



ECA
Piloting Safety

OPERATION OF UNMANNED AIRCRAFT SYSTEMS IN VERY LOW LEVEL

– Guidance for their safe integration –

The safe and efficient co-existence of manned and unmanned aircraft in the airspace is one of the major challenges in aviation for the next decades. The rapid growth in Unmanned Aircraft Systems (UAS), civil and military, has increased the demand for access to non-segregated airspace. It is recognised that the use of small UAS at lower altitudes is now a driving force of economic development. This revolution, based on a 'disruptive' technology, has already created new services in many fields of activity and new possibilities for airborne tasks that could not have been done before or were too costly to operate.

At the same time, the safe integration of UAS into the current environment may include constraints to UAS operations and additional risks to manned aviation airspace users. The collective aim should be to minimise these operational constraints and to remove the safety risks as far as possible, while maintaining or improving the current levels of safety and security in the skies over Europe.

Given the variety of UAS operations and utilisation, this paper concentrates on the so-called "Very Low-Level Airspace" (VLL), which is usually understood to be the volume of air below 500ft above (non-built-up) ground level. This boundary was chosen by various stakeholders under the mistaken assumption that manned aviation does not normally operate below 500ft AGL. Irrespective of that definition, the basic assumptions and problem statements made can be assumed to be consistent valid for other areas of UAS application as well.

The term Remotely Piloted Aircraft Systems (RPAS) is often used in the context of ICAO regulation for international UAS operation in airspace classes A to C. Being a subset of UAS only, this paper does not intend restrict itself to RPAS, especially as new technologies might enable highly automated pilotless, often subsumed as 'autonomous' flights in the future.

This paper discussed and provides guidance on the safe integration of UAS in VLL and the current aviation system.

BASIC ASSUMPTIONS

The main objectives of professional manned aviation are to safely transport humans and goods, as well as surveillance and aerial work, training and research. While not all operations reach the same target level of safety or follow the same standards, the infrastructure, regulations and procedures that have evolved over the past decades have led to a comprehensive set of rules that allow for an acceptable level of safety. As the

nature of UAS, as well as its use and operation, differs from manned aviation, a direct comparison between the respective operational procedures is by nature difficult. As regards to sharing the same airspace, it is very challenging if not often impossible for manned aviation pilots to timely spot and avoid UAS with the means available today. The “See & Avoid” practice commonly used in manned aviation which gives responsibility to the pilot for separation will not work reliably and safely anymore (note: even before introducing UAS the safer way of conducting civil aviation has been and is the addition of ATC control for separation). This is especially problematic in the less-restrictive airspace classes for which many UAS flights are planned.

It is therefore assumed that the flight planning, organisation, detection and collision avoidance of air traffic in the VLL airspace will be supported by an UAS Traffic Management System (UTM), such as the European U-SPACE concept. All positions and statements have to be viewed in relation to each other and cannot stand by themselves in order to encompass the entity of the UTM concept.

Policy Guidelines

1.1 ICAO airspace classes and UAS airspace categorisation have to be coherent. An exclusion of manned aviation from certain parts of the airspace for the benefit of UAS operation would be neither desirable nor practicable.

1.2 An UTM system shall enable UAS pilots to adequately separate their UAS from manned aviation and protect all airspace users from hazardous proximity to and collisions with their UAS at all times.

The implementation of a “buffer zone” between UAS VLL flights and the 500ft height boundary can ensure the required target level of safety for manned aviation flights taking place above 500 feet.

1.3 Information on airspace must be human-interpretable and user-friendly so the UAS pilot can check the conformance of the UAS position and adjust its flight path according to live requirements. UAS shall be able to receive real-time information via a constant and robust data connection to process it.

2.1 The application of minimum height requirements and a minimum distance from settlements and open-air assemblies of persons shall be considered especially for VLL operations to protect the safety of those on the ground, even in the event of contingencies and emergencies.

2.2 The application of standard cruising altitudes could be a measure to safely separate UAS from each other, but this is not deemed to be suitable for separation from manned aviation aircraft.

2.3 The UTM system should provide guidance and set boundaries to UAS operation. To ensure the UAS has the utmost freedom of operation possible, the remote pilot shall be assisted by on-board functionalities, such as “remain well clear” and “collision avoidance”, potentially allowing UAS to separate themselves. Notwithstanding this, the final responsibility for the safe conduct of the flight rests with the pilot-in-command.

