EASA/NAA TASK FORCE

Report

Study and Recommendations

regarding

Unmanned Aircraft System Geo-Limitations

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Report

Study and Recommendations regarding Unmanned Aircraft Geo-Limitations

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1 Foreword

During the Latvian Presidency of the Council of the European Union, European Commission representatives, Directors General of Civil Aviation of the EU Member States, data protection authorities and leaders of manufacturing industry and service providers met in Riga and confirmed the importance of joint European action, building on the orientations given in the EC Communication, on opening the Remotely Piloted Aircraft Systems (RPAS) market.

At that occasion, the aviation community stressed the necessity for European regulators to ensure that all the conditions are met for the safe and sustainable emergence of innovative drone services. At the same time, regulations must help the industry to thrive and adequately deal with citizens' concerns.

EASA recognises both the benefits that the safe deployment of unmanned aircraft in Europe can offer and the need to manage the associated risks if that ambition is to be realised.

Recent events, involving unmanned aircraft, have shown that the probability of a collision with "traditional" aircraft, with potentially hazardous consequences, has to be thoroughly considered. Even if the vast majority of drones are expected to be operated in safe conditions by safe operators, there are areas or zones where uncontrolled access by unmanned aircraft would have the potential to create severe hazards.

This is why I decided, in April 2016, to launch a Task Force involving EASA and National Aviation Authority specialists tasked to review existing practices and technologies, to gather the views of worldwide key stakeholders and provide recommendations aimed to decide whether unintended entry into such areas should be strictly regulated, through geographical and/or performance limitations.

You will find several proposed actions in this report in the area of "geo-fencing" and related aspects, focusing on the "open category", and the risk it might create to manned aircraft.

This report represents the outcome of this work and I commend it to you. It now falls to us all to take these recommendations forward quickly and coherently so that our society can be assured of the safety of drone operations and benefit from the advantages that drones offer.

I would also take this opportunity to thank the members of the Task Force for their hard work in such a challenging time frame. I also offer my thanks to the wider community who have so generously given of their time and expertise to support the Task Force members develop this document.

Patrick Ky

EASA Executive Director

August 2016

2 Executive Summary

The growth in numbers of small unmanned aircraft systems (UAS), or “drones”, is matched by the significant range of benefits that their use promises. Those benefits will not be fully realised, however, unless there can be confidence that such UAS can be operated safely.

Reports of increasing numbers of safety incidents have understandably given rise to concern not just among the manned aviation community but amongst pioneering UAS manufacturers and operators and the wider public.

Responding to a call from the EASA Executive Director, representatives of the National Aviation Authorities of Finland, France and United Kingdom joined with EASA specialists to form a Task Force to examine thoroughly the risk to manned aircraft from the operation of UAS (mainly in the “Open” category, as defined in Ref. 7) and to consider how best to manage the risk. The Task Force assessed the current understanding of the risk, collated the actions of manufacturers, users and authorities to manage the risk, identified emerging best practice and looked at future options.

The Task Force focused its attention on the means to prevent a conflict with the potential consequence of a collision between a small unmanned aircraft and a large commercial aeroplane operating into a major aerodrome. The Task Force recognised that this constitutes a primary threat to aviation safety and lends itself to mitigation through “geo-limitations” and associated technology. Whilst there are opportunities in product design, operating practices and regulation to manage that risk, too little is known about the likelihood and consequences of such a collision to optimise those opportunities. Thus, further work, including research activities, is needed on understanding that risk.

Since the beginning of its work, the Task Force identified the need to establish globally agreed terminology that includes “geo-limitation” and related terms (e.g. “geo-fencing”), as well as the need to develop the associated concepts, the main of which the Task Force believes to have captured in this report. The definitions of the key concepts used in this report are included in Appendix C (sec. C.2. Definitions)

In forming its views, The Task Force analysed available information and then gathered data and advice by consulting a wide range of stakeholders involved in UAS manufacture, operation and regulation around the World. That consultation was performed in two ways: a survey questionnaire addressing a wide variety of stakeholders, and meetings with some stakeholders (in particular with a number of industry representatives). Appendixes contain both the questionnaire that was circulated and the description of stakeholders' engagement.

Having analysed this information, the Task Force presented a range of conclusions and recommendations. Among the main Task Force conclusions are:

- Geo-limitation solutions cannot be expected prevent malevolent behaviour, a rationale that applies to many of the Task Force recommendations. Thus, the Task Force focused on the prevention of the unintentional breach of limits.

- The Task Force noted that EASA's work to define rules at EU level for UAS operations had yet to conclude and would, in fact, take note of this report. The current lack of information on a number of aspects prevents the production of the required impact assessments. In this context, the Task Force assessed the foreseeable geo-limitation solutions, their benefits and limitations, what would be needed to make them possible and what further work was needed to accelerate implementation of those solutions.

- With regard to geo-limitations and their implementation, the Task Force identified as main elements:

    - Provision to UAS operators of up to date, accurate and easily understandable information that helps them to determine restrictions or requirements in effect at the location where they want to operate. This information could be more easily provided to UAS operators by integrating it into the remote pilot station or make it accessible through a standalone mobile application.

    - UAS performance limitations, including height or altitude limitation and range (horizontal distance to the remote pilot station or to the take-off point) limitation. The Task Force favoured height limitation as the main performance limitation that can effectively contribute to mitigate the risk of collision not only in the vicinity of aerodromes.

    - Requirement for UAS designs to include built-in features that warn the remote pilot when the unmanned aircraft is starting up in, or approaching to, a zone subject to UAS restrictions.

    - Requirement for UAS to incorporate geo-fencing, which requires position-sensing and control functions, sufficient to comply with any restrictions on where and when a UAS might operate.

- The Task Force concluded that, when establishing geo-limitations of sensitive zones, Member States use the concept of Prohibited and Restricted zones, as defined in the rules of the air.

- To respect these geo-limitations through the use of automatic functions (i.e. geo-fencing, performance limitation functions) and, at the same time, allow the removal of such limitations for authorised operators, the Task Force identified the need to define "hard-locked" and "soft-locked" geo-limitations and the corresponding un-locking processes.

- When regulating the use of such automatic functions the Task Force noted the need to keep rules technology-neutral and to provide the UAS manufacturing industry with appropriate scope to generate solutions and to propose any necessary technology standards. Besides, product requirements and standards must be applicable to UAS operating in Europe, and not just those produced by European manufacturers.

- When mandating automatic geo-limitation functions, the Task Force concluded that the mandate should apply to all products for operation in a given sub-category within the Open category, those sub-categories being established so as not to exclude the majority of UAS sold for recreational use. Mechanisms to grant exemptions in order to cope with specific needs and situations might be necessary.

- With regard to mandating a retrofit of these automatic functions to the existing UAS fleet, the Task Force concluded that, considering the relatively short average lifetime of UAS products and difficulties (or impossibility) of implementation, retrofitting should not be mandated and, instead, further operational limitations should be considered where appropriate.

- Regarding model aircraft, the Task Force concluded that current rights for their operation granted by Member States should be grandfathered. As Member States are best placed to deal with this particular segment of Unmanned Aviation, no “geo-limitation” functions should be required for that segment at European regulations level. Besides, in most cases, the technology involved in model aircraft would not make it feasible to implement automatic geo-limitation functions.

- For homebuilt UAS, the Task Force concluded that requirements similar to those for consumer-retailed UAS should apply in terms of, at least, pilot competencies, registration and electronic identification. Similarly, the COTS guidance navigation control components of homebuilt UAS should be subject to the product requirements applicable to UAS that are subject to geo-limitation function requirements.

- Regarding industry standards, the Task Force identified a number of “geo-limitation” related aspects as candidates. The Task Force identified EUROCAE as the organisation best suited to lead the European effort to develop standards working in coordination with ESOs and other industry standard bodies. Any standards must be a good fit to the characteristics of the small UAS business and be able to achieve tangible results that can be implemented by the small UAS industry in the short timeframe that this particular business segment requires.

These conclusions led the Task Force to formulate a number of recommendations, which have been presented throughout the report and put together in section 7.2.

Finally, it must be noted that this Report is just an initial step to address “Geo-limitation” aspects for UAS. The content of the Report, and its recommendations in particular, indicate follow on activities that are needed. The Task Force sees JARUS as the right forum to drive these activities forward on the regulatory side. This is because JARUS has gathered together a significant number of national aviation authorities and other relevant organisations, has been working for some years on regulatory material for Light UAS, and now includes representatives of stakeholders directly involved in the segment of small UAS and in the operations that are more likely to be affected by “geo-limitations”.

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3 Introduction and Methodology

3.1 Introduction

The growth in numbers of small unmanned aircraft systems (UAS), or small "drones", is matched by the significant range of benefits that their use promises. Those benefits will not be fully realised, however, unless there can be confidence that such UAS can be operated safely.

Reports of increasing numbers of safety incidents have understandably given rise to concern not just among the manned aviation community but amongst pioneering small UAS manufacturers and operators and within the public more widely.

Recent reports of unmanned aircraft conflicting with manned aircraft or suffering loss of control suggest that the probability of a potentially hazardous collision with a manned aircraft in European airspace needs to be thoroughly explored.

EASA's related December 2015 Technical Opinion (Ref. 7) suggested that unmanned aircraft operated in accordance with the existing regulations by competent operators do not represent significant risk. However, where a real risk of conflict with manned aircraft exists, there is a need to consider the options for how best to restrict or prevent unmanned aircraft operations.

Among these options are the enforcement of legal instruments, the establishment of geographical and performance limitations, that may be implemented, as an inherent part of the small UAS build ("geo-fencing") or the denial of access to specified airspace through intervention that is independent of the UAS and its operator.

The EASA Executive Director formed a Task Force to consider these matters and to provide concrete, prompt recommendations including guidance to States on choosing risk mitigation options appropriate to their risk situation.

Prior to this report being published in August 2016, the work of the Task Force had been shared with the team preparing the EASA «Prototype Commission regulation on unmanned aircraft operations» (Ref. 9) and has been taken into account in the preparation of that document.

3.2 The Work of the Task Force

The remit of the Task Force was set out in the Terms of Reference attached to this report at Appendix A. The members of the Task Force are listed in Appendix B.

The Terms of Reference called on the Task Force to examine specifically geographical limitations ("geo-limitations") for small unmanned aircraft operations in the "Open" category of the EASA Technical Opinion (Ref. 7), as barriers to prevent the risk of conflicts between these unmanned aircraft and manned aircraft, specifically commercial air transport aircraft, that could lead to the collision between them.

Issues such as security, privacy, visual intrusion or noise are not addressed in this report.

The Task Force assessed the current understanding of the risk, collated the actions of UAS manufacturers, users and authorities to manage the risk, identified emerging best practice, looked at future options and generated suggestions for how a State in Europe might best manage the risk in its Territory.

In forming its views, the Task Force analysed available information and gathered data, and took advice, from a wide range of stakeholders involved in (small) UAS manufacture, operation and regulation around the World.

Stakeholders' consultation was performed in two ways:

- A Survey Questionnaire addressing a wide variety of stakeholders. The questionnaire is presented in APPENDIX E: SURVEY QUESTIONNAIRE, and the list of stakeholders who provided their answers to this questionnaire is included in APPENDIX F: STAKEHOLDER ENGAGEMENT.

- Meetings with some stakeholders, in particular with industry representatives, as indicated in APPENDIX F: STAKEHOLDER ENGAGEMENT.

An analysis of stakeholder responses to the questionnaire is provided in APPENDIX J: SURVEY RESPONSES.

With regard to the questionnaire, the Task Force noticed that some questions attracted very low response rates; the Task Force considered the related data insufficiently robust to draw conclusions from. Similarly, some questions attracted clusters of respondents around alternate replies reflecting the different perspectives of the respondents; the consistent perspective of manned aviation respondents, for example, was, at times, at variance with the similarly consistent perspective of the unmanned community. The Task Force took account of these variances.

Having analysed this information, the Task Force presents, in this Report, its main discussions, conclusions and recommendations.

4 Understanding the Risk

4.1 The complete risk picture

Understanding the threats generated by UAS operations and determining which of those risks to focus on are clearly fundamental steps to optimising measures to control those risks.

Whilst UAS operations present threats to privacy and security the Task Force's remit was safety and, more narrowly, the effect of small UAS, conforming to EASA's "Open" Category, on the safety of manned aircraft operations in Europe.

Even within this narrower remit, the Task Force recognised that there was a very wide range of potential threats to the safety of manned aircraft to consider. APPENDIX G: UNMANNED/MANNED AIRCRAFT COLLISION RISK INFORMATION includes an example bow tie diagram that depicts these threats.

The Task Force judged that it was not only possible to prioritise these threats but desirable to do so, in order to focus attention on those capable of the most severe adverse safety consequences for manned aviation. Such threats matter also to the unmanned aviation community that is understandably keen to continue to develop and expand its capability and its freedoms to operate.

The Task Force's scope is further limited to conflict of a small unmanned aircraft operated within the Open Category (as defined in Ref. 7) with a manned aircraft. Although this could potentially lead to the distraction of the crew of the manned aircraft, or to an unsafe collision avoidance manoeuvre, the Task Force concentrated on the risk of a collision.

Furthermore, the Task Force has neither sought to address risks caused by UAS operators who know the rules but deliberately breach them, nor by issues such as loss of control of the UAS, or cases of navigation errors caused by the use of erroneous data.

The Task Force believes that the material provided in this report should assist in assessing the link between threats and mitigation measures.

4.2 Focus on mid-air collisions

As set out above, the Task Force's focus is on collision between a manned aircraft and a small unmanned aircraft operated in the Open Category defined in EASA Technical Opinion (Ref. 7).

The Task Force did note that a subset of small UAS operated under the Open Category is being considered by some States as "harmless". The Task Force considered that such UAS could at this stage be excluded from consideration as a mid-air collision risk. However, mitigation may yet be required for such UAS when the risks associated with the hazardous distraction of the crew of a manned aircraft are considered.

In considering the risk of a collision between a manned aircraft and a small unmanned aircraft, the Task Force considered that the key risk to address was firmly centred on a collision with a large commercial aeroplane; this view was supported by the responses received to the related survey question as shown in Figure 4-1.

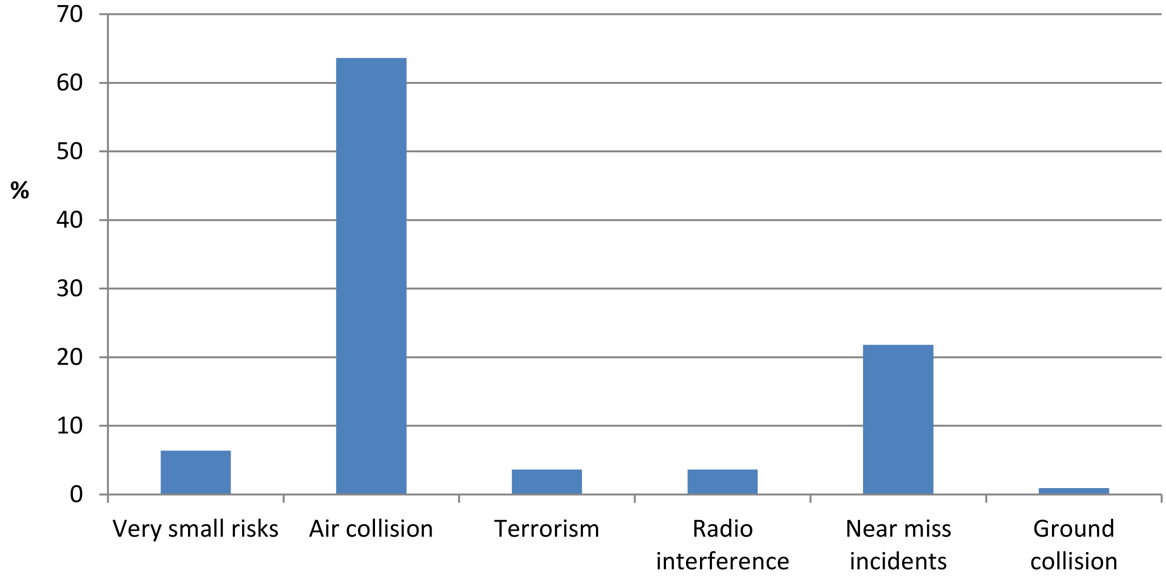

Figure 4-1: Responses to the question on "Main Perceived Risks"

This, in turn, led the Task Force to further concentrate its attention on measures to prevent unauthorised UAS activity at, or in the vicinity of, major aerodromes. Some of the associated mitigating measures, such as establishing geo-limitations, may also benefit other aerodromes (including heliports) and sensitive sites provided matters such as availability of, and update rates for, geo fencing data are taken into account.

The Task Force also recognised that its work would not, as a result, directly address a range of other known collision risks. Of particular note are risks to those operating manned aircraft at low levels outside the aerodrome environment. The low level environment would appear to the Task Force to be dominated by recreational flight, aerial work and military operations as well as by rotary wing HEMS, SAR and police operations. The rotary wing operations are of particular significance given the likelihood that incidents requiring such operations may also attract UAS operators seeking to gather video and photographic material relating to the incident and to the response of these operators.

4.3 The likelihood and consequences of a collision

As set out in APPENDIX G: UNMANNED/MANNED AIRCRAFT COLLISION RISK INFORMATION, the Task Force explored the extent to which the probability of a collision between an small unmanned aircraft and a manned aircraft in Europe was known. The Task Force also examined the level of understanding of the consequences of such a collision.

In relation to likelihood, examining the responses to the survey question on the type of initiative under which the likelihood of collision was being assessed by the consulted stakeholders (see question 3 of APPENDIX E: SURVEY QUESTIONNAIRE), the Task Force saw that 12 were working on the consequences of collision with the work to date focussed on simulation and on extrapolation of bird-strike data.

Whilst there is ample evidence of the public perception of these matters, the Task Force's investigation found that robust, reliable and validated data does not exist in respect of either the probability of a collision or of the consequences.

Such understanding as does exist is undermined by the lack of robust data on how many UAS are operating, where they are operating and how many hours of operation they are building. The absence of a coherent incident reporting system for UAS operators and the uncertain reliability of conflict reports filed by the manned aviation community further contribute to the low level of confidence in the understanding of the risk picture.

In order to address above issues, the Task Force provides the following recommendation:

REC.1:

The Task Force recommends the following actions for EU and Member States to improve the reporting of occurrences involving small UAS:

- to educate operators/users of small UAS in the use of the occurrence reporting system available in Member States.
- to educate European and other manufacturers of small UAS to implement and maintain a reporting system, and encourage them to inform EU / Member States of their findings.
- to seek cooperation of small UAS manufacturers and operators (potentially via national associations) to improve authorities' knowledge of the small UAS fleet and their operations in Europe.

When considering the consequences of a collision between a manned and an unmanned aircraft, the Task Force found that, whilst some research has been conducted to date, this is not comprehensive enough, and has been limited to simulation and modelling work, which will have to be translated into information that would optimise the management of the risk.

The Task Force concluded that whilst there are opportunities to manage the risk of a collision between a manned aircraft and a small unmanned aircraft through product design, operating practices and regulation, too little is known about the likelihood and consequences of such a collision to optimise those opportunities.

REC.2:

The Task Force recommends that, at EU level:

- An effort is made to **understand the current and projected likelihood of a collision in Europe between unmanned and manned aircraft**. Key points of focus should be fixed wing aircraft arriving and departing major aerodromes; fixed wing aircraft at high level away from aerodromes; rotary-wing aircraft at low levels away from aerodromes.
- A **programme of research should be set up**, based on the **recommendations of the EASA "Drone Collision" Task Force**, to establish the consequences of a manned aircraft/small unmanned aircraft collision and share the results to inform future safety measures required to secure safe UAS operation.

The Task Force considered that, despite the lack of validated data on the likelihood and consequence of a collision between a manned aircraft and a (small) unmanned aircraft, the increasing numbers of UAS being sold, the increasing number of reported occurrences of collisions or near collisions and the clear evidence of potential risk to manned aviation are sufficient to justify the Task Force's mandate and to support its recommendations.

5 Options for Managing the Risk

5.1 Introduction

The Task Force recognised that there are opportunities to manage the risk of a collision between a small unmanned aircraft and a large commercial aeroplane at or near major aerodromes.

Through the survey on the current situation (including stakeholders' consultation) , the Task Force identified risk mitigation actions that were already in place or were being developed by aviation safety regulators, civil enforcement agencies, UAS manufacturers and others in the manned and unmanned aviation community.

Some of these mitigations were predicated on securing safety through good UAS design and safety-conscious behaviours by UAS operators; others on preventing unsafe operations by uncooperative UAS or UAS operators.

In this Section, the Task Force summarises the results of the survey to identify the main technology and regulatory solutions for managing the risk.

5.2 A Definition Problem

One obstacle to progress identified by the Task Force was that some key terms of significance for managing risk mitigation were not defined in a manner commonly understood across the global community.

Among the key terms for the Task Force were "geo-limitation" and "geo-fencing". For these and other terms, the Task Force agreed to work with the definitions given in sec. C.2. Definitions.

The current absence of globally accepted definitions of such terms is unhelpful to those designing regulatory requirements or industry and to those seeking to comply with them. The Task Force also recognised that definitions of such terms can only truly be meaningful in a situation in which the role of the functions described by these terms is understood within the wider context of the operational environment of which they are a part – often described in a CONOPS document and in the wider context of the system of players involved in implementing those functions. Given that these matters are important to a global community, the Task Force stressed the **need to establish, at international level, standard definitions for key UAS terms, including "geo-limitation" and "geo-fencing"**.

5.3 Survey of UAS Technology Solutions

5.3.1 Small UAS in Europe

No accurate data was presented to the Task Force on how many small UAS might be currently operating in civil operations in Europe. In the survey, the respondents provided estimates ranging from thousands to millions. Having analysed key country data on manufacturer annual sales and production turnover and scaled according to population, the Task Force estimated that **more than 3 million production small UAS** (excluding “homebuilt” and model aircraft) may currently be **in use in Europe**.

The Task Force noted the following additional information regarding small UAS operating today in Europe:

- Most small UAS in the market are **below 2 kg** (this could represent 98% of the current market) and the majority correspond to the **multi-rotor configuration** (typically 4 or 6 rotors).
- The average time a small UAS stays in production ranges between 1 to 5 years, but the most common types of small UAS have a **production life of around 2 years**.
- Excluding “model aircraft” (which are typically designed for recreational or sport use only, and are in most cases manually controlled, usually through a RC link), small UAS rely on a **guidance-navigation-control (GNC) system with a certain level of complexity**, that usually provides **self-stabilisation** and some **automated functions**.
- Most small UAS manufacturers provide **updates to software through downloads** from their websites. In most cases, the currency of software in these small UAS relies on the user or **operator voluntary action to download and install the latest software version**.
- **Most navigation** functions used by these small UAS in the market are based on **GNSS receivers, air data sensors** (only barometric pressure sensors in the case of multi-rotors)**, and inertial measurement units** (IMU, usually MEMS). Some small UAS have **additional means to increase vertical position accuracy** (e.g. vision sensors, ultrasonic sensors, etc. for positioning in close proximity with terrain). Small UAS manufacturers claim that with this equipment their small UAS can achieve accuracies in positioning of **1.5m height and 5m lateral** or even lower values. Future GNSS (e.g. Galileo and future SBAS enhancements) should improve the accuracy and reliability further for those (small) UAS relying on such technology for their position determination. It must be noted that other technologies, like RFID, could also provide the (small) UAS with means to estimate the unmanned aircraft geographical position.

5.3.2 Current and envisioned technological solutions to address the risk

From the information gathered, the Task Force noted the following technological solutions, currently available or in development, to reduce the likelihood of a collision between a small unmanned aircraft and a manned aircraft.

5.3.2.1 Solutions to prevent conflict with manned aircraft

Among the main aspects and solutions identified to prevent conflict with manned aircraft are:

- **Provision of geo-limitation information**

  Providing UAS operators with accurate and up-to-date information on geo-limitations that apply in the zones where those operators intend to operate is a first and paramount step required for safe UAS operations. Just the provision of this information alone might reduce unintended infringements of those limitations substantially.

There are several initiatives to facilitate provision of this information to the UAS operator in an immediate, convenient and easily understandable manner. These are mainly through the use of tools like apps for portable devices (e.g. tablets or smartphones) or implemented as part of the HMI of the UAS control station.

Since the information provided must be up-to-date and verified, authorities from several Member States and other States outside Europe have undertaken initiatives to develop such information system and tools.

A number of companies are also involved in the development of tools to provide that information and more services to the UAS operators and other stakeholders (e.g. aerodrome managers, ATC, authorities, …). Some of these companies cooperate with small UAS manufacturers to provide their UAS with these kinds of tools.

- **Geo-fencing and performance limitations**

Currently there is a leading manufacturer of small UAS suitable for operations under the "Open" category (Ref. 7) that already incorporates a geo-fencing function in its current consumer market products to protect sensitive zones. As described in APPENDIX I: EVOLVING TECHNOLOGY SOLUTIONS, this function informs the remote pilot of proximity to a "geo-limited" zone and prevents the unmanned aircraft from entering that zone, unless the sensitivity of that zone is not the highest and the UAS operator has confirmed its right to operate in such zone (which refers to the concept of "soft-locked" versus the "hard-locked" geo-limitations, as defined in sec. C.2. Definitions). This function requires that the GNSS-based navigation is enabled to allow the UAS to determine its geographical position, and the software version includes the geo-fencing function and related geo-limitation data (geo-limited zones).

Leading manufacturers of small UAS are also equipping their products with functionality that enables performance limitations. Most typical among these limitations are maximum height and maximum distance to the control station. Some manufacturers also enable the user to define limits below the maximum built in limitations. Some manufacturers are considering as "geo-fencing" the setup of a cylinder resulting from the combination of limitations in distance to the control station and in height.

The Task Force understood that, even if the technology to implement geo-fencing and performance limitations already exists, **not all small UAS can be fitted with such technology and, consequently, cannot comply automatically with geo-limitations**. For example, it may not be feasible or economically viable to provide smaller UAS with position determination capability, or in the case of older models it might not be possible to retrofit them with geo-limitation functionalities. Given these issues, and the expectation that small UAS might be in use for only two years or so, the Task Force felt that the compliance period allowed for any regulations requiring specific technological solutions should take account of these factors.

The Task Force was also aware that "Do It Yourself" or "Homebuilt" UAS, built by enthusiasts from kits or entirely from base components, are very popular. Such devices are in principle assembled in a fashion that might not comply with industry standards observed by the main manufacturers and cannot be assured to have built-in geo-fencing capability.

- **Air traffic situational awareness**

  As indicated above, solutions being developed by some companies to provide geo-limitation information are also proposing wider information provision, like situational awareness of the operation of other UAS in the vicinity. For such service, some companies rely on UAS registration to their service and the provision of basic information that includes the zone and time of operation.

  With regard to situational awareness of UAS operators of surrounding manned aircraft traffic, current solutions rely mainly on detecting that traffic with:

  - Cooperative technology means like ADS-B receivers (ADS-B IN function, which requires manned aircraft to be operating with an active ADS-B OUT transponder, or using a SSR transponder without ADS-B OUT but being operated in a controlled airspace where that transponder is being interrogated by the ATC SSR system)
  - Non-cooperative means like primary surveillance radars (PSR), available only at some aerodromes (e.g. some flight test centres for UAS are equipped with such radars, coupled with SSR to provide surveillance of both UAS and manned air traffic).

  With regard to the use of ADS-B OUT transponders by UAS, there are some stakeholders (including authorities from some MS) that are advocating it as a means for UAS to become "visible" to manned aviation and, therefore, increase the likelihood of preventing manned/unmanned aircraft conflicts. However, as some consulted stakeholders also pointed out, there is an issue of potential saturation of ATC systems in many MS if all UAS were required to be equipped with those transponders. Besides, even though there are already solutions suitable for small UAS, size, weight and power (SWaP) are still constraints for the smallest UAS.

- **Unmanned aircraft in-flight identification**

  The possibility for aerodrome and enforcement authorities to be able to identify an unmanned aircraft whose operation may pose a risk to manned aircraft in the vicinity of aerodromes or at any other location is another key feature to prevent potential conflicts with manned aircraft (as well as to prevent any other safety, security or environmental issue related to sensitive zones).

  As indicated in sec. 5.4, a number of MS are already considering requiring this capability by electronic means (a.k.a. "e-identification" / "e-ID"). In fact, current Italian regulation on civil UAS is already requiring this capability as of July 2016, and French parliament introduced a proposal for a "drone" act that would require this capability in 2018. The electronic identification device (EID) must be able to at least transmit real time data from the unmanned aircraft, UAS owner/operator and basic flight parameters, as well as the being able to record these data.

- **UAS Traffic Management (UTM) system**

The abovementioned aspects, from provision of geo-limitations information to identification are expected to become, in the future, part of a so called UAS Traffic Management (UTM) system.

Stakeholders consulted expressed the following ideas about UTM:

- UTM and ATM systems should be interoperable
- Geo-limitation functions are a step towards UTM and will be a part of it
- The UTM system should be the backbone infrastructure for all information and aircraft
- The impact on manned aviation should be kept to a minimum
- Low cost and low weight sensors are needed

Stakeholders expressed a view that geo-limitation needed to be an integral part of a future UTM system together with a Detect & Avoid system. In their view, the UTM system would optimally utilise existing technical standards (e.g. for ADS-B) or have no requirements for manned aircraft so as to avoid inflicting additional costs on manned aviation. The balance has to be struck between manned and unmanned needs.

Currently, implementation of a UTM system is not technically feasible and thus there is still time and scope for technical advancements that would lower the cost of implementing new capabilities into UAS.

The EU Single Sky Committee (SSC) expressed the view that the future UTM system should include the following features:

- A standardised data link for UAS
- Human equivalent capability Detect & Avoid system
- Contingency planning for data link loss situations
- Cyber security resilience
- Interoperability with normal airspace and airport operations
- Unique human factors aspects regarding UAS and their integration to UTM/ATM.

It is important to note, however, that the time table for a UTM system is some years into the future and thus geo-limitation standards will be determined before any UTM standards would be in force.

More information on these solutions and technologies is included in APPENDIX I: EVOLVING TECHNOLOGY SOLUTIONS.

5.3.2.2 Solutions to prevent infringing UAS from colliding with manned aircraft

Among the main aspects and solutions identified to prevent a UAS already infringing geo-limitations from colliding with manned aircraft are:

- **Detect & Avoid capability**

  A detect and avoid (DAA) capability in UAS has long been considered a key enabler for the integration of UAS operations in non-segregated airspace. Several R&D projects have been addressing this subject (e.g. MIDCAS and ASTRAEA in Europe) and leading manufacturers of military UAS are currently testing DAA systems for some products (e.g. in the MALE category).

  UAS operations in airspace where manned VFR and IFR flights are conducted require the use of technologies to address both cooperative and non-cooperative air traffic;, for the moment (and foreseeable future) this implies the use of equipment that can only be integrated into large UAS (like those in the MALE category).

  Therefore, despite initiatives addressing DAA systems for UAS, no effective solution integrated in small UAS is expected to be available in the foreseeable future for air traffic detection and avoidance. Nevertheless, as small UAS are expected to operate mainly below VFR and IFR flight levels (which in most cases start at 500 ft), other kinds of solution are being explored to manage the potential risk of conflict with other air traffic; these include the UTM systems mentioned earlier (sec. 5.3.2.1)

  However, it should be noted that some small UAS are already being equipped with a capability to detect and avoid fixed obstacles along their path. Progress from this start point may yet be quicker than currently envisaged.

- **"Anti-drone" solutions**

  An increasing number of solutions are being proposed to detect an "intruder drone" in a sensitive zone and to disable it by different means, such as jamming or spoofing the UAS (e.g. their C2 link and/or GNSS signal), capturing in flight the unmanned aircraft (e.g. via nets carried by another "drone", or using "drone falconry" with large predatory birds) or destroying it (e.g. using fire arms, electromagnetic pulse, lasers …).

  It must be noted that there are already plans to install "anti-drone" solutions in a number of airports worldwide. However jamming, and even more spoofing, may disturb aircraft avionics and CNS systems and thus impair aviation safety; installation of "anti-drone" systems near airports needs careful consideration.

5.4 Survey of Regulatory Initiatives

5.4.1 Current national regulations and "geo-limitation" related aspects

The Task Force analysed the regulatory and enforcement approach currently adopted by MS and other States outside Europe in relation to geo-limitations. The results are summarised in APPENDIX H: EVOLVING REGULATORY THINKING to this report.

Careful examination of the results generated by these regulations should assist in continuously improving regulatory thinking.

Some aspects to highlight with regard to current national regulations in place addressing UAS operations are:

- Most regulations **focus on the professional use of UAS**. For recreational use, most States are providing some basic recommendations through the use of leaflets, educational videos, etc. (see examples in APPENDIX H: EVOLVING REGULATORY THINKING)
- Most regulations focus on **small UAS** (in most cases the threshold is 25 Kg MTOM). Larger UAS usually require a case by case authorisation (including certificate of airworthiness or permit to fly).
- Operations allowed are usually in **VLOS**, but BVLOS may be allowed or authorised in specific cases.
- A **maximum height (AGL) for UAS operation** is established in most cases. The most common values for operations outside segregated airspace are: 400ft/120m (e.g. Ireland, Malta, Netherlands, Spain, Sweden, UK), 500ft/150 m (e.g. Finland, France, Italy), 300ft/100m (e.g. Belgium, Czech Republic, Germany).
- **Maximum distance of the unmanned aircraft to the remote pilot** is established in most cases. For VLOS operations, a number of national regulations just indicate that the unmanned aircraft must be within the visual sight of the remote pilot, and others indicate a maximum value, 500 m being the most common (e.g. Austria, Czech Republic, Croatia, Ireland, Italy, Netherlands, Romania, Spain).
- **Minimum distance to aerodromes** is also defined in most regulations. As it can be seen in APPENDIX H: EVOLVING REGULATORY THINKING, there is a variety of values across the different national regulations. The most common value is 5 Km (e.g. Denmark, Finland, Italy, Norway, Poland, Switzerland). The reference point from which the distance is measured is not always clearly indicated (in some cases the ARP is mentioned, in others it is simply the "distance to the runway", and in others it is not mentioned).
- **Remote pilot competence** is required in most cases (where the UAS is being used in pursuit of a business i.e. "professional use").

With regard to the provision of geo-limitation information and, in particular, information on the sensitive zones, it is worth noting that a **number of MS and other states outside Europe are already providing or developing the capability to provide that information via an app for portable devices** (e.g. tablets, smartphones) for the use of UAS operators. APPENDIX H: EVOLVING REGULATORY THINKING includes some examples.

5.4.2 Options for improving the safety of UAS operations

One of the goals of the Task Forces stakeholder survey was to uncover ways to evolve regulatory thinking. Thus, in this section answers from respondents to the survey were analysed to indicate the most relevant aspects to improve safety of UAS operations and, in particular, those aspects related to geo-limitations.

As shown in Figure 5-1 below, when considering the question of how best to constrain UAS operations, there was no single approach favoured by respondents. An analysis of the responses received indicated that safety promotion, pilot training and information dissemination together made up around half of the responses.

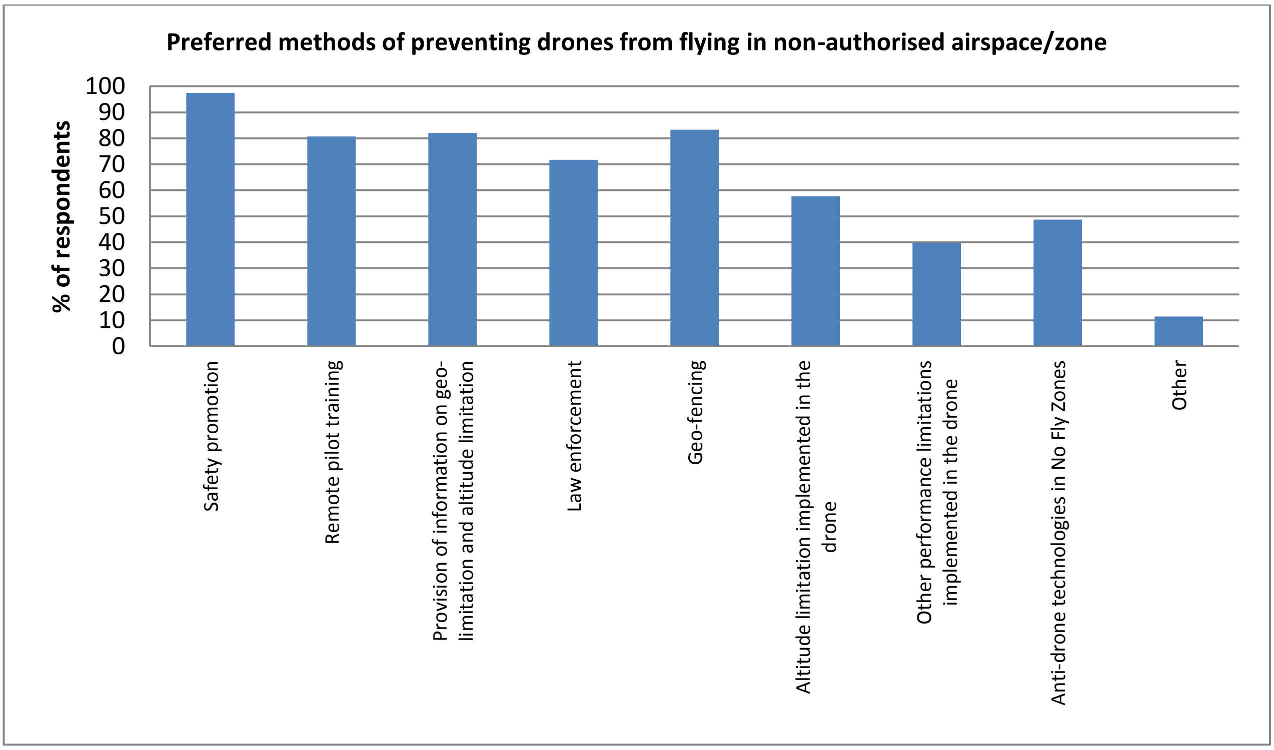

Figure 5-1: Preferred methods of preventing UAS from flying in non-authorised airspace/zone

Turning specifically to “geo-limitation”:

- The provision of information on geo-limitations has, logically, wide support from most respondents. As part of this, some stakeholders mentioned the use of “*aviation authority updated, internet based, and easy to use map for UAS with all no-fly zone information and warnings*”, whereas other mentioned the “*development specialised maps for drone pilots*”
- “Geo-limitation” functions, that is the combination of geo-fencing and performance limitation functionalities, made up around half of the responses.

Some other stakeholders also indicated the "mandatory registration of equipment at purchase" and the "mandatory identification of drones".

