Project 740859

D4.9 – REPORT ON STANDARDISATION, REGULATION, AND SOTA PROGRESS V5 – PUBLIC VERSION

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Executive summary

The project **ALADDIN - Advanced hoListic Adverse Drone Detection, Identification and Neutralization** is funded by the European Commission (EC) through the European H2020 research and innovation programme with Grant Agreement 740859.

This document, ***Deliverable D4.9 – Report on standardisation, regulation, and SOTA progress V5 – Public version***, is an extract of the fifth release of six reports to be issued on a biannual basis throughout the whole duration of the ALADDIN project.

Unmanned Aerial Vehicles (UAV) or Systems (UAS), commonly termed drones, are becoming an ordinary presence in everyday citizens' life, with a continuous market increase in a growing number of useful applications. The drone proliferation is however generating serious security issues. In recent years, newspapers and mass media have reported dozens of incidents involving drones flying over restricted areas and around critical infrastructures, such as airports, nuclear plants, official buildings, or during public events, including the alleged use of drones for terroristic purposes. Drone technology has evolved at a faster rate than imagined, leaving regulation and counter-drone capability far behind.

The recent incidents of small **drones flying too close to UK airports** (Gatwick in December 2018, during Christmas holiday and Heathrow in early January 2019) **and in Spain** at Adolfo Suárez Barajas airport (February 2020), which caused a huge flight service disruption, demonstrated to the public the severe impact of the drone threat in everyday life and prompted an acceleration in both regulatory activities and Counter UAV business development.

The availability of open international standards is a key enabling factor for the development of markets in all business sectors, including the **Security** sector. Since the beginning of this decade, the European Commission is pointing out the necessity to address the gaps in the standardisation and regulation framework for an innovative and competitive Security Industry.

A number of standardization and regulation bodies are currently working on filling these gaps on UAV and counter-UAV (C-UAV) related topics, such as producing harmonized standards and regulation for the ***safe operation of UAVs*** in different zones of the airspace, according to their category. The most important standardization bodies dealing with UAV-related topics include EUROCAE work group WG-105 at European level, ISO technical committee ISO/TC 20/SC 16 and ICAO RPAS Panel at International level. There is an increasing effort to harmonize European standards with standardization activities outside Europe, such as those of the ASTM technical committee F38 and the RTCA special committee SC-228.

Current EUROCAE hottest topics include Specific Operations Risk Assessment (SORA), UAS Traffic Management (UTM), UAS E-Identification and UAS Geo-Fencing. Most importantly, in 2019 EUROCAE launched WG-115 **Counter UAS (C-UAS)**, with the mandate to develop standards to support the safe and harmonised implementation of Counter-UAS Systems into airport and Air Navigation Service Provider (ANSP) systems. UTM is also the core of current ISO standardization activity within ISO/TC 20/SC 16, along with more general topics, such as UAS operational procedures included in the ISO standard published in 2019. ASTM standards include, among others, those published in 2018 on UAS Registration and Marking, and BVLOS Small UAS Operations, or in 2019 on UAS Remote ID and Tracking, while other standards are still in preparation, including those concerning Operation over People.

Important standardization and regulation activities affecting C-UAV technology are also those pertaining to ***electromagnetic emissions*** – relevant to radar and RF sensing or neutralization, as well as ***Privacy and personal data protection*** – mostly relevant to Electro-Optical sensors. Concerning electromagnetic emissions, apparently there is a lack of applicable standards for radar used in drone detection application. Furthermore, given the ambiguous legality of radio frequency (RF) jamming technologies, there does not appear to be European standards applicable to such neutralization equipment. The recent adoption of the General Data Protection Regulation (GDPR) - Regulation (EU) 2016/679, which became enforceable from 25 May 2018, could speed up the development of standards for privacy and personal data protection management in support of Union's security industry.

Concerning the regulation progress, the European Aviation Safety Agency (EASA) is working at an unprecedented pace to improve the ***drone safety regulation*** thus overcoming the current fragmented regulatory framework especially for the smaller UAS. In the EU framework up to 2018, Regulation (EC) No 216/2008 (the 'Basic Regulation') established the main principles and common rules for civil aviation in the EU and defined the area of competence of the EU and of its Member States (MSs). According to it, most of EU Member States adopted national regulations to ensure the *safe operations* of civil drones (UAS) below 150 kg, but there were no harmonized rules at EU level. EASA has been working actively towards a revision of the Basic Regulation to extend the scope of the EU competence to regulate UAS even below 150 kg, also to allow free circulation of UAS throughout the EU. Following the Notice of Proposed Amendments issued in May 2017 (NPA 2017-05 - open and specific category) and the publication on the 06/02/2018 of EASA **Opinion 01/2018,** approval of the new EU regulation was expected by 2018-2019. A notable progress in this direction is the publication on the 22nd August 2018 of **Regulation (EU) 1139/2018**, (the new 'Basic Regulation') which repeals Regulation (EC) No 216/2008 with effect from 11 September 2018. In June 2019, the European Commission adopted the Delegated Regulation **(EU) 2019/945** and Implementing Regulation **(EU) 2019/947** (the 'UAS Regulation'), containing technical and operational requirements for drones. The publication by EASA of **Decision 2019/021/R** containing the relevant Acceptable means of compliance (AMC) and Guidance material (GM) completed the process. The EU regulation will be applicable in one year to give Member States and operators time to prepare and implement it. Ongoing regulatory activities are concerned with operations in the specific category (e.g. Opinion No 05/2019 on standard scenarios) and U-Space. Member States are preparing for transposing the EU regulation into national implementation in the coming 3 years after its entry into force. Meanwhile, the Joint Authorities for Rulemaking on Unmanned Systems (JARUS) facilitates harmonisation of standards within the EU Member States and other participating authorities.

As stated previously, the main progress regarding ***Privacy and personal data protection*** is the entry into force on 25 May 2018 of the **General Data Protection Regulation** (**GDPR**) - Regulation (EU) 2016/679. However, the recent escalation of the drone threat, as publicly demonstrated by the serious incidents of drone sighting at Gatwick, Heathrow and Adolfo Suárez Madrid-Barajas airports, will likely trigger tougher regulation and heavier restrictions with impacts on Privacy and personal data protection.

In addition to the progresses in standardization and regulation, the document provides also the ***State Of The Art (SOTA) analysis*** of C-UAV technology as reported by published reports and online sources. Mini-UAV threat appeared as important in 2014, when many companies started to propose anti-UAV solutions. Single domain solutions focused on one aspect of the problem, either detection or neutralization of the threat. Detection mainly involves radar and/or electro-optical/infrared sensors whereas countering the threat mainly involves radio-frequency piloting and jamming of the UAV communication links. On the other hand, complete C-UAV systems are based on integration of (at least one) sensor, tracker/identifier and a neutralization effector (usually jammer). A number of systems and subsystems (sensing and neutralization equipment, data processing and data fusion techniques, cartographic and other supporting software) are currently available on the market. However, the threat is evolving very quickly and is mainly unpredictable: hence, single domain solutions are inadequate and should be integrated in flexible systems, able to accept different sensors and effectors. The overall trend is therefore toward multi-sensor integration and enhanced automation, although many points, such as drone versus bird discrimination, remain challenging tasks.

Additionally, new trends are gaining interest. The main one is related to swarms of drones either as a most frightening threat requiring superior detection and neutralization capabilities or even as potential countermeasure if employing sophisticated algorithms (currently a topic of academic research) to form a self-organized network of defence drones to intercept the intruder drone. Recent developments with potential impact on C-UAS systems include the requirement for integration with U-Space services/UTM systems and technological progresses of Artificial Intelligence/Machine Learning.

The constant stream of announcements in the specialised press of C-UAS system enhancements and new partnerships between C-UAS manufacturers or sellers demonstrate a high dynamism, especially by the global big players, both in improving the system performances and in seizing new market segments.

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1 Introduction

The project **ALADDIN - Advanced hoListic Adverse Drone Detection, Identification and Neutralization** is funded by the European Commission (EC) through the European H2020 research and innovation programme with Grant Agreement 740859. It will be implemented in compliance with the Description of Action (DOA): Annex 1 - Part A (description of the work plan) and Annex 2 – Part B (narrative description of the action) [AD1].

This document, ***Deliverable D4.9 – Report on standardisation, regulation, and SOTA progress V5 – Public version***, is an extract of the fifth release of six reports to be issued on a biannual basis throughout the whole duration of the ALADDIN project.

1.1 Purpose of the Document

This document aims at providing an overview of the State-Of-The-Art (SOTA) progress in countering malicious drones from a standardisation, regulation and technological perspective, performed by the ALADDIN project within *Task 4.2 Standardization, regulation, and technological monitoring*.

Version V5 of the Deliverable (D4.9) accounts for the analysis performed during the fifth semester of the ALADDIN project, and reports relevant information accessed from public sources up to December 2019.

