usually at a lower height than manned aviation pilots.

GROUND OBSTACLES



The most important is the way those new obstacles are reported. Simply giving coordinates in NOTAMs is not enough.

Other users without comm devices on board

We would like to see ALL traffic around us electronically.

Threats experienced by manned and unmanned users are very similar and thus both could benefit from the same (or very similar) solutions

SERVICES PROPOSED FOR DRONE USERS

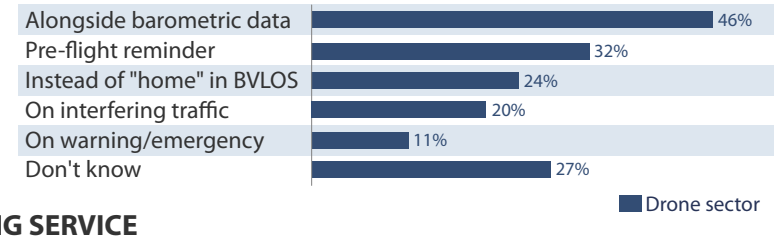
To help with the design of the ICARUS services drone users were asked two specific questions.

The first question enquired about the form of presentation of the geodetic altitude information.

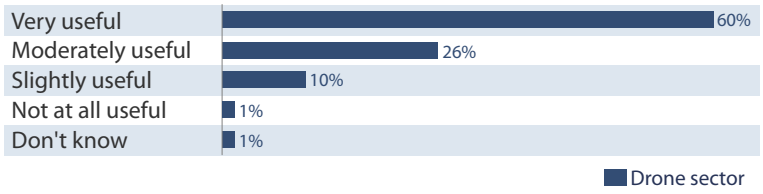
Many users (27%) did not express an opinion, but from the responses of those that did, it looks like more users would prefer to have geodetic data visible at all times rather than only in specific cases (interfering traffic, warnings or emergencies).

The second question, about the usefulness of an obstacle tracking service, received an overwhelming response with an 86% of participants considering it very useful or moderately useful and only 1% not useful at all.

GEODETIC ALTITUDE DISPLAY



OBSTACLE TRACKING SERVICE



It's about time!

CARS will be a game changer in the industry.

New altitude sources should be endorsed on a performance-based, technology-agnostic level. However, much needed is an altitude data translation service, so that all parties know in real-time at which altitude other manned and unmanned aircraft operate in relation to each one's own altitude reference.

Drone users want to use geodetic altitude measurements and approve an obstacle tracking service

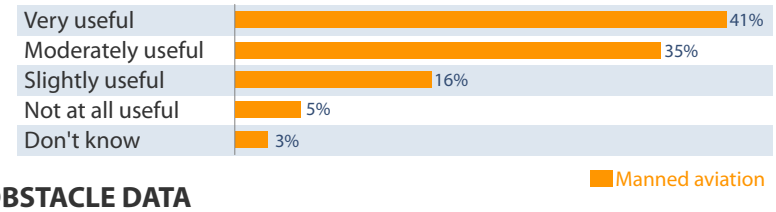
SERVICES PROPOSED FOR MANNED AVIATION

Similarly manned aviation users were asked two specific questions to better understand their particular needs.

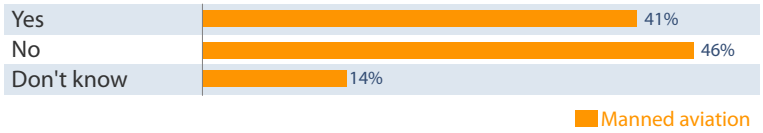
When asked about the usefulness of a service providing information about nearby UAS, most very in favour (76%), although only 41% ranked it as very useful.

The second question, about whether Electronic Terrain Obstacle Data (eTOD) is enough to plan VFR plan, received a lukewarm response with 41% answering yes and 46% answering no.

INFORMATION ABOUT NEARBY UAS



ELECTRONIC TERRAIN OBSTACLE DATA



> Why should GA adjust to drones and bear extra costs? Wouldn't that be easier to equip drones with already working solutions?