These results suggested to the Task Force that there was support for geo-limitation as a way forward, but that this should be as part of a wider solution which also emphasised safety promotion and pilot training.

The Task Force also considered the stakeholders views about ongoing activities to prevent mid-air collision of UAS with manned aircraft and to prevent UAS from entering zones for which UAS flight was not authorised. Stakeholders focused on the following ideas:

- **Regulations**

  Including adequate operational limitations in regulations addressing UAS, in particular geo-limitations, is seen as a key aspect to prevent UAS conflicts with manned aviation. As indicated in sec. 5.4.1, most national regulations already include at least limitations regarding flight height, distance to the remote pilot and distance to aerodrome. However, as noted before, there are significant differences in those limitations among the different national regulations. The Task Force acknowledges that the specific challenges facing some MS may not make it feasible to harmonise all of these limitations, but the Task Force believes there are opportunities to harmonise some of them, and that this would be of benefit.

- **Education and Safety Promotion**

  The Task Force noted that there was broad support from consulted stakeholders for Education and Safety Promotion.

  Many authorities had published educational material and organised meetings with operator organisations to increase awareness of potential hazards. Operator organisations, including manned and unmanned pilot organisations, are providing education and training to their members to help them to prevent mid-air collisions or other accidents.

  Some user organisations and aviation authorities developed, or were developing, mobile applications and websites for easy to read maps, no-fly zone area information and information on safe flying practices.

  There is a great opportunity for cooperation between States and national organisations, for pooling resources and sharing educational materials. EU/EASA, JARUS or ICAO could usefully consider this aspect when developing guidance material.

- **Geo-limitation functions and standardisation**

  The vast majority of stakeholders consulted (over 80%) supported a regulatory mandate for geo-fencing, with 20% supporting the use of hard-locked geo-limitations and more than 60% supporting soft-locked ones. The former opinion was mainly voiced by ANSP and NAA respondents whereas the latter was supported by a broad spread of stakeholders including small UAS manufacturers and operators, NAAs and manned aviation organisations.

Objectors to making geo-fencing mandatory (less than 20%) were mainly small UAS operators and two NAAs. Among the reasons for not supporting this option were: that the responsibility should always be with the operator; that no other technology was subject to regulatory limits of this kind and that regulation could not keep pace with innovation and change.

Leading small UAS manufacturers asked for caution to be exercised when considering a mandate for such function as they consider it to be an information and support tool for the operator; their key point being that it is the operator who should ultimately be the one responsible for ensuring the safety of the operation. Some of these manufacturers expressed their concern at the potential impact of geo-fencing requirements on their own responsibility and liability.

These same small UAS manufacturers also indicated that they supported "*the proposal for the EU to set up a Union-wide dynamic geo-fencing system within which national authorities qualify specific airspace as open, conditional or no-fly zones. It is highly important that competent authorities feed authorised information into a centralised web interface, using an international standardised map format. This information would then be available to operators through various service providers (e.g. smartphone apps) or could be uploaded directly onto more elaborate drones.*

Geographical limitation systems must permit legitimate operations in sensitive areas. Examples are airport operators that use drones for runway inspections, airline fleet management with drones, or drone-based precision agriculture on farms near airports. The limitation system should be designed with a "safety-by-default" mode, but offer the operator the informed choice to override geographical restrictions, if and where the drone pilot is authorised to do so."

Therefore, even though it is clear that there are many cases where geo-fencing would enhance the safety of UAS operations, it is equally clear that the absolute prohibition of UAS flights in defined zones could prevent sensible opportunities for UAS to deliver beneficial services by operating in those zones.

This led small UAS manufacturers to define different levels of limitations assigned to geo-limited zones categorised by their sensitivity (from Hard Locked No Fly Zones around highly sensitive sites, such as nuclear submarine ports or jails, to unrestricted areas allowing complete freedom to fly), and to develop mechanisms to enable operations in such sensitive zones depending of zone category.

The approach adopted by the manufacturers is, however, founded on the principle that the operator should be responsible for where they operate; the role of the manufacturer should be limited accordingly, they proposed. Some manufacturers viewed this provision of geo-limitation functions as being to caution an operator that their intended flight would take them into a sensitive zone and, having created a record of that interaction with that operator, to allow the operator to unlock the geo-limitation should they choose to do so.

For regulators, the question was to what extent such arrangements provide a sufficient level of protection from unwanted access into sensitive zones of airspace.

As some stakeholders indicated, geo-limitation data should be required to be updated at regular intervals, failing which the UAS would become inoperative until updated.

In summary, the Task Force noted the following emerging agreements about the role of geo-limitation in controlling risk:

- geo-limitation functions should not be relied on to prevent deliberate intrusion of sensitive areas;
- there are legitimate reasons for allowing geo-limitations to be disabled (un-locked) by suitably authorised users;
- UAS operators are responsible for keeping their UAS software up-to-date so that geo-limitations are also up-to-date.
- UAS operators would need to receive information to alert them that their UAS was approaching a sensitive area;
- the UAS operator must be held accountable for complying with any restrictions on where and when they may fly their UAS, regardless of the existence or correct functioning of geo-limitation functions.

With regard to the intervention by the State in the process of authorising operators to un-lock or disable geo-limitations, the Task Force noted that some manufacturers, when allowing users of their UAS to unlock geo-limitations, created a record of each such event. They were open to amending the record they kept to make it easier for State Authorities to compare their own list of operators authorised to enter restricted flight zones with the records of the manufacturer of those who had chosen to do so.

There are currently no industry standards to support the development of geo-limitations functions (i.e. geo-fencing or performance limitations). As a result, most manufacturers have had to develop their own systems. Consequently, there are no mutual agreements on the operating principles or implementation of these functions. This might create a challenge to interoperability and to the facilitation or constraint of operations. . Put simply, without standards for soft locking, for example, one cannot take account of that functionality in deciding to allow or prevent (i.e. facilitate or constrain) operations into a sensitive airspace zone. It would be preferable that aeronautical information providers, manufacturers and other involved digital services providers agreed on a standard format of geo-limitation data so that possible future regulations on this matter could refer data providers to these requirements.

- **Registration and identification of UAS and their users**

Although registration and identification of UAS and their users does not link directly to geo-limitation regulations, registering users who are allowed to access restricted zones would help enforcement agencies in monitoring such zones. It was also recognised that registration was an effective way to reach operators for safety promotion purposes and might enhance safety conscious behaviours.

The Task Force also noted that there was broad support from stakeholders for the following elements to be promoted and standardised as a means of increasing the safety of operating small UAS:

- Detect & Avoid system
- Pilot competence
- Unmanned aircraft frangibility standards.

In conclusion, the Task Force noted that there were many options for improving the safe operation of small UAS and that any final solution would be a product of many of these options and not just a single requirement or system.

6 Paving the way towards the use of geographical and performance limitations

6.1 Introduction

As set out earlier in this Report, it was clear to the Task Force that knowledge of the likelihood or consequences of a collision between an unmanned aircraft and a manned aircraft was still immature. This made it difficult to judge how firmly to recommend the implementation of specific geo-limitation solutions.

This task was further complicated by the fact that technical solutions were being generated by the unmanned aviation community at a pace that made it possible for recommendations made today to quickly be rendered sub-optimal.

Finally, the Task Force noted that EASA's work to define implementing rules at EU level for UAS operations had yet to conclude and would, in fact, take note of this Geo-Limitation Task Force's report. The current lack of information on a number of aspects, including those needed for a cost benefit analysis for the implementation of geo-fencing, prevents the production of the required impact assessments.

In this context, the Task Force assessed the foreseeable geo-limitation solutions, their benefits and limitations, what would be needed to make them possible and what further work was needed to accelerate implementation of those solutions.

The Task Force considered that its assessment should serve as part of the inputs required to perform a necessary analysis for a regulatory impact assessment that might support the decision on a mandate of geo-limitation functions in future European regulations.

6.2 Geo-limitation and implementation options

Overall, the Task Force judged that geo-limitations offers a promising opportunity to improve separation between manned and unmanned aircraft. With the pace of development of the UAS industry outstripping that of international rulemaking and standardisation, the Task Force felt that urgent progress was needed to address the manned/unmanned aircraft collision risk in the simplest manner possible. Although its work focussed on major airports, the Task Force felt that its recommendation needed to acknowledge the potential benefit of geo-limitations regardless of the size of the airport.

REC.3:

The Task Force recommends that **JARUS** give the highest priority to the **development of a unified geo-limitation concept of operation** that prevent unauthorised use of small UAS near airports with commercial traffic, heliports, and other aerodromes, focussing on the simplest options that can be implemented in the short or medium term.

As previously indicated, the assessment done by the Task Force should serve to support the

necessary impact assessments that support the decision on geo-limitation requirements in future European regulations.

From the information acquired by the Task Force, four main geo-limitation related items emerged to mitigate the risk of UAS entering airspace to which UAS restrictions apply:

1. Providing UAS operators with up to date information that helps them to determine restrictions or requirements in effect at the location where they want to operate; this information could be integrated into the remote pilot station or be accessible through a standalone mobile application.

2. Limiting UAS performance; this may include height or altitude limitation, horizontal distance limitation (to the remote pilot station or to the take-off point)

3. Requiring UAS designs to include built-in features that warn the remote pilot when the aircraft is starting up in, or approaching, a zone subject to UAS restrictions

4. Requiring that UAS incorporate geo-fencing, which requires position-sensing and control functions, sufficient to comply with any restrictions on where and when a UAS might operate.

Recommendations on these items are presented in the following sections.

6.2.1 Performance limitations

Altitude or height limitations, speed limitations or horizontal distance limitations were the main proposals made by the respondents to the questionnaire (question 18 *"What are the main characteristics to be included in standards addressing "performance limitations" of drones?"*). Other options, such as kinetic energy or maximum duration of the flight, were also mentioned.

From the information provided to the Task Force, it was clear that the implementation of **range, altitude and height limitations were readily implementable in currently available UAS technology**; indeed, the leading manufacturers offered such features in their current products. Such limitations had the advantage of not requiring geographical data to be produced in a standardised format, stored in databases, made available to users and regularly updated.

6.2.1.1 Speed Limitation

The Task Force found that speed limitation, though promoted as a useful feature by the manned aviation community, did not provide a substantial advantage in the mitigation of the likelihood of a collision between a small unmanned aircraft and a manned commercial transport aircraft. As such, the Task Force did not favour speed limitations as the most relevant ones in terms of preventing the risk and, consequently is not further considered.

6.2.1.2 Range Limitation

Range limitation was considered by the stakeholders who promoted this option as useful in ensuring that the unmanned aircraft remained within the datalink range and that the remote pilot could keep the drone in sight.

6.2.1.3 Height vs. Altitude Limitation

The Task Force was clear that altitude limitation was distinct from height limitation. An Altitude Limitation used height above mean sea level as a reference whereas a Height Limitation was related to height above the start point of the unmanned aircraft flight or above the position of the remote pilot station. Some confusion between the terms was evident in the responses to the questionnaire.

For an altitude limitation to be effective as a means of mitigating the risk of an unmanned aircraft collision with a manned aircraft at a major aerodrome, the Task Force noted that the UAS operator would need to be aware of, and capable of complying with, the maximum altitude at the specific aerodrome at which an encounter with a manned aircraft would be prevented. Alternatively, the UAS itself would need to have the necessary functionality including navigation, autopilot control and an accurate terrain database.

However, the Task Force took note of the fact that a significant number of drone encounters reported by airline pilots took place at altitudes above 3 000 ft. Therefore, altitude limitation could be considered an effective mitigation risk for unmanned-manned aircraft collision at higher altitudes and everywhere other than airports. Furthermore, as indicated by the “Drone Collision” Task Force (Ref. 10), altitude may play an important role in the effect of collision on the manned aircraft (related to kinetic energy).

On balance, the Task Force felt that the relative complexity of dealing with an altitude limitation compared to a height limitation argued in favour of the latter. As a consequence, the Task Force felt that Altitude should not be relied on as a means of mitigating the risk of a unmanned aircraft collision with a manned aircraft at a major aerodrome. Also, establishing a relatively low height limit for UAS operations under the Open category would also avoid the need to manage altitude limits.

The Task Force saw that height limitations offered clear benefit in preventing collisions between unmanned and manned aircraft in areas where there were no “drone restricted” zones defined and as a means to assist operators to maintain visual line of sight to their unmanned aircraft.

The Task Force also felt that a height limitation had value in mitigating the risk of a collision in situations where a remote pilot, deliberately or not, flew their unmanned aircraft above the prescribed height without being aware that the flight might then interfere with commercial air traffic. This was thought to be a particular possibility in situations where the remote pilot was not in the immediate vicinity of an airport.

In relation to mitigating collision risk close to a major aerodrome, the Task Force also noted that height limitation could take the form, for example, of:

- A fixed height limit defined for all operations e.g. 120/150m. Given a 150m limit and a 3 degree final approach path, the height limitation would ensure that the unmanned aircraft does not interfere with the airport traffic when it is flying further than about 3 km from the related runway threshold; or

- A height limit below 120/150m defined for authorised operations close to the airport such as related to agricultural operations on adjoining land.

Finally, the Task Force concluded that an overall height limit should be defined for UAS operations everywhere, including those close to airports, as proposed in the following recommendation:

REC.4:

The Task Force recommends that **EASA include performance limitations**, in particular **maximum flight height,** in the future implementing rules concerning **small UAS**.

The Task Force recommends, for **unmanned aircraft with a threshold to be defined** (see REC.6), that one of the following options for a height limitation be considered:

- a “hard-locked” height limitation of 120m (400ft) or150m (500 ft)
- a “soft-locked” height limitation of 50m (165ft) or 70m (230 ft)

6.2.2 Geo-fencing function

The Task Force took note of the proposal included in the “Technical Opinion of EASA” (Ref. 7) that “*to prevent unintended flight outside safe areas and to increase compliance with applicable regulations, a functionality that automatically generates geographical limitations and identification of the unmanned aircraft for certain unmanned aircraft and operation areas should be mandated.*“

In introducing such provisions in the regulatory framework for Europe, a key issue identified by the Task Force was that almost no area in Europe could be defined as a total and definitive “no drone” zone. As a result, the Task Force believed it necessary to balance securing the effectiveness of safety mitigation measures to restrict the unmanned aircraft movements, on the one hand, and providing the flexibility to allow certain users to fly in zones to which those restrictions apply, on the other.

In its analysis of the options to move this debate forward, the Task Force recognised the value of:

- defining “geo-fenced zones” at which UAS operations were to be controlled in some way.
- complementing this zone structure with “geo-limitation functions” and, in particular, geo-fencing, that help to secure that control over the zones.

6.2.2.1 Defining geo-limited zones and levels of protection

The Task Force proposed for geo-limitations of sensitive zones the use of the concept of Prohibited and Restricted zones, which are already defined in the rules of the air (Ref. 2). According to those definitions (see sec. C.2. Definitions), UAS operations in a Prohibited Zone are normally prohibited, whereas in a Restricted Zone, UAS operations are normally subject to specified restrictions.

Based on the information gathered, the Task Force proposed (see C.2. Definitions) the following definitions with regard to the unlocking of geo-limitations in the UAS (geo-fencing, performance limitations functions):

- "hard-locked" geo-limitations are those which the automatic function (geo-limitation function) does not allow to be disabled (un-locked) other than by authorised personnel.
- "soft-locked" geo-limitations are those which the automatic function (geo-limitation function) allows to be disabled (un-locked) by any user.

Given the diverse national considerations which need to be taken into account, the Task Force judged that Member States should have the maximum amount of freedom possible to manage geo-limitations. In particular, Member States need to define the sensitive zones in their Territories, and, what intervention the State wishes to make in the process of authorising operators to override these locking of functions.

This recommended freedom and flexibility to Member States is because:

- are best placed to define which zones need to have some level of protection from UAS operations;
- may wish to define higher levels of protection at some sites compared to other sites;
- will want to choose a method for authorising UAS operations into, or within, these zones that is not only in line with the level of protection required but is also compatible with balancing the resources available in the State with the timeliness and flexibility needed by operators authorised to operate in these zones.

The information provided to UAS operators by Member States on geo-limitations needs to be accurate, up-to-date and expressed in an easily understandable manner by non-aviation qualified operators.

The following Recommendations seemed to have merit:

REC.5:

The Task Force recommends that **:**

- **Member States:**
  - **define the geo-limited zones** within their own Territories, such as airports, and decide on the associated level of protection required;
  - **provide accurate and up-to-date information on geo-limitations** associated with those zones, and express that information in a manner **easily understandable** by non-aviation qualified operators;
  - in the short-term, provide this information **through the most appropriate means** available but enable manufacturers to inform users of their products how to access this information.
- With regard to the longer-term, it is Task Force opinion that a **centralised European database** providing this information (from Member States) merits close consideration.

6.2.2.2 Prohibited Zones

Given that a Prohibited Zone is to be defined by a Designated Authority as a zone in which UAS operations are normally prohibited, the need to use UAS in such zones is expected to be relatively predictable and subject to a hard lock overridden only with the prior authorisation of a Designated Authority.

The Task Force identified a range of options available to Member States when designating the authorities to define zones and to manage operations into and within each zone. For example, a State-licensed aerodrome operator might be designated for the zones related to its aerodrome environment. Each individual zone may have a Designated Authority or the State may determine that a category of zones, such as "Prohibited Zones" should be reserved to the National Aviation Authority, for example, to control.

The large majority (2/3) of stakeholders surveyed about the best way to "*cope with the need for some professional operators to operate in certain cases in zones usually forbidden for drones (e.g. airports)*" suggested that the NAA should issue an exemption to unlock the UAS limit function.

The Task Force saw a number of other options which a Member State might select in order to permit UAS to operate in Prohibited zones:

- the UAS manufacturer provides the UAS operator with the means to override the hard locked geo-limitation, having first verified that the operator is appropriately authorised; or
- the designated authority authorises the operator to operate the UAS, which is either not equipped with a geo-fencing function or equipped with a geo-fencing function that can be disabled by the operator; or

- the manufacturer provides the designated authority with an enduring means of un-locking the geo-fences it is designated for; operators wishing to operate into that zone secure the override from the designated authority.

The Task Force did not assess whether prohibited zones were suited for airports protection. Considering the increasing potential of uses of UAS by aviation undertakings, airport authorities and for other kind of purposes in the vicinity of airports, the Task Force recommends that this question be decided at the Member State level or at a local level.

6.2.2.3 Restricted Zones

Controlling access to Restricted Zones using soft locked geo-limitation functions appeared, to the Task Force, to offer a useful and efficient opportunity for Member States to gain some assurance as to the protection afforded to locations that they might define.

The Task Force felt that UAS users should only be able to override soft locked limits having confirmed that they know the requirements in effect and fully intend to comply with them. As indicated in sec. 5.3.2.1, some leading small UAS manufacturers already offer an electronic means of achieving this control.

The Task Force also noted that the control and recording of soft lock limit override events could be linked to UAS registration where this was introduced either at EU or national level. Though the Task Force did not further investigate how this might be implemented, from the information received, registration (with the meaning specified in sec. C.2. Definitions) was seen by some to be a potential pre-condition for users wishing to participate in the overriding of soft lock limits.

The Task Force took note of the existence of authorised locations for traditional model aircraft flyers near airports. Such situations could be handled through special procedures, where those recreational users would be treated as authorised operators.

The Task Force identified three options for the control of the override of “soft locked” Restricted zone limits:

1. Allowing all users the possibility of temporarily overriding soft locked limits in order to access Restricted Zones; this option might lack credibility as an aviation safety mitigation measure if there is no control, for example through the recording of instances in which a soft geo-fence limit is overridden. Feasibility of such a system of control could be established in the medium to long term.

2. Allowing only users of registered UAS the possibility of temporarily overriding soft locked limits in order to access Restricted Zones. This would require a system linking registration and geo-fencing that will not be available in the short term.

3. Allowing only appropriately authorised users the possibility of temporarily overriding soft locked limits in order to access Restricted Zones; this option would however imply that no UAS operator operating under the Open Category could be permitted to override soft locked

limits and any operation requiring such an override would have to be conducted in the EASA Specific Category.

6.2.2.4 Inclusion Volumes

Whilst in the case of prohibited or restricted zones the focus is on controlling the entry of unmanned aircraft into a zone, the Task Force acknowledged that some drones are delivered with functionalities that allow the user to defines volumes within which drone operations were to be confined.

An inclusion volume is a volume of airspace which geo-fencing functions built into the UAS prevent the unmanned aircraft from leaving.

Making a use of this kind of feature could be valuable to enhance safety for operations to be conducted near airports. It could for example be accepted by regulators as an acceptable means of compliance with regulatory requirements, or as a standard risk mitigation measure in the frame of a risk assessment, or as a condition for operating in certain restricted zones.

6.3 Towards a set of performance based and prescriptive rules, supported by standards

6.3.1 Principles of rulemaking for geo-limitation

Among those stakeholders surveyed, there was majority support for prescriptive rules based on industry standards. Yet, detailed analysis of the responses shows that some confusion was created by the fact that the same question included the issue of rulemaking principles as well as the need for standards.

The Task Force believed that the objective of introducing new methods for more risk-based, proportionate and performance based rulemaking, as proposed in the aviation strategy for Europe set by the European Commission and in the proposed updated Framework Regulation for common rules in the field of civil aviation safety, must be taken into account as rules related to unmanned aircraft are developed.

The Task Force took note of the fact that EASA, in its Technical Opinion, "*proposes an overall flexible safety framework that sets concrete essential safety requirements so that industry can then develop the appropriate standards. Technologies to be embedded in unmanned aircraft cannot be defined or mandated in a prescriptive way at IR level, as the regulatory processes at this level cannot follow the speed of the technological development*" (page 17); the Task Force agreed with this principle.

As mentioned earlier in this report, the Task Force felt that a future regulatory framework addressing geo-limitation functions would need to include product requirements. For safety, security and consistency considerations, the Task Force expected that such requirements would be prescriptive in respect of the geo-limitation functions that certain UAS categories would need to have but not how these functions should be implemented.

It would also seem necessary to precisely identify which UAS, operators or operations should be subject to the proposed regulations with choices made consistently with the definition of the Open, Specific and Certified categories proposed by EASA.

The Task Force was clear that **regulations should not be used to prescribe how geo-limitation functions are implemented from a technological point of view**. In the context of a very innovative industry, with products whose components are not specifically designed for UAS, manufacturers will offer a variety of technological answers that will quickly change over time. Therefore, the legislation should be as future-proof and technology-neutral as possible and avoid overly prescriptive rules.

Finally, standards might be required in order to meet the following objectives:

- Free movement of goods inside the European market
- Interoperability, when there is a need to exchange data between different types of operators
- Minimum levels of quality, when required by safety objectives.

6.3.2 How geo-fencing might be implemented

6.3.2.1 General principles; the need to further define concepts and processes

In outline, the principles of geo-fencing seem rather clear.

In functional terms, the objective is that UAS with geo-fence capability are prevented from entering geo-limited zones and from taking off if already inside, or close to, such a zone. Where there are exceptions to this objective, these are precisely controlled.

In considering how best to allocate the activities required to deliver this objective, the Task Force endorsed the view of many stakeholders which pointed to the following model:

Figure 6-1: Geo-fencing delivery model

Finally, in establishing the scope of application of regulatory provisions for geo-fencing, the Task Force felt that the following considerations needed to be taken into account:

- Some small UAS are operated by recreational and professional users alike
- Whilst a small number of leading UAS manufacturers represent an important share of the small

UAS manufacturing market, there are many start-ups and other small to medium sized enterprises in the market notably catering to the specific needs of construction, agriculture, media and other professions

- There will be legitimate situations in which UAS operators will need to fly in Restricted Zones (and to lesser extent, in Prohibited zones) subject to proper authorisation and compliance with applicable requirements.

6.3.2.2 Technological and market feasibility

From the survey consultation, the Task Force found that a number of small UAS manufacturers had already implemented geo-limitation functions in their products. A small number expected that the cost impact of introducing geo-limitation functionality to their product would be high. The majority estimated that such functionality could be implemented in less than one year.

However, a more in-depth look at the answers indicates that most stakeholders sensibly argued that they were not able to give precise answers about cost impact and required time to the market as long as the regulatory requirements themselves were not established.

As indicated in sec. 5.3.2.1, the claimed nominal accuracy of sensors for position determination seems accurate enough, however, performance of the position determination is highly dependent on the environment and could be impaired in the presence of obstacles, especially in cities. Yet, considering the nature of the contribution of a geo-fencing system to risk mitigation, the fact that it would not be a unique 100% proof measure, and the fact that lateral and vertical boundaries of protection zones can be set taking into account inaccuracy and imprecision of data, they felt that current technology is satisfactory for a geo-fencing system to be developed.

Furthermore, from consultation with industry, it appeared that there was no fundamental technological barrier that would prevent the introduction of geo-fencing provisions in future European regulations, as long as those regulations do not include all small UAS, and no airworthiness certification or equipment qualification are mandated, as such requirements would be disproportionate for this segment of UAS, and operational limitations can be expected to compensate for the lack of those requirements.

Discussions also arose about the volume of data that need to be stored for geo-fencing functions and its impact on UAS design; some of those providing information to the Task Force argued that this would not be a problem, whereas others feared an increase in the price of the products depending on the number, or complexity, of the zones.

Considerations about recreational consumer acceptance of safety devices that would limit the capabilities of their product or enforce regular up-dates of geographical databases were mentioned but not analysed in depth. The Task Force believed that those considerations should not call into question the validity of mitigation measures that would increase the safety of aviation and air transport.

6.3.3 Required rules

As already explained, in the context in which it was working, the Task Force chose to identify the issues that regulations and standards should cover and then to recommend options that can be currently considered by Member States, some of which might be eventually part of EU rules.

The Task Force took the view that the following issues needed to be addressed in choosing a regulatory approach:

- What UAS geo-limitation function is to be required, and how such functions are to be secured for UAS not only designed and manufactured in Europe but also those from elsewhere in the World.
- How the geographic data defining geo-limited zones is to be generated, distributed and kept up to date.
- How user un-locking of hard-lock and soft-lock geo-limitations is to be managed and whether there is an associated role for a registration scheme.
- What the enforcement measures related to geo-limited zones should be, how enforcement is to be delivered and whether there is an associated role for a tracking and identification scheme.
- How, in introducing geo-limitations, a pathway towards a UAS traffic management system or, ultimately, a total aircraft traffic management system might be defined.

6.3.3.1 Rules and responsibilities concerning Member States

As mentioned earlier, the Task Force believed that the definition of geo-limited zones, their associated conditions and the arrangements to manage such zones should be reserved to Member States who, in turn, might designate others to undertake certain duties on their behalf.

In that definition of the geo-limited zones, the Task Force believes that Member States should follow the classification proposed in sec. 6.2.2, and this should be included in EU regulations.

A number of recommendations to Member States have already been proposed in previous sections.

Also, although not discussed in detail, the Task Force thought it likely that Member States would expect Aeronautical Information Service Providers to take on an important and specific role in publishing, in a digital format, the geographical data related to geo-fencing. This was the view of respondents to the Task Force survey who see a role for AISPs in producing and delivering geo-limitation data. Such a view would also be consistent with the draft “RPAS ATM CONOPS” document presented to JARUS, appendix Geo-fencing for ATM, section Aeronautical Information Services: “ *[Aeronautical Information Services]… are responsible for the compilation and distribution of all aeronautical information necessary to airspace users*”.

6.3.3.2 Rules that might apply to products and manufacturers

There is a clear need, as a first step, to define which UAS would be required to comply with any rules. The need to **keep rules technology-neutral** and to provide the UAS manufacturing industry with appropriate scope to generate solutions and to propose any necessary technology standards was indicated as was the need for any product standards to be applicable to UAS operating in Europe, not just those produced by European manufacturers.

Future implementing rules will need to define essential airworthiness requirements for UAS which, as previously indicated, are not expected to mandate any certification or qualification process for the small UAS segment addressed in this report. To ensure some basic safety design characteristics, rules will have to define the relevant requirements as part of the product legislation, with Regulation (EC) No 765/2008 (Ref. 3) and Decision No 768/2008/EC (Ref. 4) as the current central ones.

On the issue as to which UAS should be required to be equipped with geo-limitation functions, the Task Force felt that the idea of dividing UAS operations under the Open Category into subdivisions based on risk from differing levels of possible kinetic impacts should be considered. Even if the Task Force agreed that ideally this division should take into account the possible collision consequences rather than just mass, taking for example speed, frangibility and shape of the unmanned aircraft structure, there was an argument for choosing for simplicity a criteria based on the mass.

The Task Force was aware that mass thresholds within the EASA Open Category had been debated with:

- 0.25kg being termed “harmless” in respect of damage to people on the ground;
- 2kg being a significant discriminator given that 98% of the current UAS population was at or below this mass, and considered by many a potential threshold for damage to CAT aircraft as it is within the current aircraft and engine certification requirements for bird strike. However, its applicability to UAS must be confirmed by evidence from research initiatives (like those indicated in APPENDIX G: UNMANNED/MANNED AIRCRAFT COLLISION RISK INFORMATION); and
- 25kg being the upper limit of the Open Category.

Therefore, the Task Force considered that no geo-fencing capability should be required for UAS below a particular mass, that mechanisms to encourage such capability in heavier unmanned aircraft would be worth pursuing and that making such functionality mandatory for the heavier unmanned aircraft would appear to have merit from the perspective of taking a precautionary approach to mitigating the risk of a collision with a manned aircraft pending more definitive information on this risk being produced. The correct choice of the relevant mass thresholds should be informed by a good understanding of the collision risk noting that the population of UAS contributed to the likelihood of the event and the weight to the consequences.

REC.6:

The Task Force recommends that, if **geo-limitation functions** for certain UAS are mandated:

- the mandate shall apply to **all products for a given subcategory within the "Open" category.**
- **EASA**, **defines a mass threshold**, above which UAS sold or imported in Europe shall **integrate geo-limitation functions**;
- this threshold should **not exclude the majority of UAS sold for recreational use** and should constitute an **incentive to put onto the market lighter UAS**, representing less risk to manned aircraft.

6.3.3.3 Rules that might apply to remote pilots and operators

A significant majority of stakeholders (about 90%) who responded to the survey question "*who should carry the responsibility/liability of the safe use of drones equipped with "geo-fencing" functionality?*" mentioned the operator; indeed most mentioned only the operator. Those who did not mention the operator, but cited the data provider, the State or the manufacturer, were mainly operators and ANSPs.

The responsibility of the operator is clearly stated in the proposed future common rules amending EU Regulation 216/2008 (see. 1(a) and 2.4 of annex IX) (Ref. 5) and, provided this approach is sustained, the Task Force does not believe that there is a need for further rules.

Nonetheless, should a State decide to make mandatory geo-limitation functions, then there will be a need to ensure that operators are made aware that these functions are merely an aid to safe operation but do not absolve the operator of their responsibilities – including responsibility, for example, to keep any associated UAS database of geo-limited zones up to date.

In the context of enforcement, Member States may also wish to make provision in national law for specific fines and penalties for UAS operators who do not comply with the requirements and especially those who disable geo-limitations without appropriate authorisation.

REC.7:

The Task Force recommends that, if **geo-limitation functions** for certain UAS are mandated, then the following requirements for **UAS operators** are established in the rules:

- Certain UAS classes shall not be operated unless they are equipped with those functions;
- A UAS operator can shall not un-lock geo-limitations in order to access zones;
- A UAS operator is responsible for regularly updating their geo-limitations database;
- The scope of the learning objectives for remote pilot competence must include awareness of their responsibility to respect geo-limitations, and an adequate knowledge

of the use of geo-limitation functions.

6.3.4 Requirements for existing products and homebuilt products

6.3.4.1 Retrofitting existing UAS

In examining the matter of retrofitting geo-fencing functionality to UAS already operating in Europe, the Task Force noted the following considerations:

- The average lifetime of UAS products is relatively short
- Retrofitting may, in many cases, be difficult or impossible.
- Retrofit of mass-market consumer products are not a common practice.

Although the number of small UAS operating currently in Europe is difficult to assess, the information considered by the Task Force suggested that the figure could be as high as 3.3 million (see APPENDIX G: UNMANNED/MANNED AIRCRAFT COLLISION RISK INFORMATION). On this basis, depending on the kind of UAS concerned by geo-fencing requirements the question of retrofit might affect several hundreds of thousands if not millions units across the European States.

In their response to the survey, 20% of respondents considered that no retrofit provision should be put in place because it would not be possible and 33% felt that it was unnecessary given that UAS are expected to have a short useful lifetime (1 to 4 years although there is not the data available to support the reliability of this assertion).

Some manufacturers responding to the survey commented that retrofit of geo-fencing functionality would be virtually impossible for their products; others that it could be done only with a firmware update. For the former group, imposing a retrofit campaign would cause users to ignore the retrofit campaign. Therefore, the Task Force believes that the objective might not be reached.

Besides, given the lack of data on the associated costs and benefits, the Task Force could not recommend a retrofit obligation for geo-limitation functions.

REC.8:

The Task Force recommends that future EU regulations:

- Do not seek to enforce a general retrofit obligation for geo-limitation functions.
- Provide a time between entry in force of requirements for new products and entry in force of requirements for all products in service; this period of time should consider a right balance between safety needs and protection of consumer rights.

6.3.4.2 Applicability to homebuilt products

In the questionnaire, stakeholders were invited to comment on the feasibility of including homebuilt UAS in any regulatory framework for geo-limitations. The results could be classified into the following categories:

- The requirements must be the same for retail or homebuilt UAS; any geo-limitation requirement applying to one should apply to the other (~30%; mainly NAAs and ANSPs)
- Requirements should be the same for both kinds of UAS, but geo-fencing should not be required for either (7%; manufacturers)
- Applying requirements to homebuilt products would not be feasible (~30%; mainly UAS manufacturers and operators)
- Such a requirement should be feasible for COTS UAS autopilots, but not for all homebuilt UAS; the issue of open autopilot software code is not easy to tackle (8%)
- Other replies (25%) did not provide a clear response but roughly half of these respondents suggested that requiring geo-limitations might be envisaged and half that other mitigation means should be found for this category of unmanned aircraft.

The Task Force believed that feedback from the respondents to the questionnaire gave a good view about the several challenges and difficulties linked to the question of applicability to homebuilt UAS and COTS autopilots.

Other comments noted were:

- Operation of homebuilt UAS should be more restricted than retailed UAS
- We should rely on prosecution and strengthening of punitive rules rather than geo-fencing for small series and homebuilt products
- Rely on the responsibility of the small series and homebuilt products user.

Finally, the Task Force considered the case of model aircraft and noted that EASA, in its Technical Opinion, considers that "*there is the risk that technologies tend to be mandated because they are available. The consequence would be additional costs and efforts for manufacturers and operators, therefore every mandated requirement should be well-justified. Models are normally manually controlled and do not carry a global navigation satellite system (GNSS) unit or similar on board."* EASA also notes that *"[model aircraft] operations are rarely seen as aviation and have limited effect on traditional aviation and the safety record under the current regulatory regime seems to be acceptable. In case these operations are not covered within the 'open' category, it is intended to 'grandfather' the national or local arrangements".*

REC.9: The Task Force recommends the following approach for model and homebuilt UAS:

- Grandfather rights for model aircraft flying activities, consistent with current national or local arrangements.
- Further explore the need for mandating product requirements including geo-fencing capacities for COTS elements of guidance-navigation-control of UAS

6.4 The need for standards

6.4.1 Aspects to standardise

Most organisations who provided information to the Task Force recognised that, apart from some manufacturer proprietary standards, there were no UAS geo-limitation standards in place at the time of writing.

Considering stakeholder consultation, the following main aspects were indicated among the main candidates for standardisation:

- Type and characteristics (e.g. size and shape) of geo-limited zones.
- Geographical data, exchange format and a geographical reference system. For data exchange format AIXM is deemed the most suitable standard, as it is the one currently in use for that purpose in aviation. For geographical reference system WGS84 was indicated as the most appropriate, considering it is the geo-reference standard for aeronautical information (ICAO annex 15)
- Data presentation; mechanisms to display geo-limitations and alerts to the pilot; definition of required new symbology.
- Geo-limitation functions performance: data accuracy, reliability, tolerance, integrity, e.g. concerning position data. The testing of such performance was identified as required to be standardised.
- Performance requirements regarding security (data encryption,…)

A standards body mentioned the need for an overall geo-limitations concept of operations (why, how and for what; see also 6.3.2.1) and of clarification on the functions such as warning to pilot or alert to someone else.

An NAA stressed the need to develop Minimal Operational Performance Standards[1], which provided the information needed to understand the rationale for equipment characteristics and requirements stated.

6.4.2 Proposed approach to standards

The Task Force was not aware of any standards being produced specifically on geo-limitations apart from a geo-fencing Appendix in a draft RPAS ATM CONOPS produced under JARUS auspices (ref. Ref. 8).

The Task Force saw a number of key challenges in developing the requested standards:

- defining and delivering to SMOs and international bodies focused mandates and precise terms of reference
- prioritising their work and managing parallel work programmes and task sequencing
- improving the efficiency of the standard setting process in order to support the European regulatory process and address the needs of UAS industry, which includes a dynamic industrial fabric composed of small and medium enterprises.

The Task Force was mindful that its remit was focused on UAS in the Open Category of EASA's Technical Opinion where no certification for UAS is envisaged. These UAS are mass-produced, low-cost, rapidly innovating consumer products. They are designed and manufactured using components that are not specifically designed for this market that do not meet stringent airworthiness requirements.

As a result, the Task Force believed that it was not, at this stage, appropriate to mandate standards for system or software architecture, components design or, more widely, how to technically implement geo-limitation functions.

This proposed approach would not prevent the definition of basic operational performance requirements, which would probably be necessary for implementation of the conformity assessment procedures foreseen by decision No 768/2008/EC on a common framework for the marketing of products, harmonised standards.

[1] A MOPS provides standards for specific equipment(s) useful to designers, manufacturers, installers and users of the equipment. The word "equipment" used in a MOPS includes all components and units necessary for the system to properly perform its intended function(s). The MOPS provides the information needed to understand the rationale for equipment characteristics and requirements stated. The MOPS describes typical equipment applications and operational goals and establishes the basis for required performance under the standard. Definitions and assumptions essential to proper understanding are provided as well as installed equipment tests and operational performance characteristics for equipment installations. Compliance with these standards is recommended as one means of assuring that the equipment will perform its intended function(s) satisfactorily under all conditions normally encountered in routine aeronautical operations. A MOPS may be implemented by one or more regulatory document and/or advisory document and may be implemented in part or in total. Source : RTCA.

It is important to highlight that any standards must be a good fit to the characteristics of the small UAS business and be able to achieve tangible results that can be implemented by the small UAS industry in the short timeframe that this particular business segment requires.

