PROFESSIONAL DRONE OPERATIONS

3rd Edition

January 2023

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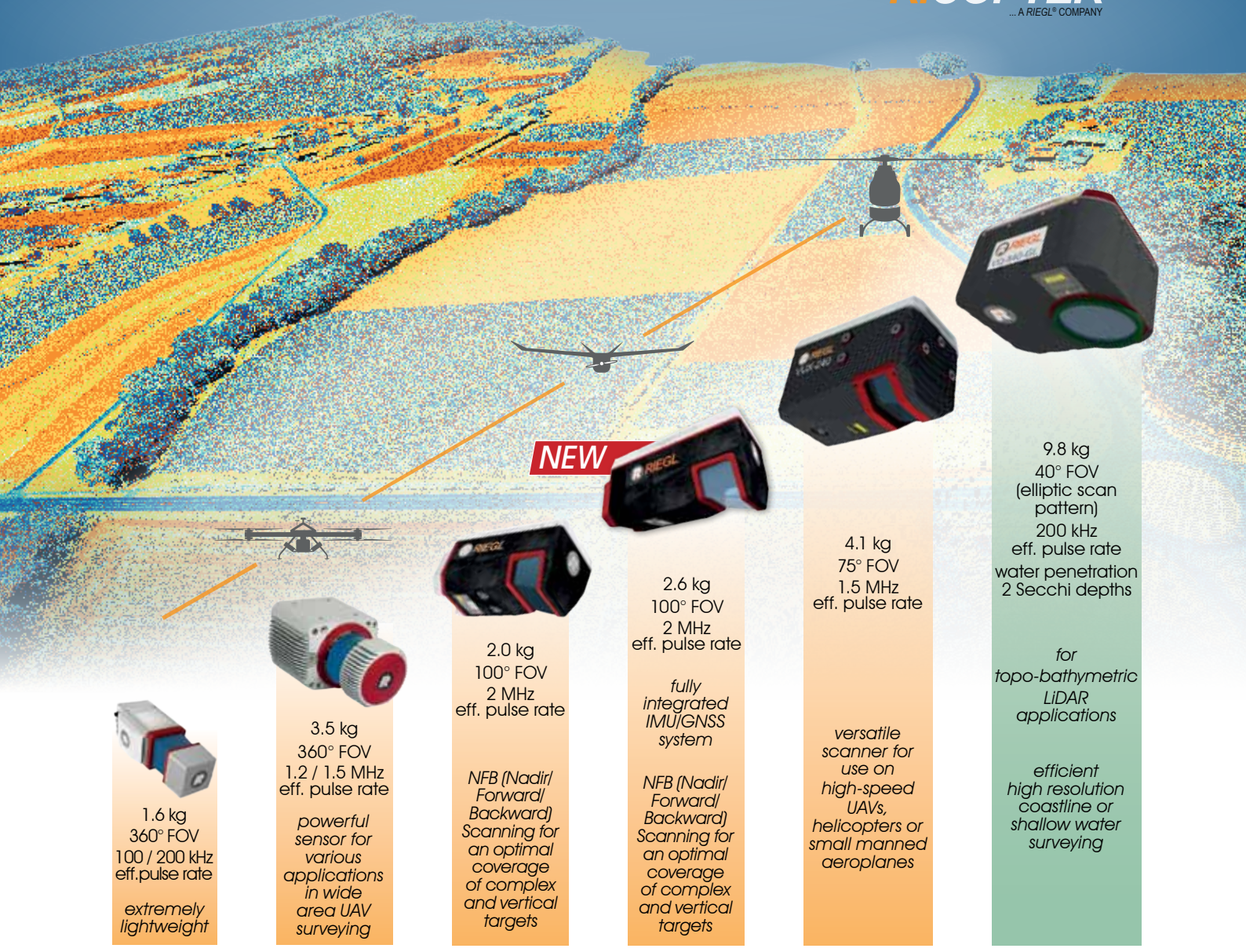

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FEATURE ARTICLES

FEATURE ARTICLE

United Systems Europe
Advancing the Professional Drone Operations Market

By Peter van Blyenburgh

Remote controlled, automated and autonomous vehicle systems are among the major technological and industrial developments of the 21st century. Their fields of application are multiple in the industry, transport, energy, agriculture, and the security sectors. These systems embody the technological progress made in several areas: IT, electronics, telecommunications, artificial intelligence, etc. and meet economic requirements since they perform very productive and secure tasks that are difficult for humans.

In addition, the design, production and use of these systems create a wide variety of jobs within a large ecosystem, which includes all links in the value chain (design, production, maintenance, training, operations). Thanks to their electric propulsion, many of these systems have a very low carbon footprint and their implementation has many environmental benefits.

However, the dispersion of the structures and initiatives of this new industry is still a major obstacle to its development. Several European countries have created platforms for exchanges between the public authorities and the industry of these new systems, but the implementation of the new European regulation concerning civilian drones shows a strong need for consultation between the various market stakeholders at European level.

In addition, several regulatory changes are necessary to frame the operations expected in the short to medium term: autonomous drones, flights out of sight of the remote pilot (BVLOS), flights over populated areas, etc., which militates for a consolidation of exchanges between industry and European regulatory authorities (EASA and the European Commission in particular).

Finally, this consultation must be accompanied by actions to promote and help the development of the sectors concerned, both financially and societally, because the acceptance of these systems will come at the cost of an intensive educational effort with decision-makers and the public.

In view of these considerations, and strong international competition in these markets, **United Systems Europe** (**USE**) proposes to bring together the energies contributing to the development of the European market for these systems in the air, land, nautical and space domains. USE plans to facilitate the de-compartmentalization between public and private actors in these emerging markets through the establishment of collaborative work, written contributions, a platform for digital exchanges, and events covering all the issues of these markets.

MAA Systems

USE aims to unite the European community of stakeholders in the field of non-military manually operated, automated and autonomous vehicle (MAA) systems deployed in the air, terrestrial, nautical and space environments, in a partnership with a special focus on the companies (small, medium and large - including start-ups), non-corporate organisations and public bodies conducting professional operations [commercial and non-commercial (including corporate operations)] with MAA systems.

The aim is to produce, in coordination with all relevant regulatory authorities and stakeholders, harmonized contributions to and proposals on various aspects that are relevant for creating and growing a sustainable and socially acceptable market for the safe operation of MAA systems for all possible current and future purposes at national, European and international level.

General Objectives

USE strives, among other things, to:

1. Proactively contribute to facilitating relationships and interaction between the communities of operators of MAA systems and regulatory authorities;
2. Facilitate relationships & interaction between national, European and international interest groups;
3. Identify existing knowledge and expertise;
4. Promote EU-wide harmonization of national approaches on topics of common interest;
5. Identify & address regulatory issues that fall under the responsibility of the individual EU MS;
6. Contribute to the harmonization of national approaches, taking into account existing documents & best practices;
7. Contribute to accelerating the harmonization process in the EU;
8. Identify gaps in the EU regulations and implementing rules, and formulate proposals for possible solutions;
9. Contribute to adapting or creating new rules & regulations in the EU (when and as needed);
10. Create a forum for exchange between national civil drone councils (and equivalent organisations involved with terrestrial, nautical & space systems), and promote the coordination of national initiatives;
11. Contribute to speeding up the implementation of solutions;
12. Mentor newcomers to the MAA system ecosystem;
13. Promote awareness of MAA systems at different levels (including the general public);
14. Contribute to the societal acceptance of MAA systems;
15. Contribute to creating connections between aviation, ground transport, shipping and space sectors already involved in MAA systems and elements in these sectors that are not yet involved with MAA systems, and promote the interaction between these sectors;
16. Give the European MAA systems community a federated voice at European and international levels;
17. Promote the coordination between national initiatives and other lawful means that may contribute to the goal.

Working Principles

USE strives to adhere to the following working principles:

1. Act with and for European stakeholders, but in contact and coordination with non-European stakeholders.
2. Focus on collaboration between all stakeholders & transparency.
3. Simplify and increase access to relevant information for all stakeholders.
4. Promote awareness & acting educationally.
5. Pool joint resources.
6. Bridge gaps in the community.
7. Strive to reach agreement among the Civil Drone Councils (and similar organizations) established in the European Union.
8. By means of written and oral contributions exercise influence on the development of a safe and sustainable market for unmanned systems (in terms of safety, security, privacy and environment).
9. Contribute to creating a sustainable market for the safe (programmed & autonomous) operations of tomorrow for MAA systems in the aviation, ground transport, shipping and aerospace sectors.
10. Promote European harmonization.
11. Take into account existing relevant regulations, rules, and best practices.
12. Not undertake any duplication of efforts deployed by other stakeholders [no conflicts with activities undertaken by existing European Union initiatives, such as, for example, by European Union organizations (such as: European Commission, European Union Agencies and Joint Undertakings, “European UAS Standards Coordination Group”), EUROCONTROL, standardization organisations, and consortia funded by the European Union].
13. Act as a sounding board for the European Commission and European Union agencies.
14. Promote economic development and job creation in the European Union.
15. Position and promote European concepts, products, services, research and developments.

Interaction, Promoting Understanding & Information Accessibility

USE strives to be a recognized forum where interaction between the stakeholders and members of the wider ecosystem of MAA system stakeholders can be established, or improved. It strives to:

1. Fulfil the role of mentor for new entrants in the MAA system ecosystem.
2. Promote mutual understanding and cooperation regarding MAA system operators between:
   - Major operators (industry) (>250 employees; turnover >€50 million)
   - Small and medium-sized businesses (SMEs) (11-250 employees; turnover <€50 million)
   - Micro companies (2-10 employees; turnover <€2 million), and sole proprietorships
   - Research institutions & knowledge institutes
3. Promote mutual understanding and cooperation regarding MAA systems manufacturers between:
   - Large producers (industry) (> 250 employees)
   - Small and medium-sized companies (SMEs) (11-250 employees; turnover <€50 million)
   - Micro companies (2-10 employees; turnover <€2 million), and sole proprietorships
   - Research institutions & knowledge institutes
4. To promote mutual understanding, information exchange, and where possible cooperation, between MAA stakeholders in the following application sectors:
   •. Air • Terrestrial • Nautical • Spatial
5. Promote understanding and relationships between the MAA systems community and potential new stakeholder groups, such as for example:
   - Regional authorities (départements, municipalities, Länder, provinces, regions)
   - Freight & passenger transport companies, and other logistics companies
   - Designers & operators of airports, heliports and vertiports
6. Make sector-specific information, in the broadest sense, more readily available to the MAA systems community, especially for small and medium-sized businesses, micro-enterprises, and sole proprietorships.

Promotion & Development of Operations with MAA Systems

The following objectives will be pursued:

1. To promote the development, production and safe use of MAA systems of all sizes and in all classes (and related products and services) for professional applications.
2. To promote the future commercial and non-commercial safe use of MAA systems (including corporate operations, as well as police, customs, coastguard, firefighting and search & rescue operations).
3. To facilitate information exchange and cooperation in the field of MAA systems between industry (manufacturers & operators, service providers), national & regional governments (civil & military), national aviation authorities, air navigation service providers, aeronautical information service providers, ground transportation service providers, maritime service providers, space service providers, training organizations, research and development centres, universities, international organizations and all other relevant stakeholders.
4. To take measures to promote the establishment, acceptance and updating of European Union, national, regional and international regulations, standards and legislation regarding the use of non-military MAA systems. Regional can be at national and European Union level.
5. To promote the creation and updating of MAA systems related standards, certification and traffic management standards at national, regional and international level.
6. To promote the development and implementation of acceptable insurance standards in the field of MAA systems at national, regional and international levels.
7. To promote the development and introduction of commonly accepted classifications and terminology

in the field of MAA systems at national, regional, European and international level.
8. To promote a level playing field relative to the deployment of MAA systems in the European Union.
9. To provide a means to build European and international consensus on topics of interest to the MAA systems community that are proposed by the participants.
10. To give the MAA systems community a voice at European and global level.
11. To provide a forum to identify and explore business opportunities and areas of interest at European and international level for the benefit of the MAA systems community.
12. To facilitate the coordination of national regulatory (implementation) efforts at European and global level, with the objective to promote operational harmonisation.
13. To initiate and coordinate national, European and international promotion efforts for MAA systems, including conferences, workshops, exhibitions and educational events, taking existing events into account as much as possible.
14. To incite & promote European & international cooperation.
15. To provide potential operators and users of data obtained by means of MAA systems a forum to present their design/technical and operational requirements to potential manufacturers.
16. To create a centralized MAA systems-related documents centre (regulatory & other reference documents).
17. To study and investigate possible solutions to any problem related to MAA systems, especially scientific, technical, operational, infrastructural, socio-economic, social, documentary, insurance and legal problems.

Application Sectors

USE strives to be involved in the field of **MAA systems** (and the related technologies) for **professional** [commercial and non-commercial (including corporate)] and **research purposes** in the **aviation**, **terrestrial**, **nautical**, and **space** environments.

Domains of Importance

The domains of interest in each of the four application sectors fall into the following categories:

1. Regulations and standards relevant to the professional (non-military) use of MAA systems [including, inter alia: police, customs, coast guard, firefighting, search & rescue, medical assistance, logistics, urban air mobility (UAM), Smart & Connected Cities];
2. Systems, products and services necessary to support the execution of safe operations with MAA systems;
3. All management and information services required to integrate MAA systems into the existing operational environment;
4. Support to European Union entities (European Commission, European Parliament, European Agencies, Joint Undertakings);
5. Creating and adapting existing infrastructure (including in the field of "Urban Air Mobility") required to accommodate MAA systems.
6. Technical, Operational and Personnel Qualification Requirements.
7. Professional education/training & examination of operators of MAA systems with the aim of achieving a uniform set of training standards in Europe.
8. Create awareness among operators of MAA systems of the ecosystem in which they are located, on the applicable rules and terminology, existing best practices, and the relevant publications.
9. Simplifying access to the necessary regulatory documents and web sites where these documents can be found.
10. Create awareness of the societal and financial benefits of the use of MAA systems (including among the general public).
11. Research on the above themes to contribute to future developments & requirements (technical, regulatory, societal).

Working Groups

The organisation's actions in the areas of interest in each application sector are carried out by working groups in, among others, the following categories:

1. Training & Qualification
2. Insurance & legal framing (including Data Protection & Privacy)
3. Operations
4. Regulations, Standards & Use
5. Support, Promotion & Awareness Creation
6. Technology
7. Security [incl. C3, Cybersecurity/Resilience, & Counter-Unmanned Systems (in the aviation, terrestrial, nautical and space environments)]
8. Education

Themes

A. <u>Aerial Operations Sector</u>

In the field of MAA systems for the aviation sector, the following themes are considered important by USE:

Education, Training, Examination & Qualification

- Qualification of flight schools - Harmonization of the learning objectives, the measurement criteria and the examination process across Europe, with the aim of mutual recognition of pilot qualifications within Europe.
- Harmonization of terminology
- Stimulate the creation of operator training, qualification & related standards for the "specific" operational category (with the aim of achieving a pan-European recognition)
- Encourage the professional training of pilots in the "specific" operational category, as well as additional qualification, examination and related standards (with the aim of achieving pan-European recognition)
- Contribute to the harmonization of safety rules for test, demonstration & training sites in the European Union and, if desired, the creation of a

European label for these sites.
- Development of the use of pilot training simulators & the related software
- Development of the possible use of virtual reality, extended reality, assisted reality, and mixed reality.

Operational Matters
- Advanced Air Mobility (AUM):
  - Transport – Automation of freight transport, including medical and emergency flights
  - Transport – Automation of transport of persons
  - Urban Air Mobility (UAM)
  - Urban logistics
- Data protection and privacy
- The harmonization of the topics not covered by EU regulations (e.g. flight schools; pilot training & qualification & exams; test, demo & training sites)
- Flight operations (below & above 400 ft above ground level (AGL); in UAS Geographical Zones; over sparse and densely populated areas; in atypical airspace; over controlled territories (Controlled Ground Areas); over urban areas; in Controlled Traffic Regions (CTRs)
- UAS Geographical Zones (Geo-zones)
- U-space/unmanned traffic management (UTM)

Regulations, Standards & Usage
- Aviation Information Services
- Security Risk Analysis & Risk Mitigation Tools
- Play a cautionary role regarding the harmonization of national approaches to the implementation of the European Union (EU) Regulation.

  Note: Any legal or natural person covered by the European Union Regulation may bring to the attention of the European Aviation Safety Agency (EASA) any alleged differences in the application of the rules between Member States. Where such differences seriously impede the activities of those persons and/or organisations or otherwise create significant difficulties, EASA and the national competent authorities of the Member States concerned shall cooperate to address those differences and, if necessary, to eliminate them immediately. If those differences cannot be resolved, EASA will refer the matter to the European Commission.
- Predefined risk assessments (PDRA) for specific user groups of unmanned aircraft systems in the European Union.
- Standard scenarios for specific user groups of unmanned aircraft systems in the European Union.
- Notified Bodies.

Security
- Counter-UAS Systems (in the aviation, terrestrial, nautical and space environments)
- Cybersecurity & cyber resilience (incl. safeguarding against fraudulent takeover of the command & control (C2) function by criminals and terrorists; the qualified takeover of the C2 function by authorities for security reasons; the protection of data collection, data storage, processing & transmission; protection against the use of unmanned aircraft systems as a hacking tool)

Support, Promotion & Awareness
Contribution to the general public's acceptance of MAA systems (including highlighting and promoting the societal benefits of unmanned systems).

Technical Matters
- Airports, heliports & vertiports and related infrastructure, standards & services
- Autonomy & Artificial Intelligence (AI)
- Geographical coverage and connectivity of mobile phone networks
- Frequency spectrum & communication (including connections via satellite)
- Detect & Avoid systems
- E-identification
- Solar cells, (hydrogen) fuel cells & energy storage
- Hybrid/electric drive
- Remote identification of the pilot
- Design of MAA systems with technical specifications corresponding to operator-defined requirements for specific operations (demand-centric development).

B. Terrestrial Operations Sector

The themes that are considered important by the foundation in the field of MAA systems in the terrestrial sector.

C. Nautical Operations Sector

The themes that are considered important by the foundation in the field of MAA systems in the sector of surface and sub-surface operations.

D. Space Operations Sector

The themes that are considered important by USE in the field of MAA systems in the space sector.

Coordination

United Systems Europe strives to coordinate its activities with, among others, the following organisations:

European Organisations

1. All relevant services of the European Commission
2. All relevant European Union Agencies and Joint Undertakings
3. European Commission's informal drone expert group
4. National accident investigation authorities & the European Network of Civil Aviation Safety Investigation Authorities (ENCASIA)
5. EUROCONTROL (Pan-European Civil-Military Organisation committed to supporting European aviation)
6. ECAC - European Civil Aviation Conference
7. NAARIC – National Aviation Authority Regulation Implementation (A group of national aviation authorities with the objective to coordinate the national implementations of the EU drone regulation)
8. National Aviation Authorities (NAAs) of the Member States of the European Union

9. European Committee of the Regions (CoR)
10. The European Parliament

International Organisations

1. ICAO - International Civil Aviation Organization
2. IMO - International Maritime Organization
3. JARUS - Joint Authorities for Rulemaking on Unmanned Systems
4. OECD – Organization for Economic Cooperation and Development
5. United Nations (UN) Food & Agriculture Organization
6. United Nations (UN) Aviation
7. World Economic Forum

Interest Groups

1. Existing non-military organisations:
   - At European level (pan-European associations and federated technology clusters)
   - At national level (national associations, federations)
   - At international level
2. Military and dual-purpose organisations:
   - At European level
   - On national level
   - At International level

Standardization Organisations & Coordinating Groups

1. ESCG - European Standards Coordination Group (managed by EASA)
2. European standardization organisations (at European & national level)
3. Other international standardisation organisations

Document Creation

The aim is to create, among others, the following documents:

1. Concept papers
2. Position papers
3. Recommendations
4. Reports
5. Reviews / Comments

Information Centre

With the objective of increasing awareness, simplifying and increasing access, especially for micro companies and small & medium-sized enterprises, the association aims to create an online repository of different types of documents in different languages (or to supply links to these documents), such as:

1. Regulatory Documents (European & Non-European)
2. Standard related documents
3. Results of study contracts funded by the EU
4. Academic Documents
5. Research and Scientific Articles
6. Draft papers
7. Position documents
8. Recommendations

Services

USE aims to provide the following services:

1. To create and maintain an online register of, among other things:
   - Unmanned aircraft system operators (commercial) in the "specific" & "certified" categories and that are registered with the relevant national aviation authority, or provide links to the relevant lists on the websites of the national aviation authorities.
   - Manufacturers / integrators (of systems, sub-systems, software, critical components)
   - Service providers (including air navigation service providers (ANSPs), aeronautical information service providers, U-space service providers (USSP), urban air mobility service providers (UAM), common information service providers (CIS), communication service providers, conformity assessment bodies, flight schools, insurance, legal offices, Qualified Entities, Notified Bodies, or provide links to the appropriate lists on the relevant websites.
   - Technology clusters
   - Flight training schools
   - Test, demonstration and training locations
   - All European Union funded, as well as regionally and nationally funded, MAA systems research projects with links to their websites, and links to the relevant sections on the CORDIS website.
   - Research organisations with MAA-related activities.
   - Academic institutions with MAA-related curricula and/or research.
2. To create and conduct webinars
3. To create and conduct online courses
4. To organize and conduct surveys (including for European Commission and European Union agencies, and European Union funded consortia), as well as surveys outsourced to the foundation by third parties
5. Conducting studies (including studies commissioned by third parties)
6. Creating, administering and maintaining a website with links to all relevant organisations
7. To propose standards for the harmonization of qualification / safety requirements for the following, with the aim of achieving pan-European acceptance and, if appropriate, granting approval labels:
   - Flight training schools
   - Remote Pilot Licenses
   - Test, demonstration and training locations

Facilitating Access To Information

The organisation strives to facilitate access to information on its activities for the participants by:

1. Creating an online library making all relevant information easily accessible to all.
2. Monitoring EU-funded research projects & maintaining a library of their results, or supply links to them.
3. Monitoring new EU-funded research projects and inform the foundation participants of opportunities.
4. Monitoring research projects (not EU-funded) and inform the foundation participants of opportunities.
5. Monitoring the web sites of relevant regulatory authorities and maintaining an online library of relevant documents.
6. Producing and posting newsletters & news flashes, and sending out automated notifications of new postings to the participants.