1.2 Scope and Intended audience

This document is the fifth release of six reports on standardisation, regulation, and SOTA progress to be issued on a biannual basis throughout the whole duration of the ALADDIN project.

The intended audience of the document are the project stakeholders (European Commission DG HOME, Research Executive Agency (REA), ALADDIN Consortium executive members) and the project team (Consortium staff).

This public version is aimed to be disseminated to a larger audience.

According to the preliminary security scrutiny in the DOA Part B [AD1], this deliverable was classified as **PU = Public**.

1.3 Structure of the Document

The structure of this document (besides the current Section) is as follows:

- **Section 2** presents a general overview of the drone threat and the ALADDIN response within the EU counter-drone policy;
- **Section 3** contains a summary of the standardisation status at beginning of the project and its progress up to present.
- **Section 4** contains a summary of the regulation status at beginning of the project and its progress up to present.
- **Section 5** contains a summary of the technological SOTA at beginning of the project and its progress up to present.
- The **last two Sections** contain the main Conclusions and References to relevant bibliographic material.

2 The ALADDIN Project in the EU counter-drone policy

2.1 The UAV growth: opportunities and threats

Unmanned Aerial Vehicles (UAV) or Systems (UAS), commonly termed drones, are becoming an ordinary presence in everyday citizens' life, with a continuous market increase in a growing number of useful applications. The civil UAV market comprises three main groups:

- **Civil government UAVs** for uses ranging from border security to law enforcement to research on wildlife.
- **Commercial UAVs** for uses including construction, agriculture, insurance, internet communications, and general photography.
- **Consumer/hobbyist UAVs**, which are mass-produced, particularly in China, for low-end UAV applications. These are low cost and may or may not use a camera. They are not engaged in commercial activity.

Recent reports ([BD1], [BD2], [BD3], [BD4]) confirm the soaring of UAV production worldwide, making it one of the three growth industries revolutionizing the world (**Figure 2.1.1** and **Figure 2.1.2**), with the highest number of units worldwide of the rotorcraft type, followed by the fixed-wing type, and the nano-type.

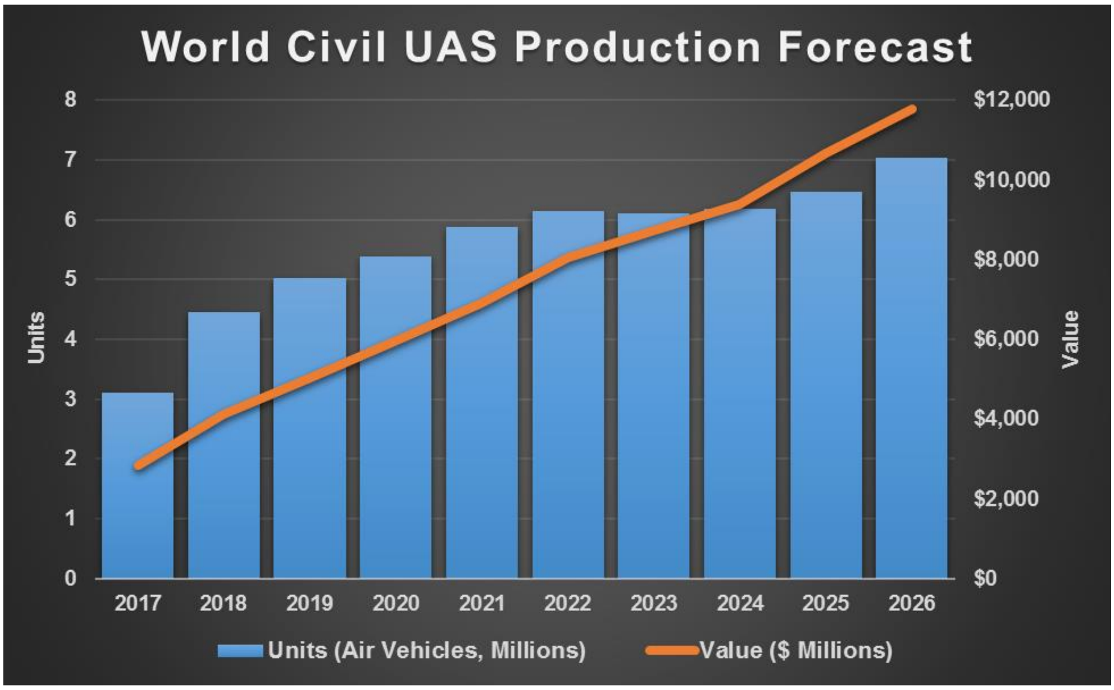

Figure 2.1.1: World civil UAS production forecast ([BD1])

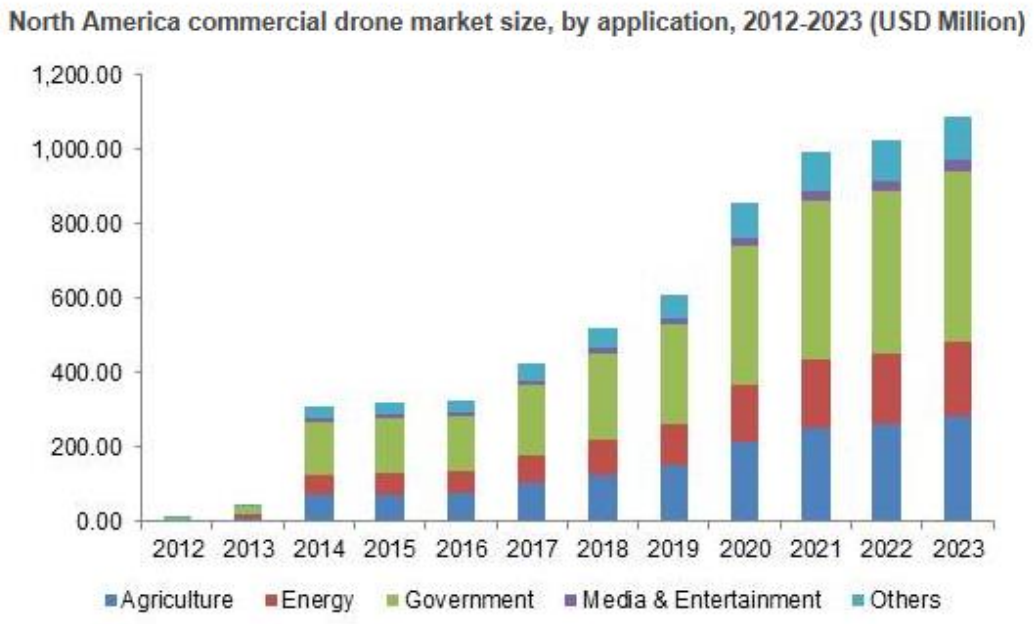

Figure 2.1.2: North America commercial drone market size forecast ([BD4])

According to the 2016 ***SESAR European Drones Outlook Study*** ([BD5]), drone market and capabilities are expanding rapidly also in Europe (**Figure 2.1.3**, **Figure 2.1.4**). *"The growing drone marketplace shows significant potential, with European demand suggestive of a valuation in excess of EUR 10 billion annually, in nominal terms, by 2035 and over EUR 15 billion annually by 2050. […] The development of the civil drone industry is dependent on the ability of drones to operate in various areas of the airspace, especially at very low levels that today are generally defined as being below 150 metres. […] Commercial and professional users are expected to demand drones in both rural and urban settings and will be reliant on beyond visual line of sight capabilities to be permitted. […] Unlocking the full potential of the market and maintaining the high standards of safety of EU aviation will require increased levels of European support. […] An estimated total of at least EUR 200 million in additional R&D over the next 5-10 years, based on expectations of the market, is required to address remaining gaps related to Very Low Level (VLL) activities that represent the majority of future drone operations. This boost in R&D capabilities would complement on-going efforts for the integration of drones into controlled airspace.*

According to the replies received on a UAS operators questionnaire issued by the European Aviation Safety Agency (EASA) in 2016 ([ND23]), in the segment of small-UAS of less than 25 kg, more than 90% of them have a maximum take-off mass (MTOM) between 0 and 4 kg. Of course, the above estimates do not take into account model and privately built aircraft, mainly used by hobbyists. Apart from being fast evolving, the UAS market is characterized by the presence of many actors relatively new to the aviation sector, especially for the small-size segment. Indeed, concerning UAS manufacturers, an important market share is accounted for by companies that are not familiar with aviation regulation. Drones in the small-size segment, especially those privately built, are likely the most susceptible for illegal activities.