6.4.3 Role of ESOs and SMOs

The Task Force acknowledged that European Standards Organisations (ESO: CEN-CENELEC, ETSI), and industry standards making organisations (SMOs, like EUROCAE, ISO, RTCA, SAE, etc.) will be involved in the generation of standards for geo-limitations.

European standards are adopted by the European standardisation organisations (ESOs), namely CEN, CENELEC and ETSI (Regulation (EU) no 1025/2012 on European standardisation). EUROCAE is recognised by the European Commission as a competent body to collaborate with the European Standardisation Organisations in other field of civil aviation (SES interoperability regulation). Besides, this SMO is devoted to civil aviation; therefore, it should play a major role in the standardisation process.

REC.10: The Task Force recommends, as being the highest priorities, that EUROCAE:

- develops Minimum Operational Performance Standards for the geo-limitation functions of UAS, taking into account JARUS work.
- is tasked to work in relation with a European Standardisation Organisation, in order to incorporate those standards in the scope of the 'Community harmonisation legislation' within the meaning of Regulation (EC) 765/2008

7 Conclusions, Recommendations and Actions

7.1 Conclusions

This Task Force was established to focus on the collision risk in the major aerodrome environment between small UAS (mainly operating under the Open category, as defined by EASA in Ref. 7) and large commercial aeroplanes.

Since the start of this Task Force, it was recognised that whilst there are opportunities to manage the risk of a collision between manned and unmanned aircraft through product design, operating practices and regulation, too little is known about the likelihood or consequences of such a collision to optimise those opportunities. Thus, the Task Force concluded that further research should be promoted at EU level to better understand the actual magnitude of the risk and, consequently, facilitate regulatory impact assessments that support the decision making on the most appropriate measures to minimise that risk. In this respect, the improvement of occurrences reported and related data quality is considered paramount.

In respect of mitigating the collision risk in the major airport environment, the Task Force concluded that measures should continue be taken to assist cooperative UAS users to avoid the aerodrome environment and to deny access to non-cooperative users.

Cooperative measures available today include education and information about the operating environment for UAS operators supplemented by safety limiters built into UAS that constrain the UAS geographic position, height, speed or distance from the operator. Non-cooperative measures like enforcement means are under development and are not the focus of this Task Force.

The work of this Task Force focused on the cooperative measure of “geo-limitations”, defined in the context of this work as limitations applied to a UAS to constrain the unmanned aircraft access to or exit from a defined zone or airspace volume. As part of the assessment of geo-limitations, the Task Force has examined the main aspects related to the “geo-fencing” and “performance limitation” functions that enable the UAS to automatically comply with the defined geo-limitations.

Since the beginning of its work, the Task Force identified the need to establish globally agreed terminology that includes “geo-limitation” and related terms (e.g. “geo-fencing”), as well as the need to develop the associated concepts, the main of which the Task Force believes to have captured in this report. The definitions of the key concepts used in this report are included in Appendix C (sec. C.2. Definitions)

Having surveyed technology solutions and current regulatory material and thinking, and having discussed the main identified “geo-limitation” concepts, the Task Force reached a number of conclusions, described in the previous chapters, of which the following ones are highlighted here:

- The Task Force recognised that geo-limitation solutions cannot prevent malevolent behaviour, a rationale that applies to many of the Task Force recommendations. Thus, the Task Force focused on the prevention of the unintentional breach of limits.

- The Task Force noted that EASA's work to define rules at EU level for UAS operations had yet to conclude and would, in fact, take note of this report. The current lack of information on a number of aspects, prevents the production of the required impact assessments. . In this context, the Task Force assessed the foreseeable geo-limitation solutions, their benefits and limitations, what would be needed to make them possible and what further work was needed to accelerate implementation of those solutions.

- With regard to geo-limitations and their implementation, the Task Force identified as main elements:

  - Provision to UAS operators of up to date, accurate and easily understandable information that helps them to determine restrictions or requirements in effect at the location where they want to operate. This information could be more easily provided to UAS operators by integrating it into the remote pilot station or make it accessible through a standalone mobile application.

  - UAS performance limitations, including height or altitude limitation and range (horizontal distance to the remote pilot station or to the take-off point) limitation. The Task Force favoured height limitation as the main performance limitation that can effectively contribute to mitigate the risk of collision not only in the vicinity of aerodromes.

  - Requirement for UAS designs to include built-in features that warn the remote pilot when the unmanned aircraft is starting up in, or approaching to, a zone subject to UAS restrictions.

  - Requirement for UAS to incorporate geo-fencing, which requires position-sensing and control functions, sufficient to comply with any restrictions on where and when a UAS might operate.

- The Task Force concluded that, when establishing geo-limitations of sensitive zones Member States use the concept of Prohibited and Restricted zones, as defined in the rules of the air.

- To respect these geo-limitations through the use of automatic functions (i.e. geo-fencing, performance limitation functions) and, at the same time, allow the removal of such limitations for authorised operators, the Task Force identified the need to define "hard-locked" and "soft-locked" geo-limitations and the corresponding un-locking processes.

- When regulating the use of such automatic functions the Task Force noted the need to keep rules technology-neutral and to provide the UAS manufacturing industry with appropriate scope to generate solutions and to propose any necessary technology standards. Besides, product requirements and standards must be applicable to UAS operating in Europe, and not just those produced by European manufacturers.

- When mandating automatic geo-limitation functions, the Task Force concluded that the mandate should apply to all products for a given subcategory of operations within the Open category, those sub-categories being defined as not to exclude the majority of UAS sold for recreational use. Mechanisms to grant exemptions in order to cope with specific needs and situations might be necessary.

- With regard to mandating a retrofit of these automatic functions to the existing UAS fleet, the Task Force concluded that, considering the relatively short average lifetime of UAS products and difficulties (or impossibility) of implementation, retrofitting should not be mandated and, instead, further operational limitations should be considered where appropriate.

- Regarding model aircraft, the Task Force concluded that current rights for their operation granted by Member States should be grandfathered. As Member States are best placed to deal with this particular segment of Unmanned Aviation, no “geo-limitation” functions should be required for that segment at European regulations level. Besides, in most cases, the technology involved in model aircraft would not make it feasible to implement such automatic geo-limitation functions.

- For homebuilt UAS, the Task Force concluded that requirements similar to those for consumer-retailed UAS should apply in terms of, at least, pilot competencies, registration and electronic identification. Similarly, the COTS guidance navigation control components of homebuilt UAS should be subject to the product requirements applicable to UAS that are subject to geo-limitation function requirements.

- Regarding industry standards, the Task Force identified a number of “geo-limitation” related aspects as candidates. The Task Force identified EUROCAE as the organisation best suited to lead the European effort to develop standards working in coordination with ESOs and other industry standard bodies. Any standards must be a good fit to the characteristics of the small UAS business and be able to achieve tangible results that can be implemented by the small UAS industry in the short timeframe that this particular business segment requires.

7.2 Recommendations and Actions

Recommendations and related actions generated in the previous chapters are included below:

REC.1:

The Task Force recommends the following actions for EU and Member States to improve the reporting of occurrences involving small UAS:

- to educate operators/users of small UAS in the use of the occurrence reporting system available in Member States.
- to educate European and other manufacturers of small UAS to implement and maintain a reporting system, and encourage them to inform EU / Member States of their findings.
- to seek cooperation of small UAS manufacturers and operators (potentially via national associations) to improve authorities' knowledge of the small UAS fleet and their operations in Europe.

REC.2: The Task Force recommends that, at EU level:

- An effort is made to **understand the current and projected likelihood of a collision in Europe between unmanned and manned aircraft**. Key points of focus should be fixed wing aircraft arriving and departing major aerodromes; fixed wing aircraft at high level away from aerodromes; rotary-wing aircraft at low levels away from aerodromes.
- A **programme of research should be set up**, based on the **recommendations of the EASA "Drone Collision" Task Force**, to establish the consequences of a manned aircraft/small unmanned aircraft collision and share the results to inform future safety measures required to secure safe UAS operation.

REC.3: The Task Force recommends that **JARUS** give the highest priority to the **development of a unified geo-limitation concept of operation** that prevent unauthorised use of small UAS near airports with commercial traffic, heliports, and other aerodromes, focussing on the simplest options that can be implemented in the short or medium term.

REC.4:

The Task Force recommends that **EASA include performance limitations**, in particular **maximum flight height,** in the future implementing rules concerning **small UAS**.

The Task Force recommends, for **unmanned aircraft with a threshold to be defined** (see REC.6), that one of the following options for a height limitation be considered:

- a "hard-locked" height limitation of 120m (400ft) or150m (500 ft)
- a "soft-locked" height limitation of 50m (165ft) or 70m (230 ft)

REC.5:

The Task Force recommends that **:**

- **Member States:**
  - **define the geo-limited zones** within their own Territories, such as airports, and decide on the associated level of protection required;
  - **provide accurate and up-to-date information on geo-limitations** associated with those zones, and express that information in a manner **easily understandable** by non-aviation qualified operators;
  - in the short-term, provide this information **through the most appropriate means** available but enable manufacturers to inform users of their products how to access this information.
- With regard to the longer-term, it is Task Force opinion that a **centralised European database** providing this information (from Member States) merits close consideration.

REC.6:

The Task Force recommends that, if **geo-limitation functions** for certain UAS are mandated:

- the mandate shall apply to **all products for a given subcategory within the "Open" category.**
- **EASA**, **defines a mass threshold**, above which UAS sold or imported in Europe shall **integrate geo-limitation functions**;
- this threshold should **not exclude the majority of UAS sold for recreational use** and should constitute an **incentive to put onto the market lighter UAS**, representing less risk to manned aircraft.

REC.7:

The Task Force recommends that, if **geo-limitation functions** for certain UAS are mandated the following requirements for **UAS operators** are established in the rules:

- Certain UAS classes shall not be operated unless they are equipped with those functions;
- A UAS operator is responsible to regularly update the geo-limitations database;
- The scope of the learning objectives for remote pilot competence must include the awareness on his or her responsibility to respect geo-limitations, and an adequate knowledge on the use of geo-limitation functions.

REC.8:

The Task Force recommends that future EU regulations:

- Do not seek to enforce a general retrofit obligation for geo-limitation functions.
- Provide a time between entry in force of requirements for new products and entry in force of requirements for all products in service; this period of time should consider a right balance between safety needs and protection of consumer rights.

REC.9:

The Task Force recommends the following approach for model and homebuilt UAS:

- Grandfather rights for model aircraft flying activities, consistent with current national or local arrangements.
- Further explore the need for mandating product requirements including geo-fencing capacities for COTS elements of guidance-navigation-control of UAS

REC.10:

The Task Force recommends, as being the highest priorities, that EUROCAE:

- develops Minimum Operational Performance Standards for the geo-limitation functions of UAS, taking into account JARUS work.
- is tasked to work in relation with a European Standardisation Organisation, in order to incorporate those standards in the scope of the 'Community harmonisation legislation' within the meaning of Regulation (EC) 765/2008

APPENDIX A: TASK FORCE TERMS OF REFERENCE

A1 Objective and Scope

The main objective of this Task Force is to produce a **set of recommendations on geo-limitation and related aspects** (e.g. UAS performance limitations, data sources, related standards, …) and the **way forward** for their implementation.

The task Force will produce a report including the recommendations based on the assessment of:

- Current understanding of risk of conflict with manned aircraft
- Survey of national measures, state-of-the-art solutions and trends.
- Regulatory approaches and standardization options.

The focus of this Task Force is on:

- **Unmanned aircraft** in the **"Open" category**, where Geo-limitation is, in principle, **most needed**, and which requires the **most urgent regulatory and standardization actions.**
- Addressing the risk of **conflict with other airspace users**, in particular, **commercial air transportation** (CAT), thus, "geo-limited" zones being considered are aerodromes, in particular **major airports**.
- Unintentional breach of limits associated to those "geo-limited" zones. Therefore, ill-intentioned breach of such limits are out of the scope of this Task Force.

Also, security, privacy, or environmental aspects are not addressed by this Task Force (although some recommendations might also be applicable to these aspects)

A2 Sub-tasks

The Task Force work is organised in the following sub-tasks:

- ST0: Task Force Coordination (including stakeholders' consultation) – Led by EASA
- ST1: Evaluation of risk of collision with manned aircraft – Led by EASA
- ST2: Survey of national measures and state-of-the-art solutions – Led by Trafi
- ST3: Assessment of performance-based objectives and standards – Led by DGAC
- ST4: Task Force Report (production and consolidation) – Led by UK CAA and EASA

A3 Overall Schedule

The Task Force is kicked-off on **April 4th, 2016**. The deadline for report finalisation was extended to the end of August, 2016.

APPENDIX B: TASK FORCE MEMBERSHIP

Organisation	Country	Name	Role	Contact email
EASA	European Union	Mr. Pascal MEDAL	Chief Engineer *Task Force Leader*	pascal.medal@easa.europa.eu
EASA	European Union	Mr. Daniel COBO-VUILLEUMIER	RPAS Technologies Expert *Task Force Secretary*	Daniel.COBOVUILLEUMIER@easa.europa.eu
DGAC/DSAC	France	Mr. Richard THUMMEL	Deputy Director *Task Force Member*	richard.thummel@aviation-civile.gouv.fr
Trafi	Finland	Mr. Jukka HANNOLA	Chief Advisor to Director General of Civil Aviation *Task Force Member*	Jukka.Hannola@trafi.fi
CAA	UK	Mr. Padhraic KELLEHER	Head of Intelligence, Strategy and Policy *Task Force Member*	Padhraic.Kelleher@caa.co.uk

ULC, the NAA of Poland, was initially a member of the Task Force but was finally unable to participate.

APPENDIX C: GLOSSARY

C.1. Acronyms

ADS-B	Automatic Dependent Surveillance – Broadcast
AGL	Above Ground Level
AISP	Aeronautical Information Service Provider
AIXM	Aeronautical Information Exchange Model
ANSP	Air Navigation Services Provider
ARP	Aerodrome Reference Point
ASSURE	Alliance for System Safety of UAS through Research Excellence
ATC	Air Traffic Control
ATZ	Aerodrome Traffic Zone
ATM	Air Traffic Management
BVLOS	Beyond Visual Line Of Sight
C2	Command and Control
CAA	Civil Aviation Authority
CASA	Civil Aviation Safety Authority (Australia)
CAT	Commercial Air Transport
CEN	*Comité Européen de Normalisation*
CENELEC	*Comité Européen de Normalisation Électrotechnique*
CNS	Communications, Navigation, Surveillance
CONOPS	Concept of Operations
COTS	Commercial Off The Shelf
CTR	Control Zone
DAA	Detect And Avoid
DGAC	*Direction Générale de l'Aviation Civile*
EASA	European Aviation Safety Agency
EC	European Commission
ECR	European Central Repository
EID	Electronic Identification Device
ERSG	European Remotely Piloted Aircraft Systems Steering Group
ESO	European Standards Organisation
ETSI	European Telecommunications Standards Institute
EU	European Union
EUROCAE	European Organisation for Civil Aviation Equipment
EVLOS	Extended Visual Line Of Sight
FAA	Federal Aviation Administration (United States of America)
FOCA	Federal Office of Civil Aviation (Switzerland)
GCS	Ground Control Station
GEO	Geospatial Environment Online®
GPS	Global Positioning System
GNC	Guidance, Navigation, Control
GNSS	Global Navigation Satellite System
GSM	Global System for Mobile Communications

HEMS	Helicopter Emergency Medical Services
HMI	Human Machine Interface
ICAO	International Civil Aviation Organisation
IFR	Instrumental Flight Rules
IMU	Inertial Measurement Unit
ISO	International Organisation for Standardization
JARUS	Joint Authorities for Rulemaking on Unmanned Systems
MALE	Medium Altitude Long Endurance
MEMS	Micro-Electro-Mechanical Systems
MOPS	Minimal Operational Performance Standards
MS	(EASA) Member State
NAA	National Aviation Authority
NASA	National Aeronautics and Space Administration
NOTAM	Notice to Airmen
PSR	Primary Surveillance Radar
R&D	Research and Development
RC	Radio Control
RFID	Radio Frequency Identification
RPAS	Remotely Piloted Aircraft System
RTCA	Radio Technical Commission for Aeronautics
SAE	Society of Automotive Engineers
SAR	Search and Rescue
SBAS	Satellite-Based Augmentation System
SERA	Single European Rules of the Air
SES	Single European Sky
SESAR	Single European Sky ATM Research
SJU	SESAR Joint Undertaking
SME	Small and Medium Sized Enterprise
SMO	Standard Making Organisation
SSC	(EU) Single Sky Committee
SSR	Secondary Surveillance radar
SW	Software
SWaP	Size, Weight and Power
TFR	Temporary Flight Restriction
TMA	Terminal Manoeuvring Area
UAV	Unmanned Aerial Vehicle
UAS	Unmanned Aircraft System
UASSG	Unmanned Aircraft System Study Group
UK	United Kingdom
US	United States (of America)
UTM	UAS Traffic Management
VFR	Visual Flight Rules
VLOS	Visual Line of Sight
WGS	World Geodetic System

C.2. Definitions

The following definitions are used in the context of this Report:

Drone: The term drone is used by the general public to refer to an "Unmanned Aircraft".

Geo-fence: A geographical fence or "geo-fence" is a two-dimensional virtual boundary defined by geographical coordinates that divides a real world volume in two parts.

Geo-fencing: Function to make a UAS comply automatically with one or more geo-limitations based on geo-fences. The function can be implemented only in the UAS or distributed between the UAS and an external system (e.g. UTM system).

Geographic position: A specific point on the Earth's surface.

Geo-limitation: A Geographical limitation or "geo-limitation" is any limitation applied to a UAS to constrain the unmanned aircraft access to or exit from a defined zone or airspace volume ("geo-limited zone").

A geo-limitation can be constructed with elements of the following types:

- Geo-fence
- Performance limitation

A geo-limitation can be delivered to the UAS operator in two ways:

- Information provision, which can be done via different interfaces, e.g. physical map, web-based map, portable device application, …
- Automatic function based on geo-fencing and/or performance limitation implemented in the UAS (completely or partially through the intervention of an external system like a UTM system)

Geo-limited zone: A geographically limited zone or "geo-limited" zone is any zone or airspace volume where a geo-limitation is defined in accordance with the "sensitivity" classification of that zone. The zones being considered in this report are the "Restricted" and "Prohibited" zones.

Hard-locked geo-limitation. Geo-limitation that the automatic function (geo-limitation function) does not allow to be disabled (un-locked) or only by authorised personnel.

Identification: Identification is a means for a third party to positively identify an individual unmanned aircraft in flight without direct physical access to that aircraft; it requires that the unmanned aircraft be capable of interfacing with third party systems.

Inclusion Zone: A zone within which UAS operations are permitted and confined.

Performance limitation: A performance limitation is a constraint applied to a UAS operational capability. Such limitations can, for example, relate to height, speed, endurance or distance from the operator.

Prohibited Zone: Airspace of defined dimensions, above the land areas or territorial waters of a State, within which the flight of aircraft is prohibited.

Registration: Registration is a means for a third party to positively identify an individual unmanned aircraft and its owner by direct physical inspection of the aircraft; it does not require capability to be built into the UAS.

Remotely Piloted Aircraft: An unmanned aircraft which is piloted from a remote pilot station.

Remotely piloted aircraft system (RPAS). A remotely piloted aircraft, its associated remote pilot station(s), the required command and control links and any other components as specified in the type design.

(Remote) Pilot competence: Combination of skills, knowledge and attitudes required to perform a task to the prescribed standard.

Restricted Zone: Airspace of defined dimensions, above the land areas or territorial waters of a State, within which the flight of aircraft is restricted in accordance with certain specified conditions.

Small unmanned aircraft: Any unmanned aircraft with a maximum take of mass of less than 25 Kg.

Small unmanned aircraft system: Any unmanned aircraft system (UAS) including a small unmanned aircraft.

Soft Locked geo-limitation. Geo-limitation that the automatic function (geo-limitation function) allows to be disabled (un-locked) by any user, under specific conditions.

Third Party: A third party is an individual or organisation other than the operator of the UAS .

Tracking: Tracking refers to the act of continuing identification of an UAS and following of its localisation over a period of time.

Unmanned Aircraft: Aircraft operated, or designed to be operated, without a pilot on board.

Unmanned Aircraft System (UAS): System comprising unmanned aircraft and any equipment, apparatus, appurtenance, software or accessory that is necessary for its safe operation.

Warning: A geo-limitation function built into a UAS that alerts the remote pilot about the corresponding geo-limitation.

Zone: Airspace of defined dimensions, above the land areas or territorial waters of a State, within which the flight of aircraft is restricted in accordance with certain specified conditions.

APPENDIX D: REFERENCES

Ref. 1. REGULATION (EC) No 216/2008 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 20 February 2008 on common rules in the field of civil aviation and establishing a European Aviation Safety Agency, and repealing Council Directive 91/670/EEC, Regulation (EC) No 1592/2002 and Directive 2004/36/EC.

Ref. 2. COMMISSION IMPLEMENTING REGULATION (EU) No 923/2012 of 26 September 2012 laying down the common rules of the air and operational provisions regarding services and procedures in air navigation and amending Implementing Regulation (EU) No 1035/2011 and Regulations (EC) No 1265/2007, (EC) No 1794/2006, (EC) No 730/2006, (EC) No 1033/2006 and (EU) No 255/2010.

Ref. 3. REGULATION (EC) No 765/2008 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 9 July 2008 setting out the requirements for accreditation and market surveillance relating to the marketing of products and repealing Regulation (EEC) No 339/93.

Ref. 4. DECISION No 768/2008/EC of the European Parliament and of the Council of 9 July 2008 on a common framework for the marketing of products, and repealing Council Decision 93/465/EEC

Ref. 5. COM(2015) 613 final - Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on common rules in the field of civil aviation and establishing a European Union Aviation Safety Agency, and repealing Regulation (EC) No 216/2008 of the European Parliament and of the Council.

Ref. 6. Riga Declaration on Remotely Piloted Aircraft (drones) "Framing the Future of Aviation". Riga. 6 March 2015.

Ref. 7. EASA Technical Opinion. Introduction of a regulatory framework for the operation of unmanned aircraft. European Aviation Safety Agency (EASA). 18 December 2015.

Ref. 8. RPAS ATM CONOPS document draft version 2 developed by EUROCONTROL for JARUS (not yet published)

Ref. 9. “Prototype” Commission Regulation on Unmanned Aircraft Operations. EASA. 22 August 2016.

Ref. 10. “Drone Collision” Task Force Final Report.. EASA. (not published)

APPENDIX E: SURVEY QUESTIONNAIRE

Executive Directorate / Certification Directorate
General Aviation & RPAS Department

“Geo-Limitation” Task Force

Stakeholders Questionnaire

Ref. RPAS-GTF-T0_Questionnaire

"Geo-Limitation" Task Force

Stakeholders Questionnaire

Document ref.	Status	Date
RPAS-GTF-T0_Questionnaire	FINAL	05/05/2016

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1 Introduction

The recent events with unmanned aircraft , air-prox and losses of control have shown that the probability of a mid-air collision, with potentially hazardous consequences, has to be thoroughly considered.

As a matter of fact, EASA has established in its technical opinion that, while unmanned aircraft flying low level under visual line of sight, in low density airspace and, in particular, when being operated by competent operators, might not cause a significant risk, there are certain areas presenting a higher risk of conflict with manned aircraft. In those areas operations with unmanned aircraft should be limited or forbidden.

In order to help preventing unintended flight outside areas considered safe for unmanned aircraft operations, geographical and/or performance limitations for certain categories of unmanned aircraft should be considered.

Consequently, the Agency believes that concrete and prompt actions have to be taken.

Thus, the Agency decided to create a task force aiming at providing a set of recommendations on "geo-limitation" and related aspects, and to propose a way forward to implement them, focusing on unmanned aircraft in the "Open" category [Ref. 1] and on the risk of conflict with other airspace users (in particular, commercial air transportation).

This task force is coordinated by EASA and includes, as members, representatives of the civil aviation authorities of Finland, France, Poland and United Kingdom.

To achieve this objective, the task force considered of utmost improtance to gather the views on these aspects from the most relevant stakeholders. One of the main elements planned for this purpose is to carry out a stakeholders consultation process through the present questionnaire.

The results of this consultation process will highly depend on the quantity and quality of the answers received.

Therefore, the "geo-limitation" taks force would like to express its gratitude in advance for the time you are going to spend in answering the questions, and wants to highlight that the feedback from your organisation is highly valued.

2 Acronyms and Definitions

Acronyms

ATM	Air Traffic Management
CAT	Commercial Air Transport
COTS	Commercial Off The Shelf
EASA	European Aviation Safety Agency
RPAS	Remotely Piloted Aircraft System
UAS	Unmanned Aircraft System
UTM	UAS Traffic Management

Definitions

Drone. This term is used at general public level to refer to Unmanned Aircraft (see below)

“Geo-limitation”. In the context of this document, this term means geographical limitation to avoid that (certain) unmanned aircraft enter in defined airspace volumes or zones (for safety and/or security reasons). This concept encompasses from just information provided to the unmanned aircraft operator, to the implementation of the limitation in the unmanned aircraft (see “geo-fencing” below)

“Geo-fencing”. In the context of this document, this term means the implementation of “geo-limitation” in the unmanned aircraft to automatically impede the flight in defined airspace volumes or zones.

RPAS (Remotely Piloted Aircraft System). Unmanned Aircraft (see below) that is piloted from a remote pilot station.

UAS (Unmanned Aircraft System). See Unmanned Aircraft below.

Unmanned Aircraft. Aircraft operated or designed to be operated without a pilot on board.

3 References

Ref. 1. EASA Technical Opinion. Introduction of a regulatory framework for the operation of unmanned aircraft. European Aviation Safety Agency (EASA). 18 December 2015.

4 Instructions for filling in the questionnaire

The following are the main aspects to be considered when filling in the questionnaire:

1. Language: **English**
2. Please fill in fields using a **computer** (not hand written on printed copy).
3. Once you finish filling in all the answers, please save the file with the name: ***RPAS-GTF-T0_Questionnaire_ORGNAME***, where ORGNAME must be your organisation name.
4. You are encouraged to fill in **all interviewee information** requested in section 5.
5. When filling in section 7 (questionnaire) you are encouraged to:
    a. Fill in answers to questions that correspond to your stakeholder group (see table below each question, with addressed stakeholders marked). However, please feel free to answer or add any comments to questions deemed pertinent to your activity or organisation even if they are directed to a different type of stakeholder.
    b. Please provide **clear and concise** answers. Nevertheless, fields in section 7 (questionnaire) admit “scrolling” if the text exceeds the visible field size.
6. Please send the filled in form **not later than 31 May 2016** to:

    TO: Daniel.COBOVUILLEUMIER@easa.europa.eu

    CC: pascal.medal@easa.europa.eu

If you need clarification of any points please do not hesitate to contact us by using the abovementioned email addresses.

5 Interviewee Information

Please fill in the following contact details:

Interviewee Contact Details		
Name		
Current Position		
Organisation		
Postal Address		
Email address		
Telephone number		
Do you agree to be contacted for follow-on questions / clarification in case of need?		◯ Yes ◯ No

NOTE: The contact details given above will be treated with confidenciality. They will only be used for the purposes of the work conducted by this task force and will not made public.

Please choose the role of your organisation by selecting one or more of the following options:

◯ Unmanned Aircraft (Drone) Manufacturer
◯ Other (Unmanned Aviation related) Manufacturer
◯ Unmanned Aircraft (Drone) User / Operator
◯ Regulator / Aviation Authority
◯ Industry Standards Organisation
◯ Unmanned Aircraft / RPAS (Drone) Association
◯ ATM / Other Aviation related Organisation

6 Initial questions for Unmanned Aircraft (Drone) Manufacturers

Question	Please fill in your answer here
What is the number of small drones (< 25 Kg) your company sold in Europe in 2015? How many (%) are below 2 Kg?	

What is the average time that the small drones produced by your company stay in production (from entry to market to production discontinuation)?	
Does your company have an occurrance reporting system implemented for drones? Does your company have procedures in place to analyse failures, classify the severity and design changes to improve reliability?	
How is the drone software of your company being updated? Does it involve the download of the latest software version by the user/operator?	
For the different (small) drone products of your company, what are the typical values for accuracy of height/altitude and lateral positioning?	

7 Questionnaire

<table>
<tr><th>#</th><th>Question</th><th>Please fill in your answer here</th></tr>
<tr><td>[1]</td><td>As far as you know, what is the number of small drones (< 25 Kg) operating currently in Europe?

Drone Manufacturer ☒ | Other Manufacturer ☒ | User / Operator ☒ | Regulator ☒ | Industry Standards Org. ☒ | RPAS (Drone) Association ☒ | ATM / Other Aviation Org. ☒</td><td></td></tr>
<tr><td>[2]</td><td>What are in your view the main risks that (small) drones pose to manned aircraft?

Drone Manufacturer ☒ | Other Manufacturer ☒ | User / Operator ☒ | Regulator ☒ | Industry Standards Org. ☒ | RPAS (Drone) Association ☒ | ATM / Other Aviation Org. ☒</td><td></td></tr>
<tr><td>[3]</td><td>Has been your organisation involved in the assessment of likelihood of collision of a (small) drone with a manned aircraft? If so, please describe the initiative(s) (including type of manned aircraft and drone) and main conclusions (if available)

Drone Manufacturer ☒ | Other Manufacturer ☒ | User / Operator ☒ | Regulator ☒ | Industry Standards Org. ☒ | RPAS (Drone) Association ☒ | ATM / Other Aviation Org. ☒</td><td></td></tr>
<tr><td>[4]</td><td>Has been your organisation involved in the assessment of the effects that the collision of a (small) drone with a manned aircraft could cause? If so, please describe the initiative(s) (including type of manned aircraft and drone) and main conclusions (if available)</td><td></td></tr>
</table>

	Drone Manufacturer ☒ | Other Manufacturer ☒ | User / Operator ☒ | Regulator ☒ | Industry Standards Org. ☒ | RPAS (Drone) Association ☒ | ATM / Other Aviation Org. ☒	
[5]	How many incidents between manned aircraft and drones have been reported in 2015? How many of those involved CAT aircraft? How many of those were confirmed as caused by drones? Drone Manufacturer ☐ | Other Manufacturer ☐ | User / Operator ☐ | Regulator ☒ | Industry Standards Org. ☐ | RPAS (Drone) Association ☐ | ATM / Other Aviation Org. ☒	
[6]	Is your organisation involved in any activity to prevent mid-air collision of drones with manned aircraft and/or to prevent drones entering a non-authorised airspace/zone (e.g. airport)? If yes, please describe. Drone Manufacturer ☒ | Other Manufacturer ☒ | User / Operator ☒ | Regulator ☒ | Industry Standards Org. ☒ | RPAS (Drone) Association ☒ | ATM / Other Aviation Org. ☒	
[7]	What are in your view the main measures to prevent that drones fly in a non-authorised airspace/zone (e.g. airport)? Select from the list (as many as you consider) Drone Manufacturer ☒ | Other Manufacturer ☒ | User / Operator ☒ | Regulator ☒ | Industry Standards Org. ☒ | RPAS (Drone) Association ☒ | ATM / Other Aviation Org. ☒	☐ Safety promotion and education ☐ Remote pilots (including recreational users) training ☐ Provision of information on geographical limitation ("geo-limitation") and altitude / height limitation. ☐ Law enforcement ☐ "Geo-fencing" (functionality implemented in the drone and based on "geo-limitation" information, so that the drone automatically avoids flying non-authorised airspace/zone) ☐ Altitude/height limitation implemented in the drone. ☐.Other drone performances limitation implemented in the drone (e.g. speeds, data link range, …) ☐. "Anti-drone" technologies in zones not authorised for drone flights. ☐ Other(s). Please, indicate:

		Please, indicate rationale for selection:
[8]	Who should be in charge of generating the "geo-limitation" data? Drone Manufacturer ☒ Other Manufacturer ☒ User / Operator ☒ Regulator ☒ Industry Standards Org. ☒ RPAS (Drone) Association ☒ ATM / Other Aviation Org. ☒	☐ National Aviation Authority ☐ Aeronautical information Service Provider ☐ A company accredited by a governmental body ☐ Drone manufacturer ☐ Other. Please, specify:
[9]	Who should be in charge of delivering to the user / operator the "geo-limitation" information? Drone Manufacturer ☒ Other Manufacturer ☒ User / Operator ☒ Regulator ☒ Industry Standards Org. ☒ RPAS (Drone) Association ☒ ATM / Other Aviation Org. ☒	☐ National Aviation Authority ☐ Aeronautical information Service Provider ☐ A company accredited by a governmental body ☐ Drone manufacturer ☐ Other. Please, specify:
[10]	Would you support a regulatory mandate for "Geo-fencing"? Please select <u>one option</u>. Drone Manufacturer ☒ Other Manufacturer ☒ User / Operator ☒ Regulator ☒ Industry Standards Org. ☒ RPAS (Drone) Association ☒ ATM / Other Aviation Org. ☒	◯ Yes, with "hard locked" zones (zone limitations cannot be unlocked by the user/operator) ◯ Yes, with "soft locked" zones (zone limitations can be unlocked by the user/operator under certain conditions, e.g. authorisation to operate in a zone) ◯ No Please, indicate rationale for selection:
[11]	Would you support a regulatory mandate for drone performance limitations implemented in the drone (e.g. max. altitude/height, speeds, range)? Please select <u>one option</u>. Drone Manufacturer ☒ Other Manufacturer ☒ User / Operator ☒ Regulator ☒ Industry Standards Org. ☒ RPAS (Drone) Association ☒ ATM / Other Aviation Org. ☒	◯ Yes ◯ Yes, but not all performances. Please, indicate which one(s) not to limit: ◯ No Please, indicate rationale for selection:
[12]	Who should carry the responsibility/liability of the safe use of drones equipped with "geo-fencing" functionality?	☐ User / Operator ☐ Manufacturer ☐ Data provider

	Drone Manufacturer ☒ · Other Manufacturer ☒ · User / Operator ☒ · Regulator ☒ · Industry Standards Org. ☒ · RPAS (Drone) Association ☒ · ATM / Other Aviation Org. ☒	☐ The State ☐ Other. Please, specify: Please, indicate rationale for selection:
[13]	How do you see the respective role of manufacturers, data-providers, end users / operators, authorities and law enforcement bodies fit in the geo-limitation information service? Who should and how this “geo-limitation” information service should be financed? Drone Manufacturer ☒ · Other Manufacturer ☒ · User / Operator ☒ · Regulator ☒ · Industry Standards Org. ☒ · RPAS (Drone) Association ☒ · ATM / Other Aviation Org. ☒	
[14]	What would be your preferred approach for rules and standards related to “geolimitation” / “geofencing” and drone performance limitations? Please, select <u>one option</u>. Drone Manufacturer ☒ · Other Manufacturer ☒ · User / Operator ☐ · Regulator ☒ · Industry Standards Org. ☒ · RPAS (Drone) Association ☐ · ATM / Other Aviation Org. ☐	○ Performance based rules ○ Prescriptive based rules without industry standards being required ○ Prescriptive based approach based on industry standards being required ○ Other approach. Please, specify: Please, indicate rationale for selection:
[15]	With regard to the development of industry standards for “geo-limitation“ / “geo-fencing” and performance limitations, what is in your knowledge the current status? Drone Manufacturer ☒ · Other Manufacturer ☐ · User / Operator ☐ · Regulator ☒ · Industry Standards Org. ☒ · RPAS (Drone) Association ☐ · ATM / Other Aviation Org. ☐	
[16]	If standards are required, what should be the standards related to “geo-limitation“ / “geo-fencing” and performance limitations	

	to be developed by Industry Standards bodies? Drone Manufacturer ☒ | Other Manufacturer ☒ | User / Operator ☒ | Regulator ☒ | Industry Standards Org. ☒ | RPAS (Drone) Association ☒ | ATM / Other Aviation Org. ☒	
[17]	What are the main characterisitcs to be included in standards addressing "geofencing"? What are the main elements (concepts, functions, technologies) that should be promoted and given higher priority? Drone Manufacturer ☒ | Other Manufacturer ☒ | User / Operator ☒ | Regulator ☒ | Industry Standards Org. ☒ | RPAS (Drone) Association ☒ | ATM / Other Aviation Org. ☒	
[18]	What are the main characterisitcs to be included in standards addressing "performance limitations" of drones? What are the main elements (concepts, functions, technologies) that should be promoted and given higher priority? Drone Manufacturer ☒ | Other Manufacturer ☒ | User / Operator ☒ | Regulator ☒ | Industry Standards Org. ☒ | RPAS (Drone) Association ☒ | ATM / Other Aviation Org. ☒	
[19]	In addition to the above, would you consider the urgent need to promote and standardise other kind of element (concept, function, technology) to enhance the safety of operation of small drones? Drone Manufacturer ☒ | Other Manufacturer ☒ | User / Operator ☒ | Regulator ☒ | Industry Standards Org. ☒ | RPAS (Drone) Association ☒ | ATM / Other Aviation Org. ☒	
[20]	In case "geo-fencing" and/or drone performances (e.g. max. altitude/height, speeds, range …) are mandated: What would be the timeframe for the implementation in your drone products?	