2.4 Right-of-way rules, compatible to manned aviation, with priorities to certain flights and in relation to the flight phase should be adopted. Manned aviation traffic shall

always have priority. Further research on the need for prioritisation categories based on the performance and operational approval of UAS is necessary, potentially considering wake-turbulence categories.

2.5. For operation in the UTM system a new flight regime comparable to VFR/IFR shall be developed taking into account the specific operational environment of UAS operation in VLL and the necessity for safe operation of manned aviation.

2.6 A new flight plan format for UAS and the related means of distribution shall be developed to enable the correct and expeditious collection of flight data and its exchange between all relevant stakeholders and units. The data provided should include the planned procedures in case of a C2-Link loss.

The UTM system must be able to recognise the loss of a C2-Link.

2.7 Flow traffic management rules will have to provide priority to manned aviation users in the strategic and tactical phase of traffic flow management.

3.1 All UAS should be registered in a common European database, following uniform data requirements and data-protocols. Minimum information should include a unique UAS identifier, information about the owner and operator, as well as a crash- and fire-proof plaque/device on the UAS.

4.1 If ADS-B transponders are being used on UAS for identification purposes, it has to be ensured that they

- are not the sole source of information,
- are compatible with current and future infrastructure requirements
- do not negatively affect the integrity of the 1090MHz frequency band nor saturate the system.

4.2 Telecommunication networks used for UTM will have to cope with the anticipated total number of users and provide the required datalink capability at all times.

Alternative procedures for areas without coverage or insufficient bandwidth capacity must be developed.

5.1 All service providers connected to the UTM system shall be certified and subject to oversight to ensure the safety of the system and the integrity of data. Sourcing of such UTM services should be done via standardised access points open to any provider meeting the certification requirements, subject to fair and competitive market conditions.

6.1 A voluntary reporting system, catering for incidents, accidents and other mandatory reporting events in the VLL airspace shall be in place, based on the principles of a positive safety culture and just culture principles. Such a system – which is crucial for such a new and fast-growing sector – could/should be part of an already established reporting system.

7.1 UAS should be equipped with a terrain and obstacle database and sensors that enable a safe operation close to the ground or near infrastructure. Depending on the length of the mission, live updates should be possible.

7.2 Altimetry systems of UAS should be compatible to the barometric reference used in manned aviation.

8.1 UAS should be tested and certified under all environmental/weather conditions which can be encountered in VLL operation. The operational and environmental limits of a UAS have to be clear to the pilot in order to maintain a safe flight envelope. This includes among other factors wind conditions, effects of precipitation, icing and other atmospheric disturbances.

8.2 Weather data in the form of coloured charts, reports and forecasts shall be easily human-interpretable to support the pilot with the safe execution of a flight. All BVLOS flight shall require a prior review of the relevant weather data by the UAS pilot.

9.1 Financing of a UTM system shall be achieved via public funding or with user fees. Cross-financing through fees paid by the manned aviation industry is not the right way forward.

10.1 The topic of UAS operation should be presented more effectively to a broader audience so as to give all parts of society the ability to guide the legislative process with input from a well-informed and represented public. This will help balance the needs and wishes of the UAS industry, other aviation stakeholders and those of the people.

10.2 Advances in technology shall be evaluated to find a healthy balance between what is technically possible and what is beneficial to society.

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UAS in VLL – Guidance for their safe integration

1. AIRSPACE DIMENSIONS AND CLASSIFICATION

VLL UAS operations are envisaged to take place somewhere in the area below 500ft height above ground level. However, that definition is not related to today's ICAO airspace classification used worldwide. The above described height band can potentially include all types of airspace from Class G to A. UAS would have to adhere to the rules of the air and the respective airspace, as ICAO has not defined a general lower limit of applicability, meaning that all rules are to be followed from ground level upwards. Yet, already there are “grey areas” with UAS-toy and many other unregulated drones being flown at lower altitudes. This regulatory mismatch between ICAO airspace classes in which UAS do not fit as yet and the application of a “UAS airspace assessment” has to be solved.