Information & Service Provision

USE strives to make its documents and services available to, among others, the following organisations and interest groups:

1. Regulatory Authorities [national & European (incl. NAARIC) & international (incl. ICAO & JARUS)]
2. Standardization Producing Organisations (SPOs)
3. European Commission (various directorate generals)
4. European Parliament
5. European Union Agencies and Joint Undertakings
6. Relevant international organisations
7. European & international interest groups
8. Regional economic development organisations
9. Research organisations
10. Think tanks and market research organisations
11. The European and international drone community
12. The specialized and general press

Cross-Pollination

United Systems Europe strives to:

1. Foster understanding & relations between the various stakeholder groups in the ecosystem of each activity sector (aerial, terrestrial, nautical, and space).
2. In each activity sector, foster understanding & promote cooperation between:
   - Large corporate MAA System operators and:
     - SMEs + micro companies (and vice versa)
     - Research organisations (and vice versa)
   - Large producers of MAA Systems and:
     - SMEs + micro companies (and vice versa)
     - Research organisations (and vice versa)
3. In each activity sector, foster understanding & relations between the MAA System ecosystem and potential new entrants, potential end-customers and stakeholder groups, e.g.:
   - Regional authorities (départements, Länder, municipalities, provinces, regions)
   - Transport & logistic companies
   - Aerodrome, heliport & vertiport operators
4. Foster understanding & relations between the various participants in each activity sector.

The Current Situation Relative To Training

Unmanned Aircraft Systems (UAS) embody the technological progress made in several key technology areas, and their constantly growing number of potential applications hold the promise of supplying substantial societal benefits. The design, production, and the use of UAS, and the associated ecosystem, represent a significant financial sector and have the potential to create a wide variety of jobs in all 27 European Union (EU) Member States. The aforementioned prompted most EU Member States to create national UAS regulations and guidelines. However, these national approaches were not harmonised on the EU level.

Taking the aforementioned into consideration, the European Commission (EC), through the European Aviation Safety Agency (EASA), has developed, in cooperation with multiple stakeholders, the European Regulations 2019/947 and 2019/945, which are currently applicable in all EU Member States. This enormous effort has given the EU Member States a common and harmonized base.

The EU Member States requested the EC to coordinate the harmonization of the national regulatory implementation approaches by means of a European regulation.

In the context of UAS operations in the “Open” category [flight altitude: <400 feet; flight range: Visual Line-of-Sight (VLOS) operations], the EU National Aviation Authorities (NAAs) have actively addressed the issue of Remote Pilot training, and the required courses and examinations are now available online. The only remaining matters in this area are the harmonization and enlargement of the multiple choice questions (MCQ) databases, and a binding detailed syllabus.

UAS Operators in the “Specific” category [flight altitude: <400 feet; flight range: Beyond Visual Line-of-Sight (BVLOS)] will be required to employ Remote Pilots and Crew Members that are often required to be qualified in conformity with pan-European recognized proficiency “certificates”, in order to be able to operate in all EU countries. This situation requires a coordinated effort by UAS operators, recognized and/or designated training entities, subject matter experts, in coordination with NAAs and EC regulatory authorities. These entities should urgently address a significant number of issues in three domains:

- Standard scenarios (STS) and Predefined Risk Assessments [PDRA (S-)]
  STS will become applicable in all EU Member States on 1st January 2024, but there are no training and examination guidelines available, and the model documents defined in the EU Regulation are not available (nor harmonized).
- Predefined Risk Assessments [PDRA (G-)] and Specific Operation Risk Assessment (SORA)
  Additional endorsement modules for specific operational conditions (e.g. night flight, hilly environment, carriage of dangerous goods (DGs), flight over water, etc.), still have to be produced.
  Note: Those currently published in the EU Regulations are not sufficiently detailed.
- Instructors and Examiners
  The roles of these professionals and their associated responsibilities, as well as the related training and qualification requirements, still have to be defined.

The aforementioned has not taken place. Unfortunately, the Task Force, initiated by EASA to this effect, did not receive an appropriate mandate from EASA, nor adequate means. Consequently, the harmonization of the national regulation implementation approaches has been at the initiative of the EU Member States.

In summary, the operational documents & processes defined in the EU Regulations (e.g. training and examination syllabi and guidelines, progress booklets, assessment reports, etc.) are not available, nor harmonized at EU level. This is obviously not only the case for the “Specific” category, but also for the “Certified” category, which

includes UAS for the transport of freight & passengers.

The Resulting Situation

As things stand, none of the EU Member States will be able to be compliant with the EU Regulations on 1 January 2024, and the EU UAS market will not be able to develop in the "Specific" category (which holds the largest promise for the EU UAS industry).

This situation will have an impact in the following areas:

a) The absence of a harmonised EU approach to the training of remote pilots, instructors and examination results in:
   - Unnecessary pressure on the backs of the National Aviation Authorities in the EU;
   - None of the EU Member States being able to meet the Regulation Implementation deadline of 1 Jan. 2024;
   - Inequality between UAS operators in the different EU Member States.

b) Free circulation of UAS services within the EU
   Due to the absence of recognized pan-European proficiency "certificates", the free circulation of UAS operators and remote pilots in the EU will be impossible. This is in total contradiction to the established EU principal of free flow of services.

c) Airspace safety
   Remote pilots in the EU countries will not have an equivalent level of theoretical knowledge & practical piloting skills, which can have a negative impact on airspace safety.

d) Micro-companies & SMIs & SMEs (Operators)
   The majority of UAS operators are Micro-companies or SMEs/SMIs – If the current situation is not rapidly resolved, many will not be able to survive

e) Micro-companies & SMIs & SMEs (Manufacturers)
   UAS in the "Specific" category is where EU producers have the possibility to make a difference in the competition with the imported Chinese and American UAS – If the current situation is not resolved rapidly, their production & finances will suffer.

f) Job creation
   The projected job creation in the UAS domain will not take place.

g) Economic growth
   The projected economic growth in the UAS domain will be limited.

h) Societal benefits
   The projected societal benefits supplied by UAS will not become reality.

i) Investments
   The motivation for industry and investors to invest in the EU UAS domain will be eroded.

j) UAS market development
   The adoption of UAS for new applications in the private & public sectors will be limited.

Motivation & Working Group Start-Up

If the above-indicated problems are not resolved, the European professional drone operations market in the "Specific" operational category will not be able to develop, which obviously will have a negative effect on the entire drone ecosystem. Hence, the need for urgent action.

Recognising the looming threat, and subsequent to a meeting of it's members at EUROCONTROL in Brussels, Belgium on 30 June 2022, United Systems Europe initiated, based on the unanimous decision of its members, the start-up of it's first working group to deal with the most urgent topic.

Working Group 2205-1 on Training, Qualification & Examination of Remote Pilots, Instructors & Examiners - 'Specific" operational category

By means of 4 Sub-Groups & 19 specialized Focus Groups, WG 2205-1 is undertaking concerted actions to advance:

1 The harmonization of:
   - Learning objectives and training syllabi;
   - Competence assessment criteria;
   - Examination processes across Europe;

   with the aim of achieving mutual recognition of pilot qualifications in the EU.
2 Professional training, qualification & examination of remote pilots & instructors in the "Specific" category, as well as related tools, standards and recommendations.
3 Harmonization of the applicable terminology & nomenclature.
4 The qualification of flight training organisations.
5 The establishment of basic safety rules for flight training sites in the EU.
6 The establishment of compliance criteria for pilot training simulators & the related software.
7 The establishment of compliance criteria for the possible use of virtual, extended, assisted, and mixed reality. WG 2205-1 will avoid the duplication of ongoing efforts and will coordinate with the entities deploying such efforts.

WG 2205-1 will take into consideration and review all relevant existing national, European and international documents, standards and best practices.

The Sub-Groups (SGs)

WG 2205-1 has the following 4 Sub-Groups:

1. **Terminology**
   Goal: Create a list of commonly used terms and acronyms by industry, especially in the scope of training, and clarify those that are still ambiguous by aligning the corresponding vocabulary to the manned aviation ecosystem (e.g. trainer or instructor?).
2. **Modules & Training Syllabi**
   Goal: In addition to those published in AMC3 UAS. SPEC.050(1)(d), define additional operation-specific endorsement modules and write the corresponding detailed training syllabi. For each module, define adequate training and up-to-date requirements for remote pilots, instructors and examiners.
3. **Model Documents**
   Goal: Create model documents for the "Practical Skill Assessment Report" & "Progress Booklet" that must be used for practical skill training & assessment of remote pilots.
4. **Training & Assessment Guidelines**
   Goal: Define generic training & assessment guidelines for instructors and examiners, in complement to the

existing KSAs (Knowledge, Skills & Attitudes).

The Focus Groups

WG 2205-1 currently has 19 Focus Groups (FG), each with a clearly defined deliverable:

SG 1 Terminology

FG 1.1 Database of standards, norms & reference documents pertinent to WG 2205-1
FG 1.2 Terminology applicable to training & examination
FG 1.3 Terminology applicable to UAS operations-related systems, procedures & matters
FG 1.4 Terminology applicable to relevant functions, roles & responsibilities

SG 2 Modules & Training Syllabi

FG 2.1 Prerequisite training organisation guidelines
FG 2.2 Generic theoretical & practical training syllabi - Remote pilots & other personnel
FG 2.3 Generic theoretical & practical endorsement modules & associated detailed training syllabi - Remote pilots & other personnel
FG 2.4 Theoretical & practical training syllabi - Remote pilots & other personnel STS
FG 2.5 Generic theoretical & practical training syllabi - Instructor
FG 2.6 Generic theoretical & practical training syllabi - Examiners
FG 2.7 Generic theoretical & practical training syllabi - Emergency Response Plan (ERP)

SG 3 Model Documents

FG 3.1 Generic progress booklet & examination report models for remote pilots and other personnel (practical training and examination)
FG 3.2 Progress booklet & examination report models for remote pilots STS (practical training & examination)
FG 3.3 Progress booklet & examination report models for instructors (generic practical training & examination)
FG 3.4 Progress booklet & examination report models for examiners (generic practical training & examination)

SG 4 Training & Assessment Guidelines

FG 4.1 General training & examination guidelines for: - Remote pilots and other personnel
FG 4.2 Training & examination guidelines for: - Practical training of remote pilots & remote pilot examination in the context of STS
FG 4.3 Training & examination guidelines for: - The Instructor role
FG 4.4 Training & examination guidelines for: - The Examiner role

The Focus Group Teams (FGT)

In order to get the work started the 19 Focus Groups have been organised in Teams:

FGT 1 (FG 1.1)
Rationale:
1 Creation of an initial comprehensive online database is paramount for all FGTs.
2 The database will be accessible to all WG 2205-1 participants.
3 This first phase will be relatively easy & fast to activate.
4 The required workforce will be limited.
5 The members of all FGTs will be requested to supply document inputs.
6 All existing relevant glossaries, syllabi and reference documents will be gathered.

FGT 2 (Bundles FGs 2.1, 2.2, 2.3, 3.1 & 4.1)
Rationale:
1 Generic & endorsement training modules, associated syllabi & documents are the foundation for FGTs 3 & 4.
2 The work remains general and will maintain the big picture view.
3 If necessary, adjustments for the Specific category training concept will be made.
4 Initial deliverables will act as the corner stone for up-coming more detailed work.

FGT 3 (Bundles FGs 2.4, 2.7, 3.2, 4.2)
Rationale:
1 The activity will be dynamic & dual directional, support the work of the other FGTs, and benefit from the feedback of the FGT experts.
2 It will be essential that all existing standard scenarios are taken into account and used as much as possible, in order to avoid duplication of past & ongoing efforts.

FGT 4 (Bundles FGs 2.5, 2.6, 3.3, 3.4, 4.3, 4.4)
Rationale:
1 Defining skills, associated training and examination for instructor and examiner roles is very important, but currently definitely not the priority.
2 This team will benefit from the work of the other FGTs, and, in conjunction with the inputs from FGT 5, will contribute to move towards the well-recognized manned aviation processes.

FGT 5 (Bundles FGs 1.2, 1.3, 1.4)
Rationale:
1 The activity will be dynamic & dual directional, will support the work of the other FGTs, and will benefit from the feedback of the FGT experts.
2 It will be essential that all existing glossaries and relevant reference documents are taken into account.
3 All documents will be posted online in a section restricted to all WG 2205-1 participants.

Approach

The adopted approach has been presented to EASA and to NAARIC. Hopefully, WG 2205-1 will be able to contribute to the relevant Technical Advisory Body (federating the regulatory authorities of the EU Members States) that is being set up by EASA to address the training issue

For more information
https://united-systems-europe.eu/
https://united-systems-europe.eu/working-groups/

Interested in participation & questions? Contact:
contact@united-systems-europe.eu

MANAGEMENT TEAM

COORDINATION
COOPERATION
HARMONIZATION

BOARD OF DIRECTORS

Gilles Fartek
Denmark
President

Martin Kellerhals
Switzerland
Secretary

Vadim Kramar
Finland
Treasurer

Patrick Mascart
Belgium
Director

OVERSIGHT COMMITTEE

Matthis Gronstedt
Germany

Oliver Heinrich
Germany

Nikolas Kestens
France

GENERAL SECRETARY

Peter van Blijenburgh
France

SECRETARIAT

Robert Jonker
The Netherlands

ADVISORY BOARD

Vassilis Agouridas
UAM Initiative
Cities Community Europe

Nina Dorfmayr
Austro Control, Austria
National Aviation Authority

Dr Dimitrios Gkritzapis
Civil Servant / UAS Expert
Greece

Julia Sanchez
EUROCONTROL
Inter-Governmental Organisation

Ron van de Leijgraaf
Ministry of Infrastructure & Water Management, The Netherlands

Anna von Groote
EUROCAE, Europe
Standards Developing Organisation

USE - PARTICIPANT GROUPS, SECTORS, ACTIVITIES & PRIVILEGES

Group	Sector		Activity Segments	
Paying	Industry	Corporate	MAA System Operator Designer / Producer / Integrator Software & Artificial Intelligence Producer Service Supplier Service Provider	End Customer of Data Consultant, Specialist & Think Tank Test, Demonstration, Training Centre Education - For Profit Research - For Profit
		Cluster	Technology Cluster - Industry Cluster	
	Not-For-Profit		Interest Group / Association / Federation / Foundation Education - Not-For-Profit Research - Not-For-Profit	
	Privileges		Have Voting Rights at Participant Assembly Eligible to Board of Directors & Oversight Committee Access to all web site sections Receive all notifications & newsletters Can participate in all Working Groups Can participate in all foundation activities	
Non-Paying	Public Entity		European Union, Inter-Governmental, National, Regional MAA System Operator End Customer of Data	
	Other Organisations		Standards Development Organisation (National, European, international)	
	Privileges		No Voting Rights at Participant Assembly Eligible to Advisory Board Access to all web site sections Receive all notifications & newsletters Can participate in all Working Groups Can participate in all foundation activities	

USE - PARTICIPATING COUNTRIES, TERRITORIES & REGIONS

1. **Europe** is defined as follows:
   - **Member States of the European Union**:
     Austria, Belgium, Bulgaria, Cyprus, Denmark, Germany, Estonia, Finland, France, Greece, Hungary, Ireland, Italy, Croatia, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Austria, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Czech Republic, Sweden
   - **Outer Regions of Member States of the European Union**:
     France: French Guiana, Guadeloupe, Martinique, Mayotte, Reunion, Saint-Martin
     Portugal: Azores, Madeira
     Spain: Canary Islands
   - **Overseas Countries & Territories of Member States of the European Union**:
     Denmark: Greenland
     France: French Polynesia, French Southern & Antarctic Lands, New Caledonia, St. Barthélemy, St. Pierre & Miquelon, Wallis & Futuna
     Netherlands: Aruba, Bonaire, Curaçao, Saba, Sint Eustatius, Sint Maarten
   - **European Microstates**:
     Andorra, Liechtenstein, Monaco, San Marino, Vatican City
   - **Countries & Territories Associated with European Union Grant Programmes**:
     Albania, Armenia, Bosnia and Herzegovina, Faroe Islands, Georgia, Iceland, Israel, Moldova, Montenegro, North Macedonia, Norway, Serbia, Tunisia, Turkey, Ukraine
     Canada (under evaluation by the EU)
   - **Switzerland**
   - **United Kingdom**
2. **Non-European Participants** have their principal place of business and/or production in a country outside of Europe (as defined above).

USE - PARTICIPANTS

PAYING PARTICIPANTS

Industry - Corporate Activities

MAA System Operator

- Commercial (*for all applications except transport of cargo or persons*)
- Commercial (*for the transport of cargo or persons*)
- Non-commercial (*incl. corporate*)

Designer / Producer / Integrator

- MAA system for all applications except the transport of cargo or persons
- MAA system for the transport of cargo or persons
- Vehicle elements [*i.a. fuselage (elements) / airframe / wing / cowling; landing gear; nacelle; freight carriage & release*]
- MAA system element (*i.a. pilot / control station; communication; homing / self-charging station; launch & recovery; tethering system*)
- MAA sub-systems (*i.a. engines & motors; propellers & rotors; autopilots; flight/operational control sensors; navigation; positioning; Detect & Avoid; obstacle avoidance; servos*)
- Command & control, telemetry, antennas, tracking
- Payloads (imaging & non-imaging)
- Power supply (*incl. solar & fuel cells*), transmission & high capacity storage
- Automated freight loading & unloading
- Electronic identification
- Simulators, training aids & related software
- Counter MAA systems in A/T/N/S ops environments

Software & Artificial Intelligence Producer

- MAA system mission software
- Training & examination
- Data & image monitoring & processing
- ATM / UTM / U-space software
- Virtual, augmented & mixed reality

Service Supplier

- Conformity Assessment Body
- Safety Risk Assessment (SORA; PDRA; STS)
- Notified Body
- Qualified Entity
- Consultancy
- Insurance Company
- Law Firm

Service Provider

- Air Navigation Service Provider (ANSP)
- Aeronautical Information Service Provider (AISP)
- Common Information Service Provider (CISP)
- Communication Service (incl. 5G & satellite) Provider
- Urban Air Mobility (UAM) Service Provider
- U-space Service Provider (USSP)
- Take-off & Landing Service (airport, heliport, vertiport)
- Services for MAA system operations in the terrestrial, nautical and space operational environments.

End Customer of Data

- Private Entity / Coorporate Entity

Consultant, Specialist & Think Tank

Test, Demonstration, Training Centre

- Aerial MAA Systems
- Nautical MAA Systems
- Terrestrial MAA Systems
- Space MAA Systems

Education - For Profit

- User instruction, training & qualification
- Maintenance instruction, training & qualification
- Examination
- Manuals & tutorials (*i.a. operational; user instruction; maintenance & repair; spare parts; exploded views*)

Research - For Profit

- University, research institute, knowledge centre
- Consortium subsidized by the EU (*incl. SESAR JU*)

Industry - Cluster Activities

Technology / Industry Cluster

Industry - Not-For-Profit Activities

Interest Group / Association / Federation / Foundation

- National, EU & international (*in the field of MAA systems for deployment in the air, terrestrial, nautical, and space operational environments*)
- Non-Governmental Organisation (NGO)
- General Aviation (*manned aviation: sport; aerial work; business aviation*) & Aeromodelists;
- Commercial Manned Aviation (*airlines; air taxi operators*)

Education - Not-For-Profit

- Centre of learning (*school, university, academy*)
- Research - Not-For Profit

Research - Not-For-Profit

- University, research institute, knowledge centre
- Consortium subsidized by the EU (*incl. SESAR JU*)

NON-PAYING PARTICIPANTS

Public Entity - Activities

Public Entity - European Union & National Level

- European Commission
- European Union Agency
- EU Parliamentarian
- Inter-governmental Organisation
- National Ministry
- National (Regulatory) Authority
- National Governmental Authority
- Governmental Agency
- Regional authority [*département (FR); Land (DE); municipality; province (NL); region (BE, ES, FR)*]
- Economic / industrial development agency

Public Entity - MAA System Operator

- Police, fire brigade, Coast Guard, customs authority, civil security, forestry service, government executivce agency, environmental service, wild life protection service, etc

Public Entity - End Customer of Data

- Police, fire brigade, Coast Guard, customs authority, civil security, forestry service, government executivce agency, environmental service, wild life protection service, etc

Other Organisations - Activities

Standards Development Organisations

- National, European, international

The Main Challenges of Harmonised Remote Pilot Training & Examination in the «Specific» Category

By Henrik Lührs
Aircademy, Germany

In contrast to the ‘‘Open’’ category, candidates of the ‘‘Specific’’ category tend to be more “homogeneous”. On the other hand, the areas of application for the ‘‘Specific’’ category are much more differentiated. This brings many challenges, especially regarding the standardisation of training and examination.

The two greatest challenges to be considered are:
- The development of uniform training and examination standards
- The guarantee of an uniform and recognised examination.

A Uniform Syllabus As a Basis

For a European remote pilot, it is essential that training and examinations are not only recognised throughout Europe, but can also be flexibly extended in any EASA member state. For the ‘‘Specific’’ category in particular, the application areas and operational scenarios are so diverse that additional competencies should be acquired in addition to existing qualifications.

For this to be possible, a uniform and universally recognised curriculum throughout Europe is vital. It is important that this is as detailed as possible so that different training companies can guarantee equivalent training. A mere compilation of subjects or topics is not sufficient as it leaves too much room for interpretation of standardised training.

While it may sound simple at first, there are numerous challenges that a curriculum must meet. First, it must identify the necessary training content; this can cause great debate even among experts, especially regarding the depth of knowledge. For example, a balance must be struck between imparting sufficient technical knowledge and providing easily accessible training.

The field of unmanned aviation, in particular, often deals with rapid technical developments. The curriculum must not only reflect these, but also provide them in good time so that the training companies and authorities can adapt to them at an early stage. This is currently difficult to achieve, given the European harmonisation and publication processes. The situation, where a training school delivers state-of-the-art, but nevertheless outdated, training that does not comply with this curriculum, must be avoided.

Furthermore, regionally specific requirements pose a challenge for a universally valid curriculum. There are two options here: either various regional specifics are incorporated into the general curriculum, which is likely to make it significantly more comprehensive, or alternatively, additional training must be provided for certain operational scenarios. As long as this can be provided in an uncomplicated manner (possibly through self-study), the advantage of this option is that the general curriculum can concentrate on the essential points.