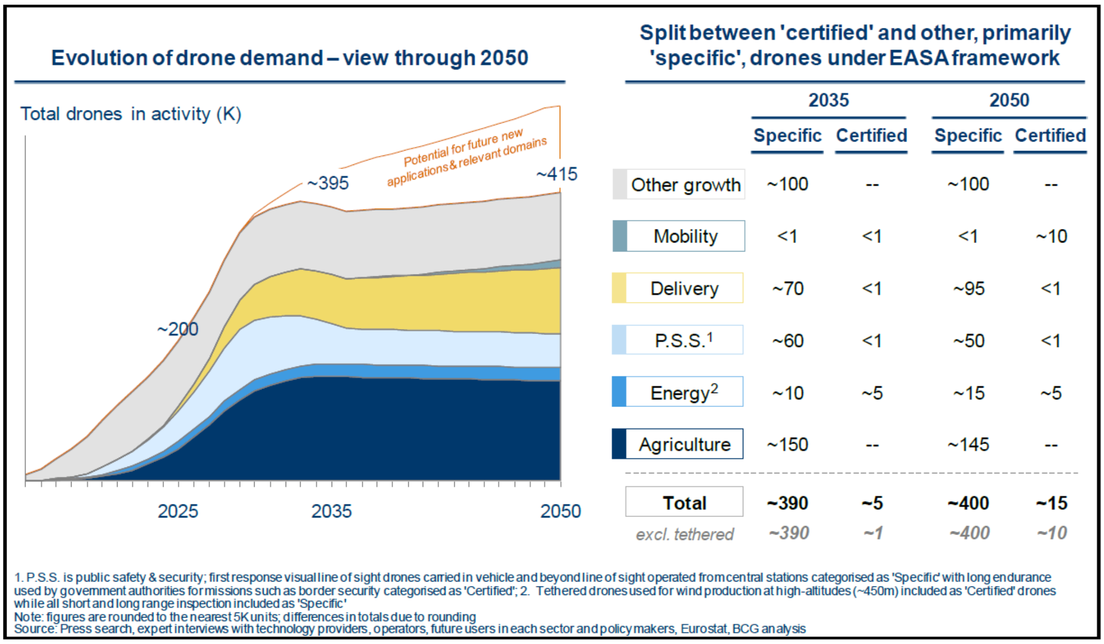

Figure 2.1.3: Europe drone demand forecast by industry domain ([BD5])

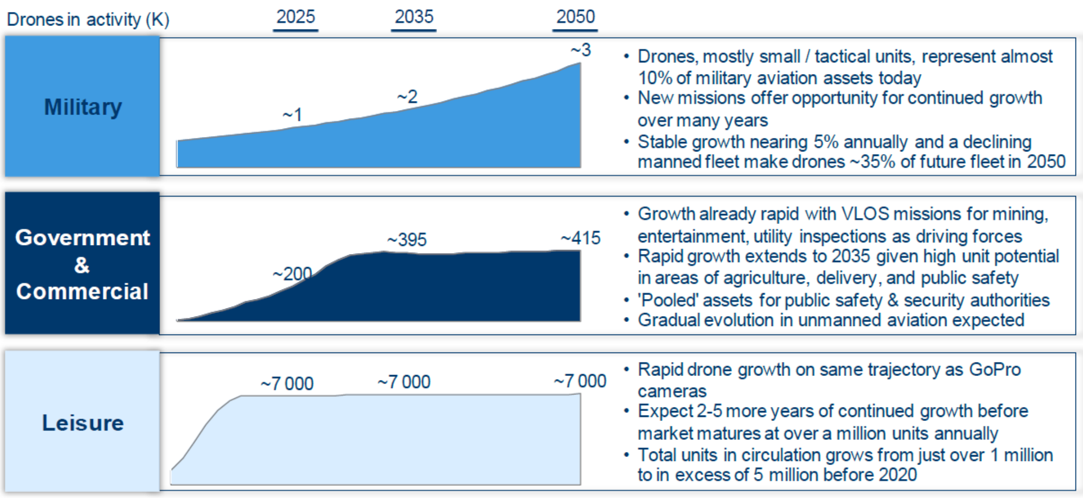

Figure 2.1.4: Europe estimate of total UAS fleet size ([BD5])

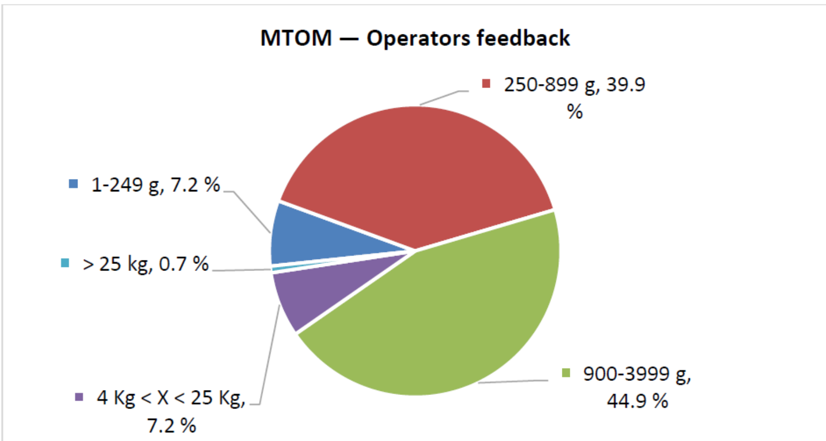

Figure 2.1.5: Distribution of drone mass according to EASA UAS operators questionnaire 2016 ([ND23])

The drone proliferation is however generating serious security issues. In recent years, newspapers and mass media have reported dozens of incidents involving drones flying over restricted areas and around critical infrastructures, such as airports, nuclear plants, official buildings, or during public events (§ 2.3). Drone technology has evolved at a faster rate than imagined, leaving regulation and counter-drone capability far behind. Hence, it is critical that governments work with regulators and industry to develop an effective Counter UAV (C-UAV) framework. Prisons, airports, sporting venues, public buildings and other sensitive sites are at serious risk, and correctly understanding the multitude of challenges that drones present is central for the effective protection of critical infrastructures and citizens.

While concern is growing about the kind of threats posed in a world filled with small, but increasingly versatile UAVs (§ 2.3), hundreds of millions of dollars are being devoted worldwide to develop Counter UAV (C-UAV) technologies, either for Military/Defence or Critical Infrastructure Protection (CIP) applications ([BD6], [BD7]). The worldwide market for counter-drone technology is expected to grow from $342.6million in 2016 to $1.5billion by 2023, according to a July 2017 research report from MarketsandMarkets ([BD8], [BD9]), with non-kinetic electronic systems estimated to grow at the highest rate during the forecast period.

The drone threat is relatively new and it is a necessity to provide a thorough solution on the detection and neutralization of rogue/suspicious light drone/UAV flying over restricted areas, even if this happens before the completion of the relevant regulatory framework. In this specific case, the fact that the criminal organisation groups and the terrorists have the absolute advantage of surprise maximises the impact of illicit activities with vast consequences to the society and the economy worldwide.

Unfortunately, facing such threats is not straightforward for various reasons. Firstly, the regulatory framework about the usage of UAVs and the legal responses to such threats is not clear and homogenous. Secondly, the operational capacity of law enforcement agencies is limited in human, equipment, and financial resources.

Despite the growing and rapidly evolving C-UAV market, before the start of the ALADDIN project there were no off-the-shelf C-UAV solutions effective enough in all operational contexts that can reliably detect, localize, identify and mitigate the threat of suspicious and potentially multiple UAVs, while taking into account the regulatory framework and the decision chain.

To address the drone threat the European Commission (EC) opened a specific call within the Horizon 2020 (H2020) research and innovation programme:*'**SEC-12-FCT-2016-2017 - Sub-topic 2**: Detection and neutralization of rogue/suspicious light drone/UAV flying over restricted areas and involving as beneficiaries, where appropriate, the operators of infrastructure'*.

In response to this call, the project **ALADDIN - Advanced hoListic Adverse Drone Detection, Identification and Neutralization** has been awarded to a Consortium of 18 European partners with Grant Agreement 740859 (https://aladdin2020.eu/). The ALADDIN project will be implemented in compliance with the Description of Action (DOA): Annex 1 - Part A (description of the work plan) and Annex 2 – Part B (narrative description of the action) [AD1].

Through a holistic approach and thanks to a Consortium of world-leading technical partners (industrial companies, small-medium enterprises, research centres and academic institutes) and end-user representatives of Law Enforcement Agencies

(LEAs) and constructors/operators of critical infrastructures, ALADDIN's ambition is to provide an unprecedented and evolving solution to the emerging **drone threat**, completely in line with the scopes of the call:

1. *New knowledge and targeted technologies for fighting both old and new forms of crime and terrorist behaviours supported by advanced technologies*
2. *Test and demonstration of newly developed technology by LEAs involved in proposals*
3. *Innovative curricula, training and (joint) exercises to be used to facilitate the EU-wide take-up of these new technologies*

2.2 ALADDIN project overview and main objectives

The main objective of the ALADDIN project is to **study and develop a state-of-the-art, global, and extensible system to detect, localise, classify, and neutralise suspicious, and potentially multiple, light UAVs over restricted areas**. This system will be tailored to operational constraints such as easiness of use and deployment, quality of detection, or safety, in order to deliver unprecedented tools for operational support, including investigations, and training.