While one possible way forward might be to implement a lower boundary to the respective airspace classes, this would risk leading to an exclusion of manned aircraft from that airspace, which must be avoided. The manned aviation community accepts that UAS are a stakeholder in the European skies. However, the exclusion of manned aviation from certain parts of the airspace for the benefit of UAS operation is neither desirable nor practicable.

1.1 ICAO airspace classes and UAS airspace categorisation have to be coherent. An exclusion of manned aviation from certain parts of the airspace for the benefit of UAS operation would be neither desirable nor practicable.

ICAO requires manned aircraft to maintain a minimum height of 500ft above ground level except with authorisation and for take-off and landing, which is why some assume that the airspace below 500 feet is free of aircraft. Sometimes in the discussion, the volume of air below 500ft is therefore called “non-navigable airspace”.

However, many manned airspace users legally fly below 500ft, such as Helicopter Emergency Medical Services (HEMS), police and military aircraft, training flights performing practice emergency procedures, glider aircraft landing outside the airfield perimeter and others including many airspace users with little protection against collisions with other aircraft. This does also include aerial work performed by helicopters and aeroplanes. Even though it is envisaged that some of these flights will be replaced by UAS, many manned airspace users will remain an integral part of the aeronautical community and their services essential for the foreseeable future.

One possibility to increase the level of safety for manned aviation aircraft flying just slightly above 500ft is the creation of a buffer zone between 500ft and the area of VLL UAS flights (similar to a transition altitude). The height/altitude measurement equipment on UAS and smaller aircraft or sports equipment (e.g. kites, parachutes), is usually not certified up to the standard of commercial manned aviation and if operating at the same indicated altitude, a significant difference can be expected. Furthermore, it is impossible to pilot aircraft at the exact same altitude for a prolonged time, and a height deviation of ± 100 feet is usually deemed acceptable.

1.2 A UTM system shall enable UAS pilots to adequately separate their UAS from manned aviation and protect all airspace users from hazardous proximity to and collisions with their UAS at all times.

The implementation of a “buffer zone” between UAS VLL flights and the 500ft height boundary can ensure the required target level of safety for manned aviation flights taking place above 500 feet.

It will be necessary to organise the airspace used by UAS depending on their requirements and abilities, as well as other factors. While large-scale solutions have been implemented for manned aviation, the short range of many UAS flights, higher flexibility of UAS in regard to manoeuvrability compared to larger fixed-wing aircraft and different flight profiles call for detailed small-scale categorisation of airspace. It remains open how this can be achieved efficiently in all detail. Techniques like clustering or rasterising of airspace might be beneficial in that regard. With the help of geo-fencing it will also be possible to limit the access of UAS to certain areas, either by inclusion (fencing-in, geo-caging) or exclusion (fencing-out), potentially with very complex polygons. In any case it must be ensured that the information provided is human-interpretable and user-friendly so that the UAS pilot can always evaluate if the UAS position is in conformance with the requirements.

Sometimes it might be necessary to adjust the airspace access for UAS on very short notice, e.g. to block the area around an accident site. This information shall be transmitted to UAS pilots without delay, while autonomous UAS shall be able to receive and process this information to adjust their flight paths in real-time. A constant and robust data connection is a key requirement to achieve this.

1.3 Information on airspace must be human-interpretable and user-friendly so the UAS pilot can check the conformance of the UAS position and adjust its flight path according to live requirements. Autonomous UAS shall be able to receive real-time information via a constant and robust data connection to process it.

2. RULES OF THE AIR

Unmanned aircraft have been part of the development of aviation since the early beginning and have already become an important part of commercial and state operations. While the unannounced or uncoordinated release of balloons has always been an area of concern, UAS operation opens up the field for possible conflicts of interest. The completely different operation of UAS in comparison to traditional manned aviation aircraft will require a review of the “Rules of the Air” in ICAO Annex 2. This is not only true for VLL operations, but concerns all altitudes up to the stratosphere, where HAPS have recently been introduced to altitudes near FL600 to provide e.g. telecommunication services.

Given the nature of VLL operations, the standard minimum flight altitudes prescribed by ICAO cannot be used. Yet, depending on the kind of operation, a certain minimum distance to the ground, settlements and aggregations of people will have to be maintained. This is especially true for Beyond Visual Line of Sight (BVLOS) flights that may have to adjust their flight path based on pre-determined parameters, e.g. during system failures, C2-link loss or unavailability of the planned route. It remains to be seen how UAS will be able to determine the above parameters without active input from a human pilot. This active input will in turn also require well-prepared data, be it via on board sensors and/or cameras or other data provided by the UTM (e.g. schedule of open-air concerts to avoid flights over large crowds). UAS shall be operated in a way to ensure the safety of people and property on the ground, even in the event of contingencies and emergencies.