Furthermore, the linguistic hurdles of the multilingual European society should not be underestimated. The standard language in aviation is English, but English is not equally accessible to everyone. Translations into other languages, however, can quickly lead to inaccuracies or interpretations of technical terms, which in the worst case, can impact safety.

Flexibility with Standardised Modules

Due to the wide range of application scenarios within the ‘‘Specific’’ category, modularisation of the learning and examination content is a natural choice. Through this, a «flexible harmonisation» can be achieved – standardised modules can cover a subject, a topic or a sub-topic area and, as such, can be used flexibly.

A qualification’s training programme then, in turn, consists of defined modules. Each module is defined by a detailed and standardised curriculum, as described above.

Modularisation also allows for limited individualisation of qualifications by requiring additional modules for use under certain conditions. For example, a member state could define an additional module for a mountainous region that must be completed before operating in that region. It must then be determined how such information can be published and how the completion of additional modules can be proven.

Uniform and Recognised Examinations

In addition to standardised training in the ‘‘Specific’’ category, examinations must also be harmonised throughout Europe. It is immaterial whether the competent aviation authority carries out the examination itself or whether it passes this task on to authorised bodies. With the latter option, there are many examining bodies, which makes a high degree of examination standardisation inevitable.

One method already practised in professional aviation in Europe is a European standardised question database, which is made available to the national aviation authorities by EASA. Regular updates ensure that feedback is incorporated and that the database remains up to date. The national authorities are responsible for the examination itself and the implementation of the database in an electronic examination system.

A possible way forward in the area of unmanned aircraft

systems (UAS) could be to use a uniform question database that is standardised on the basis of the syllabus mentioned above. In the core training areas, this would ensure that examinations in Europe are uniform and comparable, and thus also mutually recognisable without any disputes.

A question database such as this could concentrate on core areas, at least initially, and be expanded and adapted as required. If national aviation authorities see a need for additional questions, these could be added or commissioned by the authority themselves. However, it is essential to ensure that the development of these questions considers the common syllabus as this is the only way to ensure uniformity and comparability.

The Way Forward

In order to achieve the above-mentioned goals, a path that is as pragmatic as it is inclusive must be chosen. The requirements and needs of national aviation authorities must be taken into account, and these needs must also be of a level that they can be universally accepted. Modules, detailed learning objectives and any additional questions must then be developed on this basis of universality.

Promising results have already been achieved in working groups involving member states, as well as EASA and subject matter experts. Going forward, experts from industry and education, aviation authorities, and other stakeholders should be implicated.

The initiation of USE Working Group 2205-1 was a first step in this direction. This working group consists of 4 subgroups and 19 focus groups that deal with the challenges of standardised training and examination in detail, including both the development of detailed learning objectives for theoretical and practical training as well as any prerequisites for this (for example, the definition of important terms).

It would be desirable for the team of this USE working group to be joined by other experts from European countries to work together on the foundations of standardised European UAS ratings for the "Specific" category.

Henrik Lührs
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FEATURE ARTICLE

Installing Bird Diverters with Drones

By Ákos Haramia
Aliter Technologies, Slovakia

Bird collisions with overhead powerlines are a big issue that is not widely known to the public. It is proven that yearly millions of birds collide with powerlines, causing injuries or their death. It is common to mark the powerlines with mostly big red and white balls, to make them visible for manned low altitude flights. This issue is now taken into consideration with birds as well. Powerlines are being marked with so-called ''bird diverters''. Their purpose is to make the powerline visible to the birds. There are many types of markers, using different approaches to making the lines visible.

As a standard way of marking the powerlines, heavy machinery or helicopters are used. This has its obvious downsides with heavy machinery getting stuck, or damaging the crops underneath the line, and even not being able to get to some sections of the a powerline due to difficult terrain. Helicopters are expensive and also pose a danger when flying so close to powerlines. As a specialized drone developer, we were approached by a Swedish marking manufacturer with the question, if it would be possible to develop a drone capable of installing bird diverters on powerlines. The biggest challenge would be that we would have to make the drone work with the powerlines kept energized. This meant that a lot of development work was required relative to the electronics of the drone. We decided to not use an existing commercial platform and to develop a totally new aircraft, with most parts 3D printed for easy replacement in case of crashes.

Firefly
Bird Diverter

BDC-Mini

After a couple of iterations, we started using the BDC-MINI. It is capable of installing one bird diverter per flight, but with an efficiency of up to 350 diverters/day. In most cases, we have been requested to conduct bird diverter installation operations in places that are difficult to get to by the standard ways. Most of the customers, after seeing the operational efficiency, decided to hire us for all of their markings. Since we do not require the powerline to be de-energised and do not use any heavy machinery, outsourcing the service makes the operation very cost effective for utility companies. The drone uses a mechanical mechanism to attach the diverter to the line. The weight of the bird diverter is 2,5 kg.

Structurally, the drone consists of 2 main parts. The drone platform and the installation mechanism. The installation mechanism works on a mechanical basis whereby the stress in the spring mechanism of the diverter is multiplied by the mechanism itself. The drone pushes the open diverter clamp towards the powerline and the clamp closes under this force. The mechanism is mostly made of 3D printed parts to make sure that they are easily replaceable in case of damage. The drone is a custom built specifically for this purpose. Its main job is to carry the bird diverter and the attachment guidance mechanism, but also keep the flight controller and other essential electronics safe from electronic discharge.

Our attachment guidance mechanism works exclusively with the Snapfast clamp, developed by the Swedish company Hammarprodukter. Hammarpodukter manufactures signs and marking systems. We install not only bird protection products, but also signs and other aerial marking systems. These products make the lines

visible for birds, thus preventing collisions. The birds are capable of seeing the lines earlier and being able to manoeuvre around them. The bird diverters stay on the powerlines for a long periods of time (5-10 years)? The powerlines segments that are to be equipped with bird diverters are carefully selected by bird protection organisations. Research has proven that bird mortality drops with 94% on a powerline that is equipped by the Firefly Bird diverter.

Firefly bird diverter installation operations require, in most cases, involves two persons, a remote pilot and an observer. In a typical scenario, the remote pilot flies the drone and uses it as an “elevator”, while walking under the powerline. A distance is measured on the ground, and subsequently the drone flies up vertically and installs the diverter.

When the powerline is not accessible, a drone with two cameras is used. A forward-looking camera is used during the approach to the powerline; the second upward-looking camera is used to guide the drone to the exact place on the line. In this case, the distance is measured using GPS. Multiple sets of batteries are used each day; they are continuously charged throughout the day. The efficiency of the drone installation is around 200 diverters/day. The record of our crew is 350 diverters/day. This year we have started using a new type of drone that is capable of removing the markers from the powerline.

In Europe we have supplied bird diverter installation service in Austria, Belgium, Cyprus, Denmark, France, Germany, Hungary, and Sweden, and we have a partner supplying these services in the USA.

Thanks to the EU legislation, it is easier for us to fly in Europe. Outside of the European Union, we have partners who fly our drones to make sure that they comply with the applicable legislation.

Ákos Haramia
Aliter Technologies
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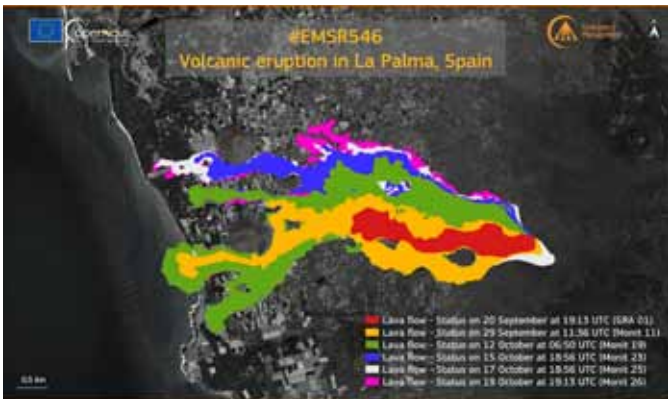
fiihaa.com



Lava Flow Mapping - General Directorate of Safety and Emergencies of the Canary Islands
Image: Copernicus Emergency Management Service

Medical Delivery Drone - Avy, The Netherlands

Oil Slick Detection - Rijkswaterstaat, The Netherlands

Tundra drone with Ground Penetrating Radar
Hexadrone, France

FEATURE ARTICLE

Opening New Frontiers - What Augmented Reality Brings to Drone Operations

By Emilie Cohen
Arnaky Labs, Finland

ANARKY LABS

What Is Anarky Labs & What Do We Do?

We are a Finnish start-up founded in March 2020 and our first product, AirHUD, is the first real Heads-Up Display for drones. We use augmented reality (AR) to give pilots unreached situational awareness. Our vision is to create a product that benefits drone remote pilots, but not only. We think the outside use of augmented reality is only starting, and that it holds potential for numerous purposes. Air taxis, air traffic management, building inspections…, the possibilities are endless!

Fig. 1 - The augmented reality view given to the drone pilot with AirHUD, showing the drone indicator always pinpointing drone's location, with map and video feeds beside it, and also mission waypoints in real world locations, and even building meshes that enable real-time distance indication between the drone and the nearest building.

Research-based Innovation

We have conducted long hours of research on how to achieve real-world scale- and location-based visualisation of data with augmented reality. These are crucial elements in our solution, that make it unique in the world, and now we do have US patents to prove it! We have also studied the algorithms for satellite-based drone localisation, one key element of AirHUD being its precision. In the field of user-friendliness, we conducted a thorough investigation on the visualisation of various digital twin data sources. As a concrete result, we now offer regulatory airspace volumes as a standard feature. We have also spent a lot of time doing research, in close coordination with regular remote pilots, on using augmented reality to aid in piloting drones.

Development & Test Programmes

To fully demonstrate the operational benefits of augmented reality, we conducted (and continue to do so!) a comprehensive testing and development programme with regular test flights. As a start-up, we need to understand where the industry is going and how the use of the drones is evolving. Therefore, we have thus a precious cooperation with research facilities such as VTT Technical Research Centre of Finland and Oulu University to apprehend the possible future needs of drones in professional operations. Our feedback channels from early customers using the system is essential to collect ideas and to improve AirHUD. We are also broadening the support of drone platforms and the targeted operations, according to client needs. For example, the support of aviation data, which will supply remote pilot teams with shared situational awareness.

Finally, we are now expanding AirHUD capabilities to drone training operations making it possible to fly a simulated drone in a real environment, but also a real drone in a simulated environment.

Example of Flight Missions Benefiting From AirHUD

We have identified various flight missions that can benefit from this technology:

- Inspections (buildings, roads, agriculture, forest, oil & gas, mining, industrial sites, etc…)
- Night flights
- EVLOS / BVLOS flights
- Observation and control of autonomous flights
- Search and rescue
- Security
- All missions where easily understanding the legal requirements helps in operational efficiency
- Training of demanding drone operations (simulated Specific Category flights for example)

Challenges

Of course, we are facing some challenges, but none of them are insurmountable. For example, we are aiming for AirHUD to become the reference platform for commercial EVLOS drone operations without observers. We know already that these discussions with the regulator may take some time! We are also aiming at getting AirHUD recognized as an official training tool, which is a long process.

Regarding the solution itself, we are naturally facing some resistance to change, as AirHUD disrupts the way that drone operations are currently conducted. While

Fig. 2 - AirHUD enables the pilot to even fly the drone behind obstacles and still see their location and intuitively their relationship to their surroundings.

Fig. 4 - Height indicators, including ultrasound / camera-based short range detection, are always shown, even when flying partially or totally beyond visual line of sight

some are finding these changes frightening, others, such as law enforcement remote pilots, are embracing the new possibilities.

Our last challenge is, as with all innovations, to keep on top of the technologic curve!

Economic Benefits Of AR For Drones

The benefits of drones using augmented reality are almost endless and mostly financial:

Fig. 3 - AirHUD makes it trivial to conduct night flights as the drone is always pinpointed in the air, no matter how far away.

- On average, less personnel is needed per mission
- EVLOS / BVLOS and night flights will be easier to conduct and thus become more common
- Augmented reality facilitates manual, resulting in a reduced need for the creation of precise and complex waypoint missions
- By visualizing the quality of data collected by the drone at the location of operation, augmented reality will help speed up and simplify operations
- Increased safety and operational efficiency result in flight cost savings

The Finnish UAV Ecosystem (FUAVE)

We have been a member of FUAVE since March 2021. The goal of FUAVE, a multidisciplinary research consortium funded by the Academy of Finland, is to support the development of the Finnish unmanned aviation knowledge base and related business opportunities. The organisation has been a fantastic place to network and connect with experts in the field. We now have several cooperation projects that started thanks to meetings organised by FUAVE.

Emilie Cohen
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FEATURE ARTICLE

Overview of Professional Drones Activities in Ireland

By Julie Garland
Avtrain, Ireland

Our mission at Avtrain is to encourage prolific drone operations while keeping the skies safe through the highest standards of training and certification. We live by the 3Ds – if it is Dull, Dirty or Dangerous, then a drone should be doing it. We hold an approval as Recognised Entity issued by the Irish Aviation Authority for the grant of EASA Open A2 and all Specific Category Authorisations, Declarations & Light UAS operator Certificate (LUC) and independent verification of compliance with Operational Safety Objectives (OSOs) to a high level of robustness. We use a mix of innovative new online technologies to deliver our training courses and provide consultancy services.

Ireland and the Regulatory Environment

With the advent of the EASA regulations the drone industry in Ireland has been flourishing. Both 2019/945 and 2019/947 have been fully implemented with no National Standard Scenarios, unlike other member states. Brexit has contributed to this growth, as we are one of the last remaining native English speaking EASA member states, which can help in encouraging third country business, such as those inbound to Europe from the USA, to locate in Ireland. Coupled with our positive business environment, corporate tax regime, government supports, through the likes of Enterprise Ireland and the IDA, make Ireland an attractive location. And of course, there is the weather; if you can fly a drone in Ireland you can fly it anywhere!

Other than the Geographical Areas, there are no local differences to the EASA regulations, which gives a certainty to operators and makes cross border applications very simple. There is a section on the Irish Aviation Authority's website dedicated to drones, and if any Aeronautical Notices are published, they will be available here: **https://www.iaa.ie/general-aviation/drones**

The following statistics are from the IAA in November 2022 and show the dramatic increase in the applications from 2021 through 2022 with the % increase year on year reflecting the industry growth:

Item	Total	Increase 2021/22
Operator Registrations	8,000	+ 54%
RP Certs Open A1/A3	12,615	+ 48%
RP Certs Open A2	1,337	+ 120%
RP Certs STS	354	N/A (only digitally available in 2022
Operational Authorisations	96	+ 146%
LUC	2	0%

As you can see, two LUCs were granted in 2021, and while there have been no additional LUCs granted yet in 2022, one additional application was submitted in November 2022 and 2 more are in progress for submission prior to yearend.

Training and Certification

The IAA were the first European Member State to have a "Drone Register" back in 2015, and with the implementation of the EASA regulations they developed MySRS – My Safety Regulation System. This allowed for the digitisation of all applications for drone pilots and operators from registrations to applications for Open A1/A3, A2 and STS Remote Pilot Certificate of Competence and Theoretical Knowledge Certificate for Specific Category and Operational Authorisations.

At Avtrain both the training and exams can be completed fully online through the Avtrain Learning Management System portal with on demand fully proctored exams available 24/7 for the clients convenience.

Appendix 4 declarations of compliance with Appendix 3 are not yet available for operators wishing to carry out the practical assessments of their own pilots, but this will be available in early 2023. In the meantime, a Recognised Entity such as Avtrain can carry out the practical skills training and assessment, and upload it to MySRS. Currently, LUC Applications continue to be processed manually.

A drone pilot from any jurisdiction can carry out their training at a Recognised Entity such as Avtrain, and following the successful completion of the theoretical knowledge portion, we endorse their application on MySRS and the IAA issue their EASA certificate. This is a seamless process, as it is totally digital and fully online.

For an operator to register itself, the individual or corporate entity, should register in the Member State where it is a resident (private individual), or where it has it's principle place of business. The NAA in that EU Member State will then have ongoing oversight of their operations and authorisations, even if they choose to carry out their training in a different Member State. Third country operators should register in the Member State where their first planned operations will take place, and that country's NAA will then have continuing oversight of their operations. It should be noted, that a LUC application can only be submitted by a legal entity and not an individual person.

Industry issues

The greatest bottleneck for the industry is the lack of acceptable published standards and standardisation between Member States. EASA standardisation audits of

Member State NAA will commence in early 2023, and these are welcomed, as there is significant divergence in both the implementation and application of the regulations. National Standard Scenarios have added to this confusion.

For the drone delivery sector there is significant confusion on operations and risk management regarding VLOS/(EVLOS?)/BVLOS and the differing requirements in individual Member States. Is a method of impact reduction required and to what level? Is overflight of uninvolved people allowed, if mitigated? Can the delivery take place in a public area, or in a private garden? If a parachute is fitted to the drone, how do we mitigate operations below the parachute deployment height?

In the aerial survey sector, fitting a parachute to an aircraft may in fact cause an incident or accident, particularly with very few standards available for specific aircraft. Aircraft may be operating beyond the manufacturer's MTOM, the centre of gravity of the aircraft and it's stability may be negatively affected causing additional wear and tear on motors. And when the parachute does deploy following the activation of a Flight Termination System where will the aircraft ultimately touch down – possibly outside of the planned operational area?

There is no definition of an "adjacent area", and consequently, it is impossible for an operator to know, if it has made the correct assessment of the "adjacent area". Geographical Areas differ significantly from country to country, and the instructions to get permission to fly in an area where flight is restricted, can often only be published in a local language, and a "geo-zone manager/point of contact" may not be appointed.

As can be seen from the localised figures from Ireland above, the rate of growth of the industry is exponential, and the resources of NAAs across the EU Member States are already stretched. This will be a significant bottleneck for the industry, unless the NAAs are staffed with additional experienced personnel – a task that should not be underestimated.

In conclusion, the drone industry is thriving, but the bottlenecks for the industry need to be resolved. We are currently only carrying out operations in the Open and Specific Category, but Certified Category operations are approaching fast, and we need to look towards the future and build a solid foundation now. The possibilities are endless when it comes to drone usage - they are limited only by our own imaginations.

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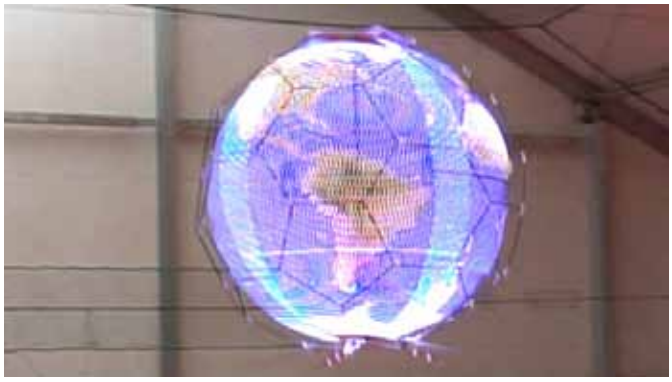
Whale Tagging
Ocean Alliance, USA - Photo: DJI, China



Spherical Drone with Projection on Exterior (indoor flight)
NTT - Docomo, Japan

Delivery UAS
Manna Drones
Ireland

Delivery UAS
Alphabet Wing, USA

FEATURE ARTICLE

Specific Category Training Modules
A Austomizable Training Approach To Standardization

By Lluis Amat, Delia Gamboa, Jordi Salvador
BCN Drone Center, Spain

The use of Unmanned Aircraft Systems (UAS), commonly known as drones, is increasing rapidly as one of the most attractive and innovative technologies, thanks to its potential to be incorporated in multiple industry sectors. Consequently, there is the need of capable centres to test and validate this technology and to properly train the professionals for the new UAS job opportunities to come.

BCN Drone Center is a UAS Test Site for civil unmanned robotic systems. Inaugurated in 2014, it has had users from more than 100 different countries, an international benchmark in the UAS sector. BCN Drone Center is managed by CATUAV, a pioneer company in the European civil UAS sector, founded in 2000, running testing, evaluation, and certifications processes. The company shares its wide experience in the sector by giving consultancy services to all test site users when needed.

The centre has a segregated airspace of 5.000 hectares with a flying altitude of up to 4.500 feet AMSL, enabling the performance of experimental flights Beyond Visual Line of Sight (BVLOS) or at higher altitudes, facilitating flight approvals for any type of UAS, even those above 25 kg or with a wingspan of more than 3 meters. Inside the airspace, there are both unpopulated and populated areas, allowing to apply CONOPS at different GRC levels.

The test site, completely powered by renewable energy, has the necessary infrastructure to carry out any R&D testing programme; it includes a hangar, an office, a workshop, meeting rooms, test equipment, ground controls station, etc.

This makes BCN Drone Center the perfect place to perform any R&D project and to test, evaluate and certificate UAS technology, as well as to train the professionals to boost the UAS industry. As part of its activity, BCN Drone Center conducts workshops, where participants receive instruction on different UAS-related topics, aimed at both new users, as well as established professionals in the sector.

Regarding the current UAS regulatory framework, the present training scheme for UAS remote pilots follows a staggered approach, beginning with almost no training requirements for the lowest risk operations and increasing these training requirements as the operation and the UAS become more complex. EASA classifies the risk depending on how the surroundings and the persons not involved in the operation are impacted, considering both air and ground risks. Consequently, a small and light UAS may require a high-risk training to operate, if it is going to be operated in a high-risk area.

In the "Open" Category, the remote pilot needs to undergo a standardised theoretical training for operating under A1/A3 Subcategories. And, if the remote pilot wants to operate under the A2 Subcategory, he needs to submit a self-practice declaration to the competent authority and pass an additional theoretical training exam, as this category allows the remote pilot to be up to 30 meters from people not involved with the operation.

For the "Specific" Category, the training requirements become tougher. For a declarative national STS, it is

required to pass a theoretical exam with the Authority and to obtain a practical training certificate from a recognised training facility. The STS Scenarios allow the remote pilot to use UAS with a maximum take-off mass of up to 25 kilograms and operate it in controlled land areas in urban environments, which are considered high risk areas.