ALADDIN will also assess relevant technologies, threat trends, regulations, and other important issues such as societal, ethical, and legal (SoEL) frameworks in order to develop new knowledge made available to LEAs and infrastructure designers, constructors, and operators through innovative curricula.

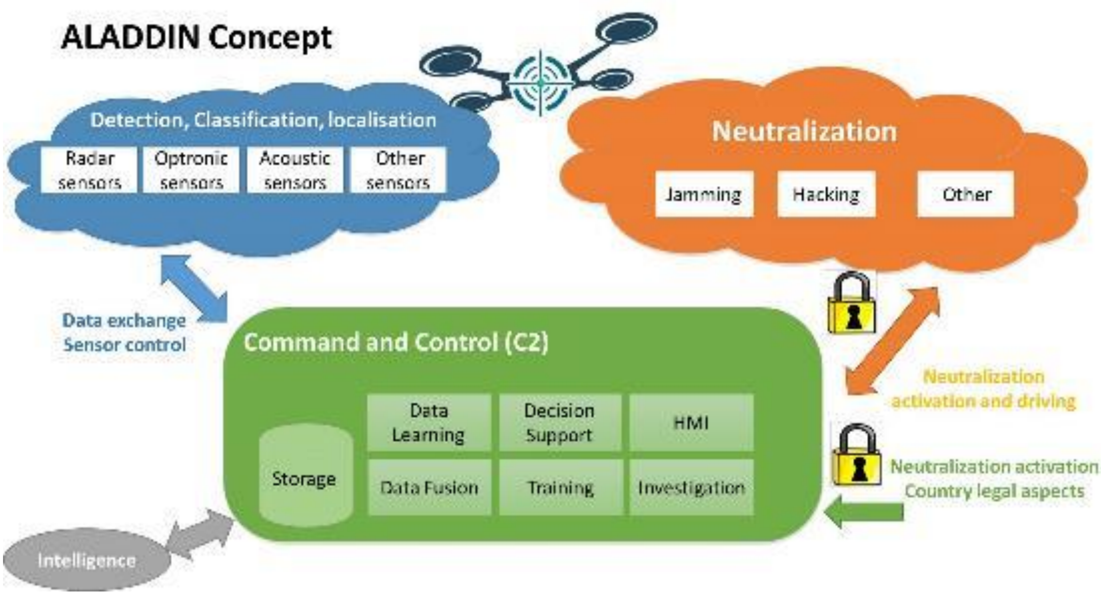

Figure 2.2.1: The ALADDIN platform concept

The **overall concept** of the ALADDIN project is the development of a seamless, tightly integrated system for countering malicious drones. The ALADDIN platform (**Figure 2.2.1**) will tightly integrate multiple modules materializing the three core sub-systems:

- the **detection, classification, and localisation** sub-system
- the **advanced command and control (C2)** sub-system
- the **neutralization** sub-system

ALADDIN is an ambitious research and innovation project racing against organised criminal groups and terrorism and facing important challenges at the technological and integration level as well as barriers in the non-technological domains, including **political and economic barriers** in adopting new technologies and **legislative or cultural differences at national level** in terms of privacy and other legal constraints. The SWOT Analysis presented in **Table 2.2.1** summarizes the position of the ALADDIN project.

Table 2.2.1 SWOT Analysis for the ALADDIN project

SWOT Analysis for the ALADDIN project	
STRENGTHS	**WEAKNESSES**
Consortium composition and size Collaboration and cooperation capacity of partners Accumulated Expertise in ICT Security domain Use of diverse and state-of-the-art sensors and software Hands-on involvement of end-users Very strong return on experience on real and practical use case with leads to a clear understanding of the UAV solution to be developed Adaptability and flexibility	Lack of knowledge on the new forms of criminal and terrorism activities involving UAVs (to be improved via the workshops, the Advisory Board, the discussion between LEAs…) Study of a broad set of crimes rather than on specific types (i.e. smuggling, drug dealing etc.)
OPPORTUNITIES	**THREATS**
Active role in participating in the definition of the Regulatory framework Improve investigation capabilities Reduce time to crime resolution Prevent terrorism endeavours Update current LEA practices and capabilities Boost EU Security Industry Decipher the use of UAVs in criminal and terrorism activities	Lack of Regulatory framework for the operation of UAVs/drones Fluid policy and legislation environment Adoption readiness by users Change in current LEA practices Vendor and market response Potential erosion of goodwill and commitment of users Poor reception by civil society Uncertainty around EU Data Protection Directives

ALADDIN follows an **iterative and incremental** development in order to implement a **user-centred design process** all along the project duration. Continuous implication of end users and iterative evaluation of the project results aims at ensuring that the work is addressing real operational needs and constraints. This methodology will enable the regular revision of the user needs, technical design, scientific approaches, and prototypes as well as the early implementation of corrective actions.

The work plan consists of **nine work packages** with an overall project duration of 36 months enabling **two main iterations**, leading to two incremental releases of the ALADDIN system (**Figure 2.2.2**). Each one of the two main phases (**beta** and **final**) is a **complete development cycle** composed of requirement collection, platform design, development, integration, and end-user testing and evaluation.

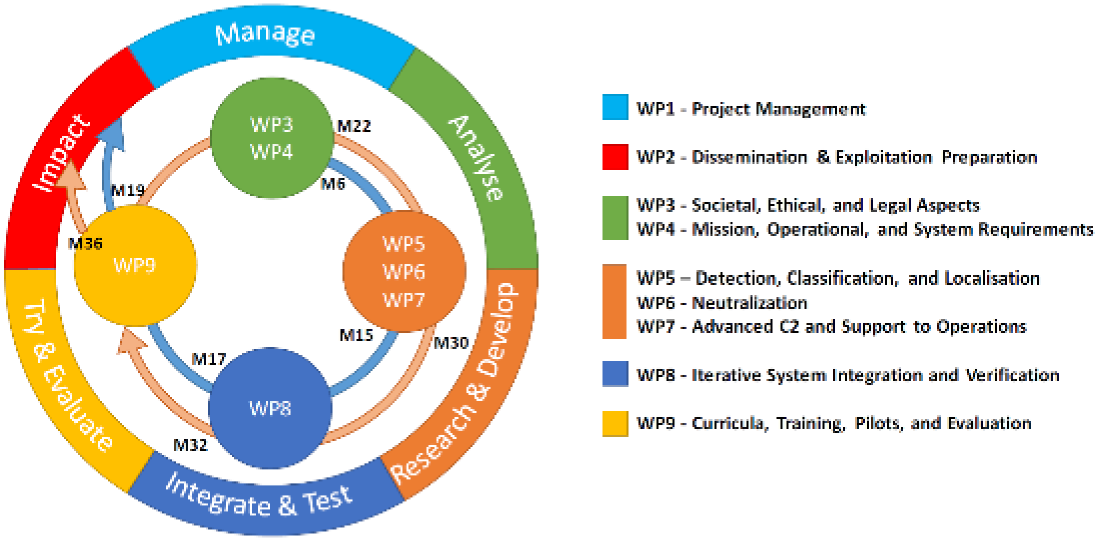

Figure 2.2.2: Work Breakdown Structure of the ALADDIN Project

2.2.1 Standardisation, regulation, and technological evolution: monitoring and impact

One of the main purposes of the ALADDIN project is the assessment of relevant technologies, threat trends, regulations, and other societal, ethical, and legal (SoEL) issues to improve the LEAs' capability in facing the emerging drone threat. According to the **ALADDIN user-centred** approach, as stated in the DOA [AD1], one of the main **Expected Impacts** of the ALADDIN project is: "*LEA officers provided with better tools to help them on their (specialized) daily work".* To this aim, *the ALADDIN project will closely monitor the evolution of threats, technologies and regulations throughout the project, keeping LEA activities and tools up-to-date.*

According to the DOA Annex 1 - Part A, work package **WP4** - **Mission, Operational & System Requirements** *will gather and refine end-user's requirements and constraints, while monitoring relevant standardisation initiatives and technological evolution, in order to define and refine pilot scenarios as well as functional specifications and system architecture.*

In particular, task **T4.2 – Standardization, regulation, and technological monitoring** will produce internal reports to *inform the project about external technology and product evolutions as well as relevant working group activities, standardisation and regulation initiatives, which will be fed into the design process* of the ALADDIN system. *During the whole project, great attention will be paid to international standards and emerging technologies/research results/projects/products in order to determine, in agreement with end-users, which of them are the most relevant to use or to comply/interoperate with […].*

Task T4.2 is complementary to task **T2.3 – Contribution to standardisation and regulations**. *This task aims at organising and carrying out the activities related to the dissemination of the project results towards the standardisation initiatives […]* and *the appropriate actions to disseminate WP3 results towards the regulation initiatives* *relevant to UAVs in order to propose changes in laws and regulations aiming to better control UAV threats and simplify LEAs operations, including investigation.* This activity may include Dissemination of WP3 results that may derive from those included in D3.1 “Data protection, Social, Ethical and Legal frameworks” [AD2] and in other WP3 public deliverables.