2.1 The application of minimum height requirements and a minimum distance from settlements and open-air assemblies of persons shall be considered especially for VLL operations to protect the safety of those on the ground, even in the event of contingencies and emergencies.

The main objective of any UTM system is the organisation of an orderly and safe flow of traffic. Similar to manned aviation, one of the possible measures to achieve this is the implementation of cruising altitudes or levels. However, the close proximity to the ground as well as differing certification standards and equipage levels could complicate the application of this concept in VLL. Especially the fact that manned aviation users usually maintain their altitude within a margin of 100ft or more, could jeopardize the use of cruising altitudes. Nevertheless, this might be a tool to safely separate UAS from each other.

2.2 The application of standard cruising altitudes could be a measure to safely separate UAS from each other, but this is not deemed to be suitable for separation from manned aviation aircraft.

A major concern of any pilot, either with manned or unmanned operations, is the prevention of collisions with other airspace users. Manned aviation users shall be protected from collisions or hazardous proximity to UAS. Obviously, this also applies to UAS in relation to each other. While the UTM can supply tools for collision prevention on a tactical and strategic level, it will most probably not directly control an Unmanned Aircraft. This is the pilot’s responsibility, as the (remote) pilot will have to ensure a safe conduct of flight operations. The UTM system should provide information on heights/altitudes, speeds, airspace restrictions etc. Potentially it could even provide suggestions on where to fly in case the minimum required distance between two or more

UAS and/or manned aircraft is lost. In the end it will be the pilot's responsibility to evaluate if the proposed path is safe and appropriate. As there are currently no separation standards between UAS, it would surely be beneficial to start operations with bigger safety buffers until such standards have been established. Furthermore, UAS that are being more and more automated may require on-board functionalities similar to an ACAS (or DAA) system. Using the aforementioned technology, it would be possible to include a "remain well clear" and a "collision avoidance" function for UAS to separate themselves from other UAS and manned aircraft, thereby allowing the UTM to set the boundaries, but allowing UAS to operate as freely as possible.

2.3 The UTM system should provide guidance and set boundaries to UAS operation. To ensure the UAS has the utmost freedom of operation possible, the remote pilot shall be assisted by on-board functionalities, such as "remain well clear" and "collision avoidance", potentially allowing UAS to separate themselves. Notwithstanding this, the final responsibility for the safe conduct of the flight rests with the pilot-in-command.

Core principles of the right-of-way rules such as giving way to aircraft with an emergency or landing and departing traffic should apply. This also includes certain State UAS and those on medical, search and rescue and disaster relief missions. Technical capabilities to notify the UTM system on these missions, as well as standards regarding the input and handling of these, have to be developed. These right of way and prioritisation rules have proven successful in manned aviation and can be applied equally to UAS operation.

However, as regards manned aviation traffic, the danger of collision and thereby the threat to people on board the manned aircraft is to be ranked higher than a short-time deviation of a UAS. Therefore, manned aviation shall always have priority over UAS operation. The UTM system should organise the flow of traffic in such a way that UAS on a converging course or those approaching head-on can take alternate paths to stay separated from each other or/and from manned aircraft. With UAS of different categories, different performance classes and subject to different operational approvals flying in the same airspace, it might be worthwhile to study the need for further prioritisation needs, potentially even based on wake-turbulence categories.

2.4 Right-of-way rules, compatible to manned aviation, with priorities to certain flights and in relation to the flight phase should be adopted. Manned aviation traffic shall always have priority. Further research on the need for prioritisation categories based on the performance and operational approval of UAS is necessary, potentially considering wake-turbulence categories.

Manned aviation flights are categorised to either operate under "Visual Flight Rules" (VFR) or "Instrument Flight Rules" (IFR). Both are based on a number of prerequisites and are essentially a type of performance-based operation: is the weather sufficient, the aircraft equipment certified, the pilot rated accordingly, and does that conform to the type of airspace used and the quality of air traffic control service provided? A very strict set of rules has been developed for both types of operations, but neither really fits for certain operations of UAS.