Up to this point, the remote pilot training requirements are well-defined by both EASA and the National Aviation Authorities (NAA), but this standardisation disappears when it comes to remote pilot training on operational authorizations (also in the Specific Category), since the training requirements must be proposed by the operator, based on the CONOPS, and accepted by the NAA on a case by case basis. For this purpose, EASA has issued Acceptable Means of Compliance (AMC) establishing guidelines for the theoretical and practical training of those remote pilots and identifying specific endorsement modules with the aim of granting more interchangeability in the training modules between different CONOPS.

As a training facility recognised by the Spanish Aviation Authority, BCN Drone Center offers the above-mentioned theoretical and practical courses for remote pilots desiring to obtain the national STS pilot certificate, including the radio communication rating and personalised assessment for conducting the first steps as a UAS operator. Furthermore, this year, BCN Drone Center has begun offering courses for endorsement modules in the specific category (for operational authorisations), such as for fuel powered drones, BVLOS operations, delivery, and flight operations at altitudes above 120 m.

The ‘‘Specific’’ category training modules are divided in two parts:

- A first theoretical part, in which the particularities of each CONOPS are properly explained. There is a special focus on the contingency and emergency common procedures in each case, which are key for the remote pilots to safely deploy later their own applications.
- The second part of the module is based on flight practice. Again, with a focus on the simulation of contingency and emergency procedures, so training participants can see real flight examples of how to proceed in each case and get a hands-on experience with this type of operation.

Being the first time this type of training was performed, a participant survey was conducted. They found the training well balanced between theory and practical seasons, which allowed them to learn and apply the modules they had been taught. This methodology also proved a good way to give the flexibility to each participant to adapt the training to its needs, which is a key factor, as BCN Drone Center receives clients from different fields who want to apply the UAS training into their specific sector, while following the training course together during the same week.

This module configuration also has the potential to become easily standardised for the ‘‘Specific’’ Category. As each of them can have the same syllabus in any EASA

member state, it is possible to move from the current case-by-case training authorisation to a common framework. The combination of them can be a flexible solution and become a more personalized training, allowing the course followers to use the modules to create the required CONOPS, focusing on the topics of interest. The training system tested at BCN Drone Center may allow companies and organisations to have pre-trained remote pilots with a common and well-known training syllabus, without depending solely on each remote pilot-specific training. It is expected to be able to add further required modules in the future, as this approach is easily scalable.

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FEATURE ARTICLE

Critical Infrastructure Resilience & Counter-Drone Systems
An Opinion on the Situation in Europe

By Dr Oliver Heinrich & Malte Krumm
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Recent drone attacks on Ukraine's electrical power plants causing blackouts in more than 1,1000 towns and villages, reports about unidentified drone sightings over Norway's offshore platforms days before the attacks on the Nord Stream pipelines, as well as alleged espionage by drone flights near several sensitive areas in Norway and Sweden, have moved the issue of European Union (EU) critical infrastructure resilience, once again, to the top of the current political agenda (cf. Opening remarks by EU Commissioner Johannson at the press conference on EU critical infrastructure resilience on 18.10.2022, SPEECH/22/6265).

Already back in 2020, the EU Security Union Strategy [COM(2020) 605 final] identified, inter alia, a "future proof security environment by enhancing cyber security and protecting critical infrastructure and public places" as one of its four main strands of necessary actions for the period of 2020 to 2025. The Strategy explicitly referred to the hazard potential of drones misused by criminals and terrorists in public spaces and over critical infrastructures. While the European Commission acknowledged the European regulatory framework for drones, laid down in Regulation (EU) 2018/1139, Implementing Regulation (EU) 2019/947, and Delegated Regulation (EU) 2019/945, as an important first step to minimize potential hazards, in particular by careless and reckless drone pilots, it also stressed a need for additional action, including information sharing, guidance and good practice for use by all, including law enforcement, as well as for additional testing of drone countermeasures.

This article provides an overview on the most recent and prospective EU efforts to meet this need for additional action in favour of critical infrastructure resilience by counter-drone systems. In addition, it aims to clarify roles and responsibilities in the multilevel context of the EU and its Member States. In this context, particular attention is paid to a new legislative proposal, the Directive on the resilience of critical entities [CER-Directive, cf. COM(2020) 829 final]. Long after the proposal's publication at the end of 2020, an inter-institutional agreement was finally reached in June 2022. The proposal is expected to be voted on in the European Parliament early in November 2022. A first analysis reveals that it might turn out to be a game-changer for an internal market of critical infrastructure entities, as well as counter-drone systems.

EU Policy & Guidance Material In The Field Of Counter-drone Systems

The willingness of the EU actors to support and engage in the field of critical infrastructure resilience in general, and counter-drone systems in particular, is reflected in several policy actions, published as well as announced over the course of the last two years.

EASA Drone Incident Management At Aerodromes Part I-III

In the aftermath of several incidents, involving drones near or inside the perimeter of airports, as well as in their immediate proximity, and in the arrival and departure paths of runways since 2018, most prominently at London Gatwick and Heathrow airports in December 2018, the European Aviation Safety Agency (EASA) established a Counter Drone Task Force in November 2019 to develop an action plan in order to ensure that aerodrome operators, aircraft operators and air traffic services (ATS) providers are prepared to take preventive action as far upstream as possible, and to react to the misuse of drones with minimum disruption of operations, while still being able to accommodate friendly drone operations [European plan for Aviation Safety (EPAS) 2020-2024, pp. 54 f.]. As one of the five proposed actions to reach this objective, EASA - in collaboration with national law enforcement bodies, aerodrome operators, as well as the European Commission's Directorate for Migration and Home Affaires (DG HOME) - proposed to develop comprehensive guidance material for relevant stakeholders to ensure that counter-drone measures are swiftly considered and implemented from a global safety perspective. A tripartite manual on Drone Incident Management at Aerodromes was published in March 2021. Part 1 of the manual, entitled "The challenge of unauthorized drones in the surroundings of aerodromes", is freely available online. Part 2 ("Guidance and recommendations") and Part 3 ("Resources and practical tools") have been made available only to relevant stakeholders and authorities due to the sensitive nature of the subject matter, but can be accessed in case of a duly motivated request to EASA (aerodromes@easa.europa.eu).

Although the manual itself is technology-neutral and does not recommend any specific counter-drone system, Part 3 provides an overview of available systems and offers some guidance as to the procurement and testing of counter-drone solutions. In line with the distribution of competences described in detail below, in particular the EU principle of subsidiarity, the manual acknowledges that security forces and law enforcement authorities are organised at the national level. It provides that it is the Member States' responsibility to include arrangements to dictate how law enforcement authorities shall respond to drone incidents in their national counter-drone strategies and associated national operational arrangements. For this reason, Part 3 of the manual contains, inter alia, a methodology for a local risk assessment, advice for procurement and testing of technological counter-drone

solutions, an overview of different technological counter-drone solutions, and guidance for the initial response to a drone incident by first responders.

EU JRC Handbook For Counter-drone Protection Of Critical Infrastructures

In addition to EASA's efforts, the European Commission's Joint Research Centre (JRC) announced during the Amsterdam Drone Week 2022, that it will publish an additional "Handbook for counter-drone protection of critical infrastructures" at the end of 2022. According to Paul Hansen, Project Manager at the JRC, the Centre is developing a risk analysis framework for critical infrastructure, and common criteria for aligning counter-drone solutions with the results of an analysis of the specific infrastructure risk. Apart from the handbook, which has not been published at the time of writing, it is worth mentioning that the JRC is also providing a comprehensive overview of international best practices, standards, and technical support regarding counter-drone measures on an ongoing basis, (cf. JRC Technical Report, Karlos/Larcher, A guide to key information on the protection of Public Spaces, 2021, pp. 33 ff.).

Handbook For Securing Urban Areas From Non-cooperative Drones

A third policy document, the "Handbook for securing urban/metropolitan areas from non-cooperative drones", has been announced on several occasions by European Commission officials and was scheduled for publication in late 2021. Advertised as a top-level, non-technical, accessible handbook addressing relevant audiences and stakeholders such as regulatory authorities and law-enforcement agencies in urban contexts, it is based on an extensive study of different metropolitan approaches in countering threats posed by drones. Apart from practical guidance and support by sharing best practices, the study also aims to identify possible needs for further legislative engagement.

EU Drone Strategy 2.0

Finally, the EU Drone Strategy 2.0 is a high-level EU policy initiative aiming to enable drones to contribute, through digitalization and automation, to a new offer of sustainable services and transport, while accounting for possible civil and military technological synergies. The strategy is supposed to provide a forward-looking vision for the future holistic development of the sector with a time horizon of 2030, which can foster the uptake of this innovative technology in Europe, while establishing the right balance between safety, security and other societal concerns, and a sustainable economic environment. The European Commission will present the Strategy to the public on the 29th of November 2022 in collaboration with SESAR JU in Brussels.

According to first insights on the Strategy's content given by EU officials, "increasing system resilience and counter-UAS capabilities" will form one of the ten priorities of the new Strategy under the umbrella of two main objectives:

1) Building a European drone service market; and
2) Strengthening the European civil and defence industry capabilities.

While it remains to be seen, which precise legislative or policy actions will be based on the new Strategy, it is more than likely that new funding and financing opportunities provided under Horizon Europe, the European Defence Fund (EDF), or by the European Investment Bank (EIB) will be available for counter-drone projects, too.

EU Competence In Critical Infrastructure Protection

In order to understand the distribution of competences between the EU and its Member States in the field of critical infrastructure protection, it is essential to start with the EU primary law, notably the Treaty of the European Union (TEU) and the Treaty on the Functioning of the European Union (TFEU).

In line with the principle of conferral, enshrined in Article 5(1) TEU, the EU shall only act within the limits of the competences conferred upon it by the Member States in these treaties to attain the objectives set out therein. In addition, the principle of subsidiarity in Article 5(3) TEU governs the exercise of EU competences in areas in which the EU does not have exclusive competence by safeguarding the ability of Member States to take decisions and action as close to the citizen as possible. It authorizes intervention by the EU when the objectives of the relevant action cannot be sufficiently achieved by the Member States, but can be better achieved at EU level by reason of the scale and effects of the proposed action.

The protection of critical infrastructures against physical threats is not directly addressed in the EU treaties. Closely related activities in the field of counterterrorism and police cooperation however constitute a key plank in making the EU an Area of Freedom, Security and Justice (AFSJ), a domain subject to shared competences between the EU and its Member States, Article 4(2)(j) TFEU. As further specified in Articles 67 to 89 TFEU, this area relates to common policies on border checks, asylum and immigration, judicial cooperation in criminal, as well as civil matters, and police cooperation.

In respect of critical infrastructure protection, as part of the broader field of internal security, this means that the EU has the authority to legislate where security can be improved through coordination and cooperation among the Member States, in particular their security agencies. However, considering the principle of subsidiarity, this does not apply for security issues that are of an entirely regional or local nature. Thus, due to its close ties to national sovereignty, the actual safeguarding of critical infrastructures as part of national public security, is by its very nature a genuine responsibility of the individual Member State. This is confirmed by Article 73 TFEU, which stipulates that any form of action in the context of the EU's objective to create the ASFJ "shall not affect the exercise of the responsibilities incumbent upon Member States with regard to the maintenance of law and order and the safeguarding of internal security".

A New Internal Market For Services Of Critical Entities & Counter-drone Systems?

Notwithstanding these limitations in competence, the EU did not, and does not refrain from acting in the field of critical infrastructure protection and resilience.

The new CER-Directive will be based on Article 114 TFEU, which involves the approximation of laws for the improvement of the internal market. Like the AFSJ, the internal market is subject to the rules of shared competences between the Member States and the EU, cf. Article 4(2)(a) TFEU. A substantial difference however is the circumstance that is subject to significantly more influence of the European institutions regarding the adoption of legislative harmonization measures.

According to the proposal, the new legal basis of the Directive is justified by the shift of its aim, scope and content, increased interdependencies, and the need to establish a more level playing field for critical entities. Instead of protecting a limited set of physical infrastructures from the disruption or destruction, which would have significant cross-border impacts, the proposal aims at enhancing the resilience of entities which are critical for the provision of services, and which are themselves essential for the maintenance of vital societal functions or economic activities in the internal market of the EU.

The new CER-Directive (as negotiated at time of writing) will expand the scope of its predecessor from only two sectors (energy and transport) to cover in total eleven sectors of critical entities (energy, transport, banking, financial market infrastructures, health, drinking water, waste water, digital infrastructure, public administration, space, and food). While Member States will be obliged to adopt a national strategy for reinforcing the resilience of critical entities, and to carry out regular national risk assessments to identify critical entities by using a common methodology, critical entities themselves will have to carry out site-specific risk assessments of their own, taking measures to ensure their resilience, and to report disruptive incidents.

In addition, a Critical Entities Resilience Group, bringing Member States and the Commission together, will evaluate national strategies and facilitate cooperation. Member States will have to empower a single or multiple national competent authorities to enforce the relevant rules, in particular to conduct on-site inspections, and to introduce penalties in case of non-compliance.

The European Commission will be tasked, inter alia, to support Member States and critical entities in complying with their obligations under the new CER-Directive, in particular by preparing a Union-level overview of cross-border and cross-sectoral risks to the provision of essential services, and by facilitating information exchange among experts. Furthermore, the Commission will complement Member States' activities by developing best practices and methodologies, and by supporting cross-border training activities and exercises to test the resilience of critical entities.

For these reasons, the Commission will be empowered to adopt delegated acts establishing detailed rules specifying some, or all, of the measures to be taken by Member States to ensure that critical entities take appropriate and proportionate technical and organizational measures to ensure their resilience, e.g., adequate physical protection of sensitive areas, including fending, perimeter monitoring tools, or detection equipment. In addition to that, the Commission shall adopt implementing acts in order to set out the necessary technical and methodological specifications.

Particularly noteworthy is the fact that the proposal is not limited to a support function in favour of a resilient internal market itself. In fact, it stipulates new obligations for critical entities, as well as Member States aimed at improving their ability to provide services and their oversight in the internal market, thereby establishing a new internal market for services of critical entities themselves.

It is more than likely that suppliers of counter-drone systems will benefit from these developments, too. On the one hand, Member States will soon have to include threats by illicit drone use in their new national strategies. On the other hand, critical entities will have to evaluate, based on their individual risk assessments, whether or not, to implement counter-drone systems as risk mitigation measures. The fear of penalties imposed by national authorities in case of non-compliance might provide for an additional incentive to perform an in-depth risk assessment.

In the end, harmonized standards for risk assessments and mitigation measures for critical entities, paired with the outlined EU policy efforts and distribution of best practice guidance on counter-drone systems, might flatten the entry-barriers to a formerly fragmented market. They will provide an excellent opportunity to expand counter-drone services on a pan-European level.

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FEATURE ARTICLE

Scotland's Drone-Based National Logistics Network for Medical Supplies

By Fiona Smith
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With 16 partners involved, Project CAELUS (Care & Equity – Healthcare Logistics UAS Scotland) brings together a wealth of knowledge and experience across a number of industries. CAELUS has received recognition across the political spectrum with a motion in the Scottish Parliament saying the project was innovative and pioneering. Project CAELUS was recently called a "game-changer" for how NHS Scotland delivers healthcare by Humza Yousaf, the Scottish Government Health Secretary.

AGS Airports leads the CAELUS Project, which will be the UK's first medical distribution network. It secured £10.1 million in funding from the Future Flight Challenge at UK Research and Innovation (UKRI) in July 2022, the second successful round of funding for the CAELUS consortium. which brings together 16 partners.

Together, the consortium partners are working to deliver what will be the first national drone network that can transport essential medicines, bloods and other medical supplies throughout Scotland including to remote communities.

Since securing £1.5 million in January 2020, the CAELUS consortium has designed drone landing stations for National Health Service (NHS) sites across Scotland and developed a virtual model (digital twin) of the proposed delivery network, which connects hospitals, pathology laboratories, distribution centres and GP surgeries across Scotland.

NHS Scotland has said it will bring its "Once for Scotland" approach to the project, the second phase of which will involve live flight trials and removing remaining barriers to safely using drones at scale within Scotland's airspace. The CAELUS project is set to revolutionise the way in which healthcare services are delivered in Scotland.

A drone network can ensure critical medical supplies can be delivered more efficiently; it can reduce waiting times for test results and, more importantly, it can provide equity of care between urban and remote rural communities.

As well as undertaking live flights, CAELUS will begin to deploy the physical infrastructure needed to support the drones across Scotland. This will involve building prototype landing bases, as well as digital and communication infrastructure. CAELUS will work with local communities to ensure they understand why and how the drones will be used.

The live flight trials will be operated by the CAELUS consortium members Skyports and Dronamics. The UK-based drone services provider is an experienced operator of medical and dangerous goods cargo flights. The company performed early trial flights with NHS Scotland in 2020 and 2021, flying over 14 000 km in the region to date. The consortium's next live flight trials will take place in 2023.

Project CAELUS was recognised for its excellence in innovation at the Scottish Transport Awards in September 2022, and has received the Excellence in Technology and Innovation award. The project's latest phase was launched at an event at Glasgow Airport in September and received more political backing through the Public Health Minister Maree Todd, who gave the keynote speech where she said: "This innovative project will help position Scotland at the forefront of drone technologies to deliver essential healthcare supplies to people more quickly and provide equity of care between urban and remote rural communities. It also demonstrates an effective industry partnership showing that when businesses, universities and public sector work together they can deliver for Scotland and outperform the competition, attracting welcome funding at this challenging time."

The CAELUS consortium comprises:

AGS Airports	ANRA Technologies
Arup	Atkins
Cellnex	Commonplace Digital
Connected Places Catapult	DGP Intelsius
Dronamics	NATS
NHS Scotland	Plane Finder
Skyports	The Drone Office
Trax International	University of Strathclyde

AGS Airports

AGS Airports Limited was established in 2014 to invest in Aberdeen International, Glasgow and Southampton airports and is the second largest airport group in the UK. A joint venture by Ferrovial and AGS Ventures Airports Limited, an entity controlled by Macquarie European Infrastructure Fund 4 LP.

AGS Airports supports tens of thousands of jobs and contributes in excess of £2 billion in GVA to the UK economy every year. In 2021, AGS Airports launched its sustainability strategy, setting out how it will balance the undoubted economic and social benefits of aviation with its climate change responsibilities. AGS Airports has:

- Reduced its direct carbon emissions by 52% since 2018.
- Achieved carbon neutrality in 2020.
- Committed to achieving net zero for direct emissions by the mid-2030s.

Eventhough the project's focus is on healthcare, AGS Airports is of opinion that CAELUS could pave the way

for the deployment of drone-enabled logistics in other sectors and has the potential to change the way airspace is used by manned and unmanned aircraft. It also has clear environmental benefits, as it will play a key role in reducing the carbon emissions generated by existing, road-based distribution networks within Scotland.

Atkins

Atkins is leading on the physical infrastructure of the project and, in particular, identifying and designing the different landing sites for each drone. This involves determining the size and use of each site, assessing accommodation or storage for the drones required, and how best to connect the site to essential utilities to power and fuel these electric vehicles and the site infrastructure - including exploring self-sufficient sites powered by renewable off-grid technology.

Larger drones will require a storage hangar connected to regional airports such as Aberdeen and Glasgow, whereas medium-sized drones will also need to be connected to hospital sites, meaning a landing site large enough to accommodate the drone, its battery storage and charging equipment, and allow access for any essential maintenance.

When it comes to the smaller of drones, which will be required to land in remote areas, Atkins is taking a modular approach to create a more efficient and sustainable logistics network. It is creating a "pop-up port" that could be deployed when needed, rather than creating permanent buildings in the middle of countryside. This modular, functional-mobility concept could even see temporary buildings used for a couple of weeks before being folded away and towed by electric vehicle to the next site. There is a keen focus on sustainability beyond the aircraft, for example by charging batteries using solar or wind power.

Creating this complex network of unmanned aircraft will require significant technical and regulatory aerospace work to ensure these aircraft can be safely integrated into existing airspace; develop the infrastructure to support the network; and also ensure the security of airspace management systems and cargo at every point in the network.

A large focus of the CAELUS project will be on exploring how best to overcome these challenges and operate a network of this type in Scotland – mirroring another Future Flight Challenge project that Atkins is leading with partners across the aviation industry to test and develop an end-to-end advanced mobility ecosystem.

NATS

NATS, the UK's principal air navigation services provider, is leading the airspace management work of Project CAELUS by developing the concepts for how airspace could be safely managed, and the procedures that will be required to safely integrate a network of multiple drones with existing flight operations. Once a Concept of Operations is developed, a live trial will take place with consortium partners to test the proposals in a real-world setting.

This project has the potential to revolutionise the way in which healthcare services are delivered in Scotland – a medical drone delivery network could ensure critical medical supplies can be delivered more efficiently, reduce waiting times for test results, and improve healthcare access for rural communities. However, for this to happen, the drone network needs to be effectively integrated into the airspace structures that keep all things airborne safely separated. Developing ways of doing this is NATS' focus for the project.

This is a great example of how uncrewed aviation can support the NHS, and shape the way our skies are used in the future by paving the way for similar integrated airspace projects across the UK.

ANRA Technologies

ANRA develops digital products used by air traffic services and drone operators to manage the operations of drones. In the CAELUS project, ANRA is leading the development of a Digital Twin of a Scottish Medical Delivery Network aimed at developing actional data for how such a network would operate across Scotland. The purpose of the Digital Twin is to be able to demonstrate the performance and safety of operations at a network level through the use of real-world services (UTM, airspace entities, weather etc) together with drone models to simulate the system.

NHS Grampian/NHS Scotland

NHS Grampian leads the "Once-for-Scotland" approach on behalf of the NHS Territorial Health Boards alongside the Scottish Ambulance Service (SAS) to understand the benefits that UAS technology can bring to the delivery of routine and emergency activity, respectively, in the 21st healthcare delivery model.

The Scottish Ambulance Service is on the frontline of the NHS, despatching immediate emergency medical assistance or clinical advice to over 5 million people across Scotland, covering both the islands and the mainland population.

The NHS Territorial Boards provide acute and community healthcare services to the same island and mainland populations. With approximately 26% of Scotland's population living in remote or rural areas spread across 69% of the land mass, service delivery can encounter constraints which contributes to treatment inequity.

For both SAS and NHS Scotland, equity in the delivery of healthcare is a key driver for involvement in this project as NHS Scotland considers how to remobilise and redesign services to fit the needs of Scotland's health and social care challenges.