The monitoring activity of T4.2 aims primarily to help the Consortium in designing the system architecture and functional specifications of the ALADDIN platform in order to develop the most advanced, yet user-friendly, counter-drone system fit for the purpose of **Civilian Security** and compliant with current European regulation and standards, allowing its interoperability with third-party components.

Secondarily, the monitoring activity of T4.2 will have a positive impact on the entire European community by providing an up-to-date overview of the standardization, regulation, and technological state of the art (SOTA) related to drone and counter-drone emerging topics. In addition, the active participation of ALADDIN partners to standardisation and regulation initiatives within T2.3 will contribute to addressing the most urgent problems and barriers in order to ensure the European technical leadership and competitiveness in the security domain.

A summary of the internal reports about standardization, regulation, and technological monitoring will be included in the biannual Deliverable “*Report on standardisation, regulation, and SOTA progress”*. Although not exhaustive, the various issues of this Deliverable aim to provide an overview of the evolution of the major (counter-) drone topics on the standardization, regulation, and technological perspectives. More in-depth information may be found in the relevant literature and referenced material.

2.3 Threat analysis

UAVs can represent both **passive** threats, unintentionally disrupting ordinary citizen lives, and **active** threats of criminal activities or terrorism, with high destabilization potential. Passive threats include possible airborne collisions of drones flying too close to aircrafts. A study of the US Federal Aviation Administration (FAA) into drone safety has suggested that collisions with aircraft are more damaging than bird strikes[1]. The FAA study ASSURE recreated a collision between a drone and an airplane using a computer simulation and the models of two types of drone (the DJI Phantom 3 Standard quadcopter and a fixed-wing Precision Hawk Lancaster Hawkeye III). The Final Report of the study[2] pointed out that windscreens on aircraft were particularly vulnerable to damages. A similar study in the UK, conducted by military research firm Qinetiq on behalf of the UK government, suggested that drone strikes could cause critical damage to planes. Other drone threats include the collection of sensitive data by un-malicious users and the possible misuse of such data[3], causing high legal and

[1] http://www.bbc.com/news/technology-42238115, 5 December 2017

[2] ASSURE UAS Airborne Collision Severity Evaluation Final Report http://assureuas.org/projects/deliverables/sUASAirborneCollisionReport.php

[3] https://www.nytimes.com/2017/11/29/technology/dji-china-data-drones.html; https://gcn.com/Articles/2017/11/29/DJI-drone-snoops.aspx; http://securityaffairs.co/wordpress/66351/intelligence/dji-drones-cyberespionage.html

ethical concerns. The huge impact on everyday life of this kind of UAV threat (passive) became apparent in December 2018 - January 2019, when two major incidents of drones sighting caused huge flight disruptions at the two biggest UK airports.

Active threat include the possibility of using (mini and small) UAV for criminal activities, such as smuggling of drugs/cigarettes or other illegal goods into prisons or across borders, and for terroristic purposes, by carrying spy cameras or powerful explosives. The statement that *"Terrorist Drone Attacks are not a matter of IF but WHEN"*[4] indicates the severity of the asymmetric threat on the prosperity, the political stability and the well-being within the European Union (EU).

On the military side, there is a lot of concern about the potential for small, weaponized drone swarms, demanding for a multilayer detection capability with either electronic or kinetic mitigation, depending on the area of operations and rules of engagement. The potential threat from small UAVs in the hands of terrorists has attracted the attention of regulatory agencies not only in Europe but also in America, such as US FAA, which launched its Pathfinder Program in May 2015 as a partnership with industry to explore the next steps in unmanned aircraft operations.[5]

An interesting commentary in the Unmanned Airspace website[6] looks at the different types of actors behind the rogue drone threat, pointing out that "the difference between a drone being a toy or a weapon is the decision made by the operator," as a speaker said at a recent counter-UAS event in London. According to the expert (Tony Reeves of Level 7 Expertise): *What has become strikingly apparent is there is a close similarity between the nefarious drone operators above to similar groups operating in the cybersecurity world. Perhaps the way that nefarious actors behave is a human trait rather than being defined by the tool.* In his analysis, he divides the ***nefarious drone operators*** in the following categories:

- **Uninformed hobbyist**: This person doesn't know they're doing anything wrong; they don't know enough to check what is and what is not allowed, and where they are allowed to fly.
- **Disruptors**: This is a wide-ranging group, divided into a number of sub-categories but all characterised by knowing that they shouldn't be flying where, when or how they are.
    - Disruptive (1) – Shortcut / risk taker.
    - Disruptive (2) – Deliberately outside the rules, for reputation.
    - Disruptive (3) – Deliberately unsafe.
    - Disruptive (4) – Deliberately disruptive.
- **Protestors.** Protestors tend to carry or broadcast a strong message, and are not averse to being apprehended and/or arrested on live video.
- **Criminals.** The criminal use of drones is largely confined to activities connected to financial gain. The primary issue faced is the use of drones to

[4] Terrorist drone attacks are not a matter of 'if' but 'when', 2016. http://europe.newsweek.com

[5] J.R. Wilson 2016. *The dawn of counter-drone technologies.* Military & Aerospace Electronics, November 1, 2016. http://www.militaryaerospace.com/articles/print/volume-27/issue-11/special-report/the-dawn-of-counter-drone-technologies.html

[6] "The drone threat: a guide to the bad and the very bad actors", May 31, 2019 https://www.unmannedairspace.info/commentary/the-drone-threat-a-guide-to-the-bad-and-the-very-bad-actors/

smuggle contraband (usually mobile phones, drugs or money) into prisons. [ ] There is a new sub-group which has appeared recently, utilising drones to film live sporting events and place "in-play" bets.

- **Terrorists.** A committed terrorist is incredibly hard to stop, and there is a near-continuous 'leakage' of terrorist / insurgent drone tactics from the Middle East conflict areas – in particular Iraq / Syria and Yemen / Saudi Arabia. [ ] The terrorist's intent is to achieve their objective at all costs. [ ] Hard to detect, deliberately covert until the moment of attack, operating in small cells and highly motivated; the terrorist presents the hardest challenge for security organisations.
- **Other hostile actors i.e. Nation States or sponsored / supported actors**. Houthi-backed rebels have launched drone attacks on Saudi airports, using commercially available drones with a payload of explosives. Press reports says Saudi authorities have shot down the drones.

2.3.1 Escalation of the drone threat

During the lifetime of the ALADDIN project, the world has witnessed an escalation of the drone threat, either passive or active.

2.3.1.1 Drone incidents: aircraft near misses and airport security

UAV-related incidents have often been reported as causing hazards to aircraft, or to people or property on the ground. Safety concerns have been raised due to the potential for an ingested drone to rapidly disable an aircraft engine, and several near-misses and verified collisions have involved hobbyist drone operators flying in violation of aviation safety regulations[7].

The recent **incidents of drone sighting at UK airports** demonstrated to the public the severe impact of the drone threat in everyday life and prompted an acceleration in both regulatory activities (§ 4.2.1) and Counter-UAV business development.

Recent news in UK and worldwide mass media report two big incidents of drone sighting at the major UK airports:

- **Gatwick**, which in the run-up to Christmas was repeatedly forced to close between 19 and 21 December 2018 due to reported drone sightings[8], with about 800 flights cancelled, affecting 120000 people[9].
- **Heathrow**, which was forced to ground departures with an emergency one-hour halt because of a drone sighting on 8 January 2019[10].

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[7] https://en.wikipedia.org/wiki/List_of_UAV-related_incidents

[8] https://www.theguardian.com/uk-news/video/2018/dec/20/thousands-stranded-at-gatwick-airport-due-to-drones-video 21/12/2018

[9] https://www.theguardian.com/uk-news/2018/dec/20/tens-of-thousands-of-passengers-stranded-by-gatwick-airport-drones 21/12/2018

[10] https://www.theguardian.com/uk-news/2019/jan/08/heathrow-airport-departures-suspended-after-drone-sighting 08/01/2019

These incidents have received high emphasis in the websites of UK-based C-drone conferences: **Countering Drones 2019** (10-11 July 2019, London, UK) and **Counter UAS 2019** (16 - 18 April 2019, London, UK), designed exclusively for the military.

The **Countering Drones** website[11] highlights that *the **drone incident at Gatwick Airport** has brought the threat of malicious drone use into the mainstream, and the serious economic and personal impact that this has had on businesses and private individuals cannot continue to be ignored. Following the incident at Gatwick, we now expect investment and real commitment to tackle the issues* (including improvements to the regulatory environment)*, in order to assure businesses and the public of an effective response to future incidents*. These incidents confirm the concerns expressed earlier when Defence IQ published global airport drone threat map[12]. *The threat posed by drones to airports is real. Even though regulations have been recently updated in some countries and countermeasures currently trialled, the safety risk they pose along with the potential financial loss they could cause is still present.*

The **Counter UAS 2019** website[13] emphasize the supporting role of military C-UAS capabilities in the capacity of Military Assistance to a Civilian Authority (MACA). *The recent **incident at London Gatwick Airport** has also highlighted the role the military has to play in supporting civilian organisations during crises until more effective Counter-UAS capabilities are procured by civilian operators of Critical National Infrastructure.*

Related newspaper articles announce new anti-drone powers handed to Police in response to Gatwick incidents[14], and millions investment in further anti-drone systems by Heathrow and Gatwick airports[15].