It has been suggested to use the principle of "Visual Line of Sight" (VLOS) and "Beyond Visual Line of Sight" (BVLOS), with the main criteria being the ability to provide separation to other aircraft by direct line of unobstructed and unaided sight. A similar

concept to categorise UAS operations is “Radio Line of Sight” (RLOS) and “Beyond Radio Line of Sight” (BRLOS) with the main criterion being the Command and Control (C2)-Link functions and thereby the ability to directly control the UAS. Unfortunately, as of today, most States do not define these two concepts as performance-based. For example, in some countries VLOS is defined as a distance of 500 meters from the pilot (while in EASA terms VLOS means an operation in which the remote pilot maintains continuous unobstructed and unaided visual contact with the UA, allowing the remote pilot to monitor the flight path of the UA in order to maintain separation and avoiding collisions). This fixed distance is *irrespective* of the size, speed and altitude of the UAS, the environmental conditions and therefore the ability of the pilot to see the UAS. Such rules may have come into effect by the need to start the regulatory process but cannot truly represent the spirit of the original VLOS/BVLOS concept and are therefore useless when being applied in real flight conditions.

2.5. For operation in the UTM system a new flight regime comparable to VFR/IFR shall be developed taking into account the specific operational environment of UAS operation in VLL and the necessity for safe operation of manned aviation.

Planning and announcing flight intentions will be a vital functionality for any UTM system. The provision of a flight plan-like information to the system by the pilot/operator of a UAS will enable the UTM system to direct the flow of traffic in a timely manner. While a uniform ICAO flight plan format exists for manned aviation, there is no such provision for UAS. Again, due to the different needs of UAS compared to manned aviation, a new flight plan format that includes UAS relevant data should be developed. As there is currently neither standard nor central means of distribution available, this core function must be mutually coordinated between all States, preferably on a global scale, as to enable the correct and expeditious collection of data and its exchange between the relevant stakeholders and units.

Current proposals suggest that a UAS might divert from its planned track in case of a C2-Link failure. In order to ensure all other airspace users’ safety, this information should be part of the flight plan message and the UTM system should be able to identify a C2-Link loss situation. Some UAS users such as police, military and emergency rescue services may be unable or unwilling to file flight plans due to the nature of their missions. Rules on how to accommodate these users in the VLL have to be found.

2.6 A new flight plan format for UAS and the related means of distribution shall be developed to enable the correct and expeditious collection of flight data and its exchange between all relevant stakeholders and units. The data provided should include the planned procedures in case of a C2-Link loss.

The UTM system must be able to recognise the loss of a C2-Link.

It can be expected that not all flights will always be able to operate the intended route. Flight planning software should encompass a solution to adjust flight plans in these cases. A modus operandi has to be developed to allow for management of airspace capacity in case of saturation. Will there be a slot-time system similar to the one for manned aviation? Can UAS users with a nearby base “claim airspace” for their operations and block others that are just infrequently passing through? Should priority be given to uniform traffic flows? The traditional concept of “first come first serve” will certainly create inequality between early users and late-comers and a balance has to be found to create an equal and fair playing field for all parties concerned. This also includes manned aviation, which should have priority over UAS flights due to various

reasons such as: humans on board, need for higher level of safety or nature of the mission (e.g. HEMS).

2.7 Flow traffic management rules will have to provide priority to manned aviation users in the strategic and tactical phase of traffic flow management.

3. REGISTRATION

A basic requirement for UAS operation is the proper registration of the UAS and its pilot. This is the basic foundation for identification services and ensures the correct attribution of the UAS to its pilot and operator. In order to enable seamless cross-border compatibility and operations, it would be preferable to have a common European (and/or even a global) registry that can be accessed by all relevant authorities and bodies. A well-working UTM system will require good and uniform datasets to work efficiently, which means that the stored data must/shall be identical in all European countries. The minimum set of data for registering a drone should include a unique identifier for the UAS, information about the owner and operator including contact information and a crash- and fire-proof plaque/device on the UAS stating all essential information.

3.1 All UAS should be registered in a common European database, following uniform data requirements and data-protocols. Minimum information should include a unique UAS identifier, information about the owner and operator, as well as a crash- and fire-proof plaque/device on the UAS.