	Drone Manufacturer ☒ Other Manufacturer ☐ User / Operator ☐ Regulator ☐ Industry Standards Org. ☐ RPAS (Drone) Association ☐ ATM / Other Aviation Org. ☐	
[21]	In case "geo-fencing" and/or drone performances (e.g. max. altitude/height, speeds, range …) are mandated: What would be the cost impact for the implementation in your drone products? Drone Manufacturer ☒ Other Manufacturer ☐ User / Operator ☐ Regulator ☐ Industry Standards Org. ☐ RPAS (Drone) Association ☐ ATM / Other Aviation Org. ☐	Please select: Low impact Medium impact High impact Remarks (if needed):
[22]	In case "geo-fencing" and/or drone performances (e.g. max. altitude/height, speeds, range …) are mandated: How do you propose to cope with the need for some professional operators to operate in certain cases in zones usually forbidden for drones (e.g. airports)? Drone Manufacturer ☒ Other Manufacturer ☒ User / Operator ☒ Regulator ☒ Industry Standards Org. ☒ RPAS (Drone) Association ☒ ATM / Other Aviation Org. ☒	
[23]	In case "geo-fencing" and/or drone performances (e.g. max. altitude/height, speeds, range …) are mandated: How can be ensured that the drone software containing "geo-fencing" data is up-to-date, also considering that the latest changes may happen while the user/operator is operating the drone? Drone Manufacturer ☒ Other Manufacturer ☐ User / Operator ☐ Regulator ☐ Industry Standards Org. ☐ RPAS (Drone) Association ☐ ATM / Other Aviation Org. ☐	
[24]	In case "geo-fencing" and/or drone performances (e.g. max. altitude/height, speeds, range …) are mandated:	

	What should be the best ways to reduce the risk that users/operators disable these limitations (without having authorisation to do it)? Drone Manufacturer ☒ | Other Manufacturer ☒ | User / Operator ☐ | Regulator ☒ | Industry Standards Org. ☒ | RPAS (Drone) Association ☐ | ATM / Other Aviation Org. ☐	
[25]	In case "geo-fencing" and/or drone performances (e.g. max. altitude/height, speeds, range …) are mandated: How do you recommend (small) drones already in the market should be addressed (retrofit or additional limitations or other)? Drone Manufacturer ☒ | Other Manufacturer ☒ | User / Operator ☐ | Regulator ☒ | Industry Standards Org. ☒ | RPAS (Drone) Association ☐ | ATM / Other Aviation Org. ☐	
[26]	If retrofit provisions for (small) drones already in the market were adopted, to what extent such provisions could be applied to your products? How could they be technically and commercially fulfilled? Drone Manufacturer ☒ | Other Manufacturer ☒ | User / Operator ☐ | Regulator ☐ | Industry Standards Org. ☐ | RPAS (Drone) Association ☐ | ATM / Other Aviation Org. ☐	
[27]	How do you think abovementioned limitations ("geo-fencing", performance) could be addressed for homebuilt drones? Would it be feasible to enforce the implementation of those limitations to elements like COTS "autopilots"? Drone Manufacturer ☒ | Other Manufacturer ☒ | User / Operator ☒ | Regulator ☒ | Industry Standards Org. ☒ | RPAS (Drone) Association ☒ | ATM / Other Aviation Org. ☐	
[28]	What are your views about "geo-limitation" / "geo-fencing" and performance limitations for (small) drones in a future	

	implementation of an “UAS Traffic Management” (UTM) solution and the evolving general ATM system? What requirements and interoperability issues do you foresee? Drone Manufacturer ☒ / Other Manufacturer ☒ / User / Operator ☒ / Regulator ☒ / Industry Standards Org. ☒ / RPAS (Drone) Association ☒ / ATM / Other Aviation Org. ☒	
[29]	Do you have any additional comment or remark?	

APPENDIX F: STAKEHOLDER ENGAGEMENT

F1 Initial meetings with manufacturers

Initial contacts with some small unmanned aircraft and related manufacturers and operators took place at the beginning of this Task Force, namely:

- With DJI and UniFly in Madrid, in April 2016.
- With Parrot, FPDC (Fédération professionnelle du drone civil), Airinov and Hionis in Paris, in April and June2016.

F2 Stakeholder survey listing

The task Force would like to thank the following organisations for their answers to the survey conducted in May 2016 via the questionnaire in Appendix C:

F2.1 Small unmanned aircraft manufacturers and related associations

Blue Bear (UK)

Delair-Tech (France)

DJI (China)

Dron Hause, S.A. (Poland)

Drone Alliance Europe (see also "small unmanned aircraft operators")

Drone Manufacturer Alliance Europe (DMAE) (representing DJI, GoPro and Parrot)

Gatewing, NV (Belgium)

MAVinci GmbH (Germany)

Parrot (France)

senseFly (Switzerland)

Squadrone System (France)

Yuneec Europe GmbH (Germany; parent: China)

F2.2 Other unmanned aviation related manufacturers, engineering consultancy and R&D organisations

Airbus Helicopters (France, Germany, Spain)

Albatroz Engenharia (Portugal)

ATLAS (Air Traffic Laboratory for Advanced unmanned Systems, Spain)

CATEC (Centro Avanzado de Tecnologías Aeroespaciales, Spain)

Hionos (France)

Honeywell Aerospace (UAE; parent: USA)

IPTSAT (Italy)

RPAS Services (France)

SPH Engineering (Latvia)

UniFly (Belgium)

F2.3 Small unmanned aircraft operator

Azurdrones (France)

Clear Flight Solutions (Netherlands)

EDF S.A. / DTG (France)

Gérard Garnier (drone pilot, France)

Poledrones / SNCF (France)

RUAG (as operator, Switzerland)

Thorsten Indra Photography / Aerialcam (Germany)

Unmanned Aviation Solutions B.V. (Netherlands)

WeFly (Denmark)

F2.4 Unmanned Aviation Associations

DARPAS (Dutch Association for professional use of RPAS)

Drone Alliance Europe (currently including: Altitude Angel, amazon Prime Air, Delft Aerial Robotics, Gatewing, ParaZero, UniFly; see also "small unmanned aircraft manufacturers)

FIAPR (Italy)

SAPRITALIA (Italy)

Swiss Federation of Civil Drones (SFCD) (Switzerland)

UAS Norway (Norway)

UAV DACH (Austria, Germany, Netherlands, Switzerland)

European Air Sports & Federation Aeronautique Internationale (Europe)

Large Model Association (UK)

F2.5 Industry Standard Bodies

EUROCAE (WG-73 & 93)

ASTM (F-38)

ISO (TC20/SC16)

F2.5 National Aviation Authorities

F2.5.1 EASA Member States

Austria (Austro Control GmbH)

Belgium (Belgian CAA)

Czech Rep. (CAA-CZ)

Denmark (Danish Transport and Construction Agency)

Estonia (Min. Economic Affairs and Communications - Aviation Div.)

Finland (TRAFI - Finnish Transport Safety Agency)

France (DGAC)

France (DSAE)

Germany (LBA)

Iceland (Icelandic Transport Authority)

Italy (ENAC)

Latvia (Latvian CAA)

Lithuania (Civil Aviation Administration)

Malta (Transport Malta)

Netherlands (Min. Transport & Environment)

Norway (Norwegian CAA)

Poland (CAA-PL)

Slovak Rep. (Slovak Civil Aviation Division)

Spain (AESA)

Switzerland (FOCA)

United Kingdom (CAA UK)

United Kingdom (personal views of Mr J Dickson, UK MAA)

F2.5.2 Other States

Australia (CASA)

Canada (Transport Canada)

India (Dir. General of Civil Aviation)

Israel (CAA Israel)

Japan (Japan CAB)

Turkey (DGCA)

UAE (GCAA)

USA (personal views of Mr. C. Swider, FAA)

F2.6 ATM and Other Aviation Organisations

F2.6.1 Air Traffic Management (ATM) Organisations

DFS (German ANSP)

DSNA (French ANSP)

ENAIRE (Spanish ANSP)

ENAV (Italian ANSP)

EUROCONTROL

NATS (UK ANSP)

PANSA (Polish ANSP)

SESAR Joint Undertaking

F2.6.2 Other Aviation Organisations

AOPA (Aircraft Owners and Pilots Association) – Germany

British Helicopter Association (BHA)

CoyotAir (Helicopter operator, Spain)

European Cockpit Association (ECA)

European Helicopter Association (EHA)

European GNSS Agency (GSA)

Frazer-Nash Consultancy Ltd.

International Air Transport Association (IATA)

Quotec GmbH/Ltd (Aviation service provider, Switzerland)

Réseau de Transport d'Électricité (RTE)-STH (Helicopter operator for RTE, France)

The Task Force would also like to thank he European Commission, ARPAS UK, ASD, CANSO, EDA, FPDC (French Professional Drone Assoc.), French National Council for Civil Drones, RPAS Finland, and UVS International for having assisted in circulating the questionnaire.

F3 Meeting with manufacturers, Cologne 9 June 2016

THE NOTES THAT FOLLOW REPRESENT THE TASK FORCE'S INTERPRETATION OF THE INFORMATION IMPARTED TO IT BY THE PARTICIPANTS; IT MAY NOT ACCURATELY REFLECT THE INTENT OF THE CONTRIBUTORS

F3.1 Attendees

Ms. Gaelle LEMAIRE and Ms. Paula IWANIUK (G+ Europe / DMAE, Drone Manufacturers Alliance Europe)

Mr. Matt KOSKELA (AirMap)

Mr. Brendan SCHULMAN and Mr. Christian STRUWE (DJI)

Mr. Yannick LEVY (Parrot)

Mr. Jürgen VERSTAEN and Mr. Koen MEULEMAN (Unifly)

Mr. Stefan Ronig (EASA)

EASA Task Force members

Apologies:

Mr. Marcel DE GRAAF / Mr. Eric GOOSSENS (Yuneec)

Having introduced the Task Force and its work and reviewed key points from the EASA Technical opinion, each of the representatives presented their perspectives.

F3.2 Key points arising

F3.2.1 Understanding of Risk

Likelihood of a collision: No coherent data available on numbers of UAS active nor hours flown but thought plausible that there are 3.3m active UAS active in Europe weighing 0 – 25kg and that 90% or more weigh less than 2kg.

Consequence of a collision: Some of the manufacturers are participating in the US "ASSURE" programme but live testing with representative aircraft engines and airframes of the consequences of a collision will depend on funding and are at least two years away.

Public perception of risk has been assessed in the UK and suggests that UAS are regarded as risky unless in the hands of trusted organisations such as police, fire service or armed forces.

F3.2.2 Incident Reporting

The value of a robust system for UAS operators to report safety incidents (e.g. loss of control events due human error, equipment failure, attempting flight beyond battery life etc.) was recognised. The unmanned aviation community typically does not participate in the ECCAIRS reporting system but has not created a separate coherent reporting system. There is no evidence that a reporting culture exists among the "drone" community. Manned aviation reports of incidents involving UAS are often of dubious quality and credibility. As a result, there is no clear understanding of the nature, or frequency, of the incidents that are occurring. This means that there is no context in which to place those incidents which are reported and often re-reported in the media. On the other hand, those manufacturers present would value information about where and what MOR events are being reported by the manned community; DMAE would be a focal point to which to direct such information.

F3.2.3 Risk control

Responsibility: Manufacturers keen to emphasise that responsibility for complying with regulations, including avoiding restricted airspace unless authorised, should lie with the operator unless, for example, a design or manufacturing fault has caused the transgression.

Education: Needs to favour tutorials or information provided to the operator when it is needed during operation. Supplying printed instructions and rules is not effective – users assume that the UAS is flyable out of the box without instruction and so cannot be relied on to read any accompanying documentation.

Registration: Manufacturers report that FAA and IAA have seen an improving culture of responsible behaviour among users with both countries seeing reductions in UAS incident reports since introducing their systems.

Focussing: Risk management could be more focussed were EASA's proposed Open Category subdivided into "Nano" 0-250g, "Micro" 250g-2kg and "Mini" 2– 25kg. Thus, for example, geo-fencing might be applies in a graded manner – for Nanos: not required; Micros: geo-fence data provided as information to the operator but not built into the UAS; Minis: geo-fence is an automatic function built into the UAS.

F3.2.4 Definitions

It was confirmed that agreement on the definitions of some key terms is needed.

"Geo-limitation" is seen as a useful term encompassing not only "geo-fencing" but also other limitations.

"Geo-fencing" relates to a geographic position and may be distinguished from other limitations in that it is a function which relies on the UAS being capable of interfacing with externally supplied data.

"Performance limitations" are seen to relate to limits on unmanned aircraft operating height, distance from the controller or speed and are self-contained in the UAS.

"Registration" is considered to be distinct from "Identification" (rather than an example of it) because registration is independent of the technology of the UAS and associated with an "after the event" identification of the owner.

“Identification” is not only seen as a function that requires some capability to be built into the UAS, it is also associated with providing a third party with a means of flight management, guidance or intervention.

“Tracking” is a term being used to refer to the act of in-flight identification over a period of time.

F3.2.5 Limitations

Geo-fenced No Fly Zones: Valuable but not all manufacturers can accommodate anything but circular no fly zones described by a point and radius; this is particularly the case if there are thousands of examples across Europe to be included. One manufacturer had described three levels of zone – “Restricted”, “Authorised” and “Warning” – with the associated geo-fence being “hard-locked”, “soft-locked” or “not locked”. A soft-lock can be unlocked by the operator through a process that positively identifies them and their UAS and positively requires them to acknowledge that they are authorised to access the no fly zone; access lasts 24 hours to the particular zone only and a record is created of the event.

Altitude limit: Usually is described relative to the start point of the flight rather that to altitude as used in manned aviation. One manufacturer uses 120m (400 feet) as the standards setting resulting in the unmanned aircraft hovering when arriving at that ceiling. The user can select a 500m maximum – to provide flexibility to, say, fly over a cliff or off the side of a mountain.

Range from operator: Range is usually described as being from the start point of the flight rather than specifically from the operator (i.e. does not account for the controller following the drone).

Speed: often built as a limitation into UASs but mainly of use in preventing injury to those on the ground. Typical small unmanned aircraft weights of less than 2kg and max speeds of the order of 45kph suggest that drone speed is unlikely to represent a significant contributor in a mid-air collision with a large commercial aeroplane. This is, however, unproven.

F3.2.6 Standards

Many bodies are seeking to generate standards including ISO, EUROCAE, RTCA, ICAO and the Global UTM Association. What is needed are basic standards or, better yet, principles which help manufacturers to develop products for Europe with alignment with the global standards being developed by bodies such as JARUS. There is a strong preference for technology neutral standards that are risk based and operation-driven or that provide for interoperability across the unmanned community or between the unmanned and manned communities. Commonality across jurisdictions would be welcomed.

No Fly Zones: A standard approach across Europe to describing which airports are to be protected would be valued.

Mapping: A single reliable mapping source at State or European level would be valuable even if a multitude of map providers draw on this source.

CE standard: If intending to seek UAS compliance against a CE standard, care needed over the nature and extent of testing to be required.

Technical standards: on data formats, protocols and telecom standards should be left to the industry to develop and propose allowing EASA to recognise those that are agreed or to step in where there is no clarity and a need for interoperability.

Retrofit: Not favoured given the limited lifespan of UAS though no data available to indicate the extent to which the arrival of the next generation of UAS every 2 years leads to the permanent retirement of older models.

F3.2.7 UAS Traffic Management Systems

Long term vision is for UTM to be fully integrated with ATM with one single system covering all airspace.

Global UTM Association has launched an initiative to develop UTM concepts. Concepts are also being worked on by NASA and others. NASA UTM timeline suggest that BVLOS standards are available in 2019 with physical and organisational infrastructure to follow.

One manufacturer had developed a product to allow aerodromes to automate their interaction with UAS operators. UAS operators could use an App to advise the aerodrome of their intended flight allowing the aerodrome to log this and provide advice (e.g. “OK to fly but not above 400ft and be advised of regular manned aircraft in the overhead”). The aerodrome can readily change the advice for specified locations and times. Work is underway to integrate with manned aviation ADS-B feeds in order to provide traffic alerts to UAS operators.

Another manufacturer used an App to provide UAS users with local risk information based on NOTAMs, assist in gaining formal Aviation Authority authorisation for flights as required and create logs of flights undertaken. Insurance companies have shown an interest in making the use of the system a condition of the insurance.

APPENDIX G: UNMANNED/MANNED AIRCRAFT COLLISION RISK INFORMATION

G1 INTRODUCTION

As indicated in the main body of this report, the EASA Technical Opinion (Ref. 7) proposed the use of "geo-limitation" as one means of keeping low the risk of UAS operations in the "Open" category.

The Agency had already planned further regulatory work on this and other measures related to Open category operations as part of its programme for UAS. However, the rapid increase in the number of reports of manned-unmanned aircraft airproxes, and the consequent alarm in the aviation community and society in general (including the escalation of media headlines on this issue), triggered the Agency to decide to address this risk in a more urgent manner.

The launch of this "Geo-limitation" Task Force was one of the immediate measures taken by the Agency. As indicated in APPENDIX A: TASK FORCE TERMS OF REFERENCE, the aim of the Task Force was to provide an initial set of recommendations for "geo-limitation" and related aspects, focusing mainly on small UAS operating in the "Open" category and their risk to manned aviation, in particular to commercial air transportation.

The Task Force recognised that understanding the risk requires:

- A sufficient perspective on the actual magnitude of the risk, including:
    - Number of occurrences related to this risk in relation to the number of operations of small UAS
    - Knowledge of the potential consequences of airprox events, particularly a collision between a small unmanned aircraft and a manned aircraft.
- A risk assessment that allowed identification and analysis of the key safety barriers needed to control the threats and prevent the top event related to the hazard as well as those required to mitigate the consequences of that event.

To achieve a sufficient level of understanding of the risk clearly requires robust, reliable and validated data. Unfortunately, as the Task Force's investigation found, currently there is not sufficient data of the required quality.

Nevertheless, this Appendix summarises the information gathered by the Task Force regarding:

- Risk in perspective:
    - Number of occurrences reporting in Europe and consideration of the number of small unmanned aircraft and their estimated number of fight hours in civil operations in Europe

  - Initiatives researching the effects of small unmanned aircraft collisions with manned aircraft.

- High level risk assessment, using bow tie technique, to identify threats and main barriers to prevent hazard and its main consequences.

This summary is presented below.

G2 COLLISION RISK - LIKELIHOOD

G2.1 Occurrences Reported

G2.1.1 Occurrence reporting systems

To assess the occurrences of airproxes in European airspace that reportedly involved unmanned aircraft, the Task Force took as it source the data held in the European Central Repository of occurrences (ECR)[2] and data directly provided by the aviation authorities of some Member States (e.g. UKAB[3] and answers to the Task Force survey questionnaire as set out in APPENDIX E: SURVEY QUESTIONNAIRE). To compare with occurrences outside Europe, information from other countries was also assessed (e.g. from FAA UAS Sighting Reports in the US, and answers to Task Force survey).

The Task Force also sought to understand what occurrence information was available to manufacturers e.g. for cases in which loss of small UAS control was caused by failure(s) in the system. Having consulted a number of representative manufacturers (see APPENDIX F: STAKEHOLDER ENGAGEMENT), the Task Force concluded that most did not currently have a systematic reporting system in place and, in most cases, are limited to analysing failures when the small UAS are brought in for repair or when customers provide feedback. In addition, such information as was available to manufacturers was not usually (or not systematically) provided to the relevant aviation authorities.

Therefore, currently the only sources for information on occurrences mainly stem from third parties (mainly manned aircraft pilots involved in an occurrence) and rarely from small UAS operators whose reports are fed into the national reporting system and, ultimately, are included (or should be) in the ECR.

G2.1.2 Occurrences reported in Europe

Most of the data on reported occurrences in the EASA Member States was gathered from ECR data ranging from January 2010 to May 2016.

[2] ECR-ECCAIRS: http://eccairsportal.jrc.ec.europa.eu/
[3] UK Airprox Board: https://www.airproxboard.org.uk/

As much of this data comes from the ECR (data from the EASA MS only), there are some challenges with regards to data quality such as the lack of narrative, which makes it hard to verify the data and some insufficient event coding. However, it is a good basis for a general overview.

Information is summarised in the following figures:

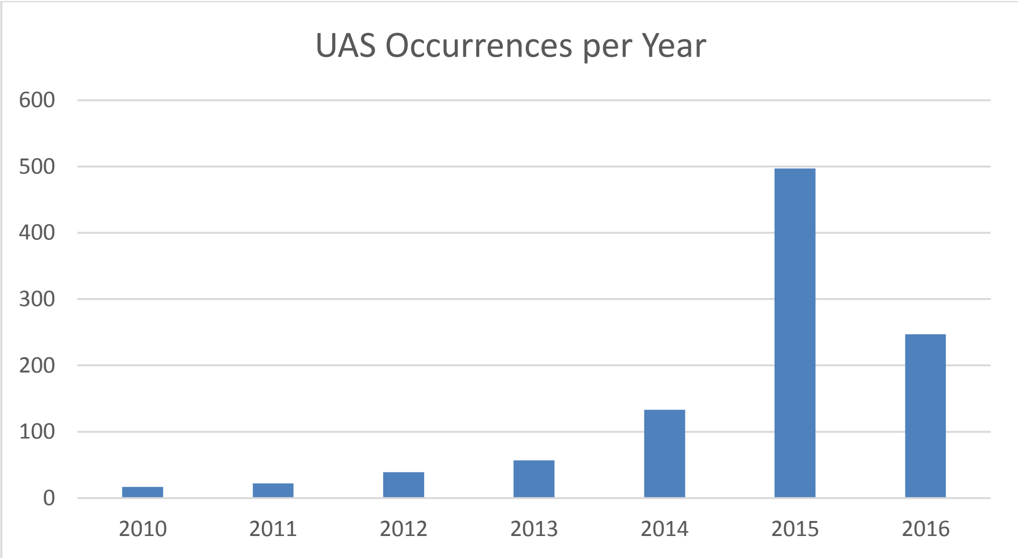


Figure G-1 UAS occurrences per year – from 2010 to 31 May 2016

Figure G-1 indicates a significant increase in the number of UAS occurrences per year from 2010 to mid-2016, with a radical jump in 2014. Up to end of May 2016, the number of occurrences reached already half of all in 2015, and this did not take into account the reporting process time lag between an occurrence happening and it being reported through a NAA to the ECR.

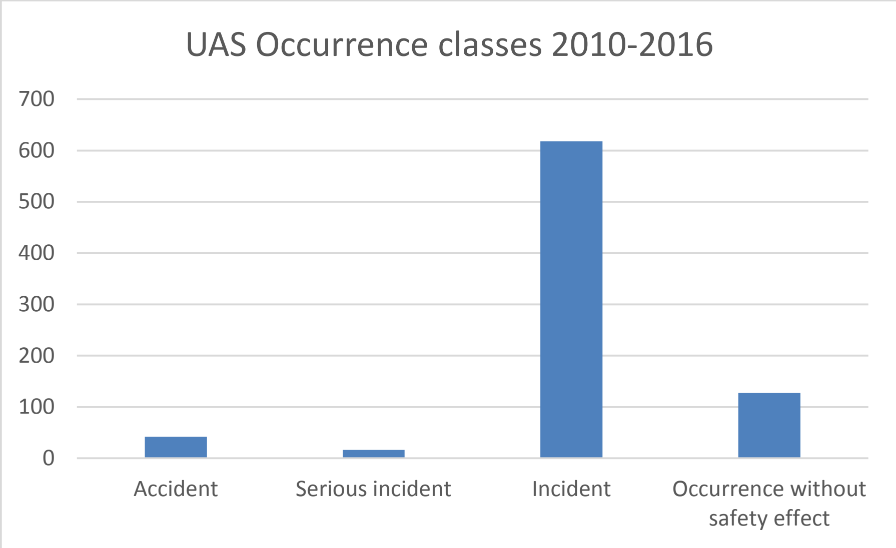


Figure G-2 UAS occurrence classes (from 2010 to 31 May 2016)

As shown in Figure G-2, **most occurrences in that period were incidents**. The majority of the 42 accidents reported resulted from the crash of the unmanned aircraft for either technical reasons or loss of control but not involving manned aviation. However, three of them correspond to a collision between a manned non-commercial aircraft and an unmanned aircraft. Nevertheless, none of those accidents caused fatalities or injuries.

From the analysis of the event types, **Airborne Conflict** (defined as a potential collision between an unmanned and a manned aircraft in the air) is the **most common type of occurrence** and closely associated with this type of occurrence were a number of occurrences classified as interference with aircraft.

Figure G-3 below show the distribution of UAS occurrences by EASA Member State (those with no occurrences reported are not included)

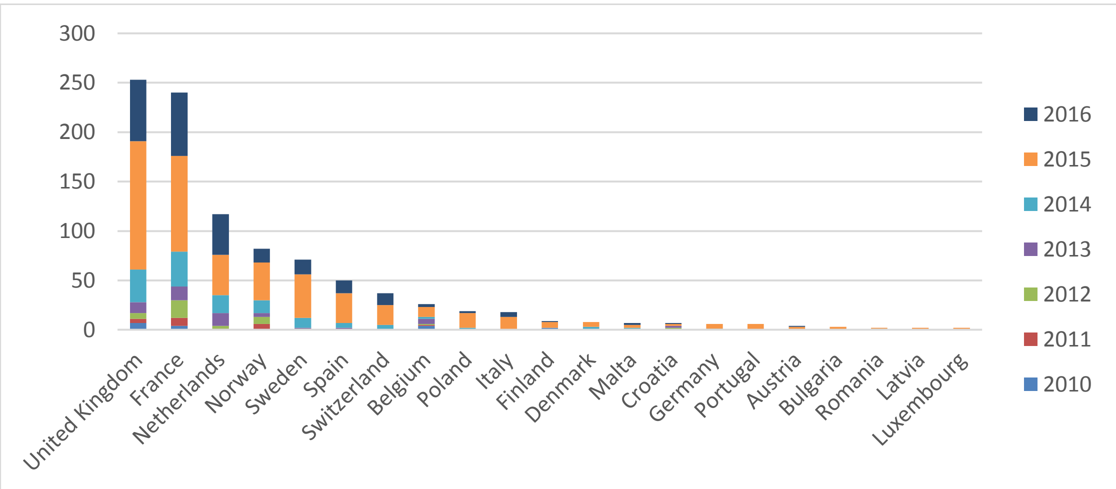


Figure G-3 UAS occurrences per EASA Member State (from 2010 to 31 May 2016)

From Figure G-3, it is clear that **most EASA Member States have filed reports of occurrences involving (small) UAS**, being **UK and France** the Member States where more occurrences have been reported.

From the analysis of flight phase of the manned aircraft and type of airspace where occurrences took place, depicted in Figure G-4 below, it can be concluded that **"En-route" and "approach" flight phases** accumulate the highest numbers of occurrences, and that **CTRs (Control Zones) and TMAs (Terminal Manoeuvring Areas)** are the type of airspace where most occurrences were reported.

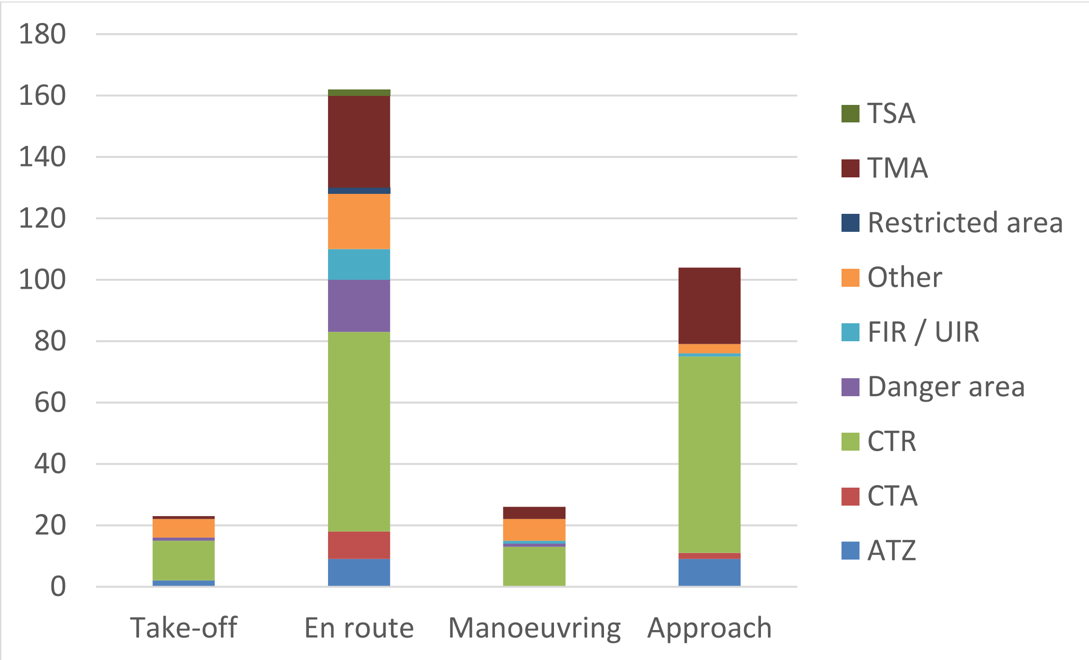


Figure G-4 UAS occurrences in relation to flight phase and type of airspace (from 2010 to 31 May 2016)

G2.1.3 Occurrences reported outside Europe

The Task Force was also able to gather information from some countries outside Europe.

Australia: CASA's response to the Task Force survey was that, in the past 12 months, there were 22 events including 16 accidents reported to the Australian Transport Safety Bureau. CASA did not have data on how many of these occurrences involved CAT aircraft nor how many were confirmed to involve UAS.

Canada: According to Transport Canada's response to the survey, 85 incidents were reported in 2015, mostly by manned aircraft pilots (none confirmed, pilot testimony only).

Israel: CAA Israel's survey response was that, in 2015, there were 8 incidents involving small UAS; three were at 3,500-4,500 ft, the rest at low altitude around airports.

Turkey: DGCA Turkey responded that 5 incidents were reported, 2 of them involved CAT aircraft.

United States of America: The FAA made available on their website the following information on "UAS sighting reports"[4]:

- 2014 (November-December): 43 reports
- 2015 (full year): 1210 reports
- 2016 (January): 93 reports

G2.2 Number of Small Unmanned Aircraft and Extent of Civil Operations

The Task Force found **no reliable figures for the size of the fleet of small UAS and the number of civil operations - either in Europe or worldwide**.

Generating consistent and reliable figures was made more difficult, and potentially impossible, by the fact that the UAS market segment defined by the "Open" category could include "traditional" model aircraft and "toys" that do not incorporate the level of automation or sophistication of current consumer "drones". In addition, most of the leading manufacturers of "small consumer drones" had not released official figures of their sales.

Nevertheless, considering the feedback received from consulted stakeholders (APPENDIX F: STAKEHOLDER ENGAGEMENT), the Task Force was able to generate the following gross estimates for "small civil drones" in Europe:

- Number sold in 2015: around 1.7 Million, of which 98% are UAS with unmanned aircraft mass below 2Kg
- Number in service: above 3.3 Million, excluding "toys" and model aircraft.

Even though estimates could not be obtained for the number of flight hours for this segment of UAS, it seemed that the total annual **number of flight hours in Europe could be at least in the order of tens of millions**.

Therefore, the **number of occurrences reported so far was very low given the estimated activity of these UAS** (probably less than 1 per 100 000 flight hours). Of course, such estimates must be treated with caution; they serve only as very rough estimates.

G3 COLLISION RISK – THE EFFECTS

Given that the highest priority risk it considered was of an unmanned/manned aircraft collision, the Task Force was keen to understand not only the likelihood of such an event but

[4] https://www.faa.gov/uas/law_enforcement/uas_sighting_reports/ (retrieved in May 2016)

also the consequences of such a collision. The Task Force noted that several related research initiatives had been launched; all were ongoing with no results available at time of writing.

Among these initiatives were:

G3.1 EASA Task Force

In May 2016, EASA launched a Task Force[5] to complement the work of the "Geo-limitation" Task Force by specifically assessing the risk of collision between "drones" and aircraft.

The mandate for this Task Force was to:

- *Review all relevant occurrences including the occurrences collected by the European Member States,*
- *Analyse the existing studies on the subject of impact between drones and manned aircraft,*
- *Study the vulnerabilities of aircraft (windshields, engines, and airframe) taking into account the different categories of aircraft (large aeroplanes, general aviation, and helicopters) and their associated design and operational requirements,*
- *Consider the possibility to do further research and perform actual tests (for example on windshields).*

This Task Force, chaired by EASA, included representatives of aircraft and engine manufacturers and intended to consult European Member States and other relevant stakeholders as well as foreign authorities.

Both EASA-led Task Forces were being coordinated and feeding each other with the necessary information and conclusions.

G3.2 ASSURE Initiative

ASSURE is partnership of twenty-two of the world's leading research institutions and more than a hundred leading industry / government organisations in the USA. ASSURE members are core to three FAA UAS test sites, lead four FAA research centres, have seven airfields and a 340 UAS fleet. Currently, one of the main ASSURE research projects is **"A-3 UAS Airborne Collision Severity Evaluation"**[6] (within the "Airworthiness" domain).

This research proposes to evaluate the severity of a collision between a small UAS (under 55 pounds weight) and commercial and business jet airframes and propulsion systems. This

[5] https://www.easa.europa.eu/newsroom-and-events/press-releases/easa-creates-task-force-assess-risk-collision-between-drones-and (retrieved in May 2016)
[6] http://www.assureuas.org/projects/funding/A3AirborneCollisionSeverityAbstract.pdf (retrieved in May 2016)

research will utilise proven simulation techniques validated by test on aircraft hardware. Due to the high level of concern related to this topic, initial simulation analysis will be focused on providing a rough order of magnitude severity evaluation of a yet to be determine UAS with a commercial jet airframe.

The tasks in this proposal will be completed cooperatively using the resources at WSUNIAR, Ohio State University, Montana State University and Mississippi State University each university offering unique capability appropriate to the various tasks in this proposal.

G3.3 Other Initiatives

A number of studies have been conducted to provide a preliminary analysis on potential consequences but requiring further confirmation by initiatives such as those mentioned above.

Among these studies, one to be highlighted was carried out by CASA who issued the report "*Potential damage assessment of a mid-air collision with a small UAV*", published in 2013[7]. This report analysed the potential damage to manned aircraft from a mid-air collision with a small unmanned aircraft. The scenarios of engine ingestion and impacts on the fuselage and cockpit windscreen were considered. The aim of the study was to provide velocity estimates above which penetration of the aircraft structure could be expected. The consequences of the penetration were found to depend on the impact location and were not explored in this report.

G4 RISK ASSESSMENT

Although predicting the likelihood of a collision between a small unmanned aircraft and a manned aircraft was difficult and the severity of such an event not yet fully understood, the Task Force recognised, nonetheless, that the risk was real and that a small number of events could have a dramatic impact on the future of the entire unmanned aviation business.

To help to assess how best to control this risk to a tolerable level, a number of organisations, particularly some European NAAs, have already assessed this risk with the aim of identifying the most effective measures to prevent a collision and to minimise the consequences of such a collision.

The methodology increasingly used by these organisations was the so called "bow tie" technique; one of several barrier risk models available to assist in the identification and management of risks.

[7] https://www.casa.gov.au/sites/g/files/net351/f/_assets/main/airworth/papers/potential-damage-assessment-mid-air-collision-small-rpa.pdf (retrieved in May 2016)

As an example of the use of this technique for the risk assessment, Figure E- 1 shows an initial high level scheme of an analysis performed in the frame of the Task Force work by DGAC France, based on bowties produced CAA UK, Trafi and JARUS (JARUS guidelines on specific operations risk assessment).

In this bow tie, the following conventions are adopted.

- Yellow box: the hazard - "Small UAS in close proximity to commercial aircraft such that safety is, or may be, compromised"
- Blue boxes: the identified "threats":
  - Inadvertent non-compliance with air traffic regulations by the remote pilot
  - Deliberate non-compliance with air traffic regulations by the remote pilot
  - Loss of control of RPAS due to human navigation errors
  - Loss of control of RPAS due to piloting or procedural errors
  - Loss of control of RPAS due to technical malfunction
- A number of "barriers" are identified for each "threat". Those related to the focus of the Task Force are marked with a yellow or blue vertical strip on the right. These are:
  - Effective dedicated RPAS aeronautical information system, supported by user friendly applications
  - Manufacturer built-in techniques limit RPAS altitude/height/distance from pilot
  - Manufacturer built-in techniques warn pilot that RPAS is approaching restricted or no fly zones
  - Manufacturer built-in techniques limit or prevent entry in restricted or no fly zones
- Red boxes: the identified consequences if the hazard materialises (i.e. barriers fail):
  - Avoidance manoeuvre by manned aircraft resulting in non-stabilised approach
  - Loss of control in flight of manned aircraft resulting from unmanned aircraft impact on windscreen, fuselage, fin, wing and flight control surfaces
  - Loss of control in flight of manned aircraft resulting from drone ingestion by engine
  - Disruption of air traffic flow following several pilots reports

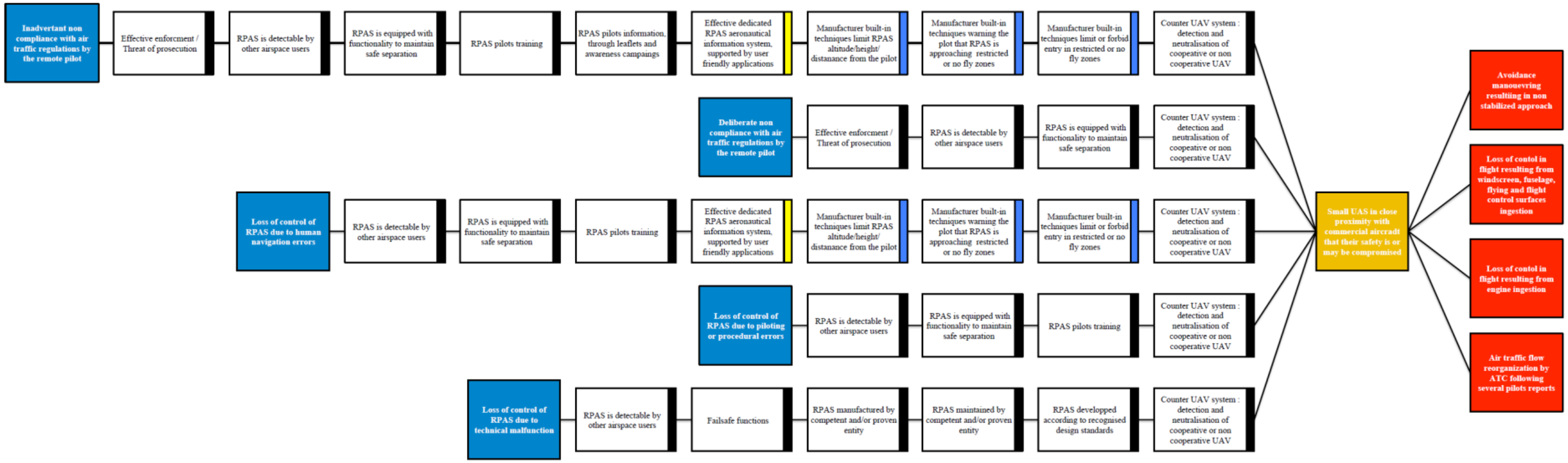


Figure E- 1 Bow-tie scheme of the risk associated to the hazard "small UAS in close proximity with manned aircraft …"

APPENDIX H: EVOLVING REGULATORY THINKING

H1 Regulatory approach in the EU

Regulation (EC) No 216/2008, the “Basic (Aviation) Regulation” (Ref. 1) establishes the main principles and rules for civil aviation in the EU. It also indicates those categories of aircraft that are excluded from this regulation, among them, **unmanned aircraft with an operating mass of no more than 150 kg**.

Therefore, the regulation of such “Light UAS” is under the remit of EASA Member States. This has created a lack of harmonization across Europe, that is deemed hampering the incipient business of civil unmanned aviation.

To solve this issue and foster this promising business, in line with the **Riga Declaration** (Ref. 6), unmanned aviation was included as one of the key elements of the new **European Aviation Strategy**, and a proposal for a new “Basic Regulation” (Ref. 5) was issued in December 2015 and is currently under discussion at EU legislation level.