> Consider the cost of fitting of new altimeters to airplanes. Many pilots don't even use altimeters, they just look to the ground estimating their altitude.

> Statistics show that very often new solutions in aviation can cause fatal accidents. Barometric altimetry works, and if something works, why should we change that?

> Without doubt very beneficial for Drones, but not so useful for GA, especially as equipage will be costly. The best height measurement devices for VFR pilots when flying very low are their eyes.

Manned aviation is interested in a service providing information about UAS traffic, but have concerns regarding safety and cost

FEEDBACK FROM OUR ADVISORY BOARD

ICARUS ADVISORY BOARD

The ICARUS consortium established an international advisory board to advise the project to ensure that its results address the real needs of the unmanned and manned communities and a fruitful interaction with the evolving U-space world.

The advisory board is invited to share the lessons learned, recommendations and best practices, and to provide feedback on the early outcomes of the project.

The advisory board will meet at least once per year, preferably in person. During the Covid-19 induced panic, meetings will take place as teleconferences, until the world regains normalcy again.

The first advisory board meeting took place in October 2020. It was devoted to introducing the project to the members of the advisory board describing the main objectives of the project. The second took place on June 2021, presenting the intermediate results.

Both meetings provided the ICARUS consortium with very valuable feedback. On each, a short live survey was conducted. The summary of the results of these surveys is presented on the following pages.

Organisations represented in the ICARUS Advisory Board

Organisation	Type of organisation
AOPA Italia	GA/UAS pilot association
AMU-LED	Sibling UAS Project
APPLA	Commercial pilot association
ASSORPAS	UAS association
ATCEUC	Air Traffic Controller association
BUBBLE	Sibling UAS Project
DACUS	Sibling UAS Project
D-Flight	U-space service provider
EASA	Regulatory Body
ECA	Aviation pilot association
ENAV	Air Navigation Service Provider
ETF	SME
EUROCAE WG-105	Standards-making organisation
GeoNumerics	SME
IFATCA	Air Traffic Controller association
IFATSEA	Air Traffic Equipment association
ISO TC/20 SC/16	Standards-making organisation
Nuair	UAS test centre
SESAR JU	Aviation organisation
Soul Software	Search and Rescue UAS association
Swisstopo	Government Organisation
University of Bologna (IT)	University
Upvision	UAS Operator

FIRST ADVISORY BOARD MEETING

The first advisory board meeting took place in October 2020.

The main objective of the meeting was to describe the project and its objectives to the members of the advisory board and to get their initial feedback.

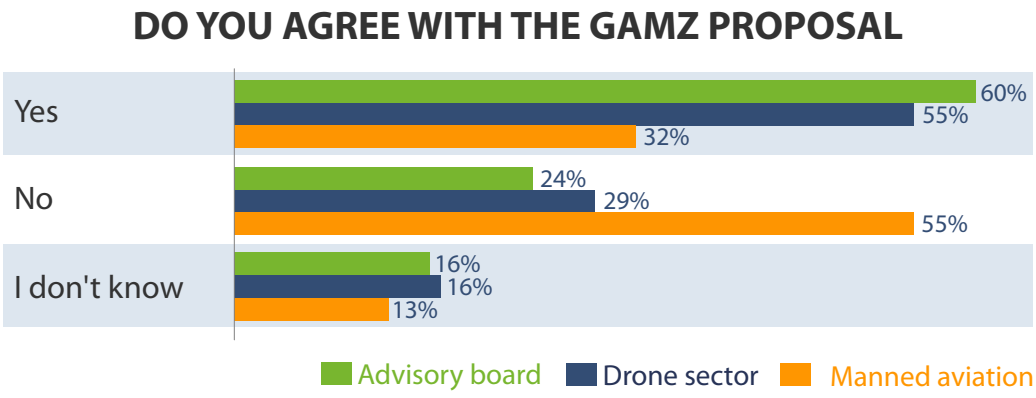
For that reason, during the meeting we conducted a real time survey using a selection of the questions that have been described in the previous chapter.