4. IDENTIFICATION

For any UTM system to operate safely, basic data on the position, movement and intention of future movement of all airspace users need to be processed. This mandates that all stakeholders / airspace users carry and operate equipment that is appropriate for the mission and certified according to the type of operation and the requirements of the airspace. This will affect the manned aviation community as well, especially where operation without a functioning transponder is nowadays allowed. There are currently two solutions proposed to enable UAS to be identified. The first uses ADS-B transponders, the second telecommunication networks.

One of the main constraints of ADS-B usage is the insecurity of ADS-B under the current DO-260B standard. It prevents ADS-B being used for safety-critical purposes such as collision avoidance, or at least the use of ADS-B may not be sole source of information for these purposes. Additionally, there are already indications that the ADS-B frequency band of 1090MHz is overstrained in areas with high traffic numbers. This may lead to loss of information and inconsistency in the data provided, which cannot be accepted.

There are proposals for UAS to use low-power solutions, thereby unburdening the frequency and reducing the power consumption of on-board equipment. Yet, to enable the use of future spaced-based ADS-B systems, the transponder must have a minimum power-output of 125W, meaning these low-power systems are not compatible with space-based ADS-B. Furthermore low-power ADS-B systems may require a dense network of ground stations; an infrastructure that does not yet exist.

- 4.1 If ADS-B transponders are being used on UAS for identification purposes, it has to be ensured that they**
- **are not the sole source of information,**
 - **are compatible with current and future infrastructure requirements**
 - **do not negatively affect the integrity of the 1090MHz frequency band nor saturate the system.**

Several research projects currently study the use of telecommunication infrastructure for identification and data exchange. It is proposed to use the already established infrastructure of broadband cellular networks. At this stage it is not fully clear how to incorporate this technology in a future UTM system, but it can be expected that solutions will be found in the near future.

Research will have to prove that the network coverage and capacity is sufficient for all UTM applications and that the number of UAS (or other telecommunication users) will not limit the datalink capability of a network access point or the network itself beyond an acceptable limit. This consideration should also include short-term mass accumulation of people, e.g. during concerts or demonstrations or other technologies using the cellular network (e.g. cars).

The emergence of a telecommunication network provided by High-Altitude Pseudo-Satellites (also called High-Altitude Platform Stations - HAPS) might help to enable reliable datalink capability for UAS. Still, by relying on a single source of connectivity, network integrity can easily be impaired during contingency situations. In addition, it can be expected that a complete coverage is not achievable in the near term and contingency measures as well as alternative procedures must be in place for those areas that are not covered by the telecommunication networks or only with insufficient bandwidth capacity. As with all critical aviation infrastructure, the respective performance standards and procedures to fulfil Communication, Navigation and Surveillance (CNS) requirements for safety-critical use have to be developed.

4.2 Telecommunication networks used for UTM will have to cope with the anticipated total number of users and provide the required datalink capability at all times.

Alternative procedures for areas without coverage or insufficient bandwidth capacity must be developed.

5. COMMUNICATION, DATA PROVISION & INFORMATION EXCHANGE – SWIM

One of the core functionalities of any UTM system is the collection and processing of data in order to supply all concerned parties with the information they require. While voice communication of some form will play a role in the early stages of UTM deployment, it will presumably be replaced by digital, non-verbal communication soon. Most scenarios foresee that UAS will be linked through some form of cloud network, using System Wide Information Management (SWIM) technology. A UTM System Manager could be at the core of the network, acting as the central link to connect regulatory and public agencies (incl. the registration database) and licensed providers (e.g. flight planning services). This allows for a flexible composition of service providers – from fully integrated to specialised solutions, depending on the user's needs and requirements. However, it also means that all providers must be certified and vetted on a regular basis to ensure the integrity of their services. Furthermore, standardised

accessibility is necessary to give all providers the opportunity to connect to the network on a fair basis. While this will open up new opportunities for service providers, it can also lead to dominance by a few companies, which in turn might even hinder the safe and speedy development of UAS applications and create dependencies in a safety-critical environment.

5.1 All service providers connected to the UTM system shall be certified and subject to oversight to ensure the safety of the system and the integrity of data. Sourcing of such UTM services should be done via standardised access points open to any provider meeting the certification requirements, subject to fair and competitive market conditions.