Under this proposed regulation, the threshold of 150 kg operating mass is removed and, subsequently, **all civil UAS in Europe**, except those defined as “State Aircraft”, **will be under the scope of the European Aviation Safety Agency (EASA)**.

Consequently **EASA established a programme for this extension of scope**. As part of this programme, the Agency has been conducting a number of activities. The main ones are:

- EASA published in December 2015 a **Technical Opinion** (Ref. 7), which proposes a risk-based operation centric concept, in which **UAS operations are grouped in three main categories:**
    - an **‘Open’ category** for 'low' risk operations where the risk for people on the ground or in the air is minimal. There is no pre-approval of the design of the unmanned aircraft, of the operator, or of the pilot. Safety is ensured through compliance with operational limitations, mass limitations as a proxy of energy, product safety requirements, and a minimum set of operational rules.
    - a **‘Specific’ category** for medium risk operations where the risk of the particular operation would need to be assessed in view of the type of operation, the territory overflown, the particular UAS or the quality of the operator. Authorisation by a national aviation authority (NAA), possibly assisted by a qualified entity (QE), following a risk assessment performed by the operator. A manual of operations lists the risk mitigation measures.; and
    - a **‘Certified’ category** for high risk operations, equivalent to 'manned aviation'. Requirements comparable to those for manned aviation. Oversight by NAA (issue of licences and approval of maintenance, operations, training, ATM/ANS and aerodromes organisations) and by EASA (design and approval of foreign organisations).

Figure H-1 summarises these categories.

Figure H-1: Operation Categories for UAS proposed by EASA

- In parallel to the development of the Technical Opinion, EASA worked on the draft for the proposed changes to the Basic Regulation referred above.

- EASA established two Task Forces in 2016: one on “Geo-limitation of UAS” (this task force) and one on the “Drone-manned aircraft collision effects”. These task forces were launched as initial steps to understand the risk and related measures to mitigate the fast increase of reported small UAS occurrences, in particular, airproxes with commercial airplanes.

- It was agreed with Member States that the Dutch Presidency, the Commission and EASA would develop a roadmap to provide more clarity on what are the plans to roll out the operation centric concept. The roadmap includes information on rulemaking tasks, development of standards, research, cooperation with international organisations and FAA. It was developed during three workshop with Member States (March, April and May 2016) and presented to Industry at a workshop in June.

- Since the above mentioned roadmap did not fully clarify all issues, EASA decided to produce a prototype regulation for ‘open’ and ‘specific’ categories by the end of the summer 2006. The result was published at the end of August (Ref. 9). This prototype regulation proposes actual rules providing the necessary clarity, notably on what are the responsibilities of the Member States and what is the flexibility offered to them. It has been called ‘prototype’ to reflect the fact that they should help preparing the formal rulemaking process that will follow. Indeed, the intention is to gather reactions which will be used to develop the necessary Notice of Proposed Amendments.

As part of future EASA “standardisation” actions, the intent is to develop recommendations on standards and principles for short term implementation by Member States and preparing future standard development, mainly on:

- Product Safety Standards „Open Category“
- Geographical data format and references
- Identification/Registration
- Pilot Competence and Safety Promotion

The terms of reference for those activities are currently in preparation.

H2 JARUS

As abovementioned, Member States have had to cope with the operation of civil Light UAS (< 150 Kg), since these are out of the scope of current Basic Regulation. To facilitate this task and contribute to harmonise national regulations, the Joint Authorities for Rulemaking on Unmanned Systems (JARUS) was created by the end of 2007 under the auspices of the Dutch CAA.

Currently, JARUS is a group of experts from National Aviation Authorities (NAAs) and regional aviation safety organisations, chaired by EASA and co-chaired by the FAA. The member NAAs extended from the original European CAAs forming the group to authorities from all over the world.

The objective of JARUS is to provide guidance material aiming to facilitate each authority to write their own requirements and to avoid duplicate efforts.

The current work developed by JARUS is organised in working groups as depicted in the Figure H-2.

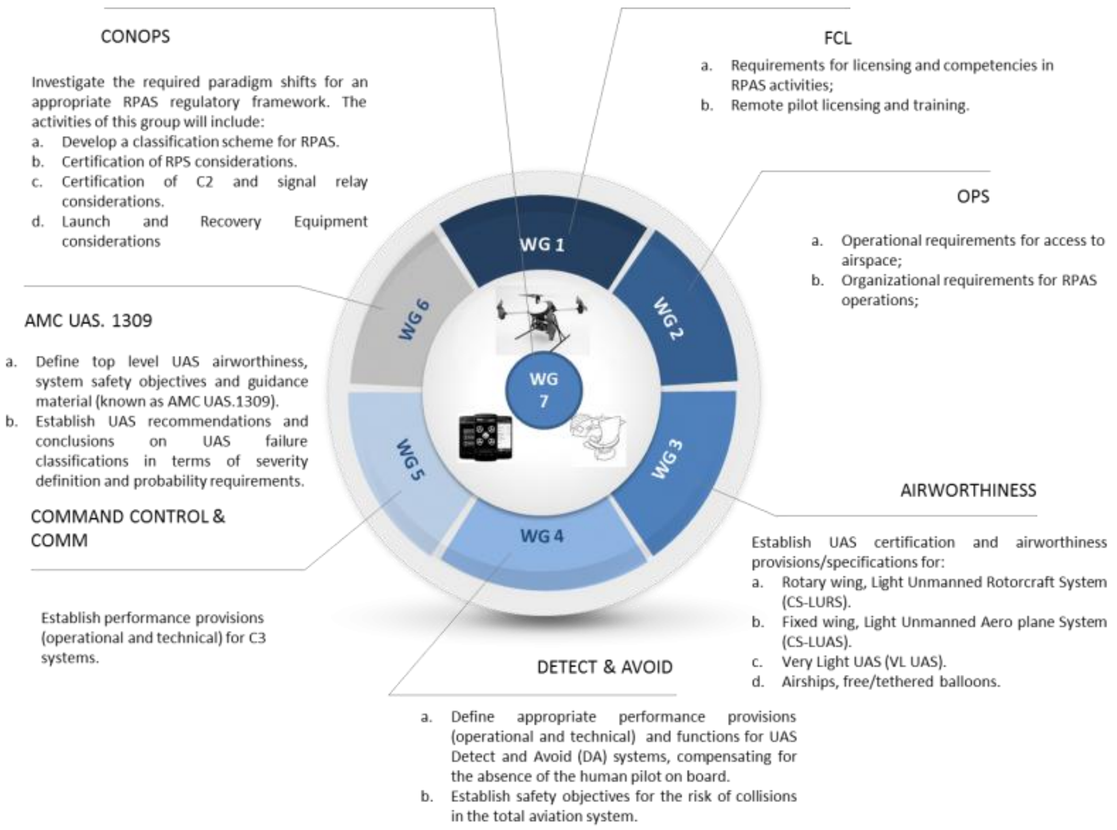


Figure H-2: JARUS Working Groups

JARUS provides in its website information on national UAS regulations[8] and regulatory material generated by JARUS.

H3 EASA Member States

Most EASA Member States have currently in place or under development regulations to address the civil operation of UAS outside the remit of the current Basic Regulation.

A summary of some basic aspects of current regulations in a number of EASA Member States is provided in Table H-1.

Table H-1: Some basic aspects of current regulations in a number of EASA Member States

EASA MS	Categories	VLOS Ops?	BVLOS Ops?	Height limit	Lateral distance	URL on UAS (retrieved 8/2016)
Austria	< 5 kg 5-25 kg > 25 kg	Yes	Yes	150 m	500 m	https://www.austrocontrol.at/en/aviation_agency/licenses__permissions/flight_permissions/rpas
Belgium	< 1 kg, recreational 1-5 Kg (class 2) > 5 kg (class 1a, 1b)	Yes	Only with derogation of rules of the air. Authorisation	300 m Above requires derogation and authorisation	Related to distance pilot-observer	
Croatia	< 5 kg 5-25 kg > 25 kg	Yes	Yes. Case-by-case approval	No	VLOS max. 500 m	http://www.ccaa.hr/english/general_381/
Czech Republic	< 0.91 kg 0.91-7 kg 7-20 kg > 20 Kg	Yes	Only in segregated airspace and over clear ground (1).	300 m AGL (class G) 100 m AGL in CTR	VLOS (2)	http://www.caa.cz/letadla-bez-pilota-na-palube?lang=1
Finland	< 25 kg > 25 Kg with a special permission RPAS Model A/C	Yes, EVLOS also	Yes, in segregated airspace	150 m	VLOS	http://www.trafi.fi/en/aviation/unmanned_aviation

[8] http://jarus-rpas.org/regulations

France	No	Yes (3)	Yes (4)	150 m 50 m (5)	100 m 200m 1 km None (6)	http://www.developpement-durable.gouv.fr/Drones-civils-loisir-activite.html
Germany	< 5 Kg 5-25 Kg > 25 Kg	Yes	Yes. Only in segregated airspace	100 m	VLOS	http://www.bmvi.de/SharedDocs/DE/Publikationen/LF/unbemannte-luftfahrtsysteme.html
Ireland	< 1.5 Kg 1.5-7 Kg 7-20 kg > 20 Kg	Yes	Yes, if DAA	120 m for <20 Kg	500 m for < 20 kg	https://www.iaa.ie/general-aviation/drones
Italy	< 0.3 Kg 0.3-2 Kg 2-25 Kg > 25 Kg	Yes, EVLOS also	Yes	VLOS: max 150 m	VLOS: Max 500m	http://www.enac.gov.it/la_regolazione_per_la_sicurezza/navigabilit-13-/sistemi_aeromobili_a_pilotaggio_remoto_(sapr)/index.html
Lithuania	< 0.3 Kg 0.3-25 Kg > 25 Kg	Yes	-	200 ft	1000 m	http://www.caa.lt/index.php?3707682770
Malta	--	Yes	--	400 ft	150 m, otherwise VLOS written approval	
Netherlands	None	Yes, EVLOS also	No	120 m	500 m (EVLOS allowed)	
Poland	< 25 kg > 25 Kg	Yes	Yes. Only in segregated airspace	--	--	http://www.ulc.gov.pl/en/270-english/current-information/3806-safe-sky-regulations-on-flying-drones-in-poland?
Romania	< 1 kg (w/o video camera) 0-15 kg (w/ video camera) > 15 Kg	Yes	Yes. Only in segregated airspace	(7)		
Spain	< 25 Kg > 25 kg	Yes	Yes, < 2 kg > 2 kg, in segregated airspace	120 m for < 25 Kg	500 m for < 25 kg	http://www.seguridadaerea.gob.es/lang_castellano/cias_empresas/trabajos/rpas/default.aspx

Sweden	• Cat1A: 0 - 1,5 kg / max 150 J / VLOS • Cat 1B: 1,5 - 7 kg / max 1000 J/ VLOS • Cat2: 7 - 150 kg / VLOS • Cat 3 BVLOS	Yes	Yes. Only in segregated airspace	120 meter for VLOS	VLOS limited	
Switzerland	• "Open" = max. 30 kg, 100m outside of crowds, VLOS • "Specific" = Else	Yes	Yes, GALLO required (8)	No limit. Depending on GALLO (8)	VLOS BVLOS, iaw. GALLO (8)	https://www.bazl.admin.ch/bazl/en/home/good-to-know%20/drones-and-aircraft-models.html
UK	< 20 Kg > 20 kg (9)	Yes EVLOS also.	yes, with DAA, segregated airspace or if OSC demonstrates that there is no 'aviation threat'	>7kg → 400 ft ≤7kg → to be seen adequately for VLOS	500 meter or VLOS limited (if less than 500m) (EVLOS allowed)	https://www.caa.co.uk/Consumers/Model-aircraft-and-drones/Flying-drones/

(1) Foreseen for research & development
(2) Understood to be not more than 500 m, but the value is not prescribed
(3) Operational scenarios S1 and S3, see Figure H-3
(4) Operational scenarios S2 and S4, see Figure H-3
(5) 150m (Operational scenarios S1 S2 with RPAS < 2kg, S3 and S4) or 50m (Operational scenario S2 with RPAS > 2kg)
(6) Depending on operational scenario, see Figure H-3.
(7) Only in segregate space out sides of the city limits; after 1 Feb 2016 130 m AGL outside of city and 270 m in city
(8) GALLO (Guidance for an Authorisation for Low Level Operation of RPAS), developed by FOCA (Swiss CAA)
(9) Operating mass

French scenarios (for "aerial work" UAS operations) indicated in the table above are summarized in Figure H-3.

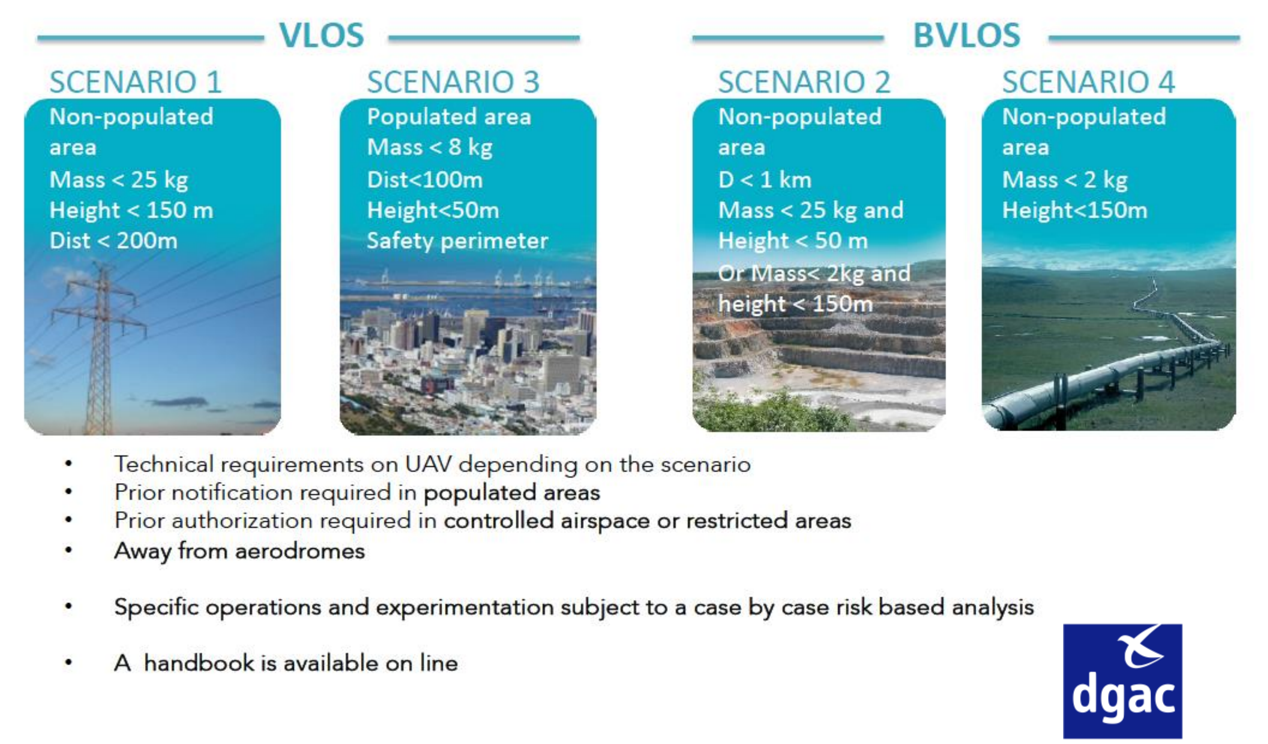


Figure H-3: French scenarios for UAS “aerial work”

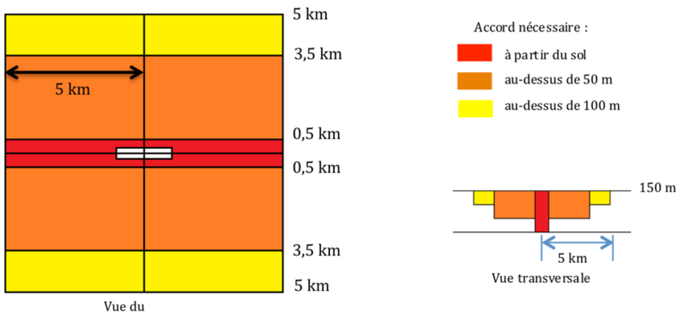
Provides a summary on limitations established in a number of Member States to protect aerodromes.

Table H-2: Limitations to protect aerodromes in a number of EASA Member States

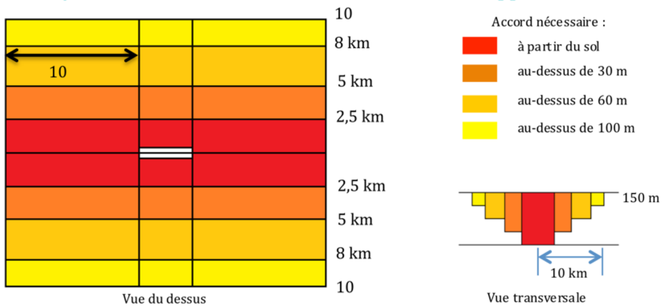
EASA MS	Limitations to protect aerodromes
Croatia	Ensure that the flight of the unmanned aircraft takes place at a distance of at least **3 km from the airport** and the approach or outgoing plane airport, except where specifically provided procedures for flying unmanned aircraft defined by the instruction for use of the airport.
Czech Rep.	• In the aerodrome traffic zone (ATZ) of a non-controlled aerodrome in compliance with the conditions set by the aerodrome operator and after coordination with the aerodrome flight information service (AFIS) or the aerodrome operator if the AFIS is not provided. Above the class G airspace, the flights in ATZ may be conducted only if the AFIS is provided. Flights of an UA and/or a model aircraft with maximum take-off mass **lower than 0.91 kg** may be performed **in the ATZ even without coordination** if they are conducted **below 100 m AGL** and below the aerodrome obstacle limitation surfaces; • In a **control zone** (CTR and MCTR) **below 100 m AGL**, except of a permission of the appropriate air traffic control unit and in the minimum horizontal distance of **5 500 m from the aerodrome reference point (ARP) of a controlled airport**, except of aerial work and public airshows coordinated with the appropriate air traffic

<table>
<tr><td></td><td>control unit and aerodrome operator. Flights of an UA and/or a model aircraft with maximum take-off mass lower than 0.91 kg may be performed in a control zone without coordination even in a smaller distance from the aerodrome if they are conducted below 100 m AGL and below the aerodrome obstacle limitation surfaces</td></tr>
<tr><td>Denmark</td><td>The distance to the runway/runways of a public aerodrome as stated in the Kort- og Matrikelstyrelsen's (Map and Land Register Administration's) map (map 25 or 1:50,000) must be at least 5 km.</td></tr>
<tr><td>Finland</td><td>Flying remotely piloted aircraft in the vicinity of an airport, i.e. within a Control Zone (CTR), Flight Information Zone (FIZ) or Radio Mandatory Zone (RMZ), is permitted at altitudes of not more than 50 metres from the surface of the ground or water, provided that the horizontal distance to the runway is at least five kilometres. If aircraft need to be flown closer to an airport or at altitudes exceeding 50 metres in these areas, the remote pilot must contact the air traffic service provider and agree separately on flight arrangements. However, arrangements must always be made separately with the air traffic service provider when flying aircraft in the control zones of Jyväskylä (EFJY) and Utti (EFUT) airports.</td></tr>
<tr><td>France</td><td>Operations of RPAS in the vicinity of airports (as defined by the zones described below) only allowed on approval of the competent authority (ATC services provider; if non, AFIS provider; if none, airport authority).
If required (and systematically for BVLOS), details of the approval shall be defined in a letter of agreement.

Runways of less than 1 200 meters



Runway of 1 200 meters or more, or with instrument approach



</td></tr>
<tr><td>Germany</td><td>The operation of unmanned aerial systems within 1.5 kilometres from the perimeter of aerodromes (with the exception of airports, see III(17)) and on aerodromes shall require the consent of the aviation supervision office or the aerodrome flight information service.</td></tr>
</table>

Ireland	The aircraft shall **not** be operated **within an aerodrome traffic zone** or closer than **8 kilometres** (5 nautical miles) from an aerodrome boundary, whichever is the greatest distance, except with the written permission of the Controlling Authority
Italy	- Operations shall **NOT be conducted within ATZ** and beneath take-off and landing paths or at a distance less than **5 km from the airport** (ARP or published geographical coordinates) where ATZ is not established; - Operations of RPA with MTOM < 25 Kg are permitted **within CTR up to maximum height of 70 m AGL** and within **maximum horizontal distance of 200 m.** - Beneath take-off and landing paths, **beyond ATZ** boundaries and **up to 15 km** from the airport, maximum height shall be **30 m AGL**.
Lithuania	If no authorisation by the ANSP, unmanned aircraft flights are prohibited: • At less than **1 nautical mile** (about 1.8 km) radius from the ARP of the Vilnius, Kaunas, Siauliai and Palanga airports regardless of the height of the flight; • Between **1 - 3 for nautical miles** (about 5.4 km) from the ARP over nearby obstacles (trees, buildings, terrain elements, wiring, equipment, etc.); • Within **3-mile radius** from ARP above 200 feet (about 60 meters) from the ground.
Malta	A remotely piloted aircraft shall not be operated within **4NM (7.5km)** from an **aerodrome boundary, or approach and take-off path** of aircraft, whichever is the greatest distance, except with the written permission of the Director General.
Norway	An aircraft without a pilot on board may not be flown closer than **5 km** to an aerodrome, unless the flight has been cleared with the local air traffic control service or flight information service.
Poland	Unmanned aircraft flights are not permitted: • Within **5 km** from ARP of a non-controlled aerodrome or in a **ATZ** unless approval; • In a CTR, unless ANSP and ATC approval.
Spain	• Operations must be carried out at a distance of least **8 km from any airport or aerodrome**, or, • In the case of flights of RPA with **mass < 2Kg in BVLOS operation**, if the infrastructure provides for **instrument flight procedures**, operation must be at a minimum distance of **15 km from its reference point**.
Switzerland	It is forbidden to use model aircraft weighing between 0.5 and 30 kg: • at a distance of less than **5 km** from the runways of a civilian or military airfield; • in the control zones (CTR), if they exceed a height of 150 m above the ground.
UK	Operators of any SUA of **mass 7 kg or less**, are strongly advised for collision avoidance purposes, to remain clear of charted aerodromes by **at least a distance of 5 km**, whether or not the aerodrome is in controlled airspace or has an associated ATZ.

Some Member States are providing leaflets, videos, and other guidance material to disseminate the rules applying to UAS operations, in particular, for awareness of recreational users. A couple of examples are presented in the following figures.

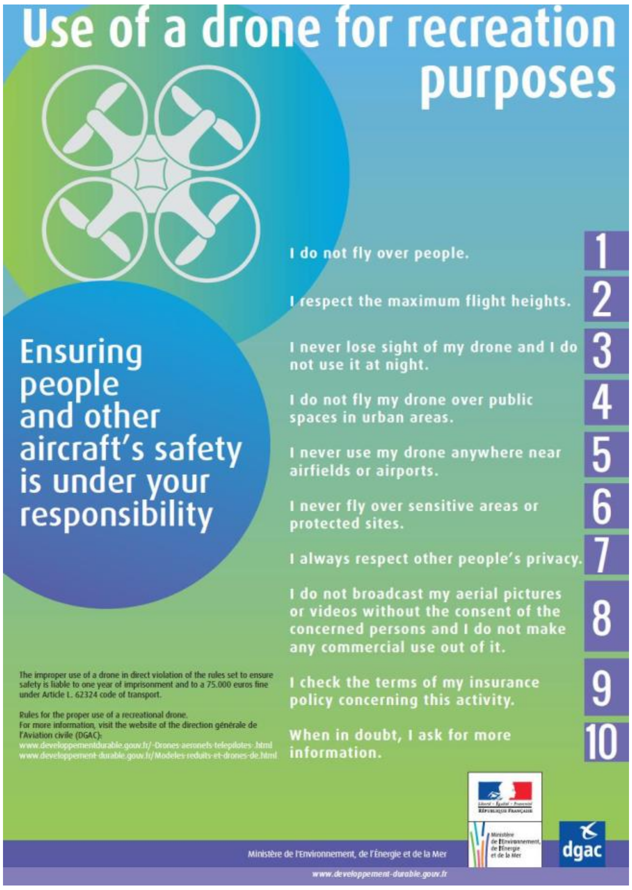


Figure H-4: DGAC (France) leaflet for the recreational use of drones

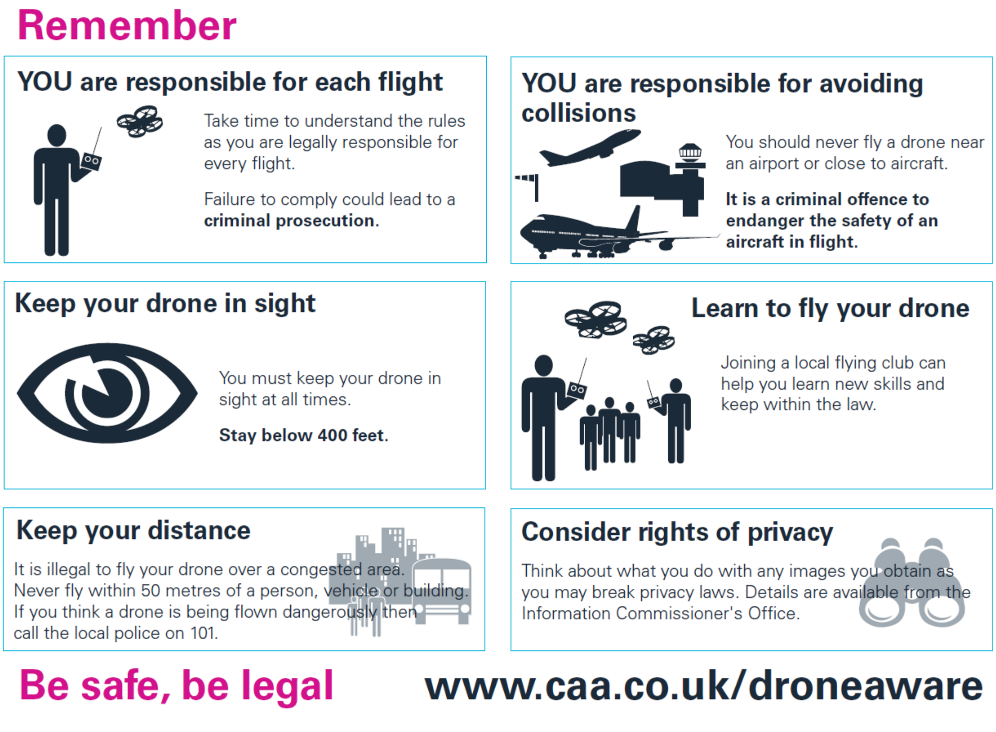


Figure H-5: CAA UK safety guide for the recreational use of drones

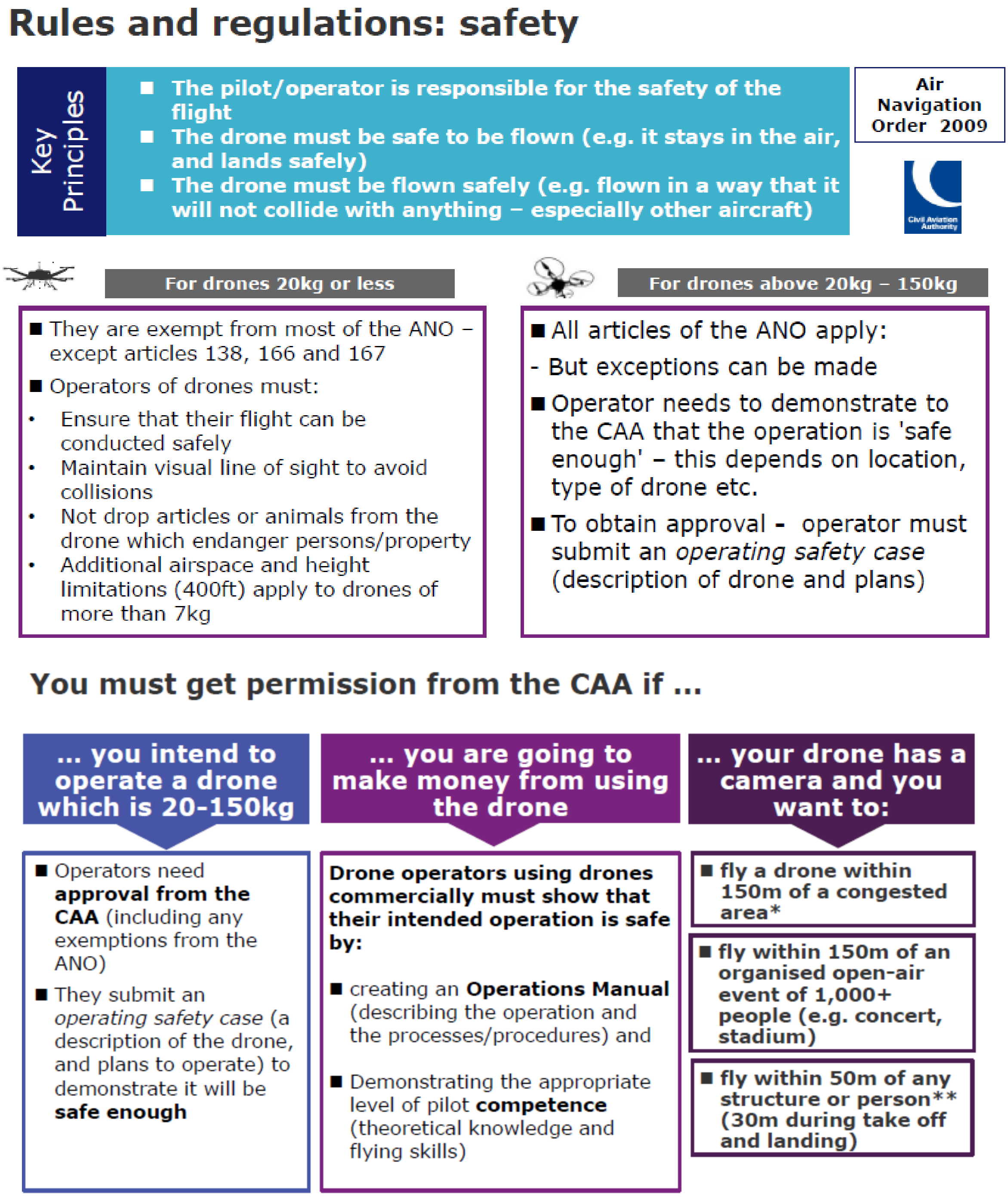


Figure H-6: UK CAA summary of national regulation for UAS operations

H4 ICAO

In 2005 ICAO began to explore the subject of unmanned aviation. It was agreed by the Air Navigation Commission (ANC) that it would be appropriate that ICAO lead the global harmonization effort to harmonize notions, concepts, terms and strategies, and coordinate the development of strategic guidance documents that would guide the regulatory evolution at international civil level.

In 2007 the ICAO established the Unmanned Aircraft System Study Group (UASSG) with the focus on creating international acceptable rules and regulations for the use of unmanned aircraft outside non-segregated airspace. This group produced amendments to ICAO Annexes 2, 7 and 13 to include RPAS, and elaborated ICAO Circular 328 on Unmanned Aircraft Systems (published in 2011)

In November 2014, the first meeting of the Remotely Piloted Aircraft Systems (RPAS) Panel, replacing the UASSG, took place in Montreal. In March 2015, the Doc. 10019 RPAS Manual was published.

A small UAS (sUAS) Advisory Group was recently created, co-chaired by CANSO and EASA.

A UAS Regulation Portal has been set up at the ICAO website[9]. It is initially providing some information on UAS-related regulations in a number of states. Figure H-7, from that portal, provides “ICAO's six basic tips for safe UAS operations”.

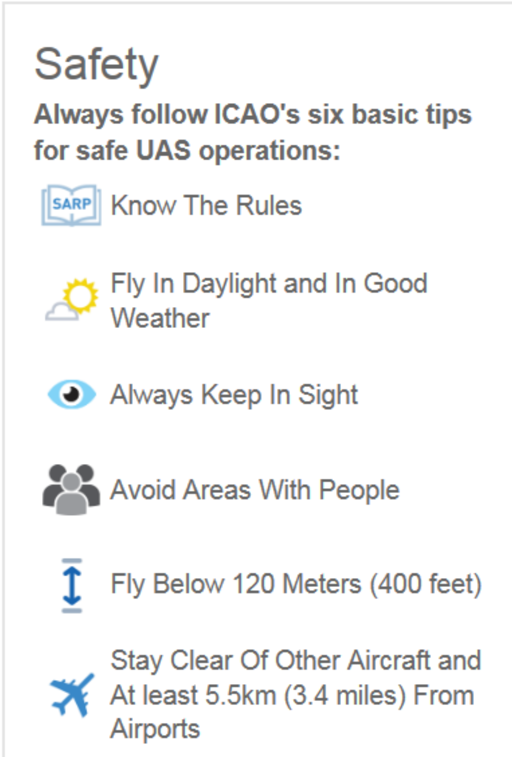


Figure H-7: ICAO's six basic tips for safe UAS operations

H5 United States

In February 2012, the FAA Modernization and Reform Act was enacted into law. It includes a section (Subtitle B) on Unmanned Aircraft Systems. This “Bill”, passed from Congress to the FAA, and provided a “roadmap” with a number of milestones with specific deadlines for the FAA in order to meet a safe integration of UAS by 2015. A number of aspects made not possible to meet the planned deadlines, in particular for the routine operation of small UAS for “professional” use. However,

[9] http://www.icao.int/safety/RPAS/Pages/UAS-Regulation-Portal.aspx (retrieved in 8/2016)

finally the "Small UAS Rule" (Part 107), including all pilot and operating rules, was produced and will be in effect at the end of August 2016.

Among the main aspects of Part 107 are:

- Unmanned aircraft must weigh less than 55 lbs (25 kg).
- Visual line-of-sight (VLOS) only; the unmanned aircraft must remain within VLOS of the remote pilot in command and the person manipulating the flight controls of the small UAS. Alternatively, the unmanned aircraft must remain within VLOS of the visual observer.
- At all times, the small unmanned aircraft must remain close enough to the remote pilot in command, and the person manipulating the flight controls of the small UAS, for those people to be capable of seeing the aircraft with vision unaided by any device other than corrective lenses.
- Small unmanned aircraft may not operate over any persons not directly participating in the operation, not under a covered structure, and not inside a covered stationary vehicle.
- Daylight-only operations, or civil twilight (30 minutes before official sunrise to 30 minutes after official sunset, local time) with appropriate anti-collision lighting.
- Must yield right of way to other aircraft.
- May use visual observer, but not required.
- First-person view camera cannot satisfy "see-and-avoid" requirement but can be used as long as requirement is satisfied in other ways.
- Maximum groundspeed of 100 mph (87 knots).
- Maximum altitude of 400 feet above ground level (AGL) or, if higher than 400 feet AGL, remain within 400 feet of a structure.
- Minimum weather visibility of 3 miles from control station.
- Operations in Class B, C, D and E airspace are allowed with the required ATC permission.
- Operations in Class G airspace are allowed without ATC permission.
- No person may act as a remote pilot in command or visual observer for more than one unmanned aircraft operation at one time.
- No operations from a moving aircraft.
- No operations from a moving vehicle unless the operation is over a sparsely populated area.
- No careless or reckless operations.
- No carriage of hazardous materials.

It must be noted that Part 107 does not apply to recreational use of UAS (unlike the "Open" category proposed by EASA)

Also to highlight, is the fact that this regulation does not require any geo-limitation function. In particular, no geo-fencing capability is required. The rationale included in the rule for this decision is :

Requiring the installation of a geo-fencing system capable of keeping small unmanned aircraft out of restricted and prohibited airspace would present a number of technical hurdles. Specifically, there are currently no design or performance standards for geo-fencing equipment to ensure safe and reliable integration into the NAS. Without appropriate geo-fencing design and performance standards, the industry and the FAA lack the data necessary to assess the accuracy and reliability of geo-fencing equipment and therefore, the FAA cannot promulgate geo-fencing equipment design requirements (i.e., airworthiness certification).

Also, geo-fencing equipment integrated on small UAS would require an evolving database of terrain and obstacle updates, restricted and special use airspace, Notices to Airmen (NOTAMs), and Temporary Flight Restrictions (TFRs). The FAA is unaware of a database that provides this full capability and therefore cannot accurately determine the effort to develop and maintain it for remote pilots. The FAA also does not have information on how frequently updates to the onboard small UAS geo-fence database would be required to maintain safe and reliable operation in the NAS.

In addition, any geo-fencing equipment required under part 107 would also need to include an override feature to allow the remote pilot to enter the airspace if he or she receives permission from Air Traffic Control or an appropriate controlling agency. Additionally, as discussed in section III.E.1.d of this preamble, this rule will allow the remote pilot to deviate from the operational restrictions of part 107 if doing so is necessary to respond to an emergency situation. Thus, an override feature may also be necessary to allow a remote pilot to respond to emergencies. A geo-fencing system without an override function that prevents the human pilot from exercising this deviation authority may impair the pilot's ability to safely respond to an emergency situation.

If these technical obstacles are overcome, a mandatory geo-fencing system may provide a marginal increase to safety by forcibly keeping small unmanned aircraft out of certain airspace in which the aircraft may pose a higher risk to manned-aircraft operations.

However, under Executive Order 12866, the FAA can adopt a regulation "only upon a reasoned determination that the benefits of the intended regulation justify its costs." Here, the FAA has no data that would allow it to quantify the benefits of a possible safety increase associated with a mandatory geo-fencing system. Conversely, a mandatory geo-fencing requirement would substantially increase the costs of this rule. If mandated, there would be a cost for developing the minimum performance standards for this equipment. Once the standards are developed, the cost to owners for retrofitting previously purchased small UAS would be realized. If it is not possible to retrofit a small UAS to include geo-fencing, a replacement cost would be incurred. Additionally, an incremental per unit cost to small UAS manufacturers for installing mandated geo-fencing on newly built small UAS.

Once geo-fencing is installed, the on-board avionics would rely upon a database of restricted airspace, NOTAMs, TFRs, obstacles, and terrain upon which to remain current. Maintaining these databases would incur additional costs, based on the frequency of database updates and the value *of the time for the individual performing the task. Finally, small UAS owners would have recurring costs for subscribing to the database supplier or app developer for updates to regulatory airspace. To sum up, mandating geo-fencing equipage would result in substantial costs and, at this time, the FAA does not have sufficient data to determine, consistent with its obligations under Executive Order 12866 and 13563, whether the benefits associated with such a mandate would justify those costs.*

APPENDIX I: EVOLVING TECHNOLOGY SOLUTIONS

Drone technology advances fast and every successive generation improves on the performance of the previous one. Information technology advances at exponential rate while possible improvements of mechanical components are more limited. Too technically specific regulation could slow down development of future aircraft and their safety devices or systems.