In response the government has announced a package of measures which include plans to give police the power to land, seize and search drones. The Home Office will also begin to test and evaluate the use of counter-drone technology at airports and prisons.

According to the press[16], during the Heathrow drone sighting the armed forces were called in to protect the UK's busiest airport using "specialist equipment", probably the Israeli-developed Drone Dome C-UAS system, which the United Kingdom had procured in August 2018[17]. *The selection of the Drone Dome comes eight months after*

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[11] https://counteringdrones.iqpc.co.uk/

[12] Drones and airports: Global threat map https://counteringdrones.iqpc.co.uk/downloads/drones-and-airports-global-threat-map?-ty-m; Defence IQ publishes global airport drone threat map, https://www.unmannedairspace.info/counter-uas-systems-and-policies/defence-iq-publishes-global-airport-drone-threat-map/, 3/10/2018

[13] https://counteruas.iqpc.co.uk/

[14] https://www.theguardian.com/technology/2019/jan/08/police-handed-new-anti-drone-powers-after-gatwick-disruption 08/01/2019

[15] https://www.theguardian.com/world/2019/jan/03/heathrow-and-gatwick-millions-anti-drone-technology 03/01/2018

[16] https://www.theguardian.com/uk-news/2019/jan/08/heathrow-airport-departures-suspended-after-drone-sighting 08/01/2019

[17] https://www.janes.com/article/82347/uk-signs-for-drone-dome-c-uas-system 14/08/2018

it was demonstrated to the UK government in January. According to its manufacturer Rafael, the United Kingdom is to receive the radar detection, electro-optical (EO) identification and communication jamming elements of the system, but not the hard-kill laser. The radar usually has a detection range of about 50 km for a target the size of a transport aircraft, but for the class of target that it is looking for in its Drone Dome application the radar would typically provide a detection range of between 3.5 km and 10 km.

Subsequent news[18] mention the decision to install the AUDS UAV Defense System to protect Gatwick airport, for a cost of around € 900,000. This is not surprising as AUDS is a UK-developed anti-drone system used also by the US military.

Other news[19] announce *Drone jamming system to protect European airports, public spaces*, according to the chief technology officer of Danish anti-drone firm MyDefence.

In early 2019, on the emotional wave caused by the incidents at UK airports, the media attention on the drone threat has a special focus on **near misses (Airprox) incidents** with ordinary aircraft. The latest figures published for 2018 by the UK Airprox Board (UKAB) and reported on the UAS Vision website[20] show a continued rise of incidents involving drones and civil aircraft (**Figure 2.3.1**). There were 120 near misses between drones and aircraft reported in 2018, up 29% than in 2017. Several of the incidents involved airliners, which were approaching Heathrow.

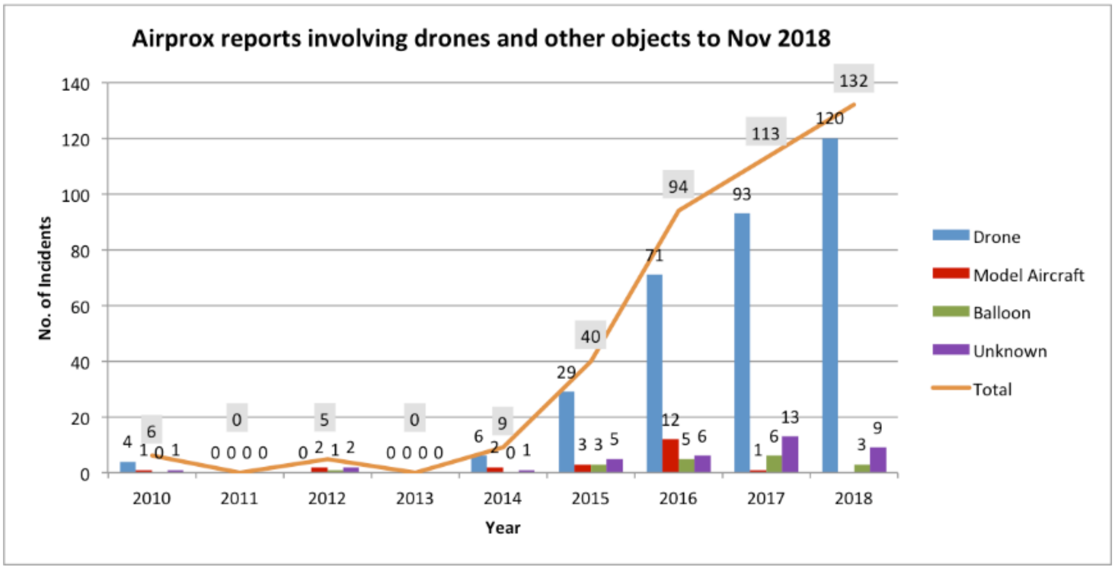

Figure 2.3.1: Near misses of drones and civil aircraft in UK (Source: UK Airprox Board)

[18] https://www.quadricottero.com/2019/01/a-gatwick-installato-il-sistema-anti.html 13/01/2019

[19] https://phys.org/wire-news/308899455/drone-jamming-system-to-protect-european-airports-public-spaces.html 14/01/2019

[20] "UK Airprox Board Reports 30% Rise in Drone Incidents", 25/01/2019 https://www.uasvision.com/2019/01/25/uk-airprox-board-reports-30-rise-in-drone-incidents/

In early 2020, other incidents confirmed the drone threat at airports. In Spain, at **Adolfo Suárez Madrid-Barajas** airport on 3rd February 2020, a set of drones forced air traffic to be deviated to other nearby airports and limited take-offs during one hour[21]. The airport was closed during almost 2 hours due to the apparent presence of drones around[22]. Spain's State Air Safety Agecy (AESA) confirmed in a tweet that "flying drones in the vicinity of an airport is a serious infraction that comes with a penalty fine of up to €90,000".

2.3.1.2 Criminal and terroristic use of drones

An article of the World Security Report (March / April 2019)[23] summarizes the recent escalation of the drone threat in just three months:

In recent months, drones have been wreaking havoc; whether they are used to infiltrate someone's privacy by recording from above, flying illicit contraband into prisons, exposing the security shortcomings of a critical infrastructure site or closing Gatwick Airport airspace for 33 hours. In that 33 hours over 1,000 flights were disrupted affecting 140,000 passengers and a suggested total cost to the airport and industry anywhere between £50 – 100 million! [ ] These are the off-the-shelf hobbyist drones used by petty criminals for unauthorised surveillance, malicious actors intent on causing trouble, activists proving a point or maybe just a simple error from a hobbyist in a field. Recently Greenpeace dropped smoke bombs from a drone onto the roof of a building containing irradiated fuel to prove a point that the Orano La Hague Nuclear Power Facility is not sufficiently protected. [ ] Hence the frenzied interest in Anti Drone technology. [ ] This article looks at just some of the myriad of options now available to counter drone threats. Among the anti-drone options, the article includes Black Knight by IDS Corporation, member of the ALADDIN consortium, and a number of other systems (AUDS, etc.).

The risk of terroristic use of drones is confirmed by news from Spain in September 2017[24]: "*The police arrested a man in Merida (Badajoz) on Friday for his alleged integration into Dáesh's I+D+I technological apparatus, for which he was looking for drones and other equipment, in addition to participating in financing the terrorist organization*."

More recent news refer to an alleged shock assassination plot against **Venezuelan President Nicolas Maduro** using two flying drones loaded with explosives on 4th

[21] https://elpais.com/politica/2020/02/03/actualidad/1580732176_100077.html

[22] https://www.thelocal.es/20200203/airspace-closed-at-madrids-barajas-airport-after-drone-sighting 3 February 2020

[23] Karen Kingham, "From Eagles to Lasers – the Evolving Business of the Anti-Drone Market", World Security Report, March / April 2019, p.14

[24] http://www.rtve.es/noticias/20170922/detenido-merida-hombre-financiar-buscar-drones-para-daesh/1621622.shtml, 22 September 2017

August 2018[25]. The worldwide echo of this event highlights risk of drone strikes[26] and that such kind of attacks will not be the last[27]. This attack has prompted concerns that such terror tactics could become more and more common in the future, especially against easy targets, such as airports and *"large stadiums full of people, including rock concerts and football matches"*, according to an associate professor at the University of the West England, in Bristol[28]. Experts say the psychological effects of a small but successful attack could far outstrip the actual physical damage, accomplishing the goal of spreading terror that many militant groups have made their mission.