6. REPORTING

As operation in VLL under the UTM-regime bears new, probably unknown risks, a functioning reporting system shall be established for safety incidents as well as accidents. This will also help to evaluate if the required target safety levels have been met and to analyse incidents and accidents in the VLL airspace. Such a system could form a part of already established mandatory and/or voluntary reporting systems. Acceptance of it within the UAS community needs to be fostered on the basis of a positive safety culture and just culture principles.

6.1 A voluntary reporting system, catering for incidents, accidents and other mandatory reporting events in the VLL airspace shall be in place, based on the principles of a positive safety culture and just culture principles. Such a system – which is crucial for such a new and fast-growing sector – could/should be part of an already established reporting system.

7. HEIGHT/ALTITUDE MEASUREMENT AND REQUIREMENTS

Most countries in Europe have implemented regulation limiting the maximum height of UAS flights, e.g. for VLOS operations. While this seems reasonable at first sight, it also creates a number of problems.

Manned aviation has traditionally used higher parts of the airspace than those envisaged for UAS VLL flights and the operational margins towards the ground are usually significant enough to easily allow for safe operation. Advanced technical solutions have been developed so that aircraft are capable of operating close to the ground, even at low-visibility, or warning pilots of high closure rates to surrounding terrain. These technologies require a number of certified sensors and systems, especially for those flights operating according to Instrument Flight Rules. The barometric measurement is usually supported by radio altimeters and a terrain database for an Enhanced Ground Proximity Warning System (EGPWS). Similar technology can also be installed in UAS so that pilots can safely navigate their UAS, especially when operating close to the ground or infrastructure or in bad weather conditions. Although it is possible that terrain data is being sent to the UAS live via datalink during its flight instead of being stored on-board, it may be safer to have all relevant terrain uploaded to the UAS before its flight.

7.1 UAS should be equipped with a terrain and obstacle database and sensors that enable a safe operation close to the ground or near infrastructure. Depending on the length of the mission, live updates should be possible.

Given the necessity that UAS operations have to be coordinated with manned aviation, the use of altitude measurement on UAS that is compatible to barometric reference is essential to ensure a common altitude reference between Manned aircraft and UAS. At least in the VLL airspace a common altitude reference must be used by both manned and unmanned aircraft to have the same understanding.

7.2 Altimetry systems of UAS should be compatible to the barometric reference used in manned aviation.

8. WEATHER AND OPERATIONAL LIMITS

Over the last decades the certification of manned aircraft has become more and more comprehensive and sophisticated thanks to the experience gained from aircraft incidents and accidents. These evolving certification rules have helped to make aviation safer and to decrease the risk associated with the operation of aircraft. A different process is proposed for UAS: Specific Operations Risk Assessment (SORA) is meant to capture the level of operational risks (on the ground and in the air) and mitigate it to an acceptable level.

The operational capabilities of UAS are often defined by their maximum, best-case abilities. Yet, their design has to be tested and approved for unfavourable or unknown environmental conditions, in order to not to leave the UAS pilot with a high degree of uncertainty regarding the safe flight envelope of the specific UAS. Among other factors this does include the ability of a UAS to perform safely under certain wind conditions, during precipitation, in icing conditions or in atmospheric disturbances. This is especially true for the VLL airspace, where little margin to error may exist due to the close proximity of the UA to the ground or built-up structure.

8.1 UAS should be tested and certified under all environmental/weather conditions which can be encountered in VLL operation. The operational and environmental limits of a UAS have to be clear to the pilot in order to maintain a safe flight envelope. This includes among other factors wind conditions, effects of precipitation, icing and other atmospheric disturbances.

In order to evaluate the given weather conditions, the pilot needs to have sufficient understanding of their characteristics, their development and the effect this might have on the UAS. Training and operational experience will be required to judge these, but the pilot must also be provided with the correct data in an understandable and user-friendly format. Pilot associations have long advocated for a better provision of human-interpretable weather information using modern technology, including coloured charts and weather reports. Assuming that many UAS pilots will not be regular users of current aviation weather information presented in the form of METARs, TAFs or SIGMETs, it will be imperative to provide weather data in such a way that the pilot is effortlessly and properly informed. In particular, all flights operating BVLOS are only to be operated after a review of the relevant weather data.