The project provides an opportunity to transform patient experience and service delivery by reimagining the existing service models to new ones, utilising new technologies. CAELUS will also contribute to the net

zero emissions ambition of the Services. By adopting the "Once-for Scotland" approach, involving the three regional NHS Innovation Hubs (North, South-East and West) the learning and benefits of this solution to develop a medical logistics network can be applied equally across Scotland.

NHS Grampian's Clinical Lead for Innovation, Dr Andy Keen said: ''We are delighted to be the lead board for Scotland on this project. Our aim, from an NHS perspective, is to test the use of drone technology in urban, remote, rural and island landscapes. We want to test if using drones to will improve important aspects of our logistics service, for example, to test the transportation of laboratory samples, blood products, chemotherapy, and medicine delivery. Ultimately, we want to explore if drone technology can speed up diagnosis and treatment of medical problems. "This has the potential to improve services for those whose care is dependent on rail, ferry or airline timetables and help keep people at home where they can be supported by families and loved ones.''

University of Strathclyde

The University of Strathclyde has been one of the principal drivers in steering the path of the CAELUS project since its conception in Phase 1 of Future Flight. Strathclyde's role has been to advise on and contribute to the development and demonstration of the beyond-state-of-the-art digital technologies, in support of the strategic design and the tactical operation of a large network of drones transporting medical payloads to ensure equity of care but also commercial viability and safety.

A team of academics from across the university departments of Mechanical and Aerospace, Civil & Electrical Engineering, coordinated by the Aerospace Centre of Excellence in Mechanical and Aerospace Engineering, is involved in the digital modelling, simulation, optimal planning/re-planning and reconfiguration of the network and its operation.

The work of Strathclyde will demonstrate how the digital technology can provide strategic and tactical solutions to operators and controllers that ensure maximum efficiency, reliability, and resilience of the network of drones.

These capabilities are essential to enable future Beyond Visual Line of Sight flights, in a future U-space environment. U-space is a set of specific services and procedures designed to ensure safe and efficient access to airspace for a large number of drones based on high levels of digitalisation and automation.

Strathclyde Business School and Management Science is supporting market analysis and exercises to understand the impact that the CAELUS network will have on stakeholders such as the NHS and its supply chain, the drone operators, the air traffic controllers/regulators, as well as on the general public. Ensuring the acceptance and a positive public perception is key to successfully introducing such radical and disruptive new technologies into the UK

Arup

In 2017, Arup recognised that the absence of any policies or regulation regarding the noise made by drones presented a significant barrier to social acceptance and their widespread introduction.

Since then, Arup has been developing ways of understanding public perception of drone noise. For the CAELUS project, it's approach will help identify existing barriers to accepting drones as part of the healthcare system, and work with the public and other key stakeholders to move past these obstacles.

Audio demonstrations, known as ''auralisations'' , have been developed using Arup's SoundLab technology. They will give people a clearer understanding of the noise generated by drones. Auralisations have previously been used to help people understand future noise levels and characteristics of a number of major road, rail and aviation projects. For the CAELUS project, they will simulate the sounds of various types of drone deliveries taking off and landing, as well as flying overhead.

The intention is that once members of the public have a better understanding of the drone-generated noise, they will be able to weigh that against the benefits of better connectivity, faster deliveries of medicines, reduced test result times, and so on – ultimately becoming more accepting of the use of drones.

Residents in areas which might be served by drones will then be invited to listen to demonstrations online before completing a questionnaire to gauge their response to the sounds (specifically in the context of improving the local provision of healthcare services).

The noise impact and social acceptability of operating drones is not well defined. Arup's previous work in this field indicates that new sources of noise can be met with increased concern from members of the public, which could compromise the development and introduction of new and emerging technologies with socially useful applications.

Building trust is at the heart of this work and interpreting the human response to noise is vital, if we are to develop impactful policies and legislation – as well as help design an ecosystem in which these technologies gain societal acceptance with minimal negative impact on daily life.

Fiona Smith
Project Director
CAELUS Consortium
Scotland
United Kingdom

FEATURE ARTICLE

Drone Operations in a CTR

By Florent Mainfroy
Clearance, France

Drones have been flying around for years now, but are still Unidentified Rules Flying Objects. Except for very large, mostly military ones, drones fly neither IFR (Instrument Flight Rules) nor VFR (Visual Flight Rules). How can manned traffic accommodate to this newcomer? Especially in congested areas such as a CTR (Control Traffic Zone)? Are Beyond Visual Line of Sight (BVLOS) drone flights possible in a safe manner?

The Balance Between Technology, Training, and Procedures

The vast majority of drones in use today do not have the tenth of the required equipment to fly IFR, nor are they certified. Having certified drones complying with IFR for every flight, if possible, would impose an unnecessary burden on the drones themselves and their remote pilots. The idea itself would seem absurd when talking about aerial wedding pictures.

Unfortunately, drones don't fly VFR either. Collision prevention in VFR vastly relies on the "See and Avoid" principle. For an aircraft to be seen far enough, it has to be large enough. The mean drone weight in Clearance' database is just above 2 kg and half the drones of our users weigh 1 kg or less.

A lot of efforts have been made to design and improve "Detect and Avoid" solutions on drones, with the ultimate goal of replacing the "See and Avoid" paradigm with technical solutions. Those efforts have to be recognized and encouraged, as they perfectly fit in the way to a safer sky. But most of these "Detect & Avoid" systems are meant to be on drones only, not on manned aircraft. This opposes the "See & Avoid" principle, in which the pilots of both (or more) aircraft are in charge of surveilling, seeing, and avoiding. Will these systems ever be reliable enough to detect and avoid a glider without any help from its pilot? What about paragliders?

But still, drones are flying. And fortunately enough, drones haven't been involved in many collisions. In this article, we'll try to walk you through the pragmatic steps that France took over the last ten years to allow drones to fly safely. Clearance has had the unique chance to support the growing number of drone operations since 2017, with more than 30.000 flight applications to ATC (Air Traffic Control) processed with our solutions, and over 50 air navigation services using our solutions.

Quick Chronological Overview Of The Regulation

Safety cannot rely only on drone remote pilots. Before European regulation, flying a drone in France for leisure purposes didn't require much more than a few hundred euros at the shop around the corner and no official training was mandatory. Long-time aeromodeling enthusiasts surely had a proven safety record, but first time drone practitioners couldn't be supposed to have an extensive aeronautical knowledge.

Having this in mind, France introduced the obligation to include an easy-to-understand safety notice in every drone package, in a Decalogue way. Rule #2 was about not flying above allowed heights. Rule #5 was about not flying too close to the airfields. No direct mention of CTRs in this short notice, but the idea of no-fly zones in congested volumes surely existed.

In 2015, a more specific regulation was created and is still valid today. The allowed height to fly a drone near an airport depends on : the presence of a CTR or not, the length of the runway, the orientation of the runway and horizontal distance between the drone and the runway, resulting in a volume looking like a reverse stairway (see Fig. 1).

Fig.1 - Red strip requires authorization for every flight. Orange: authorization is needed above 50 m. Yellow: above 100 m. The flight altitude limits have to be computed using Aerodrome Reference Point altitude, not altitude of terrain below the drone.

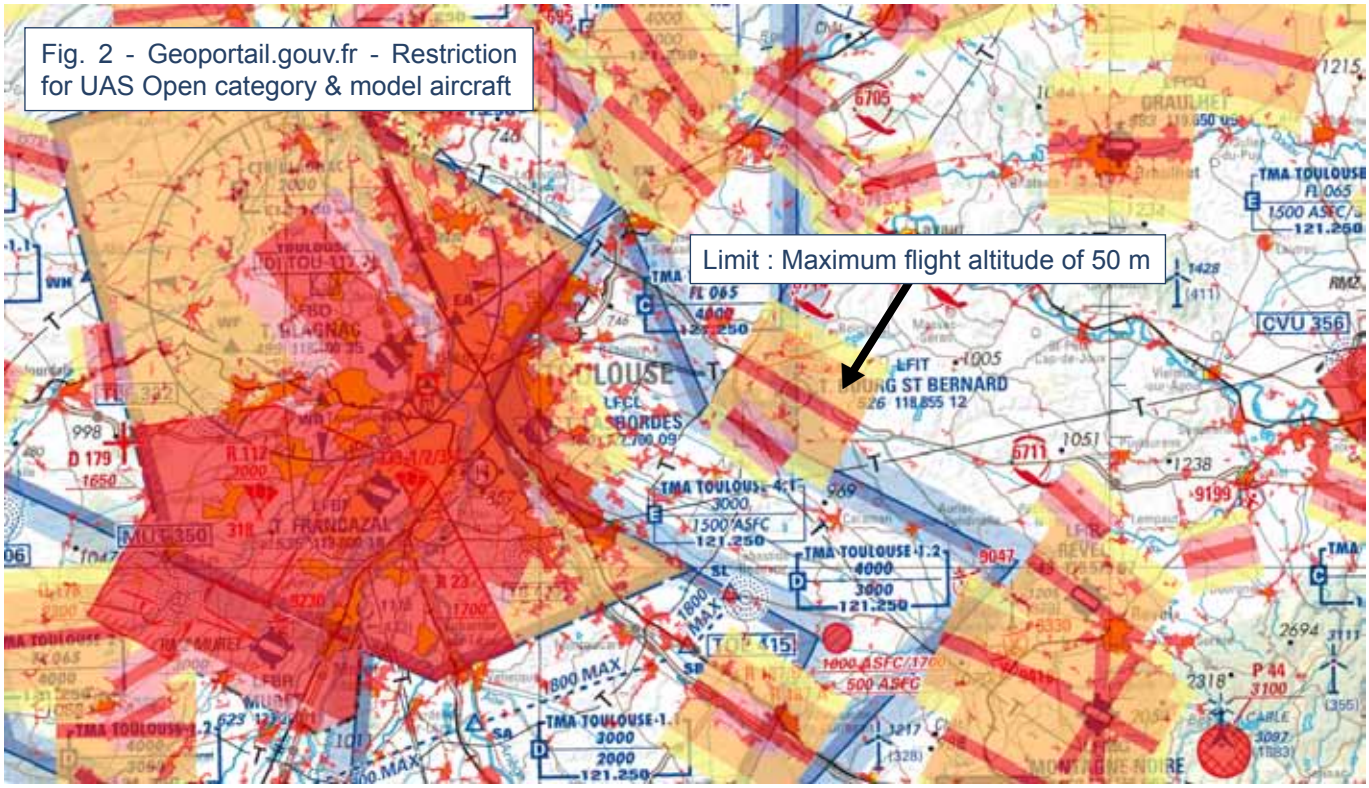

Fig. 2 - Geoportail.gouv.fr - Restriction for UAS Open category & model aircraft

In a CTR, however, an authorization is always needed to fly a drone above 50 m, even outside this runway protection jig.

Calculating the distance and the orientation to the runway, and combining it with the other restrictions applying to drone flights, soon became an intensive time-consuming task for drone operators. This resulted in drone operators applying for authorizations when none were needed or forgetting, in good faith, to request a waiver.

Historically, a distinction has been made between leisure and professional drone remote pilots in France. This distinction is now over with the European drone regulation. Professional drone remote pilots had to pass an exam, somehow similar to Open A2 exam or Specific category exam. It was less likely for leisure drone pilots to fly near a CTR without a proper authorization. Then, France decided to create an interactive map freely available on the internet, allowing a quick overview of drone flight restrictions over the territory (see Fig. 2).

At about the same time, applications like Clearance were beginning to help drone operators find out which authorizations were needed to fly and how to obtain them (see Fig 3).

So far, the safety net to avoid unauthorised access to congested airspace is built upon rules and tools to follow, more than drone's technology or remote pilot training.

The Rise of Drones

Drones have been flying for decades, but not in the same proportions as we have seen in the last ten years. Clearance solutions are in use in Toulouse-Blagnac CTR since late 2017. Figure 4 shows the number of drone flight applications through the last 4 years, with a projection for 2022 based on 10 months.

In 2021, more than 1.500 applications were processed by Toulouse-Blagnac air navigation services. If reduced to a single day, it's 4 requests reviewed, analysed and answered every day.

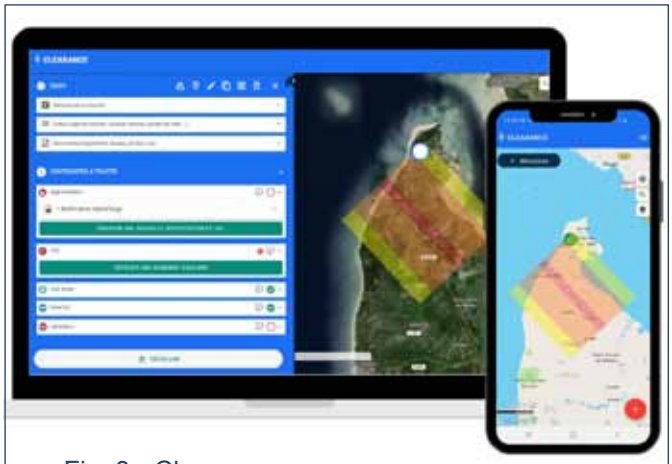

Fig. 3 - Clearance
Direct identification of flying restrictions & guidance to obtain the needed authorizations.

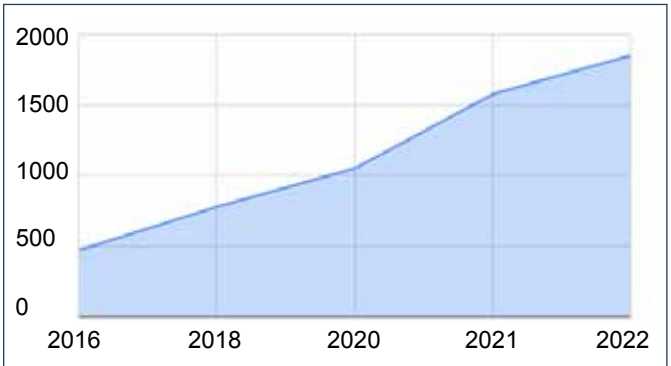

Fig 4 - Number of drone flight requests in Toulouse-Blagnac CTR per year

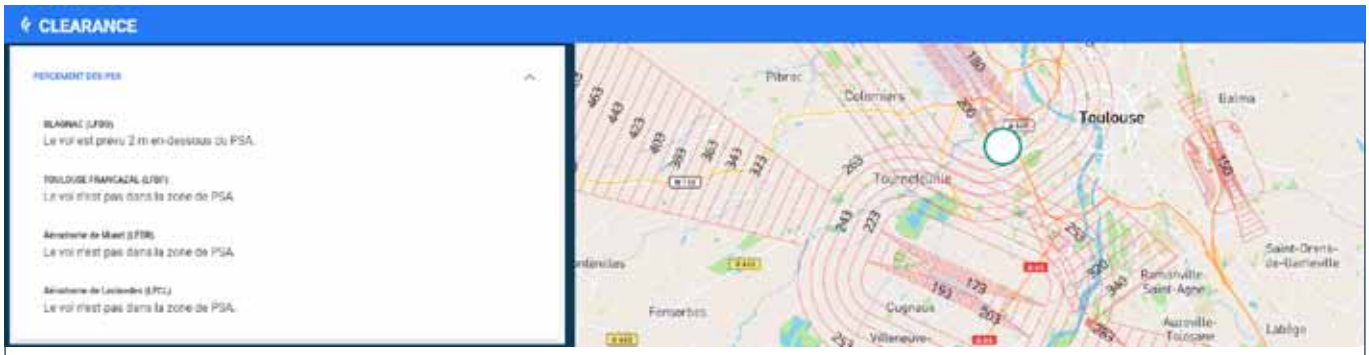

Fig 5 - Automatic computation of height below or under aerial servitudes

Drone Flight Management Tools For ATC

With the growing number of drone flights and the obvious safety need to coordinate between ATC and drone operators in CTRs, email boxes quickly showed their limits in being an appropriate management tool.

Air navigation services of large airports, or ATC in CTR located in active drone environments, began to explore new tools such as Clearance solutions for ATC.

For drone operators, these tools give the opportunity to send a flight approval request to the right contact in a single click. For ATC, such solutions have many advantages :

- Only valid and relevant requests are being received. Drone operators are not allowed to file an application without a date or a location, where such information might be missing in an email sent too quickly.
- Only requests for flights that are actually in the CTR at a height where an authorization is needed can be submitted.
- Communication is centralised in a single solution, and each information pertaining to a drone flight is stored in a single place. An integrated communication module helps to avoid phone calls.
- Volumes can be defined, and automatically compared with drone flight requests to help analyse impact on manned traffic. A frequent practice for ATC in France is to compare drone flight requests with aerial servitude to get a first idea of the drone flight potential impact on manned traffic. Such computation has been automated in the Clearance solution for ATC (see Fig 5).
- Decisions may even be automated. For example, authorizations for drones flying over a city but under 30 metres height, can be automatically granted, as they should not have any impact on manned traffic. Or applications can be automatically rejected in a given volume during an aerial meeting.

Receiving 4 applications a day for drone flights generally planned over 7 days to cope with weather conditions, means 15 to 40 potential drone flights in a single CTR every day. Keeping track of these flights can rapidly become a time-consuming and error-prone task, if dealing with paper forms. Digital solutions have begun to arise to help ATCO (ATC Officers) to be aware of potential drone flights in their CTR, without being overwhelmed with flights not planned for the current day.

How To Manage Long Range BVLOS Flights In CTR?

In 2021, Clearance recorded less than 4% BVLOS drone flights applications in CTRs. But with cargo drone experimentations beginning to pop up everywhere, BVLOS proportion is expected to quickly grow in the next few years. To understand why BVLOS flights are uneasy to manage for ATC, it's important to understand how ATC deals with VLOS (Visual Line Of Sight) flights.

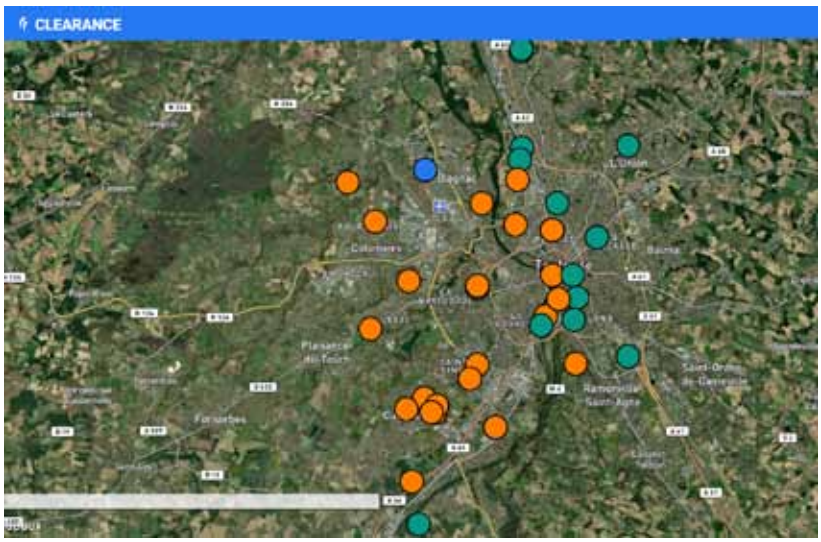

Fig 6 - 18 Potential drone flights in the Toulouse-Blagnac CTR for 15th November 2022. ● Drone flights allowed without restrictions. ● Drone flights with restrictions (limited flight altitude, tel. call to tower before take-off, …).

More than 50% of applications to fly VLOS in CTR are accepted without restrictions (green dots in Fig 6). That is because these flights are low enough and far enough from congested volumes to make an encounter highly improbable. While not being a segregation stricto sensu, no manned traffic is expected near the drone.

About 40% of applications to fly VLOS in CTR are accepted with some restrictions : most of the time a height limitation and / or a phone call to the tower before take-off. Limiting flight altitude enables to create a spatial separation between drones and

manned traffic, and asking ATC before take-off enables to create a temporal separation.

In either case, a soft quasi segregation is made by ATC before the drone flight, either because the flight is planned in a volume where no manned traffic is expected, either because of a height limitation or temporal separation. Having its drone in sight, the drone remote pilot is capable of raising an alert to ATC if its drone fly away, and ATC could then take appropriate action to divert manned traffic from the drone's path.

With drones flying in BVLOS, we lack this ultimate safety net. If the drone is flying away in an uncontrolled manner, the drone operator may not be able to inform ATC of the drone's position. If telemetry is lost for any reason, nor the drone operator nor ATC would be able to know where the drone actually is.

Still, almost 90% of BVLOS applications received in 2021 were accepted, with or without limitations. The vast majority of these applications concerned drone flights in a radius of 1 km from the drone operator. These operations are called BVLOS as the drone pilot doesn't have the obligation to keep its drone in sight at all times. But being close enough to the area where the drone is flying, the drone operator is still able to visually and audibly detect approaching manned traffic. With the expected growth of long stretch BVLOS flights, this capability will be lost.

The Future of Drone Flights in CTR

Briefly said, there is currently no perfect solution in place to handle such drone flights with regular drones. IFR capable military drones are treated as IFR aircrafts and are not the subject of the present article.

One quick and easy solution is to segregate airspace. Not in the soft way of "there should very probably be no manned traffic there, and ATC will be alerted by the drone operator if the drone escapes", but with the definition and activation of temporary segregated airspaces. Creating such segregated airspaces is a pragmatic solution to keep an acceptable level of safety in a CTR, with the drone operator alerting ATC if telemetry is lost or if the drone is not following its expected flight plan.

But segregated airspaces have many drawbacks:

- It takes weeks to create a segregated airspace;
- It's easy to miss a NOTAM, especially if they are numerous;
- A sky scattered with many segregated airspaces might not be as desirable as a freely flyable, especially in a CTR where traffic is already congested;
- Assigning a segregated airspace to a private company for private interest and thus preventing other airspace users to fly in this volume is mostly incompatible with seeing airspace as a shared and public resource.

As some experimentations might require a dedicated segregated airspace, it appears that they should not and can not become the norm.

U-space is expected to address this issue. In U-space designated airspaces in controlled airspaces such as CTRs, dynamic airspace reconfiguration will guarantee separation between manned and unmanned traffic. Flight authorisation service will guarantee 4D separation between drones in U-space airspaces, and traffic information service will keep drone operators aware of manned and unmanned traffic in proximity. Conformance monitoring service, if in place, will detect deviations of drone flights from flight authorisation and raise alerts.