A number of technological solutions, currently available or in development, to reduce the likelihood of a collision between a small unmanned aircraft and a manned aircraft are described in the following sections, with focus on geo-limitation related solutions.

I1 Solutions to prevent conflict with manned aircraft

I1.1 Provision of geo-limitation information

Providing UAS operators with accurate and up-to-date information on geo-limitations that apply in the zones where those operators intend to operate is a first and paramount step required for safe UAS operations.

Some national authorities are providing already via website that information, e.g. "Drone No Fly Zones" web by the Ministry of Infrastructure and Environment of the Netherlands[10].

Some national authorities have made available (or in the process to do so) mobile devices app to provide UAS operators with that information in a more convenient manner. For example:

- The FAA has developed B4UFLY, an easy-to-use smartphone app that helps UAS operators determine whether there are any restrictions or requirements in effect at the location where they want to fly. Key features of the B4UFLY app include:
    - A clear "status" indicator that immediately informs the operator about the current or planned location. For example, it shows flying in the Special Flight Rules Area around Washington, D.C. is prohibited.
    - Information on the parameters that drive the status indicator.
    - A "Planner Mode" for future flights in different locations.
    - Informative, interactive maps with filtering options.
    - Links to other FAA UAS resources and regulatory information.

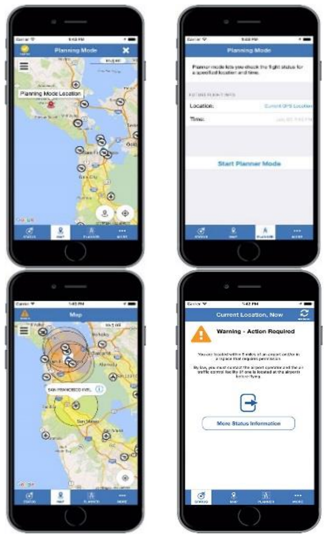


Figure I-1: B4UFLY App (source: FAA)

[10] https://kadata.kadaster.nl/dronekaart/ (retrieved 8/2016)

- Trafi (Finland) is also developing this kind of app.

An increasing number of companies offer tools to provide that information and more services to the UAS operators and other stakeholders (e.g. aerodrome managers, ATC, authorities, …). Some of these companies cooperate with small UAS manufacturers to provide their UAS with this kind of tools. For example:

- UniFly developed several products, among them UniflyLAUNCHPAD, a mobile app for UAS operators:
  - It includes: Pilot & Drone registration, Take off / Land function, Logbook.
  - It provides the drone pilot/operator with a tool to know whether he/she can fly in a specific airspace:
    - ✓ Performs Automatic Validation of Airspace, Legislation, Drone Type & Other Airspace activities
    - ✓ Indicates the pilot/operator whether he/she is allowed or not to operate in that place at that moment.

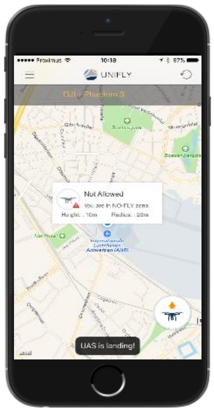


Figure I-2: UniflyLAUNCHPAD App (source: Unifly)

- AirMap offers products for developers (UAS manufacturers – it must be noted that AirMap partnered with manufacturers like DJI, 3DR, … – , SW developers, …), airspace managers, and UAS operators. For the latter, the company developed both a web-based information service[11] and a mobile app, “AirMap for drones”

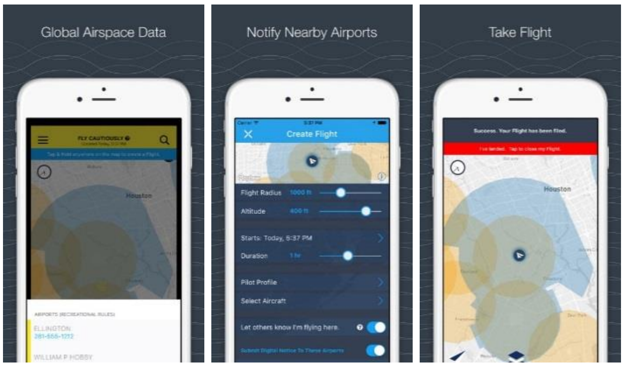


Figure I-3: AirMap for drones App (source: AirMap)

This app includes features like: View Airspace Data, Toggle Airspace Information & Advisory Map Overlays, “Super Fast” Vector Maps, Pilot Profile View, Manage UAV Aircraft, Create & Manage Flights – incl. Future Flights, D-NAS File Digital Flight Notifications, View Public Flights, Toggle between Four Different Map Styles, Search Map by Place or Location.

[11] https://app.airmap.io/ (retrieved 8/2016)

I1.2 Geo-fencing and performance limitations

DJI's GEO system is currently the industry forefront in geo-fencing solution for small UAS in the consumer market. The main characteristics of GEO (Geospatial Environment Online) are:

- It provides operators of DJI UAS (equipped with this function) with up-to-date guidance on areas where flight may be limited by regulation or raise safety concerns.
- GEO includes the following categorization of zones and characteristics:
    - Warning Zone. In these Zones, which may not necessarily appear on the DJI GO map, users will be prompted with a warning message that may be relevant to their flight. Example Warning Zone: A protected wildlife area.
    - Enhanced Warning Zone. In these Zones, the users will be prompted by GEO at the time of flight to unlock the zone using the same steps as in an Authorization Zone (see below), but the user does not require a verified account or an internet connection at the time of the flight. Example Enhanced Warning Zone: A farm which is 3 miles away from a busy international airport.
    - Authorization Zone. In these Zones, which appear yellow in the DJI GO map, users will be prompted with a warning and flight is limited by default (the drone will not enter that zone or will not take off if already inside). Authorization Zones may be unlocked by authorized users using a DJI verified account (which currently requires the user to include either a credit card or a phone number). The user has to acknowledge that understands the advisory information and accepts the responsibility. This way it is ensured that if the unmanned aircraft enters an "authorisation" zone it will not happen by accident. Example Authorization Zone: Model aircraft flying club near an airport.
    - Restricted Zones. In these Zones, which appear red the DJI GO app, users will be prompted with a warning and flight is prevented. In this case the limitation cannot be unlocked by the user. Example Restricted Zone: Washington DC. It must be noted that **current policy by DJI is to consider airports as restricted zones**.

Figure I-4 illustrates these zones for an example location and, Figure I-5, depicts steps regarding the un-locking of an "authorisation zone".

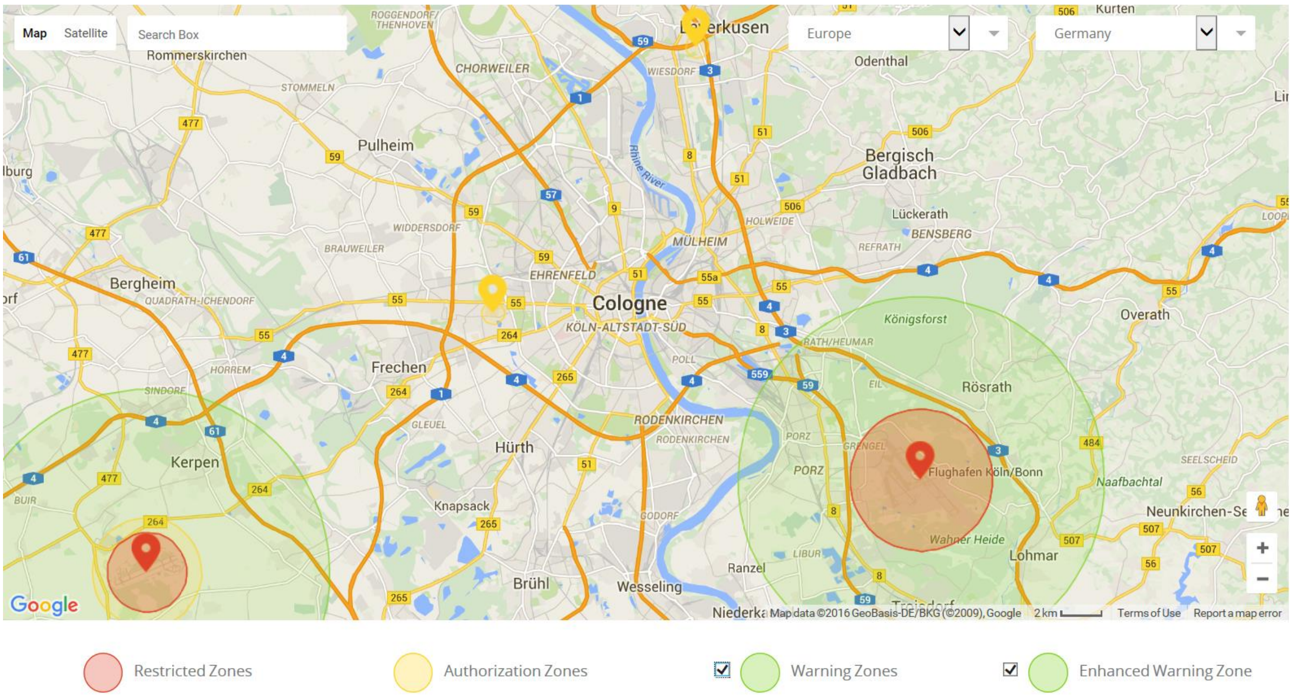


Figure I-4: Example of DJI GEO zones (source: DJI)

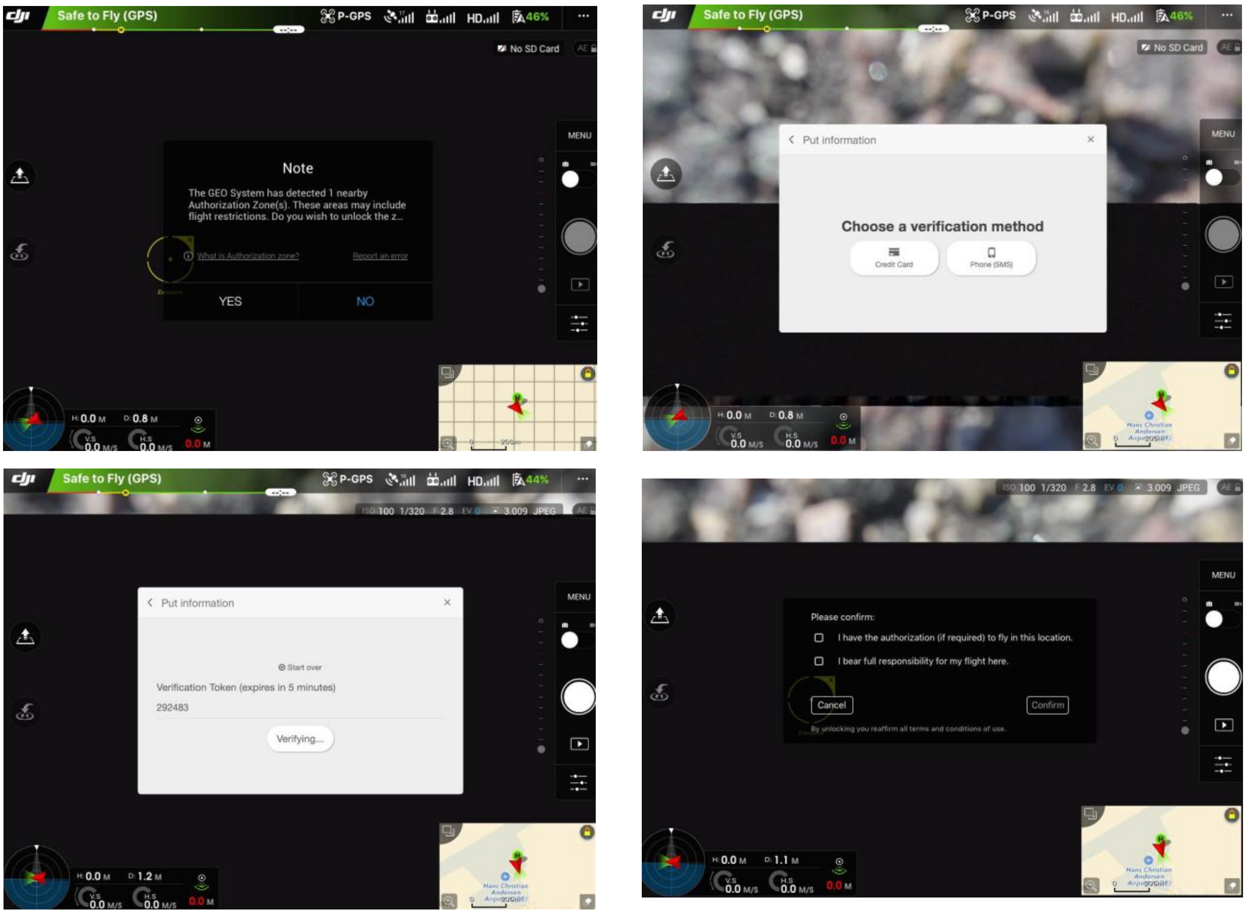


Figure I-5: Snapshot of the "Authorisation zone" un-locking process (source: DJI)

GEO provides advisory information, by means of:

- Updated airport information (at least every 28 days in accordance with AIRAC cycle). AirMap is DJI geospatial data supplier
- Live Temporary Flight Restrictions, which address safety concerns in cases like: wildfires and other emergencies, Stadium event TFRs (US), VIP travel TFRs (e.g. election year in the US)
- Non-aviation security-sensitive locations, such as prisons and nuclear power plants

DJI believes that with this feature, users will better understand airspace restrictions and help them to prevent inadvertent or unintended flights in places raising safety or security concerns.

With regard to performance limitations, many manufacturers are providing limitation functionalities that, in some cases, allow the user to set up the preferred maximum/minimum values up to built-in limits. Some manufacturers consider as “geo-fencing” the setup of the volume defined by the horizontal distance to the remote pilot and the height limit, as depicted in

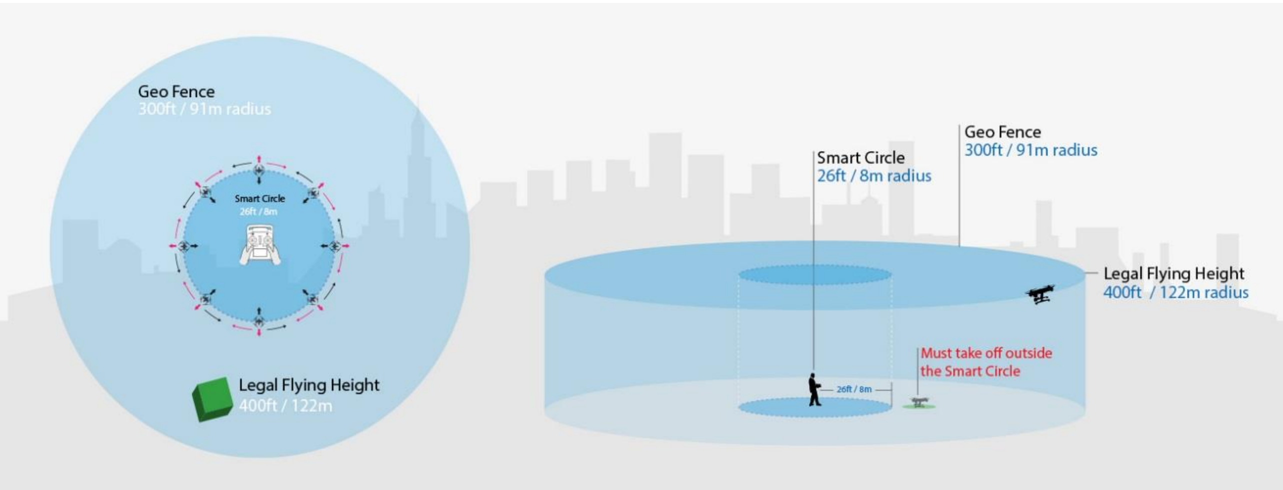


Figure I-6: Performance limitations: max. horizontal distance to remote pilot and max. height (source: Yuneec)

Regarding other means to prevent unmanned aircraft “fly away”, tethering might be a simple way (for those UAS suitable for such measure); electronic systems can also prevent flying too far away from the operator’s position.

I1.3 Air traffic situational awareness and unmanned aircraft in-flight identification

Detecting and identifying UAS for air traffic situational awareness is possible through cooperative systems like ADS-B, or systems working, for example, through the use of mobile network. Some form of broadcasted identification is expected to be a part of the future UTM system. Cooperative systems like ADS-B have the advantage of being more and more used by manned aviation and, therefore, it allows UAS operators to have situational awareness of surrounding traffic. However, the use of ADS-B might not be suitable in congested airspace, as it may saturate ATC surveillance capacity. It must be noted that a number of research projects have already demonstrated the feasibility of using ADS-B in small UAS (e.g. SJU RPAS Demo projects[12])

That kind of cooperative systems are, in principle, much lighter and less power hungry than non-cooperative solutions like those based on on-board primary surveillance (PSR) radars. With regard to PSR, there are some in the market for ground surveillance, that can detect small unmanned aircraft, e.g. DeTect Harrier radar, and are already being used in a number of test ranges and other locations for UAS operations.

Detection, identification and tracking in flight of unmanned aircraft is also paramount for infrastructure protection and law enforcement. UAS can be tracked with several different systems and these systems can be utilized around airports or other sensitive areas. These systems work with various kinds of sensors trying to listen to acoustic signatures or radio signals and some having specialized radar for detecting UAS. Locating operators near restricted areas can for example be done using triangulation of the controller's signal or by trying to detect the drone's departure point with radar. There are already a number of solutions in the market, e.g.:

- Dedrone DroneTracker is a detection/warning ground-based system utilizing Acoustic, Electro Optical, TI and Wi-Fi sensors to detect nearby UAS .

- LightCense has designed a blinking LED drone license plate system. The system allows for visual identification of the registered user either by simply looking at the drone or using a mobile phone application and the phone's camera.

It must be noted that a number of Member States (e.g. Denmark, France, Italy) are already mandating, or planning to, the use of UAS in-flight identification and tracking means.

[12] http://www.sesarju.eu/node/1627 (retrieved 8/2016)

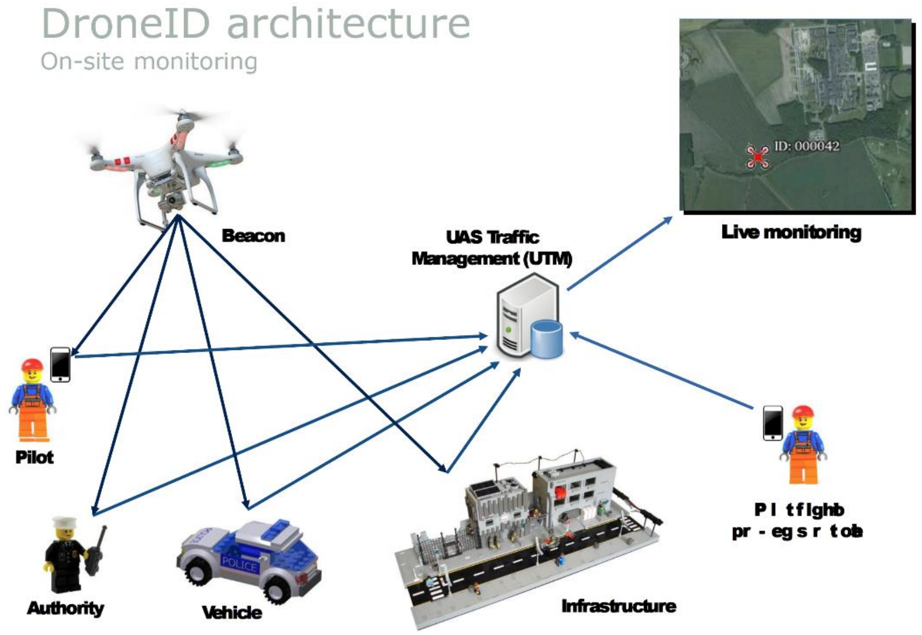


Figure I-7: Danish DroneID architecture (source: Danish Transport and Construction Agency)

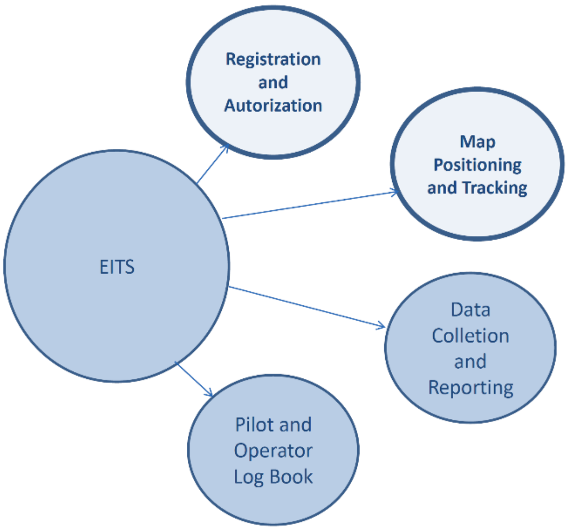


Figure I-8: Italian Electronic Identification and Tracking System (EITS) main functionalities (source: ENAC)

I1.4 UAS Traffic Management (UTM) system

NASA introduced the concept of UAS Traffic Management (UTM) to overcome the current lack of infrastructure to enable and safely manage the widespread use of low-altitude airspace and UAS operations, regardless of the type of UAS.

NASA is currently researching, in partnership with a number of organisations, prototype technologies for a UTM system. Figure I-9 illustrates the notion of NASA UTM.

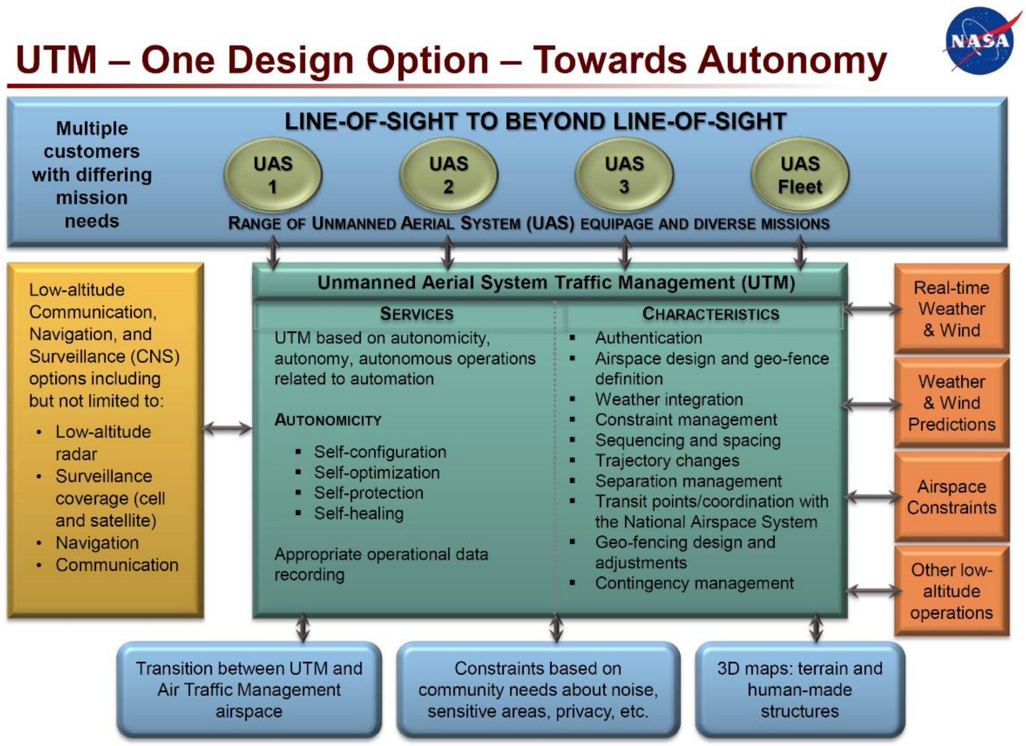


Figure I-9: NASA UTM diagram (source: NASA)

As it is shown in Figure I-9, geo-fencing is one of the elements of the UTM concept (airspace design and geo-fence definition, and geo-fencing design and adjustments).

Figure I-9 depicts the notion planned schedule for NASA UTM.

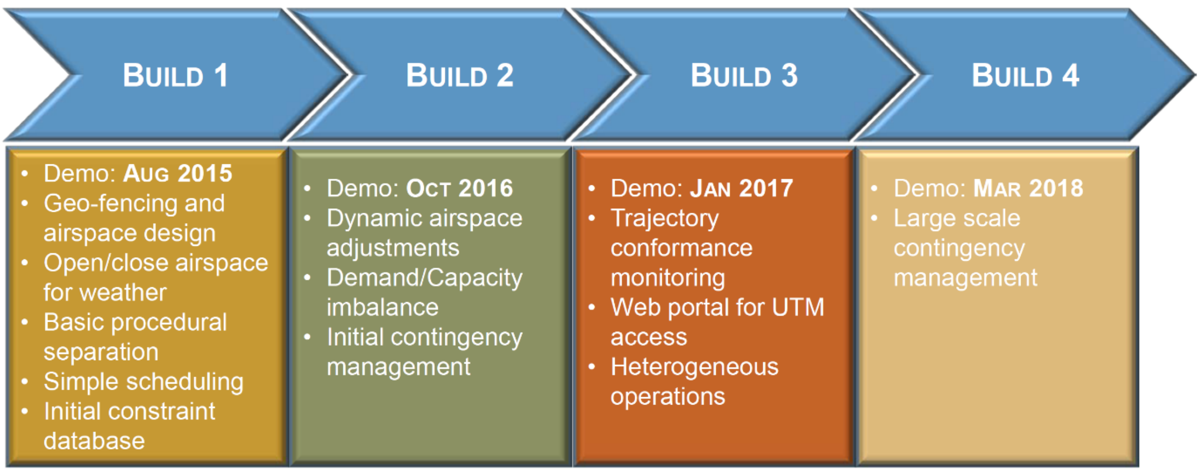


Figure I-10: NASA UTM schedule (source: NASA)

Following on NASA UTM concept, a wider and international group of UAS-related stakeholders (including manufacturers, regulators, air navigation service providers, research organisations, …) founded in a meeting held in April 2016 the Global UTM Standardization Group, now Global UTM Association. This association is being organised in working groups *to draft and distribute compliant* *blueprints, standards and protocols for UTM systems, in collaboration with regulators and other stakeholders worldwide*.

The EU Single Sky Committee (SSC) indicated, as part of the agenda items for June 2016 meeting, the need to research on "drone traffic management system". The SSC expressed the view that the future UTM system should include the following features:

- A standardised data link for UAS
- Human equivalent capability Detect & Avoid system
- Contingency planning for data link loss situations
- Cyber security resilience
- Interoperability with normal airspace and airport operations
- Unique human factors aspects regarding UAS and their integration to UTM/ATM.

The SESAR Joint Undertaking (SJU) launched a call for exploratory research projects on the integration of UAS into civil airspace within the framework of the SESAR 2020 research and innovation programme. In light of abovementioned indication of the SSC, the call specifically aims to stimulate initial solutions for "drone traffic management", supporting the sharing of airspace between manned and unmanned systems.

I2 Solutions to prevent infringing UAS from colliding with manned aircraft

Despite some initiatives addressing Detect and Avoid (DAA) systems for UAS, no effective solution integrated in small UAS is expected to be available in the foreseeable future for air traffic detect and avoidance. However, it must be noted that:

- Air traffic situational awareness can be considered the first "building block" towards a DAA and, as discussed in I1.3, there are already technology solutions addressing this aspect.
- Some small UAS are already being equipped with a capability to detect and avoid fixed obstacles along their path. Progress from this start point may yet be quicker than currently envisaged.
- Detect and avoid of air traffic can be considered, from a notional standpoint, as a "dynamic geo-fencing" function in which the air traffic is the "geo-fenced infrastructure", instead of a fixed infrastructure on the ground.

Other solutions to prevent infringing UAS from colliding with manned aircraft, especially in the airport environment, are what some termed as "anti-drone" solutions. An increasing number of solutions are being proposed to detect an "intruder drone" in a sensitive zone and to disable it by different means, such as jamming or spoofing the UAS (e.g. their C2 link and/or GNSS signal), capturing in flight the unmanned aircraft (e.g. via nets carried by another "drone", or using "drone falconry" with large predatory birds) or destroying it (e.g. using fire arms, electromagnetic pulse, lasers …). Examples of this kind of solutions are:

- *Dedrone* (see I1.3 above)
- *Blighter AUDS (Anti-UAV Defence System)*, a "counter drone system" designed by UK companies to disrupt and neutralise UAS engaged in hostile airborne surveillance and potentially malicious activity; it combines electronic-scanning radar target detection, electro-optical tracking/classification and directional RF inhibition capability. This system is being trialled by the FAA to protect US airports.
- *UWAS (UAV Watch and Catch System)*, developed by Aveillant, JPCX and DSNA services. The system integrate holographic radar technology with counter-UAV system and also incorporates high resolution cameras and jammers.
- Drone Guard, a solution developed by ELTA (IAI) that includes adapted 3-dimensional radars and electro-optical sensors for detection and identification, as well as dedicated electronic attack jamming systems for disrupting drone flight.

APPENDIX J: SURVEY RESPONSES

The Geo-Limitations Task Force survey of stakeholders was conducted using the questionnaire presented in APPENDIX E: SURVEY QUESTIONNAIRE. In APPENDIX J, the compilation of the responses received for each of the questions posed in that questionnaire is presented.

J.1 QUESTIONS TO UAS MANUFACTURERS

Question A

What is the number of small drones (< 25 Kg) your company sold in Europe in 2015? How many (%) are below 2 Kg?

From data received, the Task Force estimated:

Total sold 2015	% under 2kg
1,703,295	98%

Question B

What is the average time that the small drones produced by your company stay in production (from entry to market to production discontinuation)?

From data received, the Task Force estimated:

Average production run (years)	Production weighted average life (years)
2.7	1.95

Question C

Does your company have an occurrence reporting system implemented for drones? Does your company have procedures in place to analyse failures, classify the severity and design changes to improve reliability?

Most companies analyse failures when products brought in for repair or from customer feedback.

Question D

How is the drone software of your company being updated? Does it involve the download of the latest software version by the user/operator?

Updates downloaded from internet	Unanimous

Question E

For the different (small) drone products of your company, what are the typical values for accuracy of height/altitude and lateral positioning?

Altitude	Lateral	
Barometric sensors	GPS 95% reliability	GPS ~90% reliability
1.5m	7.8m	5m

J.2 QUESTIONS FOR ALL SURVEY PARTICIPANTS

Question 1

As far as you know, what is the number of small drones (< 25 Kg) operating currently in Europe?

From data received, the Task Force estimated (*):

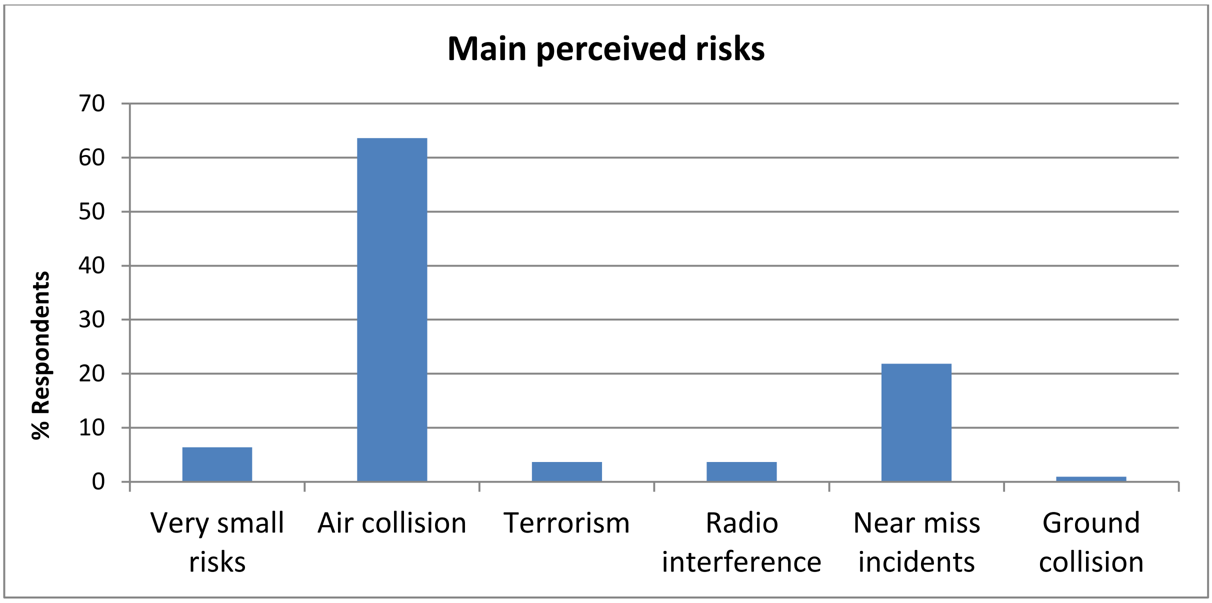
3,3 Million units

(*) Calculated as Total sold per annum x Production weighted average life. Homebuilt and ("traditional") model aircraft excluded.

Question 2

What are in your view the main risks that (small) drones pose to manned aircraft?

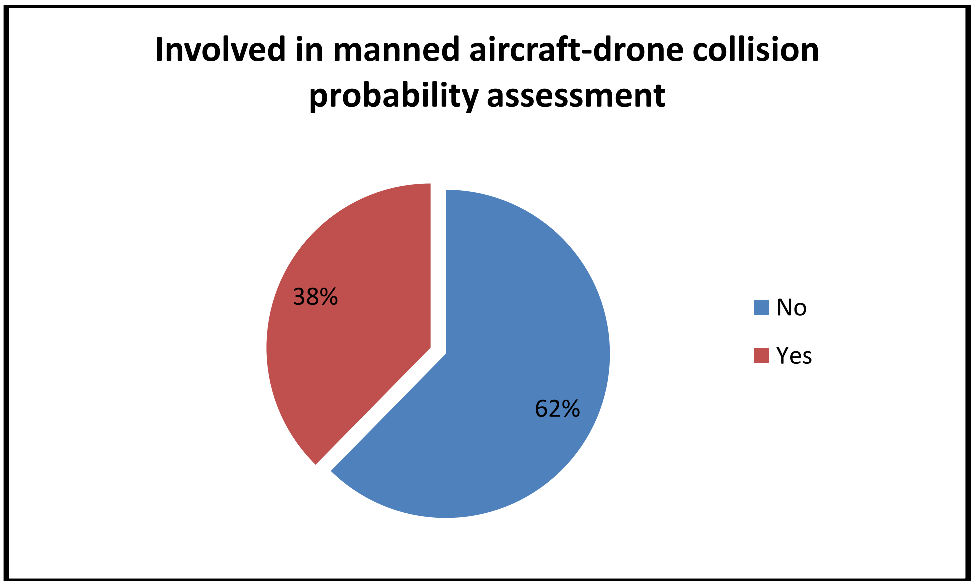
Total number of responses: 86

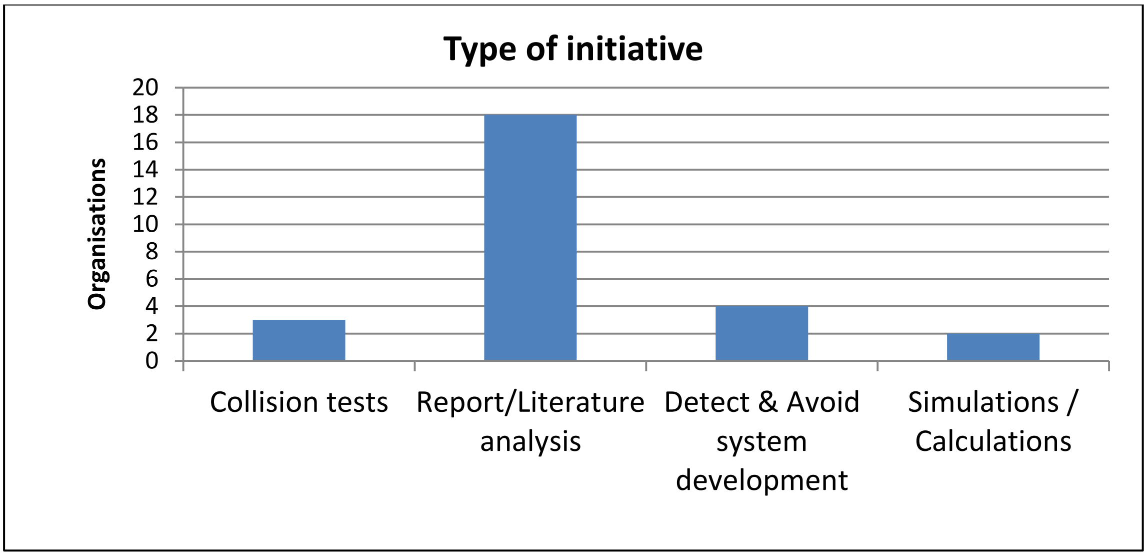


Question 3

Has been your organisation involved in the assessment of likelihood of collision of a (small) drone with a manned aircraft? If so, please describe the initiative(s) (including type of manned aircraft and drone) and main conclusions (if available)

Total number of responses: 85

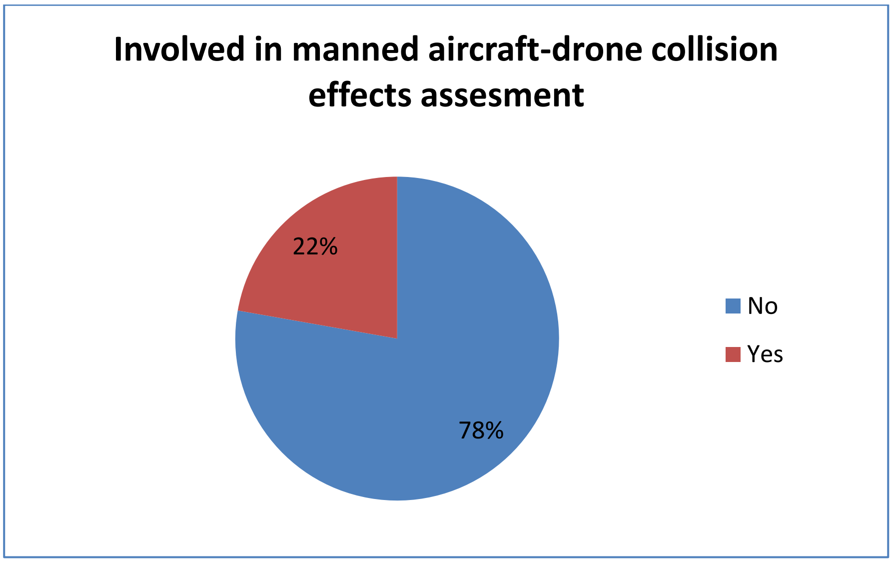




<u>Question 4</u>

Has your organisation been involved in the assessment of the effects that the collision of a (small) drone with a manned aircraft could cause? If so, please describe the initiative(s) (including type of manned aircraft and drone) and main conclusions (if available)

Total number of responses: 54



Many studies used bird strikes as analogue for assessing UAS collision effects. Bird strike studies suggest that small drones flying low pose low risk, but hard shelled batteries could pose serious threat

One simulation of impact

Question 5

How many incidents between manned aircraft and drones have been reported in 2015?
How many of those involved CAT aircraft?
How many of those were confirmed as caused by drones?