8.2 Weather data in the form of coloured charts, reports and forecasts shall be easily human-interpretable to support the pilot with the safe execution of a flight. All BVLOS flight shall require a prior review of the relevant weather data by the UAS pilot.

9. FINANCING

The ATM system is currently mainly financed by its users and in the context of commercial aviation by the passengers. While R&T and improvements in safety are often backed by public funding, public acceptance and economical fairness demand that the costs of a UTM system are shouldered by those who benefit the most from it, meaning the users. Cross-financing, e.g. through the fees currently paid by manned aviation users to ANSPs, is not the right way forward.

9.1 Financing of a UTM system shall be achieved via public funding or with user fees. Cross-financing through fees paid by the manned aviation industry is not the right way forward.

10. SOCIAL ACCEPTABILITY & FUTURE APPLICATIONS / SYSTEMS

Manned aviation has always been very visible to the public, due to its ground infrastructure and size of aircraft. Most people worldwide are familiar with air travel and many people have travelled on aeroplanes. In trying to find a balance between the needs of all concerned, manned aviation aims at reducing its environmental impact and noise pollution, while offering improved mobility, securing jobs and providing valuable strength to the economy. It is part of the public debate and widely accepted as integral part of the global transportation network.

UAS, on the other hand, are only recognised as a niche market by many. Large parts of the public are not aware of the ongoing developments and what the impact on their daily life could be. To find an acceptable balance between the wishes of UAS operators and the needs of the people, the topic of “UAS operation” and especially of “UAS operation in VLL” should be presented more effectively and proactively to a broader audience than just subject matter experts, legislators and aviation stakeholders. General acceptance of not only the benefits, but also the downside of UAS flights – especially at VLL – can only be achieved by involving all parts of society. Given the potential impact on our daily life due to the introduction of UAS, decisions should be made with input from a well-informed audience, capable of realising the potential and downsides of this new technology.

While often relatively small, UAS are also more flexible in their operation than most manned aircraft and in the context of VLL operate closely to the ground. The possible emergence of a large number of UAS will have an impact on the surrounding environment. Noticeable effects will be visual pollution, noise pollution, light pollution and potentially pollution of the air, sea or ground by remains of UAS operation, disturbance of wildlife and health risks associated with the aforementioned factors. On the other hand, UAS can for example help to reduce the pesticide load on fields by better monitoring plant growth, thereby offsetting other negative factors of their operation. As with other technologies there are pros and cons. But the public discussion should encompass the whole bandwidth of effects that UAS operations will and could have.

Finally, Technology is constantly evolving, often at a faster pace than the legislative process that accompanies its implementation. This is especially true for the UAS domain. The current goal is to integrate a still hugely unregulated technology into today’s airspace, without forgetting possible future scenarios and evolutions. Whilst we cannot close our eyes and ignore the technological possibilities and benefits that may lie ahead

of us, finding a healthy balance between what is technically possible and what is beneficial to society, without unduly hindering development, will be the key element for the safe and successful progress of the aviation industry in Europe and worldwide.

10.1 The topic of UAS operation should be presented more effectively to a broader audience so as to give all parts of society the ability to guide the legislative process with input from a well-informed and represented public. This will help balance the needs and wishes of the UAS industry, other aviation stakeholders and those of the people.

10.2 Advances in technology shall be evaluated to find a healthy balance between what is technically possible and what is beneficial to society.

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GLOSSARY

ACAS	Airborne Collision Avoidance System
BRLOS	Beyond Radio Line of sight
BVLOS	Beyond Visual Line of sight
C2	Command and Control
DAA	Detect and Avoid
EGPWS	Enhanced Ground Proximity Warning System
EUROCAE	European Organization for Civil Aviation Equipment
GNSS	Global Navigation Satellite System
HAPS	High-Altitude Pseudo-Satellites or High-Altitude Platform Stations
HEMS	Helicopter Emergency Medical Services
ICAO	International Civil Aviation Organisation
RLOS	Radio Line of Sight
RPA	Remotely Piloted Aircraft
RPAS	Remotely Piloted Aircraft Systems
SORA	Specific Operations Risk Assessment
UA	Unmanned Aircraft
UAS	Unmanned Aircraft Systems
U-SPACE	European UTM concept
UTM	UAS Traffic Management System
VLOS	Visual Line of Sight
VLL	Very Low Level.