As U-space is probably the best solution to manage BVLOS flights, especially in CTRs, designing a U-space airspace is a longer process than designing a temporary segregated airspace.

U-space regulation will apply from 26 January 2023, but one will have to wait a little longer to read insights on U-space lessons learnt.

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FEATURE ARTICLE

Remote Pilot Training, Qualification & Examination in France

By Nicolas Kestens
Climb Aero Academy, France

Situational Update

The entry into force of the UAS European regulation requires France to adapt its existing national regulatory framework, and training, qualification and examination of remote pilots still need to be adjusted in this perspective.

Although the avant-gardist French standard scenarios, in place since 2012, have widely inspired the European Commission when defining the outlines of the European standard scenarios (STS), France now faces the challenge of implementing a so-called operation centric, proportionate, performance and risk-based regulatory concept, while its operators and remote pilots are still used to perform their unmanned flights according to a purpose-based approach.

In fact, one may perceive such a change of mindset effort, combined with a new regulatory scheme, that often appears as theoretical oriented only, as a try to force a square through a circle.

Fly Your Drone Wherever & Whenever You Want

Weren't you aware of that, dear reader? Of course, you did not see the well-known, magic sentence "Special terms and conditions apply" written in Arial Narrow, 0.1pt, under this promising title. You may smile reading the beginning of this paragraph, but that is exactly the great improvement claimed by the European Aviation Safety Agency (EASA) when they announced a new categorization system ('Open', 'Specific' and 'Certified' categories).

This promise is true, and the associated terms and conditions are only mitigations to be put in place. Indeed, an unmitigated scheduled UAS operation poses a certain number of risks, might it be to uninvolved people and infrastructures on the ground (i.e. ground risk) and/or to other airspace users (i.e. air risk). This initial (unacceptable) risk level needs to be reduced to an acceptable level, via mitigating measures, in order to reach a common, predefined target level of safety so that the intended operation can be conducted safely. Prima facie, it seems the regulator has developed a fool-proof system with consistent rules. However, when it comes to remote pilot training requirements, this apparently comprehensive landscape becomes misty.

Sit Back, Relax, Follow The Cabin Crew Instructions & Rely On Providence That All Remote Pilots Are Adequately Trained

Without rapid improvements in terms of remote pilot training requirements, we should recommend airlines to advise their crew members adding this announcement on all flights departing from French airports. To define a global strategy from a high-level perspective is one step, which in our specific case has incredibly been well achieved by EASA in a record time. To provide relevant stakeholders –i.e. National Aviation Authorities (NAA), UAS operators and remote pilots– with the adequate set of tools and resources is another. Both actions are essential and complementary in order to implement the said strategy and to reach the associated objectives. In particular, this second step is actually missing from the drones regulatory flight path.

Among the most glaring examples are the absence of model operational documents (e.g., progress booklets, assessments reports) and the lack of harmonized remote pilots training and examination syllabi. How can we ensure that remote pilots trained in different EU Member States are harmoniously trained while harmonized training guidelines and material have not been published? As a consequence, how can we ensure that the desired target level of safety is harmoniously and permanently reached on an EU level? For the moment, we cannot.

Instructors & Examiners Wanted! Prerequisites: None

Let's imagine you are flying a DR 400 aircraft for the first time as a student pilot who is preparing for his private pilot license. Would you find acceptable that your instructor is a freshly-licensed private pilot, without proven instructional skills nor significant previous flying experience? Besides, should your final test be supervised by a pilot who is not officially recognised as a flight examiner? These are rhetorical questions, of course. Such fantasy however becomes a reality in the context of drones; remote flight instructors and examiners roles have not been defined in defiance of common sense and in ignorance of the experience we have with manned aviation.

Moreover, the International Civil Aviation Organization (ICAO) has just published associated recommendations in the 2020 edition of its Procedures for Air Navigation Services – Training (Doc 9868 a.k.a. PANS-TRG). Indeed, chapter 8 of the PANS-TRG describes the "Competency-based Training and Assessment for Remote Pilot Licence (RPL)", and section 8.4 is dedicated to the "RPAS Instructor and RPL Examiner Qualifications". What are we waiting for to use the expertise contained in this reference document and implement it in Europe?

Remote Pilot: Job or Skill?

When the Captain and First Officer of an Airbus 320 are safely bringing you and the other 185 passengers

from Paris to Nice, you certainly consider that their activity is a job called “Pilot”, itself made of competencies (knowledge, skills and attitudes). When an (adequately trained and qualified) person operates a drone and flies it from point A to point B, do you consider his activity is to be a job called “Remote Pilot”?

Without a doubt, the overwhelming majority of respondents to such a question would consider that the tasks and responsibilities of an airliner pilot are not the same as for the remote pilot of a two-kilograms unmanned flying machine. Albeit, what allows us to say that? Here, we are deliberately provocative for the sole purpose of initiating a work of serious, precise, documented and argued exchanges in order to provide a credible answer to this essential question.

Let’s Make European (unmanned) Aviation Safe Again!

Europe does not have to be ashamed of its aeronautical background compared to other continents. Beyond the few sarcastic statements contained in this article, and which aim above all to humbly awaken minds, it is essential to continue believing in a strong and competitive Europe in terms of unmanned aviation, which must necessarily pass by a continuity of the work already well initiated by EASA. Without rapid corrective actions from the regulator, this lack of tools and guidelines in terms of remote pilot training, qualification and examination will definitely have an impact on flight safety. And we all know it is a top priority and a well-established adage in aviation: We never compromise on safety.

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France
caa-aero.com

Octocopter with 4 fluxgate sensors for UXO detection
Mobile Geophysical Technologies, Germany

Transformer Station Inspection
Nordic Unmanned, Norway

Pelican (Agricultural Sprayer)
Pyka, USA

Quadrocopter Agricultural Sprayer
Skydrones, Brazil

FEATURE ARTICLE

Demand & Capacity Optimisation in U-space A Balancing Act

By Jan-Alexander Kleikemper
DACUS Consortium, Europe

Co-funded by the European Union

The main project objective of DACUS was to develop a service-oriented and performance-based approach Demand and Capacity Balancing (DCB) process to facilitate drone traffic management in urban environments. The project intended to integrate relevant demand and capacity influence factors (such as CNS performances availability), definitions (such as airspace structure), processes (such as separation management), and services (such as Strategic and Tactical Conflict Resolution) into a consistent DCB solution.

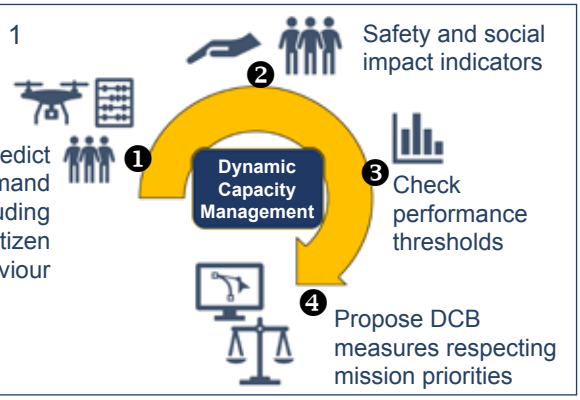
The DACUS project has explored how DCB can be provided within a U-space environment, developed a Concept of Operations (ConOps) for drone DCB in urban airspace and developed models to test fundamental aspects of this concept.

The proposed DCB process fundamentally relies on three U-space services to provide a solution: The Strategic Conflict Resolution, the Dynamic Capacity Management, and finally the Tactical Conflict Resolution, whose performances will determine the need to implement DCB solutions prior to the execution phase. These do not work in isolation but count on information provided by the entire U-space ecosystem. For this information exchange to work, the ecosystem must be based on a highly dynamic and interconnected service infrastructure.

The DCB process begins at the strategic level (several days before operation) and continuously monitors and updates the traffic situation until the actual moment of flight execution. Only when necessary, will it act on the traffic itself (i.e., a potential collision or exceeding of a capacity threshold is identified). To take a decision on whether to intervene or not, the DCB process must first quantify the level of uncertainty of the demand, for which it uses published operation plan data and other external influence factors (e.g., weather information). In parallel, a series of risk-based and social indicators are constantly monitored. These include the expected impact of operations on levels of safety, noise and visual nuisance. This requires the processing of a series of metrics (such as expected noise levels and populations densities) and other impact indicators, which are fundamental for the definition of the capacity of a given airspace.

The developed Dynamic Capacity Management (DCM) service integrated two models that reached a comparatively high level of maturity during the project duration: the Collision Risk Model, which quantified the air and ground risks as a limiting factor to determine the maximum number of drones in an urban area, and the Societal Impact Model, which measured the visual and noise effects over the population as another limiting factor. The functionality of the DCM system is explained in Figure 0.1.

Figure 1



DACUS DCB ConOps draws several parallels between existing processes in manned aviation and those proposed for U-space (such as rules of the air, operational phases, capacity enhancement and DCB in air traffic management) with the aim of highlighting differences, but also commonalities. The main differences within the U-space environment come down to the much shorter time horizon for decision-making and planning (in many cases hours instead of days), a more pronounced effect of external influence factors (such as environment, noise, and third-party risk, among others) and a much higher focus on uncertainty quantification and prediction (rather than dealing with deterministic metrics).

It has become evident that this environment is much more dynamic and multi-facetted than in traditional air traffic management, which requires the DCB concept to do the same. The concept must incorporate new business models, novel vehicles, non-human centric approaches to traffic management, much smaller operating scales, greater levels of information fidelity, diverse mission requirements and associated flight profiles, greater inclusion of societal metrics and shorter timeframes for implementation. The proposed DCB concept is based on these requirements and makes use of the state-of-the-art of relevant research to achieve them (e.g., CORUS ConOps or SESAR ER3 sibling projects).

The DCB process proposed by the DACUS project is outlined in Figure 0.2 (*next page*).

The proposed concept is built on a series of principles, which guide the DCB decisions within the U-space framework. These principles are:

1. Application of collaborative decision making to include Drone Operators within the decision-making process;
2. Prioritizing the fulfilment of mission objectives as a service to Drone Operators when selecting DCB

measures;
3. Allowing for "free-route" operations whenever constraints allow;
4. Minimization of the number of instances in which changes to drone missions are required;
5. Incorporation of predictions and the quantification of uncertainty into the DCB process, to increase robustness of DCB measures within a dynamic operating environment;
6. Recognizing the Operation Plan as the "single point of truth" which maintains continuous up-to-date information about the situation and expected evolution of the drone operation.

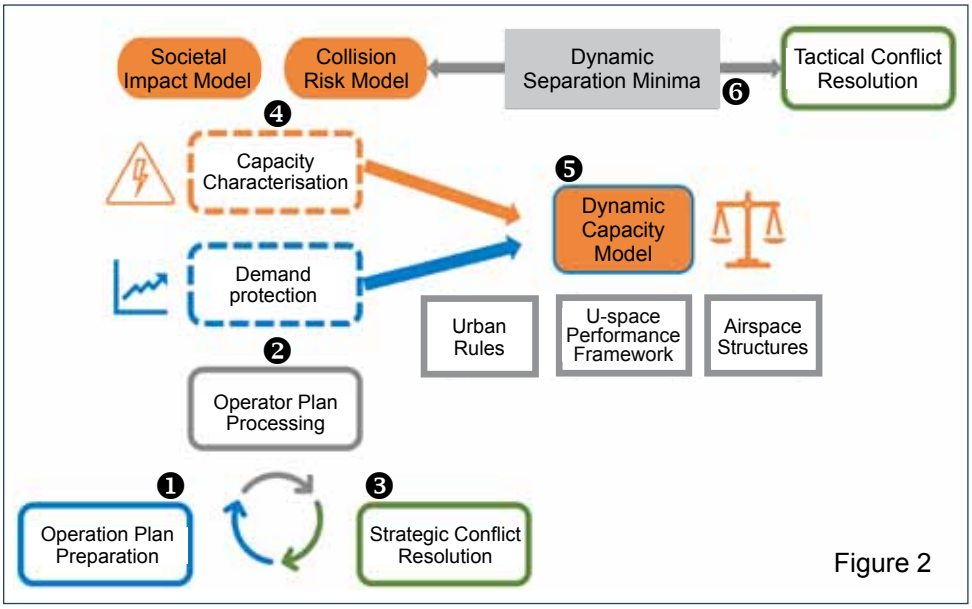


Figure 2

With the DACUS project ending in December 2022, the project consortium is emphasizing the importance of a Demand and Capacity Balancing process through the Dynamic Capacity Management service to be part of the next U-space ConOps revisions.

The DACUS Project has received funding from the SESAR Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement. No 893864.

The project's lifetime was from July 2020 until December 2022.

11 Partners were involved in the consortium, namely: CRIDA (Spain)/Coordinator, Aha (Iceland), Boeing Research & Technology (Spain), ENAIRE (Spain), EUROCONTROL (Belgium), Ineco (Spain), ISA Software (France), Sopra Steria (France), Jeppesen (Germany), Toulouse Métropole (France), TU Darmstadt (Germany).

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FEATURE ARTICLE

Drone Council Nederland

By Matthijs van Miltenburgh
Drone Council Nederland, The Netherlands

The Drone Council Nederland (DCNL), established in the spring of 2022, is a public-private partnership bringing together representatives from the Dutch drone sector and relevant governmental authorities. The DCNL is a collaboration for and with the sector to give direction to the development of drone usage in the Netherlands by bringing together relevant interests and knowledge. From across the field various parties participate in the DCNL, namely governmental authorities, agencies and municipalities, drone manufacturers and operators, special interest groups, knowledge institutions and manned aviation.

Purpose & Objectives

The drone sector in the Netherlands is very young and dynamic, and currently organised only to a limited extent. In recent years, most interactions in the drone sector have been on an ad hoc basis. To gain more insight into developments in the drone sector, the various implicated parties require stronger coordination and more structural consultation. Structural cooperation is set up in the form of the Drone Council Netherlands (DCNL), which permits policy makers and drone sector parties to join forces.

The purpose of the DCNL is to make it possible for public and private parties to jointly create a national vision for the development and usage of drones in the Netherlands. We do this in coordination with the various interests of the drone sector parties, as well as the parties outside this sector, such as general aviation. To fulfil this objective, the DCNL focuses on the following goals:

- Create consensually agreed recommendations relative to drone-related development and formulate positions relative to the deployment of drones.
- Set up a network of public and private parties to improve and secure structural cooperation between them.
- Advise on policy and decision-making, laws and regulations, and licensing, supervision and enforcement.
- Promote knowledge sharing, both among drone parties and between drone parties and parties outside the drone sector.

The advice resulting from the Council can be directed to the parties collectively, to government parties such as legislator and regulator, but can also focus on knowledge institutions or (certain parts of) the industry.

Participants

Many different sectors and policy areas are involved in the development of drones and their operation. Their impact is widespread: developments in the drone sector touch on choices regarding mobility, safety, innovation and privacy made at local, regional, national and European level. In short, a large number of parties are involved, from different perspectives and with diverse interests. The number of parties is expected to increase further in the coming years. On the other hand, we have the desire to achieve a decisive DCNL. This means that not every party can be involved to the same extent. The programme Board of the DCNL therefor consists of 10 participants and a chairman. The participants each represent a part of the industry or government. Incumbent participants and umbrella organisations all have the responsibility to organize the necessary mandate from their constituencies.

The following entities participate in the programme Board:

- Ministry of Infrastructure & Water Management
- DCRO – Association of Dutch Certified RPAS Operators
- KNVvL – Koninklijke Nederlandse Vereniging voor Luchtvaart (Royal Netherlands Association for Aviation)
- AOPA Netherlands – Aircraft Owners & Pilots Association Netherlands
- Rijkswaterstaat – State drone operators
- Dutch Drone Delta (national association to promote urban air mobility)
- Dutch Drone Platform (national network of test and innovation centres)
- Drone Netwerk Gemeenten (network of municipalities)
- Interprovinciale Contactgroep Luchtvaart (Inter-provincial Aviation Contact Group)
- DroneHub Noord Nederland (partnership to promote unmanned aviation in the northern provinces of the Netherlands.

Governance & Responsibilities

In April 2022, the DCNL organised a first meeting. During this meeting, the participating parties signed an agreement of cooperation, which describes the governance structure of DCNL and the responsibilities of the participants. The DCNL consists of a board and a number of working groups.

The Board is responsible for the steering and decision-making of the DCNL. The Board defines the work agenda and plays a strategic role in the development of the Dutch drone sector. The Board is chaired by an independent chairman who has knowledge of the drone sector. The chairman is responsible for making agreements between the cooperating parties and draws up an agenda of themes and issues.

A number of working groups have been established under the board. Currently there are two; ‘Airspace’ and ‘Responsible Flying’. This number is expected to grow

in the coming years. The working groups form the heart of DCNL. Based on the goals and themes indicated in the DCNL's strategic plan 2022, the working groups start working on concrete issues. Each working group will formulate a plan with a problem definition, an approach and an intended result. For each working group, the parties having an interest in the issue to be dealt with are explored/identified and asked to join. Thus, parties that are not members of the DCNL Board can also participate in the working groups. The set-up of the working groups is monitored semi-annually by the Board and adjusted (temporarily) where necessary.

Working Groups

- The ''Airspace'' working group works with various sector parties and government bodies to examine the issues involved with integrating drones into airspace.
- The ''Responsible Flying'' working group works with various stakeholders to develop knowledge relative to the public acceptance of drones. These insights are taken into account by the drone sector in its further development.

Activities

Drones offer opportunities for a sustainable and innovative Netherlands. The practical applications are manifold. Drones can help inspect infrastructure or nature; they can be used for package delivery; they can assist emergency services; and they drive sustainable aviation innovation. The Board is working on ''the story of drones in the Netherlands'' to better visualize the impact drones have on various sectors. A vision and strategy can help clarify how drone technology can contribute to (inter)national goals to which the Dutch government is committed.

Matthijs van Miltenburg
Chairman
Drone Council Nederland
The Netherlands

Agricultural Research - ZLTO, The Netherlands

Harbour Inspection - Avy Drones, The Netherlands

Bridge Inspection - Rijkswaterstaat, The Netherlands

Aircraft Inspection - Mainblades, The Netherlands

FEATURE ARTICLE

Enabling BVLOS Drone Operations With Absolute Connection Confidence

By Ben Gross
Elsight, Israel

When embarking on drone BVLOS operations, you will find that regardless of the mission, all drones require a number of key elements and components for top performance: Optimal SWaP (Size, weight, and power consumption), flight computer, mission planner, and a connectivity solution.

The mission planner is required in order to optimize the operations, taking into account the various conditions pre- and during flight. The optimal SWaP is a necessity for completing long-range missions. The flight computer and connectivity solution are the unique elements, which will end up being the factors determining whether, or rather how successfully, your drone can fly BVLOS missions.

This where the Elsight Halo comes in. Halo is a device, about the size of a credit-card, which provides unparalleled and unmatched connection confidence for drone BVLOS missions. It takes up to four LTE mobile networks, RF SatCom, and bonds them into a single, secured VPN link for C2 between the drone and the ground control station (GCS) – alongside complete data redundancy.

Essentially, Halo is what you would get if you were to connect a massive (virtual) LAN cable between the drone and the GCS, with an unprecedented and unheard of 99.8 percent continuous uptime.
Connection Confidence

The Halo was born, based on more than 10 years of experience with transmitting uninterrupted A/V transmissions, as well as Elsight's proprietary "6th Sense" AI-powered connectivity monitoring solution.

Today, Halo is used by more than 60 drone operators and manufacturers around the globe, including large and well-known names such as DroneUp and Spright in the United States, Speedbird.Aero in Brazil, as well as many others in Europe, Canada, Latin America, Africa, Asia, and Australia.

Halo aggregates numerous LTE and 5G mobile networks, plus other forms of communications such as RF and satellite, into a secured network pipeline. It breaks down transmitted data into packets, which are then duplicated and sent over multiple paths through the Elsight cloud, upon which the data is recombined with zero packet loss, thus creating a comprehensive whole which never loses any of the data sent over the network –be it sensor data, control, telemetry, or otherwise.
Joining this is the company's proprietary AI technology, "6th Sense", which monitors the network strength multiple times each second. "6th Sense" automatically balances the traffic along the bonded networks, shunting traffic to the links, which are most ideal for the specific drone's unique requirements, as well as the link's capability and capacity. Halo and "6th Sense" can choose a network based on the user's preferred network, a predetermined minimum bandwidth, or based on other custom preferences as decided by the drone operator.

The powerful functionality is what enables the redundancy essential for long-range UAS operations, while also avoiding the standard failover, which requires a network disconnect, drop or connectivity loss before switching over to a new network.

Additional Features

In addition to the absolute connection confidence – which provides BVLOS drone operators with the assurances that they will remain constantly and consistently connected with their drones – Halo also has a number of other supported features, each of which provide the user with added benefits, without increasing the drone's SWaP profile.

Broadcast and Network Remote ID

Drone manufacturers must soon begin to comply with the FAA's ruling requirements, and by September 2023, all drone pilots will also be required to meet the part 89 operating requirements. For most operators, this will entail flying a Standard Remote ID Drone, one which is equipped with a standard broadcast module. Halo supports both Bluetooth and cellular network Remote ID, and is working on also implementing support for Wi-Fi. With this system a drone operator will have a fully FAA-compliant Remote ID solution, well before the compliance dates come into effect.

5G Support

5G, the 5th generation of cellular-mobile communications, is poised to eventually take over from 4G as the dominant communications method. 5G brings with it greatly increased connection speeds, theoretical maximums 100 times faster than 4G. 5G supports a larger density of unique devices (which is a critical component to enabling UTM as the field develops in the future), and has much-reduced latency when compared to 4G.

When all of these features are combined, they can help BVLOS drone operators keep abreast of the ever-growing amounts of data, which are generated by sensors and modern HD cameras, while also allowing operators to take advantage of cloud server data processing. When joined with the increased density capacity of unique devices, this can facilitate drone-swarm operations at a range and

level previously unheard of. Halo provides support for SA and NSA 5G services – as drone manufacturers are ready to take advantage of the characteristics that the 5G rollout has to offer.