The analysis of the results of the survey indicated that, on questions related to technical issues, the responses from the advisory board meeting were in between those obtained from the web survey for the drone and aviation sector, thus confirming that we have been successful in achieving an advisory board with a good representation of the manned and unmanned aviation sectors.

Given that the advisory board can be considered a balanced representation, it was significative the answer to the question regarding the proposal Geodetic Altimetry Mandatory Zones (GAMZ).

As can be seen on the diagrams below, the response was much more positive than that received from the drone sector section of the public survey.

This is an important result that demonstrates that, when given enough information, the aviation sector as a whole (manned and unmanned) will agree with the ICARUS proposals.



SECOND ADVISORY BOARD MEETING

The second advisory board meeting was held in June 2021, almost exactly at the middle of the project.

The members of the advisory board had access to the preliminary results obtained during the first year of the project.

As it was the case in the first meeting, there was a real time survey during the advisory board. In total, there were eleven questions.

In particular, the members of the advisory board were asked to compare a service based solution, such as the ICARUS approach, with a hardware only solution implementing GNSS positioning.

As shown on the first diagram, the advisory board considers that a service solution like ICARUS could be slightly more expensive than a hardware solution, easier to customise and much more easy to update.

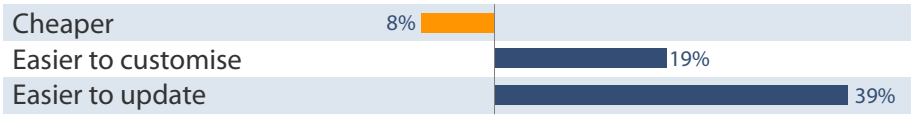
Also, the members of the advisory board were asked the following question:

Do you think that it is appropriate to require all users of U-space, including manned aviation, to use additional equipment (SERA.6005) to implement the principles of flying in the CARS system?

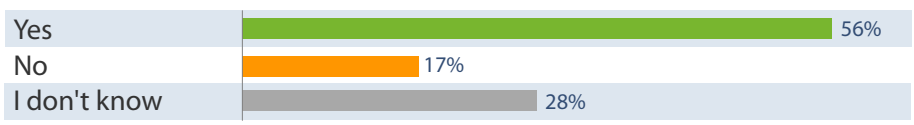
Note that this question is in direct contradiction with the doctrine that drone integration in the airspace should not impose any changes to the existing users of the airspace.

The response from the ICARUS advisory board was unequivocal, more than half of its members agreed to the question while less that one fifth disagreed.

COMPARISON ICARUS VS HARDWARE SOLUTION



USE OF ADDITIONAL EQUIPMENT



CONCLUSIONS AND RECOMMENDATIONS

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ICARUS has proposed three new U-Space services for Altitude Reference (VALS, RGIS, VCS) which are currently included in ISO DIS 23629-12.

The ICARUS Consortium launched in 2020 a survey, conducted on the project's website, which proved very informative for the progress of the project.

In the first place, the survey has provided confirmation that there are real needs for the services proposed by the project, although these needs are currently being perceived more by the unmanned aviation community.

This is not surprising, since the most professional UAS operators and remote pilots are aware of the need of ensuring safe coexistence of manned and unmanned aviation, even at very low level.

As it has been the case in previous survey initiatives performed by members of the ICARUS Consortium there exists a substantial gap between the perceived risks and opportunities arising from new technologies that can be incorporated to aviation.

Possibly the manned aviation community is hesitant knowing the high cost and the technical difficulties to retrofit legacy aircraft.

However, the potential of portable Electronic Flight Bags (EFB), already widely used even in general aviation, should be explored to implement the new ICARUS services without requiring retrofit on legacy aircraft

Manned aviation is much more conservative, assuming the thesis that "*if something works, why fix it?*", while the drone community is much more open to innovation.

Regulation 2021/666 already included mandatory e-conspicuity for manned aviation in U-space airspace. In the future, it cannot be excluded that Geodetic Mandatory Zones might be introduced, in particular in the airspace type Zu that has been proposed by the CORUS project.

ICARUS services are already appreciated by the drone community. The manned aviation community will require more convincing

Notes

Notes

To get more information about the project ICARUS, please contact us at:

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