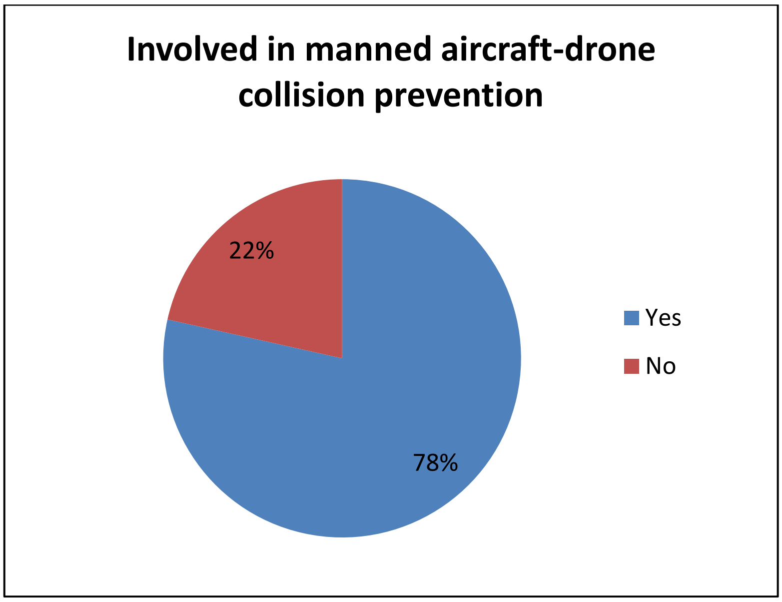
Several NAAs provided data on their recorded occurrences (used in APPENDIX G: UNMANNED/MANNED AIRCRAFT COLLISION RISK INFORMATION). From data received, the Task Force estimated:

2.2 incidents per year per 1 million inhabitants estimated to average for EU States

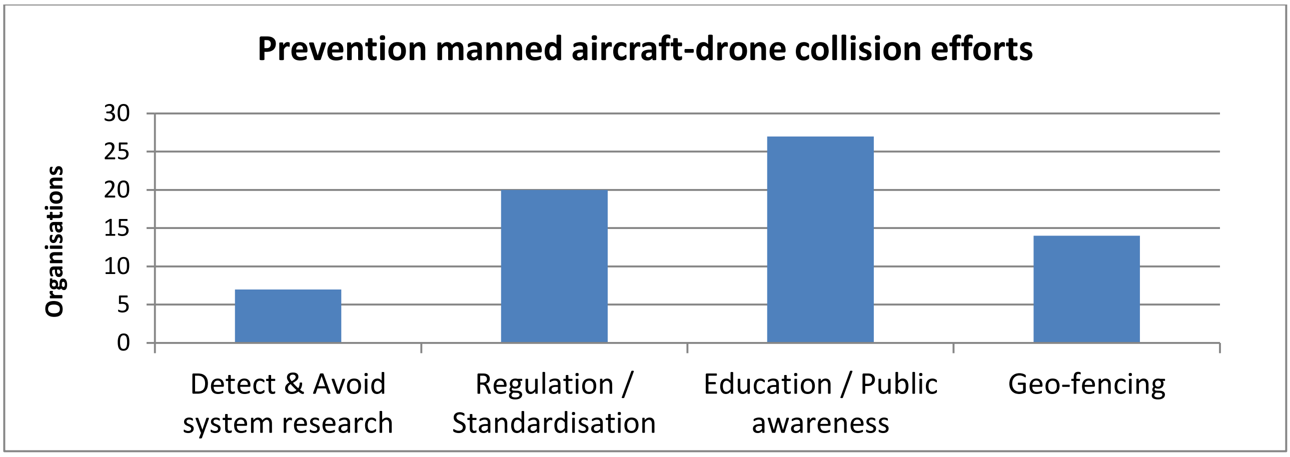
Question 6

Is your organisation involved in any activity to prevent mid-air collision of drones with manned aircraft and/or to prevent drones entering a non-authorised airspace/zone (eg. airport)? If yes, please describe.

Total number of responses: 79

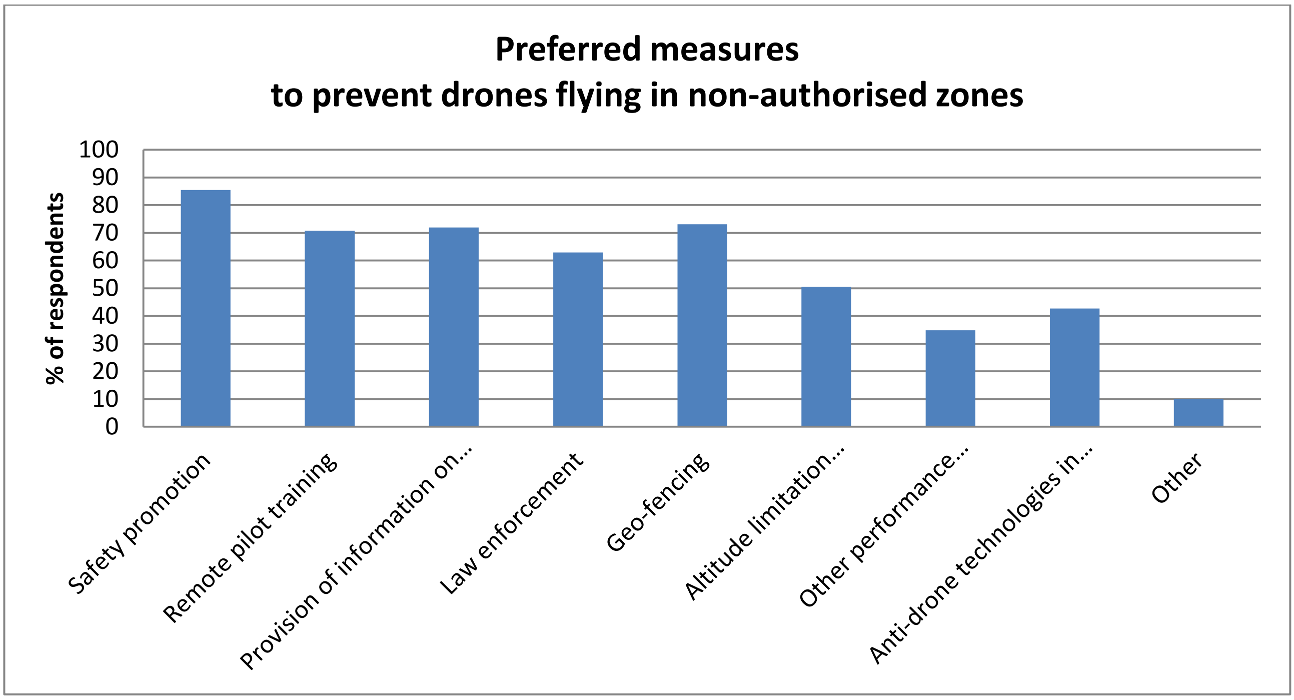


Total number of responses: 68



Question 7

What are in your view the main measures to prevent that drones fly in a non-authorised airspace/zone (e.g. airport)? Select from the list (as many as you consider)



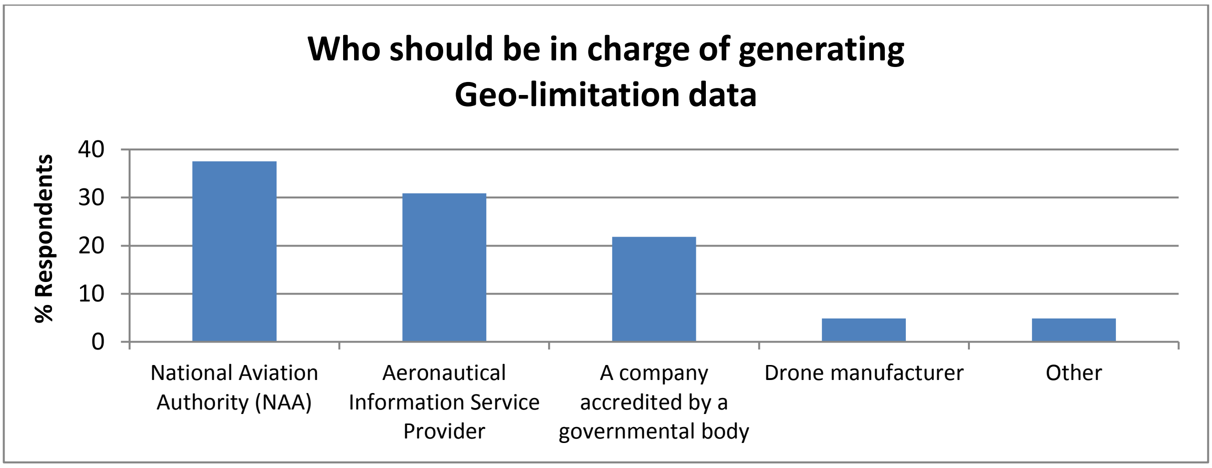
Among other measures mentioned are:

- Mandatory registration of equipment at purchase
- Aviation authority updated, internet based, and easy to use map for UAS with all no-fly zone information and warnings
- Promote the safe flying practices and educate users with easy to understand information
- Developed specialised maps for drone pilots
- Mandatory identification of drones

Question 8

Who should be in charge of generating the "geo-limitation" data?

Total number of responses: 87



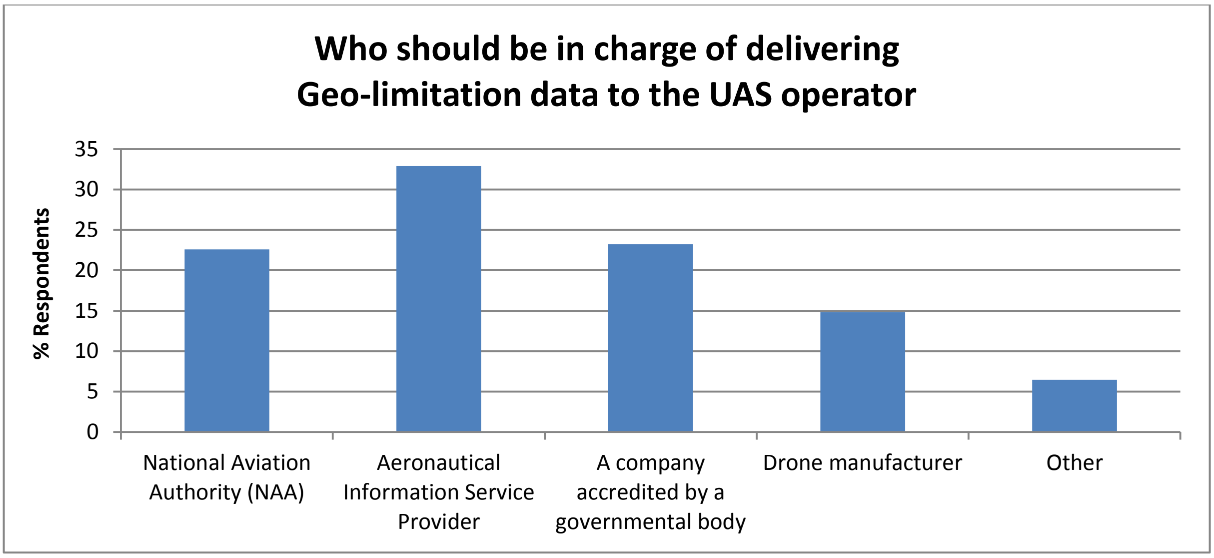
Among other organisations mentioned are:

- Ministry of Transport
- ICAO
- Service provider such as Skyward/LATAS/Air map/etc.
- A non-profit research organisation

Question 9

Who should be in charge of delivering to the user / operator the "geo-limitation" information?

Total number of responses: 87



Among other organisations mentioned are:

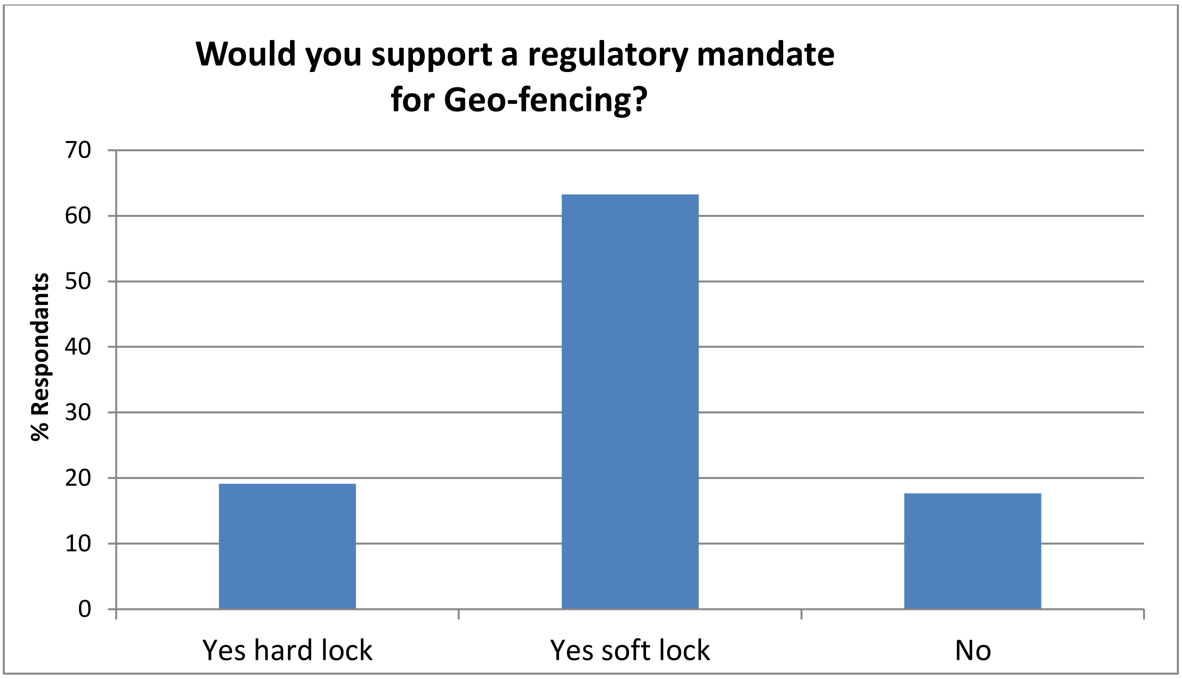
- Ministry of Transport
- ICAO
- Service provider such as Skyward/LATAS/Airmap/etc.
- EASA

Question 10

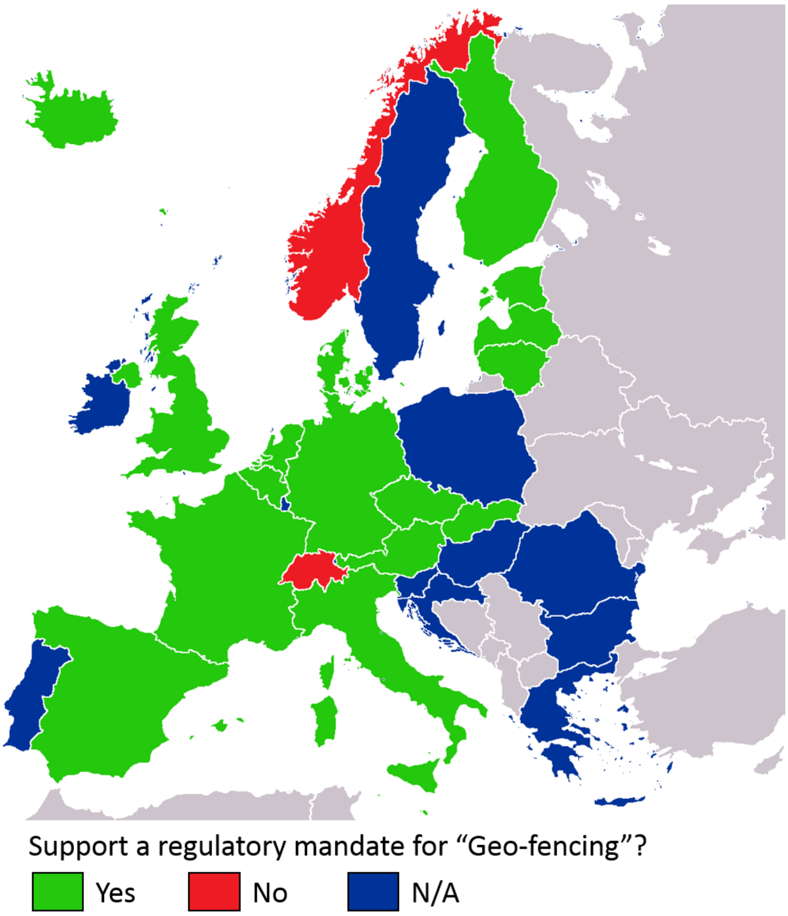
Would you support a regulatory mandate for "Geo-fencing"? Please select one option

- **Yes, with "hard locked" zones (zone limitations cannot be unlocked by the user/operator)**
- **Yes, with "soft locked" zones (zone limitations can be unlocked by the user/operator under certain conditions, e.g. authorisation to operate in a zone)**
- **No**

Total number of responses: 68



The figure below shows the answers of national aviation authorities from Member States:



Please, indicate rationale for selection:

The main reasons given were:

Reasons for Soft lock
Impossible to build an un-hackable system anyway, emergency services need to operate everywhere and unlocking could work with one-time given codes.

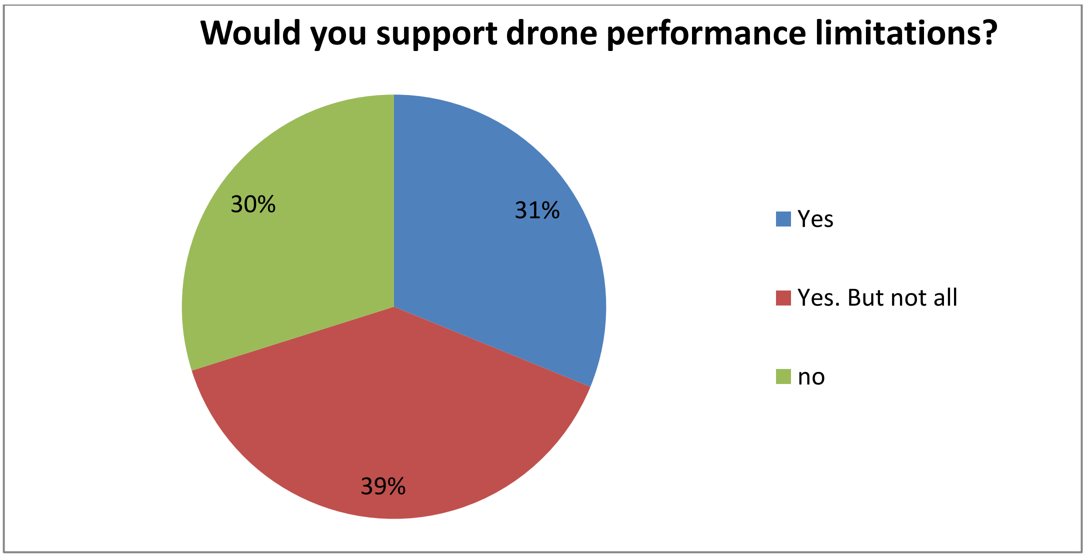
Reasons for Hard lock
To avoid hostile intentions and to prevent people from disabling the system intentionally.

Reasons for Not supporting
The responsibility should always be with the operator. Just provide easy to use information for operators. No other technology is limited with this kind of regulation either. Regulations cannot keep up with the pace of innovation and change.

Question 11

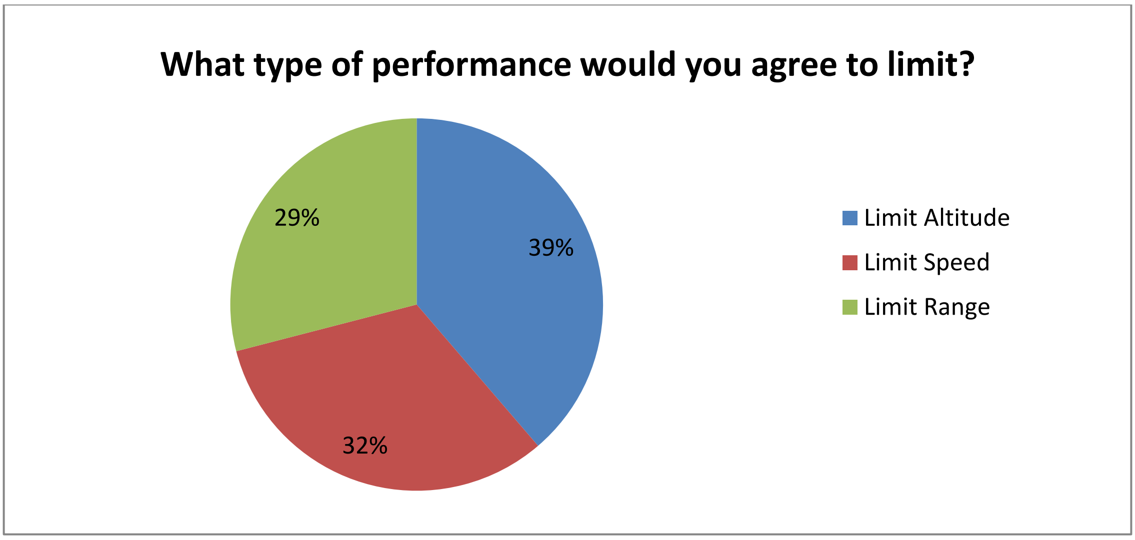
Would you support a regulatory mandate for drone performance limitations implemented in the drone (e.g. max. altitude/height, speeds, range …)? Please select one option.

Total number of responses: 77



In case you agreed to limit performance, please, indicate which one:

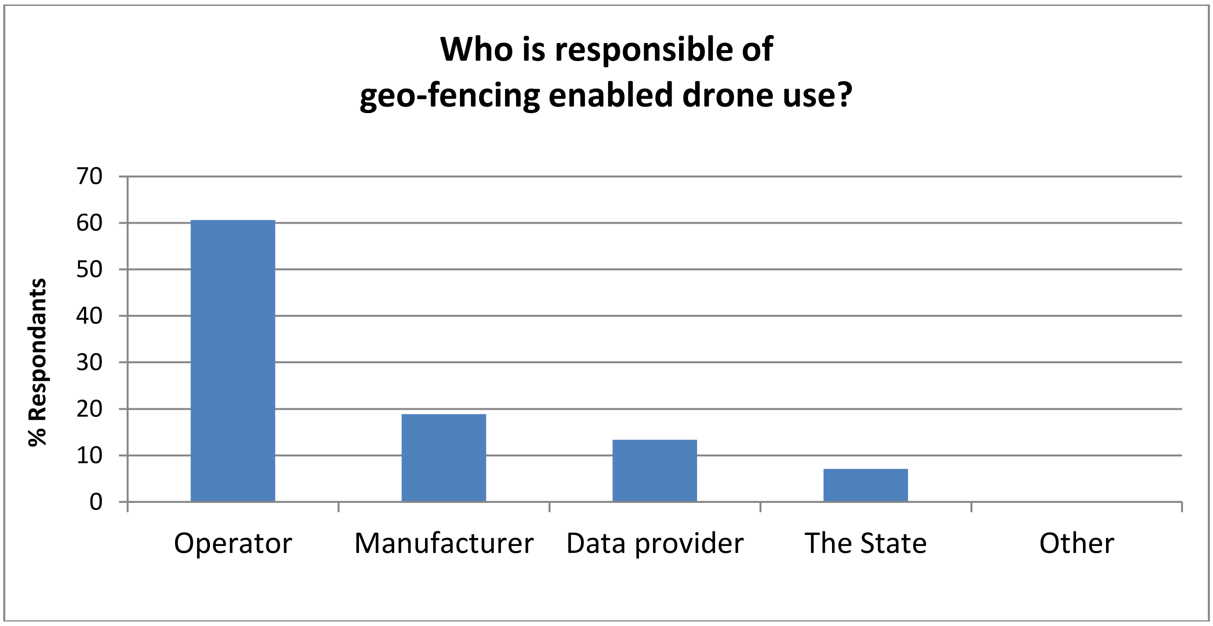
Total number of responses: 31



<u>Question 12</u>

Who should carry the responsibility/liability of the safe use of drones equipped with "geo-fencing" functionality?

Total number of responses: 87



Please, indicate rationale for selection:

The main rationales given were:

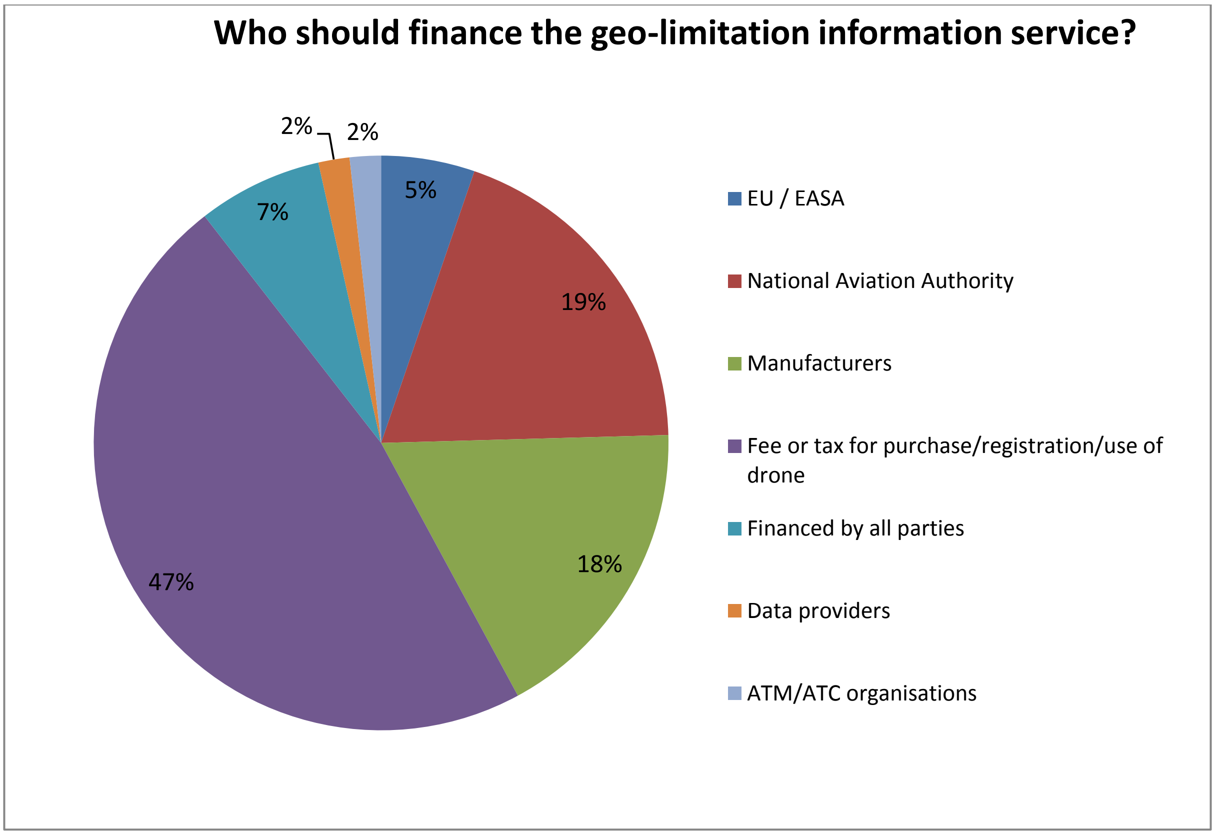
> **Rationale for operator being responsible:**
> Only the Operator has final control over technical aspects, data usage and operation.

Rationale for all being responsible:
Everyone should have some proportion of responsibility.

Question 13

How do you see the respective role of manufacturers, data-providers, end users / operators, authorities and law enforcement bodies fit in the geo-limitation information service? Who should and how this "geo-limitation" information service should be financed?

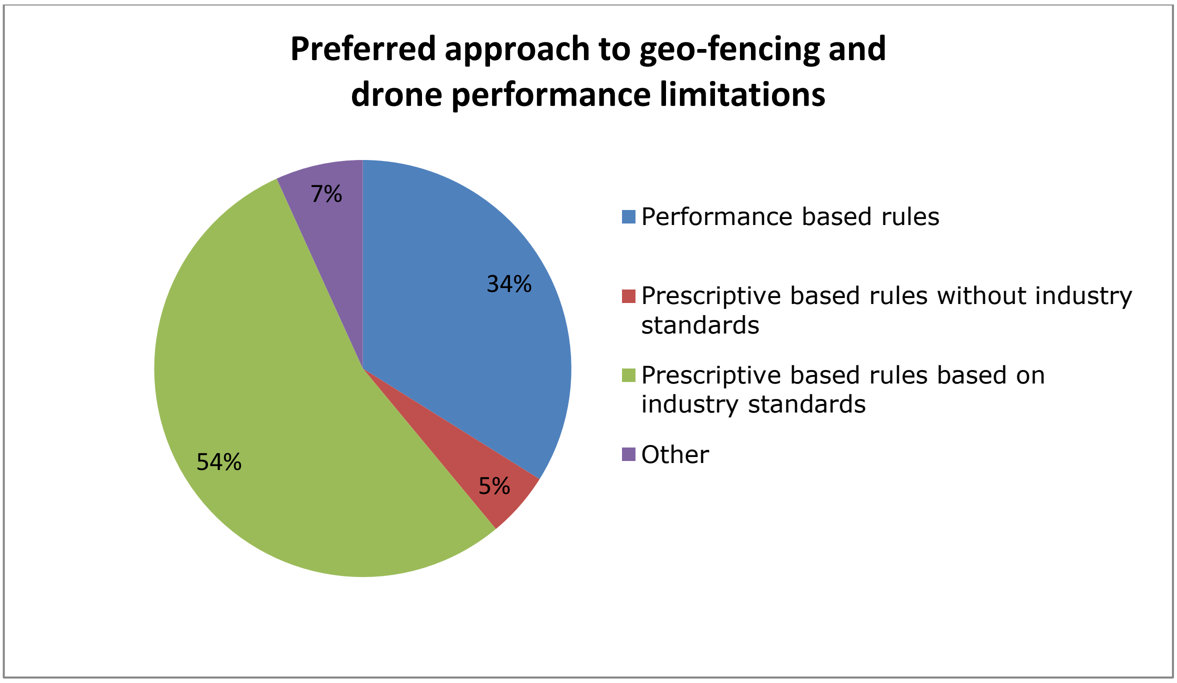
Total number of responses: 57



Question 14

What would be your preferred approach for rules and standards related to "geo-limitation" / "geo-fencing" and drone performance limitations? Please, select one option.

Total number of responses: 59



Please, indicate rationale for selection:

Main rationales given were:

Rationale for Performance based rules

- Feels practical
- Gives manufacturers freedom on how to implement

Rationale for Prescriptive based rules without industry standards

- Standards couldn't be effectively implemented, monitored, controlled or enforced
- Reaching a target without constraints gives manufacturers flexibility on how to implement

Rationale for Prescriptive based rules based on industry standards

There should be no way operator should be able to overcome the geo-fencing

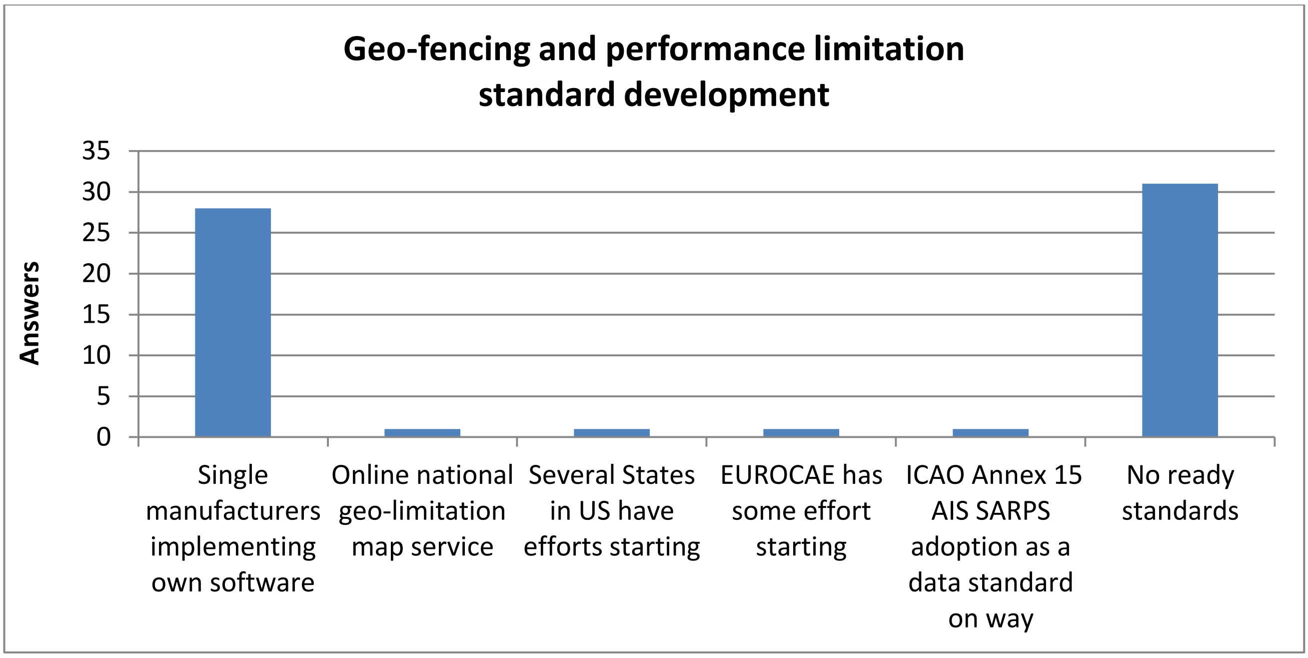
Rationale for Other

Support only for very limited geo-fencing around areas with no uses for drones. Operator should always be responsible and thus mandatory geo-fencing is unnecessary

<u>Question 15</u>

With regard to the development of industry standards for "geo-limitation" / "geo-fencing" and performance limitations, what is in your knowledge the current status?

Total number of responses: 63

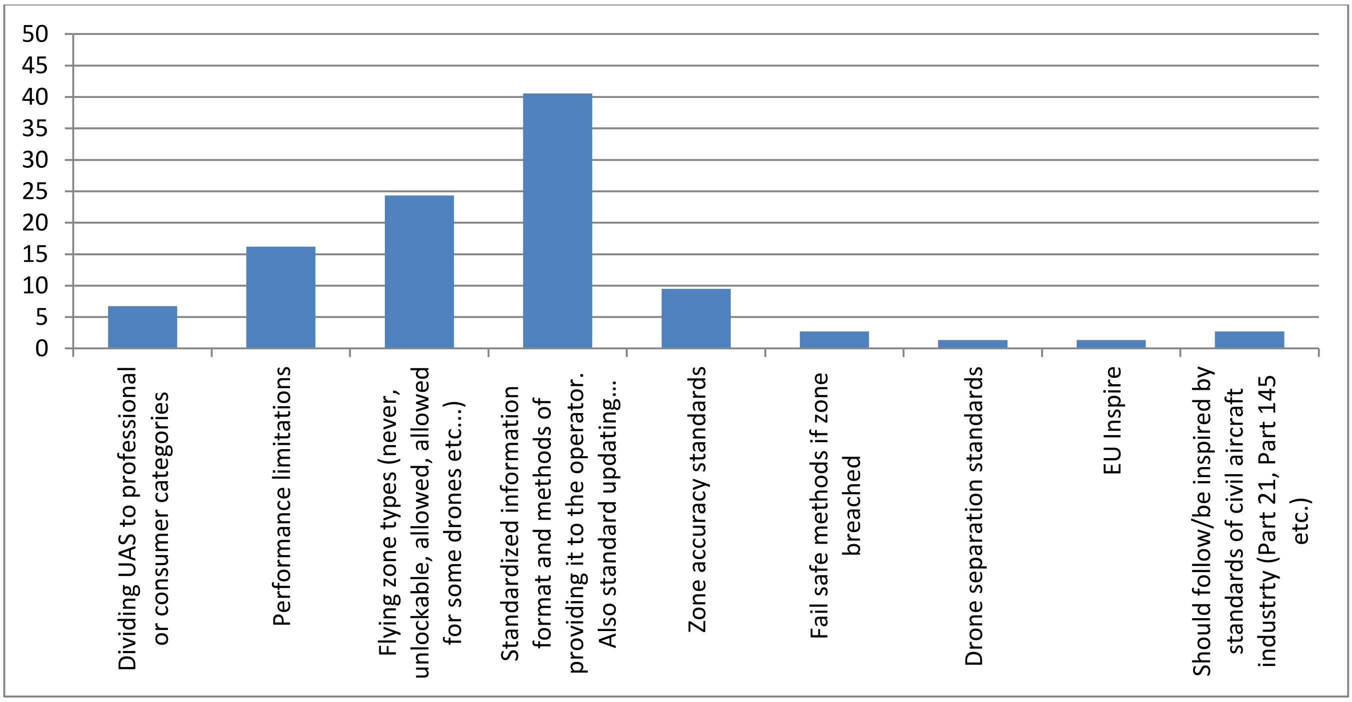


Question 16

If standards are required, what should be the standards related to "geo-limitation" / "geo-fencing" and performance limitations to be developed by Industry Standards bodies?