Hyper-Accurate GNSS

In conjunction with a partner, running the partner's software on Halo by means of a dedicated, robust API, it offers a cost-effective and precise positioning solution, which requires no additional software or hardware requirements. This hyper-accurate GNSS operates in both open-sky and urban area environments and provides cm-level accurate results on the ground. The GNSS has zero-latency positioning, and instantaneous precise positioning which eliminates convergence time.
The Future of BVLOS Operations

When looking beyond the now and into the future of BVLOS drones, it is easy to see that BVLOS is about far more than just flying outside the operator's line of sight, and includes two main industry goals:

- The ability to take off, land and operate a drone without requiring it to be "led by the hand" by a trained pilot.
- Allowing one single drone pilot to simultaneously control and supervise multiple drones from a Drone Network Operation Center (DNOC).

BVLOS operations, paired alongside a Drone Network Operation Center will exponentially increase the possible applications for the controlled drones, as well as their distance. Utilities operators will be able to inspect hundreds of miles of pipes or cables with drones. Agricultural operators will be able to cover fields hundreds of acres in size by using several drones at the same time. Retailers and delivery centers will begin carrying out efficient mid- or last-mile deliveries.

These are just a small number of the use cases, which become available once operators can take full advantage of flying their drones beyond the visual line of sight.

The Halo is a tool enabling these goals and turning them into reality. With Halo and Allsight, the Elsight cloud management platform, a single remote pilot is able to pilot hundreds of drones at ease from any spot on the planet, where each drone broadcasts its own unique ID and knows its precise location within a few cm.

Halo is the launching pad upon which future BVLOS drone operations can become reality.

Ben Gross
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elsight.com

FEATURE ARTICLE

Automated Offshore Aerial Delivery of Spareparts

By Anders la Cour-Harbo, Aalborg University, Denmark
ADD2Wind Project Manager
Jonas Nørholm Larsen, Energy Cluster, Denmark

Automated offshore delivery of spare parts is the goal of the ADD2Wind innovation project (2020-24) funded (€2 million) by the Danish Energy Technology Development and Demonstration Programme. The project partners are Aalborg University (DK), Aeroscout (CH), EMG (DK), Energy Cluster Denmark (DK), Loxar (DK), Ørsted (DK), Vattenfall (SE), Siemens Gamesa Renewable Energy (DK), Vestas (DK).

The consortium works with two scenarios: Planned and unplanned offshore services. Planned is when a lot of equipment is needed by technicians working at a wind farm. Unplanned is when a component suddenly breaks and needs replacement. In both cases, it is the intent to use automatic drones for the delivery of the spare parts.

In the planned services scenario, the drones from the ADD2wind project conduct regular cargo transport missions between the port and the wind farm. Up to 500 kg of spare parts can easily be used for each turbine during a planned service period. We imagine a situation where our delivery drone flies between 500 & 1000 times back and forth between the service port and the wind farm with equipment during weeks of service – a solution that is much cheaper than single flights on demand.

A Green Alternative

The offshore wind farms to be serviced are located more than 30 kilometres from shore, and drones can be a cost-efficient and green alternative to the vessels used today.

The vessels use 50 to 100 times more fuel than our drone. And the drone is not susceptible to waves and changing tides. If a technician is missing something, we can deliver the spare parts by drone within 30 to 45 minutes. Our drone can be in the air for up to three hours.

Cargo Container

The drone in the ADD2wind project will operate with a specially designed cargo container. When it approaches the offshore wind turbine, the drone lowers the cargo container down onto the helideck on top of the turbine nacelle. This is done using a specialized winch. Afterward, a technician can easily retrieve the bag through a hatch.

The consortium's mission is to supply a drone that can fly automatically to the wind turbine. When it approaches the wind turbine, the drone control is taken over by a remote pilot to ensure safe delivery. The drone is fitted with a video camera and a scanning LIDAR to provide situational awareness for the pilot.

Offshore Wind Industry

Some of the major global players in offshore wind participate in the project. Vattenfall and Ørsted own a large number of wind farms, and Siemens Gamesa and Vestas are two of the major offshore wind turbine manufacturers.


Scout B-330
Aeroscout, Switzerland

The wind industry players are the "problem owners" in the project. They see the potential in the technology and are willing to collaborate on innovation. The SMEs in the project are the "problem solvers" alongside us at the university. Aeroscout from Switzerland is building the drone and conducts the test flights. At Aalborg University we are building the equipment installed on the drone required for the delivery.

The Esbjerg-based company EMG is developing the drone-borne delivery container. It must be suitable for transportation in open air, be waterproof, and ultimately have the capability of enduring days in stormy weather on top of a turbine in the North Sea. It is being purpose-designed and has double layers of foam inside to keep the cargo in prime condition.

Next Step

The project partners expect to test the drone technology at offshore turbines located onshore in early 2023. An offshore test is expected to be completed during autumn 2023. The project partners are ready for testing, but are still waiting for flight permissions from the authorities in Denmark. The intention is to test the technology on three onshore wind turbines with a height of 140 metres located in the western part of Denmark in 2023. Moreover, the permissions to fly in Switzerland have already been obtained and an initial test of the delivery technology is planned for November 2022.

It is expected that the project partners will have a fully functional prototype available for deployment by the end of the project period in 2024. Currently, the focus is on potential problems and safety issues. What happens if you lose GPS, and what happens if the delivery bag does not detach? Such challenges will be addressed during the test flights in the upcoming months.

FEATURE ARTICLE

Air Taxi To The Wind Farm!

By Marcus Ihle & Jonas Janke
Energie Baden-Württemberg (EnBW), Germany

In a joint project, the energy group EnBW is investigating how off-shore wind farms can be operated with the help of heavy-lift drones.

The rotors of a wind farm are rotating around 100 kilometers from the mainland. Suddenly, an air taxi approaches and drops off three people on a landing pad 100 meters above the water. The engineers cheerfully disembark. They don't have to carry any equipment. A short time before, a heavy-lift drone had already dropped off tools and spare parts on the pad. One hour before the end of the working day, the self-flying taxi picks up the engineers again. They are home in time to eat their evening meal with their families.

What sounds like science fiction could soon become reality. That's be-cause heavy-lift drones have got what it takes to revolutionize the operation of offshore wind farms. They are faster than ships. And they are cheaper to operate than helicopters. Drones are becoming more and more automated, which in turn will have a positive effect on costs. In addition, they fly with hybrid or electric propulsion systems and thus have the potential to play their own part in achieving climate targets.

Yet under what circumstances is the use of drones actually a worthwhile proposition for wind farm operators? The "Upcoming Drones Wind Farm" (UDW) project is setting out to answer this question. Besides the energy group EnBW, the project participants include the German Aerospace Center (DLR), the German Federal Maritime and Hydrographic Agency (BSH) and the wind turbine manufacturer 2-B Energy.

Together they want to determine how offshore wind farms must be equipped in order to fly personnel and materials economically and safely over the sea by drone and what features the drones must possess to enable them to operate in this environment. Where can they land safely? How must the transport containers and cabins be designed? How do the drone and the wind farm communicate with one another? What form should the legal framework take and which authority can approve the flights? Answers to these questions can cer-tainly be found – but only with a great deal of effort.

A Long Range and Heavy Loads

Small drones are already being used in offshore wind farms. They fly around the rotor blades with thermal imaging cameras and provide photos that can identify any material damage. However, the range and load-bearing capacity of small drones are limited. The UDW project, meanwhile, involves drones with a range of about 100 kilometers that can carry loads of up to 200 kilograms. The experts involved in the project are therefore monitoring the development of high-performance drones used for transporting people very carefully. They are on the verge of a breakthrough. The German manufacturer Volocopter, for example, wants to use air taxis at the 2024 Olympic Games in the Paris region to fly passengers across the congested metropolitan area to the competition venues.

The existing technology must be adapted to meet the needs of an off-shore wind industry that will become ever more important. By 2030, wind turbines with an output of 30 gigawatts are expected to be rotating off the German coasts alone. There are plans to more than double this figure to 70 gigawatts by 2045. Offshore wind power will thus play a fundamental role in the supply of energy.

Where Drones Can Cut Costs

This expansion is costing the industry many billions of euros. Operators who want to build an offshore wind farm must participate in an auction. Whoever can operate the wind farm most inexpensively will be awarded the contract in the tendering process. This in turn means that the ongoing operating costs must be kept as low as possible.

After all, the investment has to be worthwhile.

And where can operators achieve the most cost savings? The answer lies in the area of transport and logistics. Special cargo ships are cur-rently used to transport personnel and materials to the wind farms. This takes hours. Upon arrival, the engineers – dressed in heavy safety clothing – cross over to the turbine using a platform ladder. They then have to use a crane positioned at the foot of the foundations to haul the materials up to the wind turbine. An engineer subsequently travels by elevator up to the nacelle and hoists the load to the top using a sec-ond crane. Only then can the actual work begin. This process would be much cheaper and faster if a heavy-lift drone were to drop off personnel and materials directly at the right height.

At present, the engineers remain at sea for two weeks at a time, depending on the distance of the wind farm from the coast. They live on special service vessels anchored close to the wind farms. There are material stores, a canteen, accommodation and social rooms on board. The crews work hard during their weeks spent at sea. The operators are well aware of this and create the best possible conditions, although this is expensive.

For the first time, the UDW project combines the technology of drones with that of wind farms. As such, the partners are bringing very different knowledge to the table.

The DLR is regarded in Europe as one of the leading institutions specializing in unmanned flight. By way of example, from the conception to the actual trial flights, DLR scientists are investigating various unmanned aircraft systems for transporting cargo in the ALAADy (Automated Low Altitude Air Delivery) project. Operational scenarios investigated also include the delivery of humanitarian aid.

EnBW has been gaining experience in the operation of wind farms for more than a decade. The experts at the company know how these projects have to be planned. They are familiar with the obstacles involved in the complex approval procedures and have experience of constructing wind turbines on the high seas.

Obstacle Course

Connecting the world of drones with offshore wind power sounds easier than it actually is. Even on land, planning and monitoring the flight route of a drone are difficult tasks. Completely new conditions come into play where offshore wind farms are concerned. Not just on account of the changeable and rough weather. When the wind changes direction, the rotors are realigned. Accordingly, the drone's planned flight path must be constantly updated. The aim is to manage an ap-proach in the slipstream of the rotor, stopping as few turbines as possible along the drone's path. The powerful rotors also swirl the air in the wind farms. This can also affect the flight of the drones and must be included in the calculations.

The Dutch manufacturer 2-B Energy knows how wind turbines need to be designed if drones are to land on them. The company is contributing its experience in the development of landing pads to the project and specializes in two-bladed rotors, which are viewed as somewhat exotic within the wind power industry, but they may have advantages for the approaching drones.

The German Federal Maritime and Hydrographic Agency (BSH), meanwhile, is looking at regulatory issues surrounding the project. One of the agency's current tasks is to approve new wind farms within Germany's exclusive economic zone (EEZ).

EnBW's Baltic 2 wind farm provides an idea of how complex the legal issues surrounding the use of drones in wind farms can be. Even though it is located within the German EEZ, it directly borders the Danish and Swedish EEZs. If drones were used here, they may have to pass through foreign airspace on approach. Technically, this is not a problem. The legal implications of this, however, must be examined.

Sharing Is Better Than Buying

Anyone who operates a heavy-lift drone essentially becomes an aviation company on paper. At least that is the case when people are transported. This brings with it a number of obligations. These range from certification and examinations to training for drone pilots. It creates a great deal of work for an energy company that is not familiar with aviation problems.

The aim is therefore for wind farm operators to book logistics services with specialized companies precisely when they are needed – as is already the case with helicopters. By doing so, drones can be utilized more efficiently and operated more cheaply. Different business models are also set to be calculated over the course of the three-year project.

The project extends far beyond the companies directly involved. It is intended to involve the entire drone industry. An Offshore Drone Challenge (ODC) has been organized so that individual manufacturers can show whether they are able to transport heavy loads to offshore wind farms. The tests planned in this context will establish how well the industry can already accomplish such a mission and identify the areas where work still needs to be done.

The project is being funded by the German Federal Ministry for Economic Affairs and Climate Action. At WindEnergy Hamburg 2022, a gathering for players in the wind industry, the participating organizations and companies presented themselves to the public for the first time. The dialogue is set to continue at Amsterdam Drone Week in March 2023. And perhaps it will be clearer in the following year by which time the first heavy-lift drone will land in a wind farm on the high seas.

Michael Splett
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FEATURE ARTICLE

EUROCAE Supports the Drone Industry Through Standardisation

By Anna von Groote
EUROCAE, France

EUROCAE is the European leader in the development of worldwide recognised industry standards for aviation. It takes an active role in coordinating European and global standardisation activities and developing high-quality standards that build upon state-of-the art expertise of its members, are fit for purpose and adopted internationally, support operations, development and regulations, and address emerging global aviation challenges.

EUROCAE is an independent non-profit organisation with 60 years of experience in the domain of aviation standardisation. It has a long-standing successful record in high quality and safety critical standardisation and has been recognised for following the World Trade Organisation's code of good conduct for standardisation, which is testament to its open, transparent, and consensus-based process. EUROCAE aims to increase safety and market potential in the aviation industry, facilitate interoperability, and encourage technological development in the interest of its members. We offer a platform to develop internationally recognised standards, either as a EUROCAE Document (ED), EUROCAE Report (ER), or an Internal Report. The activities are organised by Working Groups (WGs). We currently have around 50 WGs, 450+ worldwide members, including manufacturers, service providers, regulators, and research institutions, and over 5000 global experts who actively contribute to the development or revision of standards on a voluntary basis.

EUROCAE WG-105 Unmanned Aircraft Systems (UAS) is tasked to develop the necessary standards to enable safe integration of UAS into all classes of airspace, with due consideration of the emerging European regulatory proportionate risk-based approach, of the related categories of operations (Open, Specific and Certified) and of industry requirements. WG-105 maintains a close coordination and alignment with EASA, and its work programme is developed according to the needs of the industry, while supporting future EU drone regulation to enable safe and efficient drone operations. The WG is divided into six subgroups (SGs) to encompass the broad scope of the topics addressed:

- SG-1: Detect and Avoid (DAA)
- SG-2: Command, Control, Communication, and Security (C3&S)
- SG-3: U-space/UAS Traffic Management (UTM)
- SG-4: Design and Airworthiness (D&AW)
- SG-5: Enhanced RPAS Automation (ERA)
- SG-6: Specific Operations Risk Assessment (SORA)

As the SGs perform diverse activities, a Steering Committee (SG-0) was established to manage and coordinate the status of activities in WG-105. It comprises of the WG Co-chairs, Secretary, Technical Programme Manager, SG leaders, and invited stakeholder representatives. Over 20 standards have been published since its inception in 2016. This is a non-exhaustive list of some of the standards that have been published since 2016:

- DAA: o ED-271 Minimum Aviation System Performance Standard for Detect and Avoid (Traffic) in Class A-C airspaces
  - ED-258 Operational Services and Environment Definition for Detect and Avoid [Traffic] in Class D-G Airspaces under VFR/IFR
  - ED-267 Operational Services and Environment Definition for Detect and Avoid for VLL
- C3&S:
  - ER-016 RPAS 5030-5091 MHz CNPC LOS and BLOS Compatibility Study
  - ED-266 Guidance on Spectrum Access, Use and Management for UAS
- UTM: o ED-269 Minimum Operational Performance Standard for UAS Geo-Fencing
  - ED-270 Minimum Operational Performance Standard for UAS Geo-Caging
  - ED-282 Minimum Operational Performance Standard for Unmanned Aircraft System Electronic Reporting
- D&AW:
  - ER-019 Inputs to RPAS AMC 1309
  - ED-272 Minimum Aviation System Performance Standard for Remote Pilot Stations Supporting IFR Operations in Non-Segregated Airspace
  - ED-279 Generic Functional Hazard Assessment for UAS and RPAS
- ERA:
  - ED-281 Minimum Aviation System Performance Standards for RPAS Automation and Emergency Recovery
  - ED-283 Minimum Aviation System Performance Standards for RPAS Automatic Take-off and Landing (ATOL)
  - ED-284 Minimum Aviation System Performance Standards for RPAS Automatic Taxiing
  - ED-251 Operational Services and Environment Definition for RPAS Automatic Taxiing
  - ED-252 Operational Services and Environment Definition for RPAS Automatic Take-off and Landing
  - ED-253 Operational Services and Environment Definition for Automation and Emergency Recovery
- SORA:
  - ED-280 Guidelines for UAS Safety Analysis for the Specific Category with Low and Medium Levels of

Robustness
- ED-301 Guidelines for the Use of Multi-GNSS Solutions for UAS Specific Category – Low Risk Operations SAIL I and II

ED-301 was published in August 2022 and is intended for operations in Low Risk (SAIL I and II) in the specific category. Further versions of this document will deal with Medium and High Risk in the same category. SORA Operational Safety Objective (OSO) #13 is also applicable to higher Specific Assurance and Integrity Levels (SAIL) operations in the specific category but with different level of assurance, which may take the form of a Service Level Agreement (SLA) with external Global Navigation Satellite System (GNSS) service providers. This changes the approach with respect to Low Risk operations, so a new standard will be defined instead of evolving ED-301. ED-xxx titled 'Guidelines for the Use of Multi-GNSS Solutions for UAS: Medium Risk' has been initiated to address this. It is expected to be published in Q2 2024.

Some of our published standards have been recognised as Acceptable Means of Compliance (AMC) or Guidance Material (GM) by EASA. This means that applicants can use a recognised EUROCAE standard to demonstrate compliance to a certain section of a regulation.

There are several ongoing activities in each SG:

- SG-1 DAA o Draft ED-271A, Minimum Aviation System Performance Specification for Detect and Avoid [Traffic] under IFR
  - Minimum Operational Performance Specification (MOPS) for Detect and Avoid [Traffic] under IFR
  - Minimum Operational Performance Specification for Detect and Avoid in Very Low-Level Operations
  - European Industry Position Report on RTCA SC-147 ACAS sXu
- SG-2 C3&S
  - Draft ED-265, Minimum Operational Performance Specification for RPAS Command and Control Data Link (C-Band Satellite)
  - Minimum Operational Performance Specification for UAS Communications by Cellular Networks
  - UAS C2 MASPS European Stakeholders Report
- SG-3 U-space/UTM
  - Technical Specification for Geographical Zones and U-Space Data Provision and Exchange
  - Minimum Operational Performance Standard for Network Identification Service of Unmanned Aerial Vehicles for A/UTM/U-space
  - Minimum Operational Performance Standard for Flight Planning and Authorisation Service for Global Awareness in A/UTM/U-space
  - Minimum Operational Performance Standard for Traffic Information/Situation Dissemination Exchange Format and Service
  - Minimum Operational Performance Standard for U-space Geo-Awareness Service
- SG-4 D&AW
  - Minimum Operational Performance Standard for Command Unit Core Layer of UAS to be Operated in the EASA Certified Category of Operations
  - Guidance Document to Support the Development of Means of Compliance (MoC) for EASA Special Condition Light-UAS – Medium Risk
- SG-6 SORA
  - Guidelines on the Automatic Protection of the Flight Envelope from Human Errors for UAS
  - Draft ED-280A, Guidelines for UAS Safety Analysis for the Specific Category – Low and Medium Levels of Robustness
  - Guidelines for SAIL II Application of SORA
  - Guidelines for the Use of Multi-GNSS Solutions for UAS: Medium Risk

EUROCAE has established cooperation agreements with several organisations to ensure that activities within the UAS domain are coordinated and discussed. A MoU/MoC has been set up with most major Standard Developing Organisations (SDOs), and we maintain a liaison status at ISO/TC 20/SC 16, which addresses Unmanned Aircraft Systems. An MoU has also been established with GUTMA to discuss U-space topics. EUROCAE WG-105 provides inputs to ANSI Unmanned Aircraft Systems Standardization Collaborative (UASSC) Roadmap on a regular basis to support coordination of activities between Europe and North America.

The main purpose of WG-105 is to complement the UAS regulatory framework with performance-based standards. As the aviation industry shifts from prescriptive regulatory frameworks to performance-based regulations, standards are the need of the hour. When standards are recognised by the regulator, they become a means for stakeholders to comply with the corresponding regulation. There are several initiatives and ongoing activities by stakeholders from different domains that address UAS topics, therefore it is crucial to ensure a coordinated and harmonised elaboration and implementation of UAS functionalities.

The European UAS Standards Coordination Group (EUSCG) was established with this objective, and it functions as a joint coordination and advisory group that streamlines standardisation activities across Europe, essentially those stemming from EU regulations and EASA rulemaking initiatives. The EUSCG provides a link to bridge European activities to those at the international level. The main task of the EUSCG is to develop, monitor, and maintain an overarching European UAS Standardisation Rolling Development Plan (U-RDP), which is based on the standardisation roadmap that is developed by EASA and other organisations, and it includes inputs from EUSCG members. This facilitates the sharing of work between the regulator and SDOs, thus avoiding the risk of duplication and overlapping developments, while addressing gaps therein. EUSCG is chaired by EASA, and EUROCAE provides the secretary role. More information on EUSCG and the U-RDP are available at **euscg.eu**.

EUROCAE is open to worldwide participation and invites organisations to participate in the standard development

process. EUROCAE is a membership-based organisation, and it offers a full and a limited membership. A candidate membership option is also available, which is free of cost, so that members can participate in our activities for up to three months to understand the scope and nature of the standards being developed. EUROCAE standards are subject to an open consultation process, where the draft standard is distributed to the public via EUROCAE Workspace, and everyone is invited to review and comment on the document.

If you are interested in obtaining additional information, or if you would like to become a EUROCAE member, please check the membership page on our web site.

Anna von Groote
Secretary General
EUROCAE
France
www.eurocae.net

Tethered Automatic Fruit Picking - Tevel Aerobotics, Israel

Autonomous Perimeter Inspection - Nightingale Security, USA

Defibrillator Transport - Everdrone, Sweden

Fire Rescue - M450 - Vira Drone, Germany

Biological Control Capsule Distributor - Aermatica3D, Italy

Drone with Forest Survey SAR - SkyDrones & Radaz, Brazil

FEATURE ARTICLE

Drone Operations in a Critical Infrastructure Environment

By Michael Witting Schipper
HHLA Sky GmbH, Germany

With drones becoming an essential part of operations in industrial settings and critical infrastructure environments, no one can deny that, whether they are used for inspections, surveillance, mapping or logistics, they can be extremely beneficial. But what exactly is the benefit of the application of these technologies? What are the advantages for plant operations? Are they simply a fad with no long term perspective? And most importantly, how can one implement a UAS division in operations on industrial settings in a way that is realistic and efficient?