Various sources evidence the asymmetric nature of this emerging threat:

The proliferation of inexpensive commercial UAS democratises capabilities previously held by militaries, and enhances asymmetric threats.[29]

The asymmetric nature of the sUAS, especially when considering swarm tactics, makes the technology difficult to defend against[30]*.*

At dawn of 2020, the use of weaponized drones is becoming a dramatic reality: an example is **the killing of Iranian General Q. Suleimani by a US drone** in an overnight airstrike at the Baghdad airport on 02/01/2020[31]. Although military applications are outside the scope of this report, the entire world fears that this event could trigger an increased uses of drones for terroristic purposes, as "*Iranian leaders issued strident calls on Friday for revenge against the United States"*[32]*.*

Concerning the threat evolution, experts agree that the next generation of drone threats will be swarms and completely autonomous drones. Since swarms are multiple drones employed simultaneously to complete a common goal, they require a C-UAS system that can effectively mitigate the threats at an extremely rapid rate. Completely autonomous drones, which operate without using radio frequencies, GPS, WiFi, Bluetooth or any other form of signal communication, require a multi-layered defence system, that can detect and locate both RF and non-RF emitting drones through different types of sensors, and then mitigate the threat through appropriate means.

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[25] The Guardian, 05/08/2018. *Venezuela's Nicolás Maduro survives apparent assassination attempt***.** https://www.theguardian.com/world/2018/aug/04/nicolas-maduros-speech-cut-short-while-soldiers-scatter

[26] Reuters, 05/08/2018. *Apparent attack in Venezuela highlights risk of drone strikes.* https://www.reuters.com/article/us-venezuela-politics-drones/apparent-attack-in-venezuela-highlights-risk-of-drone-strikes-idUSKBN1KQ0MG

[27] Wired, 04/08/2018. *The Explosive-Carrying Drones in Venezuela Won't Be the Last*. https://www.wired.com/story/venezuela-drones-explosives-maduro-threat/

[28] Express, 05/08/2018. *Venezuela-style DRONE TERROR will SURGE with airports and football stadiums 'easy targets'.* https://www.express.co.uk/news/world/999209/Venezuela-drone-assassination-terror-Maduro-attack-terrorism

[29] https://counteruas.iqpc.co.uk/

[30] https://ndupress.ndu.edu/Portals/68/Documents/jfq/jfq-85/jfq-85_30-35_Tingle-Tyree.pdf

[31] U.S. Strike in Iraq Kills Qassim Suleimani, Commander of Iranian Forces https://www.nytimes.com/2020/01/02/world/middleeast/qassem-soleimani-iraq-iran-attack.html

[32] The Killing of Gen. Qassim Suleimani: What We Know Since the U.S. Airstrike https://www.nytimes.com/2020/01/03/world/middleeast/iranian-general-qassem-soleimani-killed.html

3 Standardisation progress

This chapter reports the main standardisation progress in ALADDIN focus areas, namely those concerning:

- UAV-related topics
- Electromagnetic emissions
- Privacy and personal data protection.

In developing the ALADDIN platform, the consortium will pursue compliance with applicable standards not only for ***UAV-related topics*** – relevant to the whole project, but also to ***Electromagnetic emissions*** – relevant to radar, jamming and communications (C2), as well as ***Privacy and personal data protection*** – mostly relevant to Electro-Optical sensors.

Starting from the situation at beginning of the ALADDIN project (§ 3.1), this chapter aims at monitoring the standardisation evolution through the project lifetime (§ 3.2).

Full chapter is accessible on request on website https://aladdin2020.eu/contact-us/

4 Regulation progress

This chapter reports the main regulation progress in ALADDIN focus areas, namely those concerning:

- UAV-related topics
- Electromagnetic emissions
- Privacy and personal data protection.

In developing the ALADDIN platform and implementing the project, the consortium will conform to the applicable regulation not only for ***UAV-related topics***– including the operation of UAVs, relevant to the whole project, but also to ***Electromagnetic emissions*** – relevant to radar, jamming and communications (C2), as well as ***Privacy and personal data protection*** – mostly relevant to Electro-Optical sensors. For additional details, please refer to Deliverable D3.1 [AD2], as this document goes into depth into the relevant regulations with respect to all the above topics.

Starting from the situation at beginning of the ALADDIN project (§ 4.1), this chapter aims at monitoring the regulation evolution through the project lifetime (§ 4.2).

Full chapter is accessible on request on website https://aladdin2020.eu/contact-us/

5 SOTA progress

This chapter reports a state of the art (SOTA) analysis and main (hardware or software) technological progress relevant to the detection and neutralization of UAVs either as individual components or as integrated counter-UAV systems, with particular reference to those involved in the ALADDIN platform concept (**Figure 2.2.1**), namely those concerning:

- Sensor technology (radar, optical, thermal and acoustic sensing, with relevant data processing techniques);
- Effector technology (jamming, hacking/spoofing and physical neutralization)
- Command and Control (C2) and Support to Operations sub-systems
- Complete counter-UAV systems, involving combination of the above components.

Starting from the situation at beginning of the ALADDIN project (§ 5.1), this chapter aims at monitoring the technological evolution through the project lifetime (§ 5.2).

Full chapter is accessible on request on website https://aladdin2020.eu/contact-us/

6 Conclusions

Unmanned Aerial Vehicles (UAV) or Systems (UAS), commonly termed drones, are becoming an ordinary presence in everyday citizens' life, with a continuous market increase in a growing number of useful applications. The drone proliferation is however generating serious security issues. In recent years, newspapers and mass media have reported dozens of incidents involving drones flying over restricted areas and around critical infrastructures, such as airports, nuclear plants, official buildings, or during public events, including the alleged use of drones for terroristic purposes. Drone technology has evolved at a faster rate than imagined, leaving regulation and counter-drone capability far behind.

The recent incidents of small **drones flying too close to UK airports** (Gatwick in December 2018, during Christmas holiday and Heathrow in early January 2019) **and in Spain** at Adolfo Suárez Barajas airport (February 2020), which caused a huge flight service disruption, demonstrated to the public the severe impact of the drone threat in everyday life and prompted an acceleration in both regulatory activities and Counter UAV business development.

The availability of open international standards is a key enabling factor for the development of markets in all business sectors, including the **Security** sector. Since the beginning of this decade, the European Commission is pointing out the necessity to address the gaps in the standardisation and regulation framework for an innovative and competitive Security Industry.

A number of standardization and regulation bodies are currently working on filling these gaps on UAV and counter-UAV (C-UAV) related topics, such as producing harmonized standards and regulation for the ***safe operation of UAVs*** in different zones of the airspace, according to their category. The most important standardization bodies dealing with UAV-related topics include EUROCAE work group WG-105 at European level, ISO technical committee ISO/TC 20/SC 16 and ICAO RPAS Panel at International level. There is an increasing effort to harmonize European standards with standardization activities outside Europe, such as those of the ASTM technical committee F38 and the RTCA special committee SC-228.

Current EUROCAE hottest topics include Specific Operations Risk Assessment (SORA), UAS Traffic Management (UTM), UAS E-Identification and UAS Geo-Fencing. Most importantly, in 2019 EUROCAE launched WG-115 **Counter UAS (C-UAS)**, with the mandate to develop standards to support the safe and harmonised implementation of Counter-UAS Systems into airport and Air Navigation Service Provider (ANSP) systems. UTM is also the core of current ISO standardization activity within ISO/TC 20/SC 16, along with more general topics, such as UAS operational procedures included in the ISO standard published in 2019. ASTM standards include, among others, those published in 2018 on UAS Registration and Marking, and BVLOS Small UAS Operations, or in 2019 on UAS Remote ID and Tracking, while other standards are still in preparation, including those concerning Operation over People.

Important standardization and regulation activities affecting C-UAV technology are also those pertaining to ***electromagnetic emissions*** – relevant to radar and RF sensing or neutralization, as well as ***Privacy and personal data protection*** – mostly relevant to Electro-Optical sensors. Concerning electromagnetic emissions, apparently there is a lack of applicable standards for radar used in drone detection application. Furthermore, given the ambiguous legality of radio frequency (RF) jamming technologies, there does not appear to be European standards applicable to such neutralization equipment. The recent adoption of the General Data Protection

Regulation (GDPR) - Regulation (EU) 2016/679, which became enforceable from 25 May 2018, could speed up the development of standards for privacy and personal data protection management in support of Union's security industry.