Note: a wish from DIY community that the data and standards will be open for usage by all willing

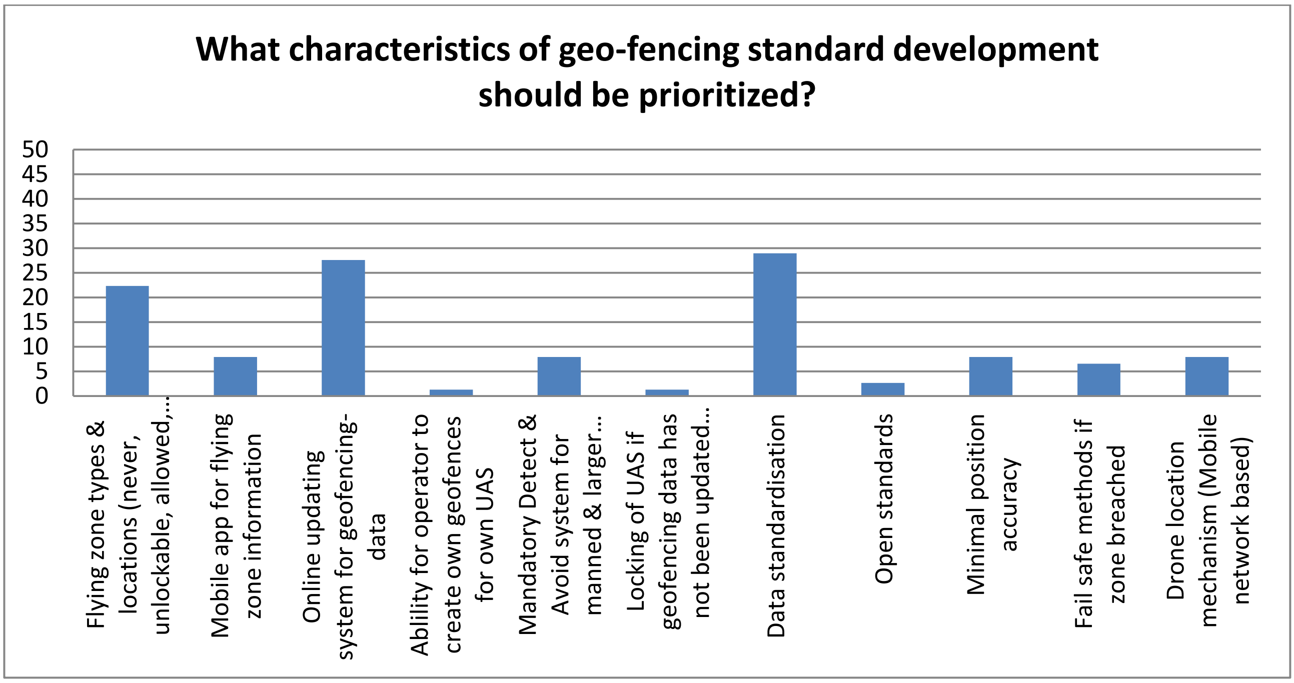
Total number of responses: 78



Question 17

What are the main characteristics to be included in standards addressing "geo-fencing"? What are the main elements (concepts, functions, technologies) that should be promoted and given higher priority?

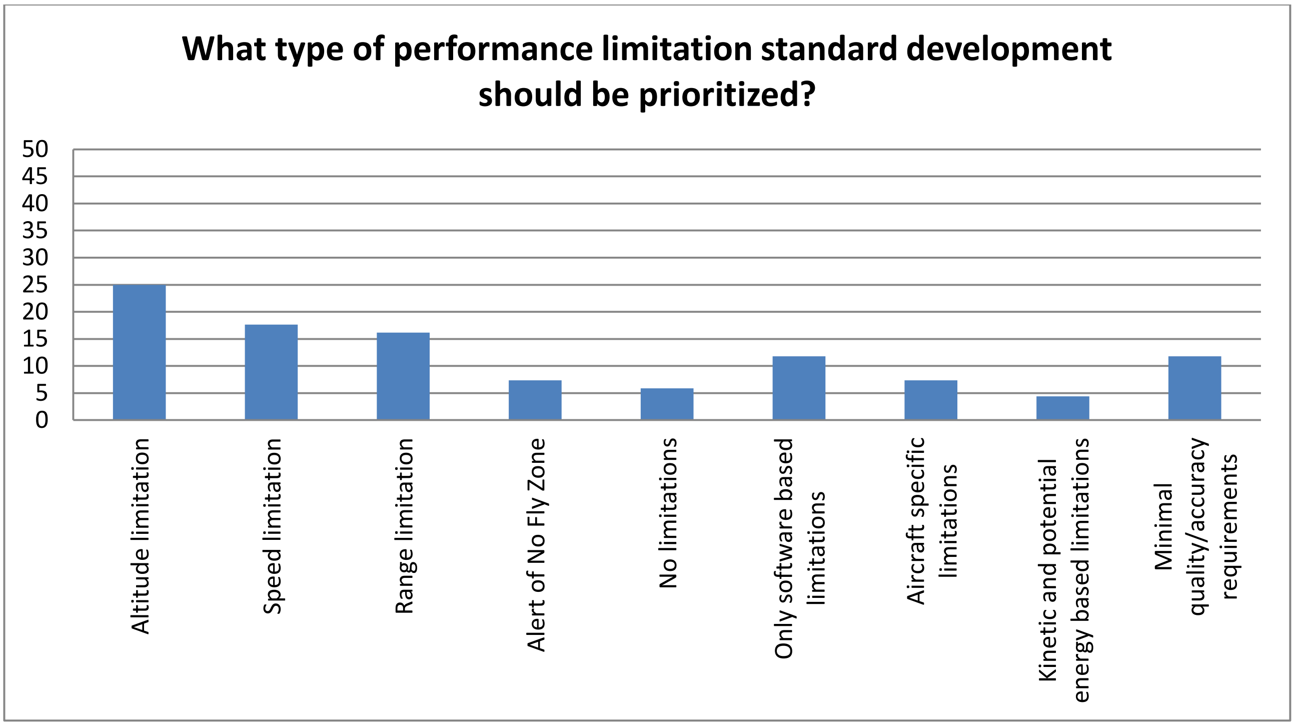
Total number of responses: 77



Question 18

What are the main characteristics to be included in standards addressing "performance limitations" of drones? What are the main elements (concepts, functions, technologies) that should be promoted and given higher priority?

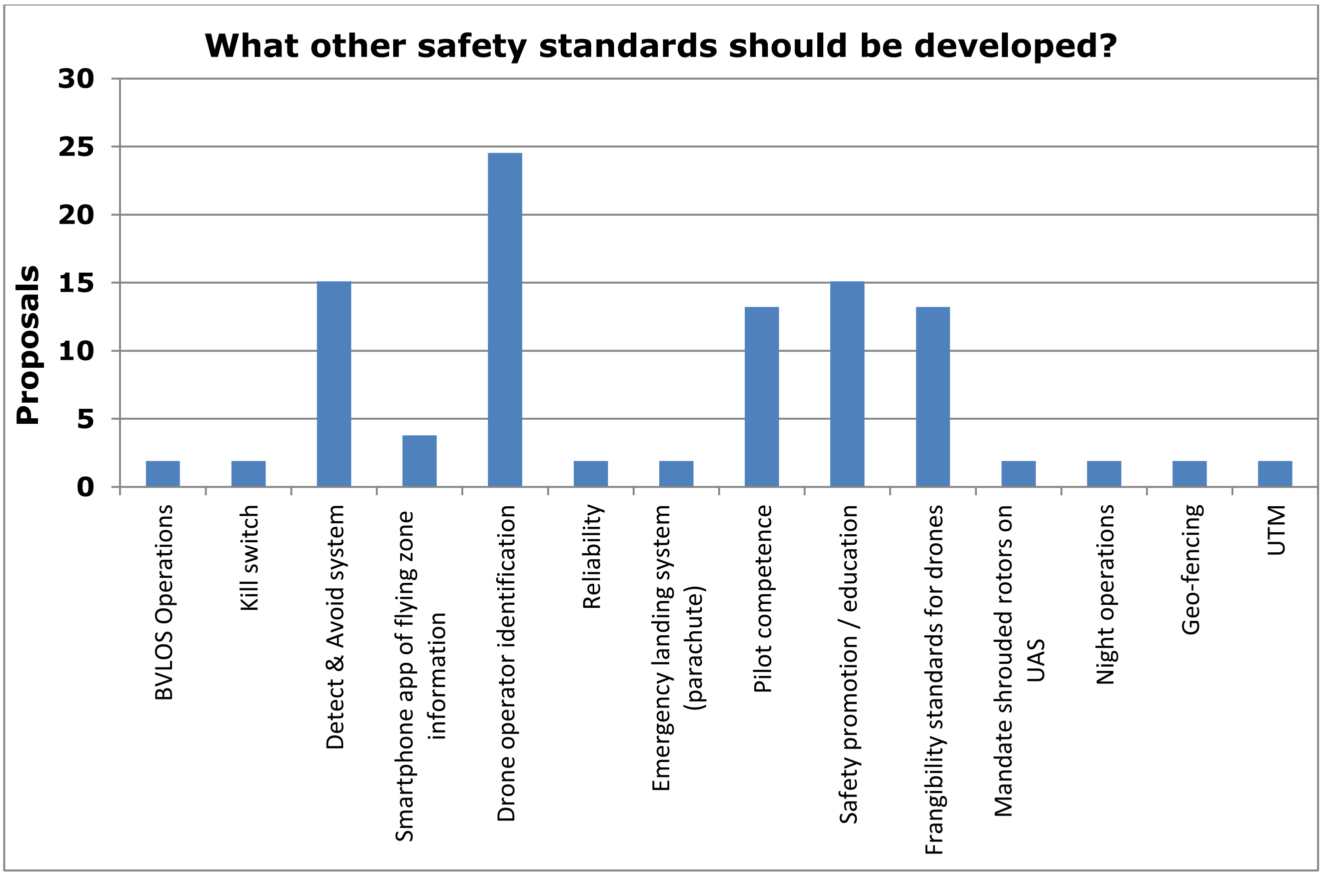
Total number of responses: 73



Question 19

In addition to the above, would you consider the urgent need to promote and standardise other kind of element (concept, function, technology) to enhance the safety of operation of small drones?

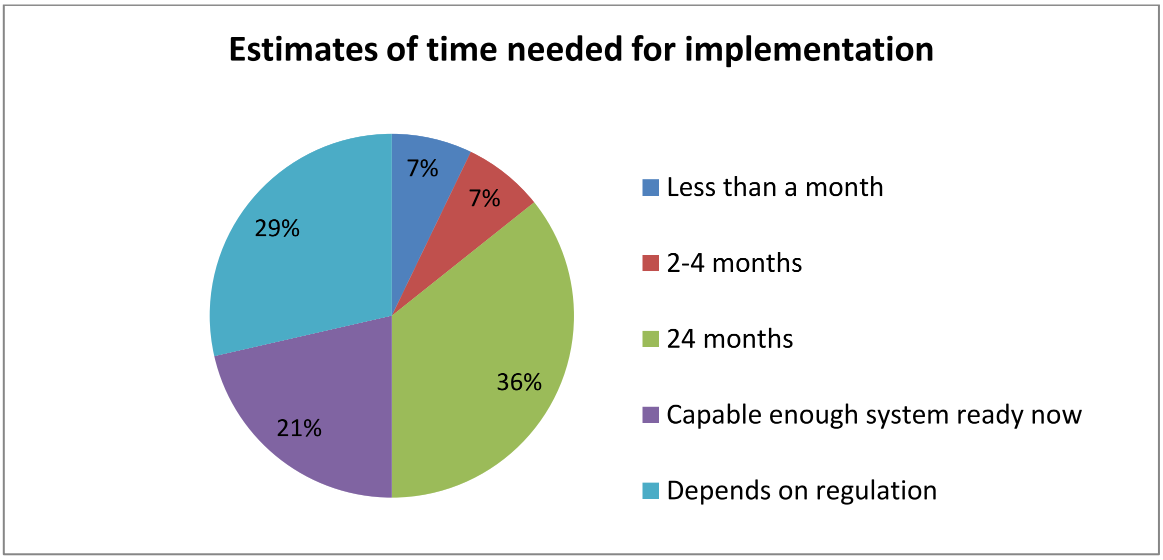
Total number of responses: 53



Question 20

In case "geo-fencing" and/or drone performances (e.g. max. altitude/height, speeds, range …) are mandated: What would be the timeframe for the implementation in your drone products?

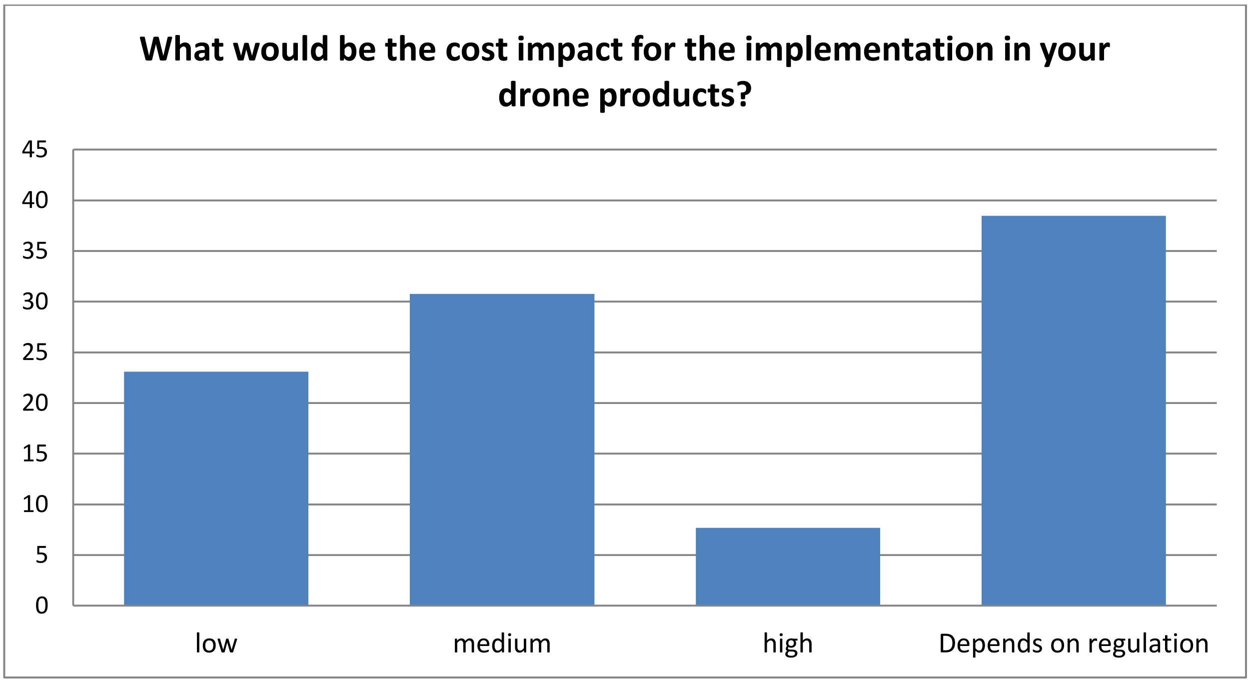
Total number of responses: 14



Question 21

In case "geo-fencing" and/or drone performances (e.g. max. altitude/height, speeds, range …) are mandated: What would be the cost impact for the implementation in your drone products? Please select:

Total number of responses: 13



Among the main remarks are:

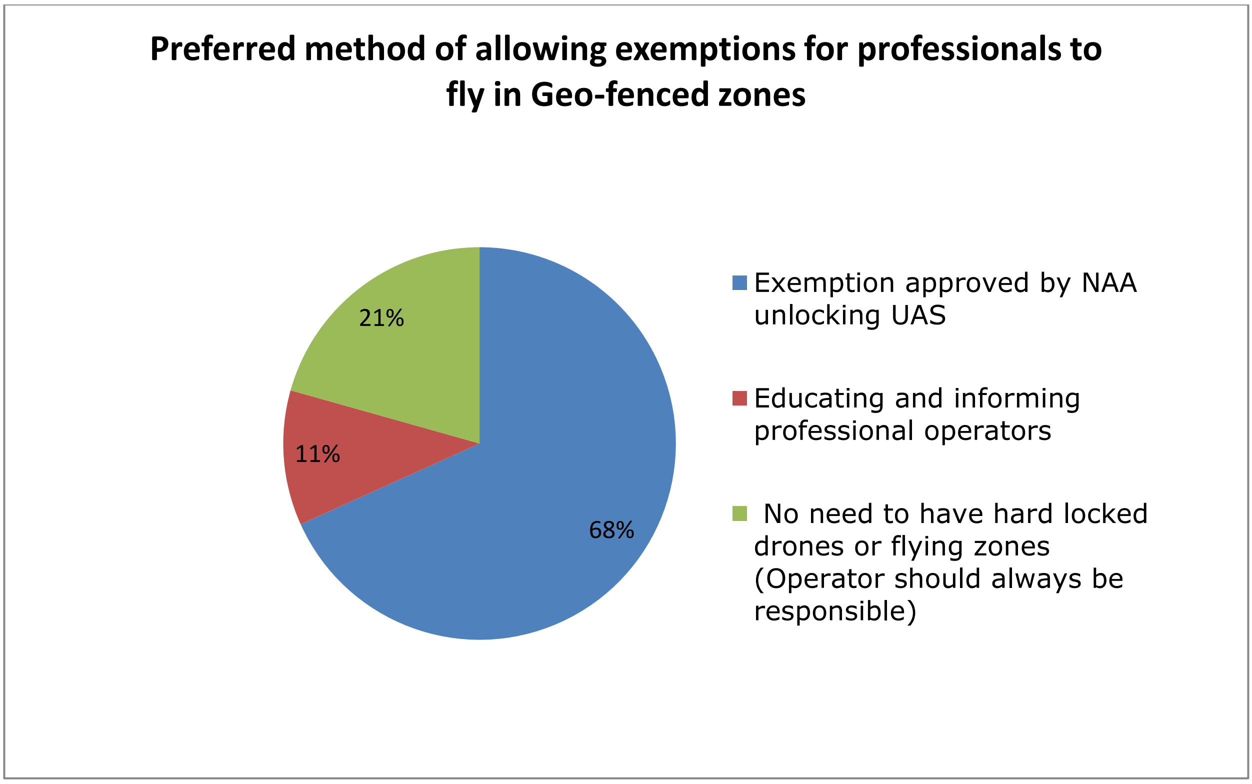
Remarks:

- Professional operators need flexibility
- Many of the suppliers have already implemented some sort of system in their products.

Question 22

In case "geo-fencing" and/or drone performances (e.g. max. altitude/height, speeds, range …) are mandated: How do you propose to cope with the need for some professional operators to operate in certain cases in zones usually forbidden for drones (e.g. airports)?

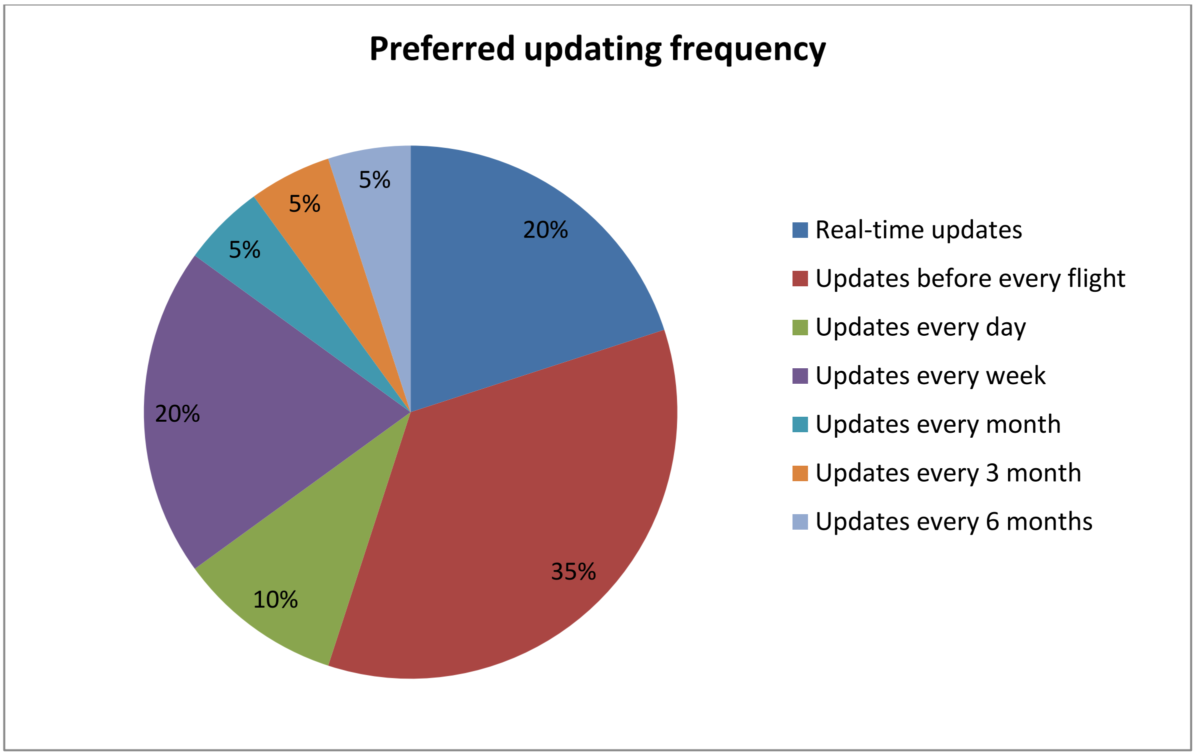
Total number of responses: 63



Question 23

In case "geo-fencing" and/or drone performances (e.g. max. altitude/height, speeds, range …) are mandated: How can it be ensured that the drone software containing "geo-fencing" data is up-to-date, also considering that the latest changes may happen while the user/operator is operating the drone?

Total number of responses: 20



Among the main remarks are:

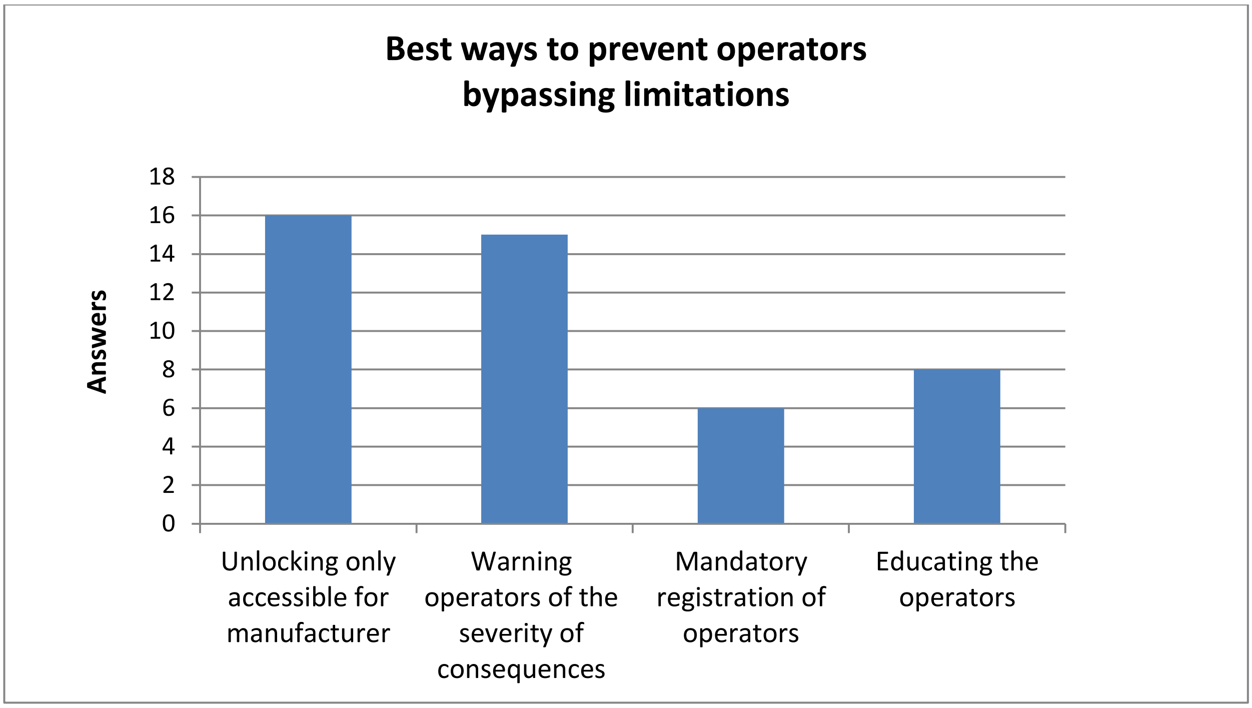
Remarks:

- Multiple notes that real-time updating is impossible to achieve technically and updating should be the responsibility of the operator
- UAS won't start if geo-fencing data has not been updated inside the period of time

Question 24

In case "geo-fencing" and/or drone performances (e.g. max. altitude/height, speeds, range …) are mandated: What should be the best ways to reduce the risk that users/operators disable these limitations (without having authorisation to do it)?

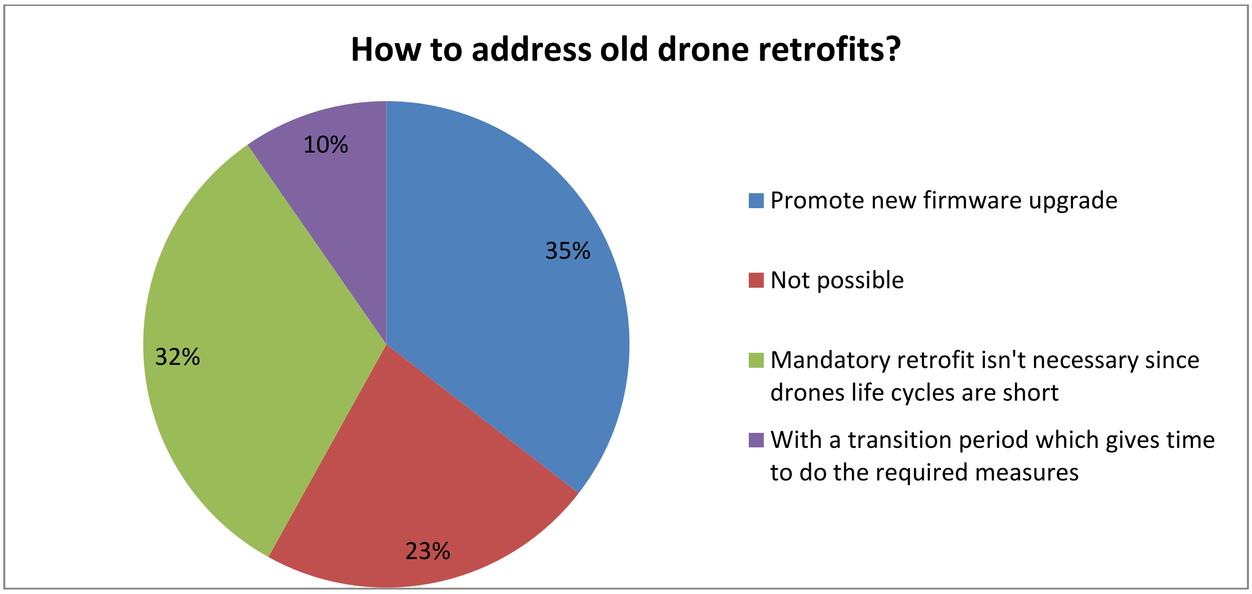
Total number of responses: 45



Question 25

In case "geo-fencing" and/or drone performances (e.g. max. altitude/height, speeds, range …) are mandated: How do you recommend (small) drones already in the market should be addressed (retrofit or additional limitations or other)?

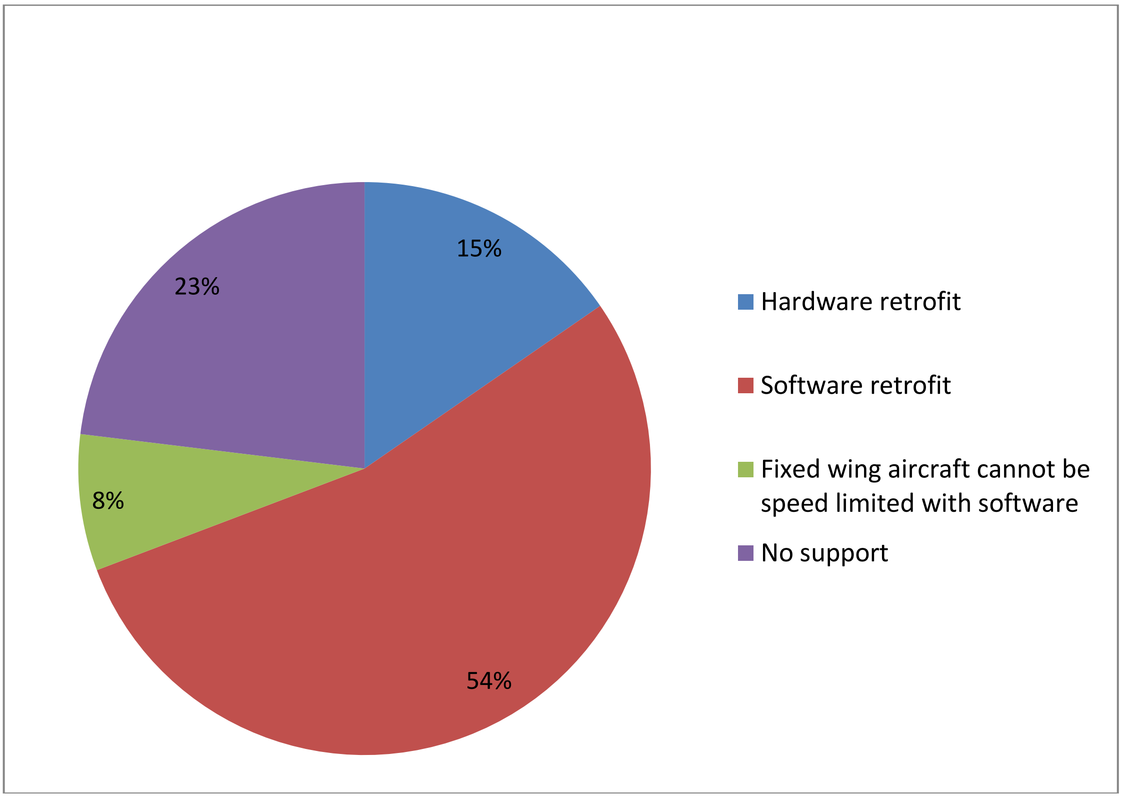
Total number of responses: 31



Question 26

If retrofit provisions for (small) drones already in the market were adopted, to what extent such provisions could be applied to your products? How could they be technically and commercially fulfilled?

Total number of responses: 13



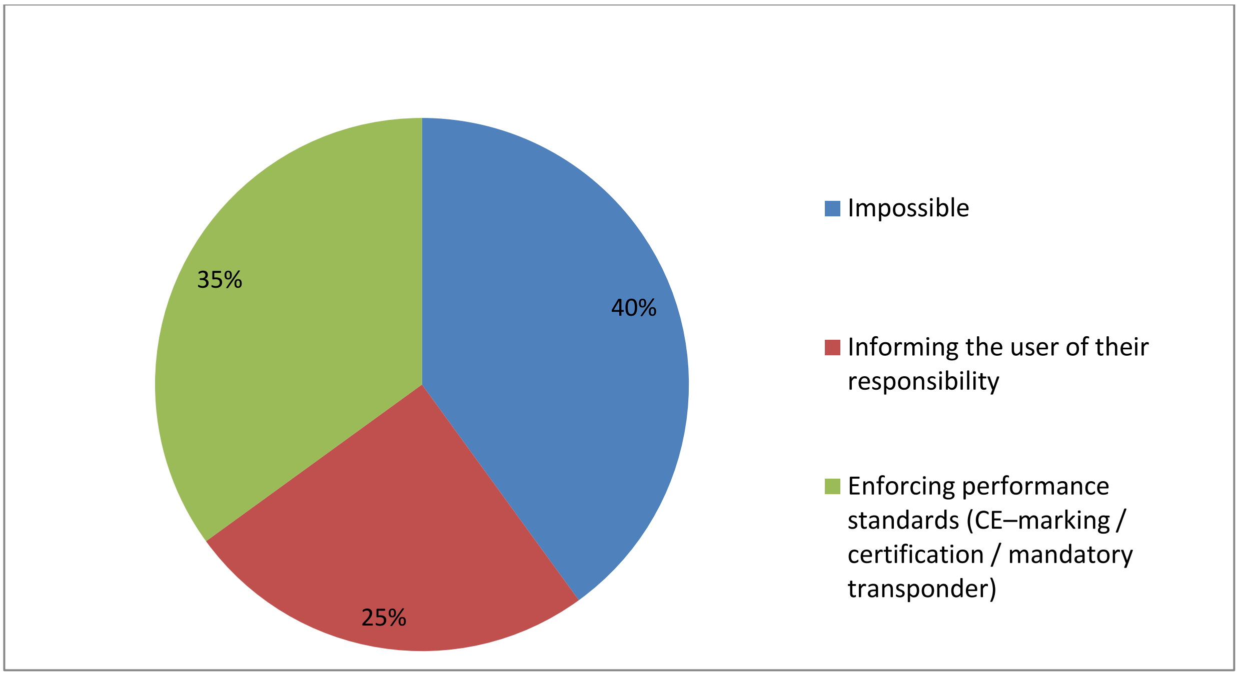
Among the main remarks are:

Remarks:
1. Hardware retrofits are considered very difficult or impossible
2. Fixed wing aircraft can't be limited in speed through software

Question 27

How do you think abovementioned limitations ("geo-fencing", performance) could be addressed for homebuilt drones? Would it be feasible to enforce the implementation of those limitations to elements like COTS "autopilots"?

Total number of responses: 40



Among the main remarks are:

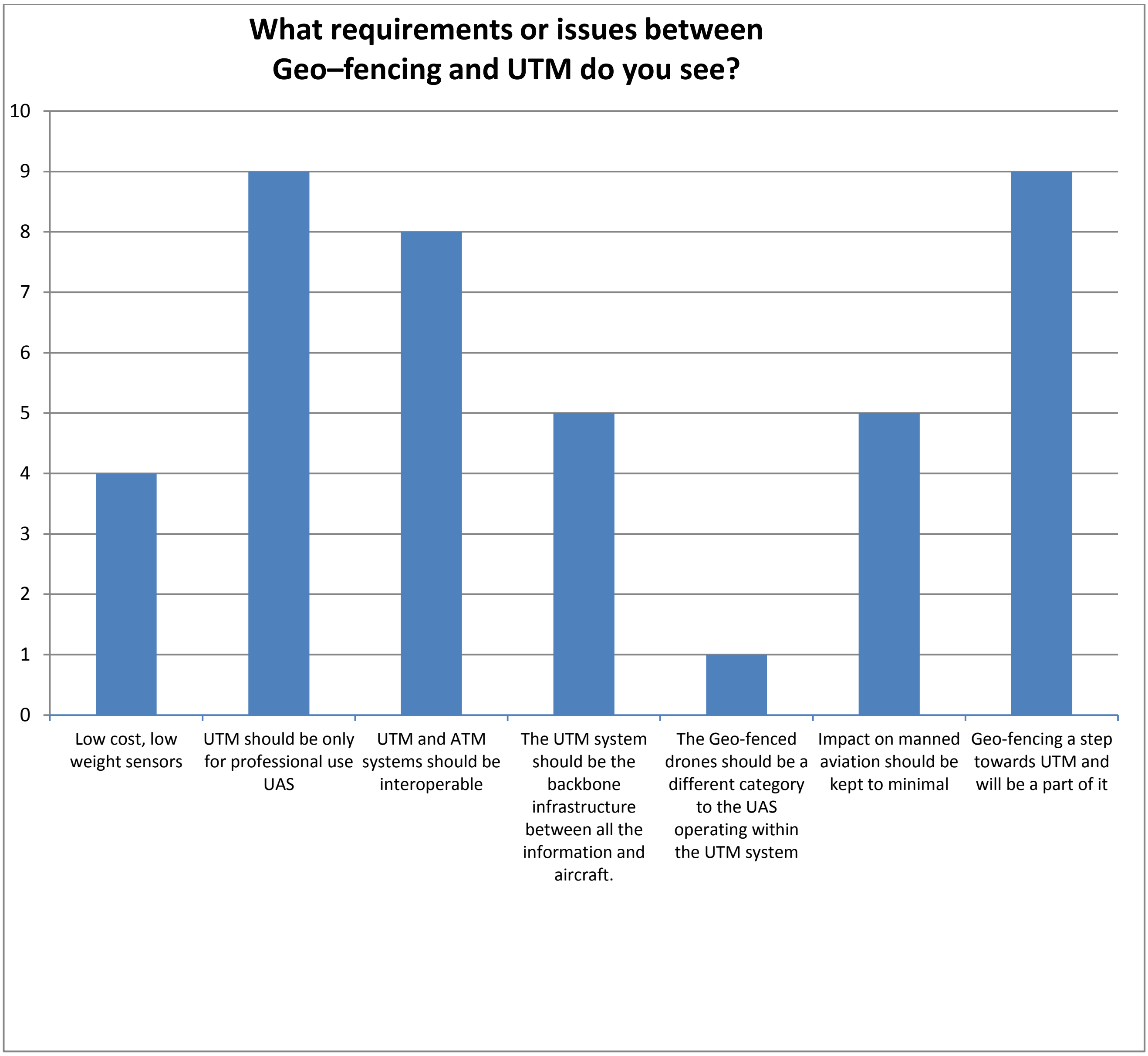
Remarks

1. COTS autopilot limiting is not feasible
2. Informing users of their responsibility to increase safety
3. Enforcing mandatory registration and transponder

<u>Question 28</u>

What are your views about "geo-limitation" / "geo-fencing" and performance limitations for (small) drones in a future implementation of an "UAS Traffic Management" (UTM) solution and the evolving general ATM system? What requirements and interoperability issues do you foresee?

Total number of responses: 41



Question 29

Do you have any additional comment or remark?

Among the main remarks are:

Remarks:

- 100% safety is impossible to achieve
- Not all drones can be technically limited, e.g. DIY or racing drones
- Educating and informing operators is key as technical solutions cannot be implemented on all drones

- 25kg is too high as a weight limit when considering impacts with other aircraft or third parties
- Important to publicise all the drone related accident reports
- Regulating technology is almost impossible due to fast changing nature. Instead, regulation should focus on the use of drones and the technology would only be additional helping instrument
- Geo-limitation / fencing is a bad definition and should be reworked
- Focusing first on registering users, easy to read maps or an easy map app and disseminating information would bring most benefits
- EUROCONTROL offers its expertise and new concept for geo-fencing
- Measures to register and mark the drones should be furthered
- A standard is better than no standard and legislating quickly is important due to strong increase in the number of drones
- Most drone traffic should stay under 150m and maybe a UAV Pilot licence for professional use might be a reasonable step
- Unmanned aircraft should be treated the same as manned. Not treated as intruders. Drones should not be criminalised. We have an excellent opportunity to design, develop and implement a total aviation system for all aircraft types which would be safe and leave a legacy.
- To exclude malicious use of RPAS we expect more from educating the users and improvement of the chances of being caught and prosecuted with punishments that do impress the others. Else, be sure to develop measure to deny the access of drones in certain areas independent of the cooperation of the drone user

END