Concerning the regulation progress, the European Aviation Safety Agency (EASA) is working at an unprecedented pace to improve the ***drone safety regulation*** thus overcoming the current fragmented regulatory framework especially for the smaller UAS. In the EU framework up to 2018, Regulation (EC) No 216/2008 (the 'Basic Regulation') established the main principles and common rules for civil aviation in the EU and defined the area of competence of the EU and of its Member States (MSs). According to it, most of EU Member States adopted national regulations to ensure the *safe operations* of civil drones (UAS) below 150 kg, but there were no harmonized rules at EU level. EASA has been working actively towards a revision of the Basic Regulation to extend the scope of the EU competence to regulate UAS even below 150 kg, also to allow free circulation of UAS throughout the EU. Following the Notice of Proposed Amendments issued in May 2017 (NPA 2017-05 - open and specific category) and the publication on the 06/02/2018 of EASA **Opinion 01/2018,** approval of the new EU regulation was expected by 2018-2019. A notable progress in this direction is the publication on the 22nd August 2018 of **Regulation (EU) 1139/2018**, (the new 'Basic Regulation') which repeals Regulation (EC) No 216/2008 with effect from 11 September 2018. In June 2019, the European Commission adopted the Delegated Regulation **(EU) 2019/945** and Implementing Regulation **(EU) 2019/947** (the 'UAS Regulation'), containing technical and operational requirements for drones. The publication by EASA of **Decision 2019/021/R** containing the relevant Acceptable means of compliance (AMC) and Guidance material (GM) completed the process. The EU regulation will be applicable in one year to give Member States and operators time to prepare and implement it. Ongoing regulatory activities are concerned with operations in the specific category (e.g. Opinion No 05/2019 on standard scenarios) and U-Space. Member States are preparing for transposing the EU regulation into national implementation in the coming 3 years after its entry into force. Meanwhile, the Joint Authorities for Rulemaking on Unmanned Systems (JARUS) facilitates harmonisation of standards within the EU Member States and other participating authorities.

As stated previously, the main progress regarding ***Privacy and personal data protection*** is the entry into force on 25 May 2018 of the **General Data Protection Regulation** (**GDPR**) - Regulation (EU) 2016/679. However, the recent escalation of the drone threat, as publicly demonstrated by the serious incidents of drone sighting at Gatwick, Heathrow and Adolfo Suárez Madrid-Barajas airports, will likely trigger tougher regulation and heavier restrictions with impacts on Privacy and personal data protection.

In addition to the progresses in standardization and regulation, the document provides also the ***State Of The Art (SOTA) analysis*** of C-UAV technology as reported by published reports and online sources. Mini-UAV threat appeared as important in 2014, when many companies started to propose anti-UAV solutions. Single domain solutions focused on one aspect of the problem, either detection or neutralization of the threat. Detection mainly involves radar and/or electro-optical/infrared sensors whereas countering the threat mainly involves radio-frequency piloting and jamming of the UAV communication links. On the other hand, complete C-UAV systems are based on integration of (at least one) sensor, tracker/identifier and a neutralization effector (usually jammer). A number of systems and subsystems (sensing and neutralization equipment, data processing and data fusion techniques, cartographic and other supporting software) are currently available on the market. However, the threat is evolving very quickly and is mainly unpredictable: hence, single domain solutions are inadequate and should be integrated in flexible systems, able to accept different sensors and effectors. The overall trend is therefore toward multi-sensor integration and enhanced automation, although many points, such as drone versus bird discrimination, remain challenging tasks.

Additionally, new trends are gaining interest. The main one is related to swarms of drones either as a most frightening threat requiring superior detection and neutralization capabilities or even as potential countermeasure if employing sophisticated algorithms (currently a topic of academic research) to form a self-organized network of defence drones to intercept the intruder drone. Recent developments with potential impact on C-UAS systems include the requirement for integration with U-Space services/UTM systems and technological progresses of Artificial Intelligence/Machine Learning.

The constant stream of announcements in the specialised press of C-UAS system enhancements and new partnerships between C-UAS manufacturers or sellers demonstrate a high dynamism, especially by the global big players, both in improving the system performances and in seizing new market segments.

7 References

7.1 Applicable documents

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[AD3] D4.5 – Report on standardisation, regulation, and SOTA progress V1 (February 2018)
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[ND10] **EN 303 364 – 3** "Primary Surveillance Radar (PSR); Part 3: Harmonized Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU for Air Traffic Control (ATC) Primary Surveillance Radar sensors operating in 8500-10000 MHz frequency band (X band), PSR in X band (8500-10000 MHz)"

[ND11] ERC Recommendation 70-03, "Relating to the use of Short Range Devices (SRD)", 13 October 2017

[ND12] **Directive 2014/30/EU** of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to electromagnetic compatibility (recast) (OJ L 96, 29.3.2014). (**EMC Directive**) http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32014L0030

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Annex A – List of Acronyms

Acronym	Meaning
AENOR	Spanish Association for Standardization and Certification (Spanish: Asociación Española de Normalización y Certificación)
AGL	Above Ground Level
AMC	Acceptable Means of Compliance
A-NPA	Advanced Notice of Proposed Amendment
ANS	Air Navigation Service
ANSP	Air Navigation Service Provider
ATM	Air Traffic Management
ATOL	Automatic Taking-Off and Landing
BVLOS	Beyond Visual Line of Sight
C2	Command and Control
C3	Command, Control, Communication
CEN	European Committee for Standardization (French: Comité Européen de Normalisation)
CENELEC	European Committee for Electrotechnical Standardization (French: Comité Européen de Normalisation Électrotechnique)
C-UAS	Counter-UAS
C-UAV	Counter-UAV
DAA	Detect and Avoid
DEW	Directed Energy Weapons
DOA	Description of Action
EASA	European Aviation Safety Agency
EC	European Commission
ECM	Electronic Counter-Measures
EM	Electromagnetic
EMC	Electromagnetic compatibility
ENAC	Ente Nazionale per l'Aviazione Civile
EO	Electro-Optical
ERA	Enhanced RPAS Automation
ERC	European Research Council
ESO	European Standardisation Organisation
ETSI	European Telecommunications Standards Institute
EU	European Union
EUROCAE	European Organization for Civil Aviation Equipment
EUSCG	European UAS Standards Coordination Group
EVLOS	Extended Visual Line of Sight
FAA	Federal Aviation Administration
FMCW	Frequency Modulated Continuous Wave

GDPR	General Data Protection Regulation
GM	Guidance Material
GNSS	Global Navigation Satellite System
GUTMA	Global UTM Association
H2020	Horizon 2020
HMI	Human Machine Interface
HPM	High-Power Microwave
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
IR	Infra-red
ISO	International Organization for Standardisation
JARUS	Joint Authorities for Rulemaking on Unmanned Systems
LEA	Law Enforcement Agency
LSS	Low, Small, Slow
MASPS	Minimum Aviation System Performance Standards
MOPS	Minimum Operational Performance Standards
MS	Member State
MTOM	Maximum Take-Off Mass
MTOW	Maximum Take-Off Weight
NAA	National Aviation Authority
NPA	Notice of Proposed Amendment
OBW	Occupied bandwidth
OOB	Out Of Band
PANS	Procedures for Air Navigation Services
PSO	Project Security Officer
RCS	Radar Cross-Section
REC	Recommendation
RF	Radio Frequency
RMT	Rulemaking Task
RPA	Remotely Piloted Aircraft
RPAS	Remotely Piloted Aircraft System
RTCA	Radio Technical Commission for Aeronautics
SAB	Security Advisory Board
SARP	Standards and Recommended Practices
SESAR	Single European Sky ATM Research
SESAR JU	SESAR Joint Undertaking
SoEL	Societal, Ethical and Legal
SORA	Specific Operations Risk Assessment
SOTA	State of the art
SRD	Short Range Device
sRPAS	small RPAS

sUAS	small UAS
SWOT	Strengths, Weaknesses, Opportunities and Threats
TRL	Technological Readiness Level
UA	Unmanned Aircraft
UAS	Unmanned Aircraft System; Unmanned Aerial System
UAV	Unmanned Aerial Vehicle
UTM	UAS Traffic Management
VLL	Very Low Level
VLOS	Visual Line of Sight
WP	Work Package

Annex B – Definitions

Expression	Meaning
Geofencing	Geofencing is a virtual geographic boundary, defined by GNSS technology that enable software to prevent a drone entering a defined zone ([ND25])
Radio Equipment	An electrical or electronic product, which intentionally emits and/or receives radio waves for the purpose of radio communication and/or radiodetermination, or an electrical or electronic product which must be completed with an accessory, such as antenna, so as to intentionally emit and/or receive radio waves for the purpose of radio communication and/or radiodetermination ([ND9])
Radiodetermination	The determination of the position, velocity and/or other characteristics of an object, or the obtaining of information relating to these parameters, by means of the propagation properties of radio waves ([ND8])
Radiolocation	Radiodetermination used for purposes other than those of radionavigation ([ND8])
Radionavigation	Radiodetermination used for the purposes of navigation, including obstruction warning ([ND8])
SOTA	State of the art (sometimes cutting edge) refers to the highest level of general development, as of a device, technique, or scientific field achieved at a particular time. It also refers to such a level of development reached at any particular time as a result of the common methodologies employed at the time. (https://en.wikipedia.org/wiki/State_of_the_art)