Luckily, HHLA Sky GmbH has had the amazing opportunity to execute drone operations in a critical infrastructure environment at container terminals for the past years. In operating drones in such a challenging context, we have been able to gather considerable experience to address the previous questions.

HHLA Sky GmbH is a technology provider from Germany for both software and hardware. The company is based in the city of Hamburg and operates regularly in its working harbour. There, we have the opportunity to improve certain tasks already being carried out on the terminal in which we are based in a more efficient way. We´ve been able to see how beneficial the application of these technologies can be in port logistics and critical infrastructure in general. We, as a company, have also experienced challenges, for which we have had to develop new operational concepts, processes and technology in a way that results in actionable data for the end-user.

One aim of the company has been to optimize already existing operations with automatic systems. To fulfil this aim, we utilize our own control centre, which is capable of controlling more than 100 simultaneous UAS flights through a mobile connection under BVLOS rules. The level of automation provided by this platform has opened new doors to a high level of quality, efficiency, and safety for different use cases.

One of the first use cases that comes to mind are inspections. Container terminals depend on multiple container cranes that require regular inspections to determine and document their status, at least twice a year. With traditional inspection methods, climbers have to execute high-risk operations on infrastructure by physically climbing the cranes. The average height of such cranes in our terminals is 83 metres in the lowered position. That means that they put themselves at risk every day to perform this task. If any mistake were to be made during an inspection, this can pose a hazard to the life of the worker due to the height at which the work is performed.

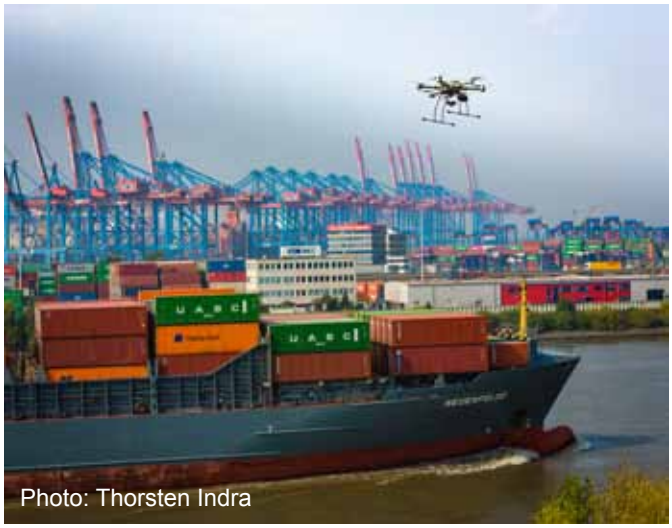


Photo: Thorsten Indra

The solution we provide significantly mitigates the risk of these operations by replacing the climber with a system that can perform the job faster, more efficiently, and which, unlike human life, is replaceable. A real benefit for work place security and insurance premiums.

Utilizing automated drone inspections also increases efficiency and reduces down time, given that, for starters, the preparation for an inspection with unmanned aircraft systems takes significantly less time than it would with professional climbers. It also takes significant less time to finish a job.

An average of 5 climbers are needed to do a full inspection of a container crane, taking an average of 24 hours to complete. In comparison, a single person can carry out the same inspection, reducing the time to 8 hours with a manually operated system. This would include the preparation phase, flights and and post processing of up to 1000 pictures. An increased level of automation further increases this efficiency, and also makes the missions repeatable. With this structured process, comparison over time becomes possible, and thereby lays the foundation to detect degradation earlier, so that maintenance measures can be carried out at the right time.

Since, as mentioned before, container cranes are typically inspected twice a year, they have to be put out of service for the amount of time it would take to perform the inspections. This inhibits the cranes from working around the clock, an action that is essential to the harbour ecosystem.

Utilizing a UAS to perform manual flights for inspections can reduce the time the cranes would be inactive by

approximately 72%, and it is estimated that it can reduce economic losses caused by this inactivity by 90%. This knowledge can be transferred to other complex infrastructures which need to be inspected regularly for safety and compliance reasons.

Having access to automation features provides an extra reduction of time to fulfil the same task. HHLA Sky GmbH has developed a feature on our control centre, which lets the user plan and execute precise automated inspection. Our so-called “Recording Mission” planning feature enables the user to execute a manual flight around critical infrastructure, which is automatically saved. These missions are anchored to a reference point device placed on top of the cranes and programmed with precise, specific camera actions. Once this process is done once, the mission simply is saved and can be re-used, again and again, as needed. It will be executed perfectly, regardless of whether the crane has changed its position or not. As a result, efficiency and effectivity is increased further.

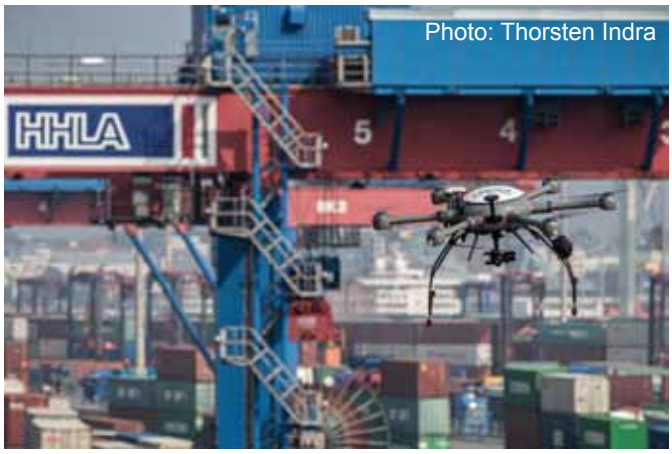
Another use case that greatly benefits from UAS operations is intralogistics. The fulfilment of spare parts and documentation transport within a critical infrastructure environment is an essential and often overlooked aspect of the business, which normally is done with cars.

Integrated Control Centre

Anyone who has seen an industrial campus or a harbor map, especially of the biggest ports in Europe, knows how complex and time-consuming it can be to drive around a terminal to simply deliver small parts or documents that may be the key to have a continuous operation. This strategy is highly inefficient, creates unnecessary costs and, for the most part, creates unwanted CO2 emissions and creates extra costs.

We have determined that the implementation of UAS can reduce the time required by approximately 50%, as well as reducing costs by 70%. On another hand, it cuts emissions caused by the use of cars to 0.

Overall, intralogistics will be a really good application for drones, but there is a trick. Since most missions would have to be long range flights, the key in order to make these tasks possible is BVLOS operations. To make that possible, one needs a safe and effective platform that meets the applicable cybersecurity standards.



On another hand, one has to be innovative, but not too idealistic. Simply having the proper technology is not enough or realistic. Just like in any operation in critical/ hazardous infrastructure environments, appropriate procedures and certified equipment have to be implemented, in order to minimize the risk of human error and to ensure a smooth execution of tasks.

The cybersecurity aspect cannot be forgotten in these environments. It is a well known fact, that protecting an information critical infrastructure is of outmost importance. HHLA Sky GmbH noticed that, in order to cover that need, a proper certification of our platform and processes was needed. Because of this need, we went trough the process, and were able to receive the world’s first IEC 62443 Cybersecurity certification for drone systems from the German inspection agency TÜV NORD.

Based on our experience, a company should put emphasis on creating a culture where crew resource management, communications, standard operating procedures and procedures for abnormal situations are kept to high standards. One must remember that, when performing simultaneous BVLOS flights, special care must be taken that mitigation measures are in place. One is basically performing air traffic controller tasks in conjunction with pilot duties. That means that a reduced “Airline Concept” must be put in place.

It would be wise for the manufacturers of the systems, meaning software and hardware, as well as the users, to repeatedly test and implement operational concepts. These two parties should stay in close communication to further improve these concepts, which will, as a result, improve the safety, quality and efficiency standards in the industry as a whole.

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Unmanned Cargo Aircraft
A New Paradigm for Future Sustainable Transport

By Gilles Fartek
Integra, Denmark

Over the last decade, the growth in logistics needs has been exponential due to the increased globalisation of economic relocations and its consequences in volumes of international freight traffic. But this expansion is also due to the ever-increasing expectations of consumers to receive products purchased through e-commerce in ever shorter lead times. This practice, further reinforced by the COVID-19 crisis and never denied since a virtual return to normal, now aims to meet the expectations of large e-commerce companies to be capable of delivering products purchased in a few hours. This evolution contradicts all efforts developed to limit the transport footprint, improve environmental protection and mobility, and drastically reduce CO2 emissions from 2035. The very high number of trucks serving urban centres contributes to the increasing congestion and pollution observed in most cities. The ecological transition imperatives developed in recent years, in particular with the Green Deal established by the European Commission in 2019, now require public authorities to take the necessary measures to limit the impact of transport activities on citizens' health as much as possible.

The Need for Alternate Transport Modes

While the maritime sector takes the lion's share of freight transport, especially over long and very long distances, air transport continues to occupy an important place, particularly for moving products that cannot withstand long periods at sea, are of strategic importance, or require quick delivery. Air cargo services consist of transporting mail and freight domestically or internationally by aeroplanes and helicopters, with many products requiring different speed deliveries. Consequently, the market needs and the volume of cargo exchanges by air may differ depending on the areas to be served, the level of competition between transport segments, the market trends, and the opportunities open to air freight companies. In 2022, the global air cargo services market represented around 59 billion Euros, showing an annual growth of 7.4% compared with 2021 [1], despite the international situation and the remaining effects of the COVID-19 pandemic.

In that context, developing drone solutions to deliver goods by air should constitute an exciting chance for the logistics sector. Initial drone transport applications were essentially focused on small packages at a short distance, ideally beyond the line of sight. However, recent developments of innovative technologies have created great expectations for the logistic sector to be capable of operating large-weight drone cargo over long distances in a reasonable timeframe. Accordingly, remotely piloted cargo aircraft (UCA) can already be considered a serious alternative of complementary means to legacy transport modes, better answering new commercial needs and practices. The latest projections [2] show that the worldwide drone transportation market could be worth 28 billion Euros by 2027. With a global drone economy still in development, and many companies struggling to fulfil their initial business plans, logistic services using drones could be the fastest-growing category with a high potential market value in the next twenty years. This should favour the emergence of UCA operations as part of the Innovative Aerial Services (IAS) [3]. This should bring opportunities for changing the paradigm for some international, regional and urban air mobility as part of the promising emerging Innovative Air Mobility (IAM) market, accommodating operations with novel aircraft designs operated in unmanned configuration, offering new air mobility for people and cargo-based operations supported by integrated air and ground-based infrastructure.

The Rise of Unmanned Cargo Aircraft

The UCA concept concentrates on the delivery of relatively large volumes of goods outside the urban environment, offering new services building on UCA cutting-edge capabilities, with new potential applications and advantages already identified:

- Transport manufactured goods from production areas to industrial parks or assembly lines, reducing distribution time while simplifying and improving logistic distribution based on specific routes not currently served by manned air freight services. This could present a significant interest, particularly by better connecting logistic and distribution centres and cities where no airport or important route or rail infrastructure allows industrial or commercial development and exchanges.
- Quickly and permanently serve areas where high-value products, raw materials, production equipment and spare parts are produced, better supporting local developments and opening new opportunities for

[1] Air Cargo Services Global Market Report by the business research company, October 2022
[2] https://www.stattimes.com/drones/cargo-drones-and-regulations-giving-wings-to-future-of-logistics-1345013
[3] According to the European Aviation Safety Agency (EASA), IAS correspond to operations and services benefitting to citizens and aviation market, enabled by new airborne technologies, include transportation of passengers and/or cargo and aerial operations.

settling locally new economic actors without the fear of being off distribution routes. Such an approach would particularly suit products in international demand but with too small volumes produced to be subject to dedicated cargo flights or not benefiting from regular passenger flights where cargo could be loaded cargo. In addition, this would reduce the problems encountered by regions having a reasonable number of inhabitants but struggling to attract scheduled long-range connections or appropriate transport infrastructures, especially when the income per capita is low.

- Establishing UCA ports could be relatively cheap compared to the benefits gained, requiring limited infrastructure, control equipment and loading facilities, and relatively easy to operate and maintain. Cargos could be transported on specific non-classic routes without having to operate from or to existing logistic hubs or aerodromes, as is the case today with manned aircraft, creating more flexibility and adaptability to the traffic. This could bring cost-benefit since the low UCA operating cost would allow for transporting directly lower volumes of cargo without waiting to reach the critical mass for transporters, also limiting the risks of damages, delays or loss of products as is the case when mixing very different types of goods.
- Using standardised UCAs, specifically designed and operating new types of air containers, would maximise the operational use and turnover of systems and rationalise costs. For example, operating cargo drones in series would not necessarily require them to return to their home bases, being potentially reused indifferently according to maritime containers. UCA rental services could also be opened to shipping companies, the air vector being stored at the destination until being used by other clients for following operations.
- In addition, UCAs could reveal their particular interest in supporting specific civil operations to deliver emergency or disaster areas supplies. This could also serve temporary needs in some regions where market needs may be irregular, seasonal, or unpredictable, with no possibility of adapting the availability of scheduled flights to the demand.

The UCA concept relies on operating multi-ton aircraft on medium to long distances at cruising speeds ranging from dozens to hundreds of kilometres per hour. Their design should offer sufficient flexibility for cargo operations and better adaptability to the needs in terms of size, speed or maximum take-off weight (MTOW) of the vehicles operated. The intention is to run UCAs mainly out of existing airports, from/to specific drone ports or small strips established in proximity of logistic centres or industrial parks and could efficiently serve the needs of different logistic companies or industries. This would create a better fluidity of logistic exchanges, providing a quicker and safer solution to distribute goods and the opportunity to establish operational pads in areas not served by regional airports or locations where the geography or the typology of exchanges does not allow easy access for logistic flows.

Cargo drones could even be particularly suitable and relatively easy to operate from rough strips or local roads, i.e. closed at night to enable this specific type of operation. This would mainly accommodate capabilities offered by new generations of Vertical Take Off and Landing (VTOL) drone systems that could arrive and depart almost vertically without requiring long prepared surfaces, hence cutting infrastructure and equipment costs for operators. Cargo drones could also complement manned cargo fleets by ensuring the last-mile delivery of large volumes of goods directly to little-populated areas or remote areas where access is quite complicated, better accommodating and complementing e-commerce requirements. For countries where developing road or rail infrastructure is very expensive or complex to achieve technically, creating a new logistic infrastructure independent of geographical or climate constraints would offer suitable solutions to national or regional authorities. This is already a matter of great interest for distributing goods over large unpopulated areas, with a particular interest for countries where manned aircraft operations are dangerous, uncertain or too costly. Of course, UCA operations should avoid as much as possible conflicting with manned aircraft activities, establishing strict rules and processes by deconflicting them geographically, laterally and/or vertically, timely when possible, or segregating them until more advanced solutions exist to integrate them fully in the airspace.

Emerging New Types of Aircraft Designs

The absence of crew on board UCAs allows for designing them somewhat differently than manned aircraft, less dependent on requirements to preserve persons on board, and more optimised for welcoming cargo in terms of structure shape, engines, safety systems, exit doors, etc. In this context, the absence of pressure inside the aircraft allows for a lighter and simpler design if flying below 25 000 feet, perfectly matching local or regional operations.

The current structure of the cross-section of the fuselage could very much evolve to better fit cargo containers, shaping the aircraft more efficiently for the purpose. This would also provide opportunities to move away from conventional aircraft shapes, not necessarily dynamically efficient, and increase the use of Blended Wing Body (BWB) or flying wings considered up to 30% more fuel efficient, greater operating range and better offload capabilities.

At the same time, broader targets would be to reduce the reliance of air cargo on fossil fuels, with the possible integration of new technology engines currently developed by the aviation sector but also by the drone industry, more oriented to new generations of electric, gas, fan-in-wing or hybrid propulsion systems. This would therefore contribute to lowering pollution and reducing the noise impact of drone operations. Since the fire on board is considered one of the main safety hazards for

a cargo aircraft, the absence of persons onboard the UCA would open the possibility for introducing innovative fire suppression techniques such as using inert gas like nitrogen generated by onboard equipment.

In terms of operations, the remote position of the pilot would favour the emergence of local or regional centralised control centres. Several UCAs could also be handled simultaneously on routes specifically designed by certified drone operating service companies handling the entire traffic in a given area, each controller being responsible for a specific segment or airspace. The notion of centralised control centres could therefore bring substantial savings with the possibility of assigning one operator to handle all UCA take-offs and landings at specific drone ports, as is already the case for pilots operating ships entering harbours, while operations along the routes could be in maximum autonomy of the drone. The knowledge of the local circumstances of these controllers would even highly increase the levels of safety and efficiency. Accordingly, unmanned air cargo operations should directly rely on permanent and dedicated infrastructures established by regional, national or European authorities, eventually under partnerships between public and private partnerships.

This could include creating dedicated transmission networks and hardened ground-air communication systems, relying on the U-space concept below 500 feet and benefitting from appropriate interfaces between the current Air Traffic Management (ATM) systems and the future Unmanned Traffic Management (UTM) systems. Dedicated air routes could be specifically defined under the form of temporally activable portions of airspace designed by aviation authorities, subject to aeronautical information, and not penetrable by other airspace users as currently the case for some areas used for decades by military fighters training at low altitude and high speed over the territories.

Regarding ground infrastructures, it will be important to ensure that the UCA design reduces the complexity of the required tasks for loading and offloading the cargo and the need for specialised ground handling equipment to be used on cargo ports.

Challenges & The Way Forward

In April 2021, the Commissioner for Transport, Adina Vălean[4]ones, confirmed that drones are clearly a potential part of the future transport and logistics landscape, with a vast potential for new cargo and delivery services. However, operating UCAs routinely in a reasonable time will require, beyond resolving the technical challenges, expanding the current legal framework to ensure the highest possible levels of safety, security, and public acceptance. This is essential to establish the well-functioning, trusted and safe environment required to enable a competitive European drone cargo services market, contributing to increasing sustainability and smart mobility of a European transport system supported more resilient to future crises.

The European Commission has already initiated the work as part of its new “Drone strategy 2.0 for a Smart and Sustainable Unmanned Aircraft Eco-System in Europe”, which is to be released by the end of November 2022. It is supposed that it will largely rely on the work of the Drone Leaders’ Group contained in a dedicated report published in April 2022 .

To ensure the necessary market visibility to the industry and the potential investors of the UCAs sector, Europe will have to quickly focus on regulatory areas not yet covered, or only in part, such as standardisation, certification, insurance, operations, personnel licences, internal competition, etc. It will also need all regulatory elements developed to be demonstrated by appropriate testing, verification and validation to favour the acceptance of routine cargo drone operations by citizens and political deciders. Specific research and development will also need to be funded through public and private investments in technological domains where specific improvements and innovation are necessary. Reaching success in constrained timelines will only be possible by adopting a holistic approach at the European level, associating the regulators, manufacturers, users, academia and research centres in a joint effort.

Potentially subject to the creation of thousands of jobs in Europe, especially for the youngest citizens, the drone cargo sector may also highly benefit from the enthusiasm, open mind and reactivity of the new technology industry sector, having already proved its capability to overcome challenges by developing and implementing new solutions quickly.

Ready to support the upcoming rise of UCAs, the Integra company is already involved in designing new solutions to help reduce technological and regulatory gaps, while intending to offer a broad set of transport services based on cargo drones in five to ten years.

Gilles Fartek
Director European & NATO Affairs
Integra
Denmark
integra.dk

[4] Report of the Drone Leaders’ Group in support of the preparation of “A Drone Strategy 2.0 for a Smart and Sustainable Unmanned Aircraft Eco-System in Europe” dated 26 April 2022

FEATURE ARTICLE

ISO TC20 SC16 UAS Standards

By John Walker - The Padina Group, USA
Chris Carnahan - AIA, USA

Although modern standards organizations have their roots in the latter part of the 19th century, the use of weights and measures was standardized during the Qin Dynasty in China (221 to 206 BCE) and in India dating back to the 5th millennium BCE. Unfortunately, as empires rose and fell across the Eurasia Continent, uniformed standards were abandoned, especially in the developing European States. England's Henry Maudslay is recognized for his tool and die inventions in 1800 that enabled the Industrial Revolution to take form, especially with his standard screw thread design that was both revolutionary and allowed for mass production.

Today's international standards organizations have transformed our world from local and regional geographic sectors into a harmonized global market through effective standardization. For example, ASTM International was organized in the United States in 1898 while the British Standards Institute (BSI) was formed in 1901 and, SAE International in 1905. The International Organization for Standardization (ISO), RTCA and EUROCAE were all formed in the ensuing decades all contributing to industry/manufacturers need for uniformed standards, this was especially the case within the global aviation sector beginning in the Twentieth Century.

At the beginning of 21st Century a global aviation revolution descended into international standards organizations and national standards bodies, with the era of Remotely Piloted Aircraft Systems (RPAS). This transportation phenomenon is transforming all aviation sectors, including how international airspace and airports will be structured. Many international standards organizations, including the International Civil Aviation Organization (ICAO) have formed committees to develop RPAS standards for national Civil Aviation Authorities (CAA).

ISO is an independent, non-governmental international organization with a membership of 167 national standards bodies, based in Geneva, Switzerland. Through its members, ISO brings together experts from across the international community of experts to share knowledge and develop voluntary, consensus-based, market relevant International Standards that support innovation and provide solutions to global challenges (**https://www.iso.org/about-us.html**).

Within ISO, Technical Committee (TC) 20 is responsible for Aircraft & Space Vehicle standards. The scope of TC20 includes standardization of materials, components and equipment for construction and operation of aircraft and space vehicles as well as equipment used in the servicing and maintenance of these vehicles. In 2014, ISO established ISO/TC20/Sub-Committee (SC) 16, Unmanned Aircraft Systems (UAS), which develops standards in the field of unmanned aircraft systems (UAS) including, but not limited to, classification, design, manufacture, operation (including maintenance) and safety management of UAS operations. ISO TC20 / SC16 now includes 25 participating member States and 11 observing member States with 10 published ISO standards and 24 standards in development.

International standards organizations are uniting in meaningful ways to ensure quality standards are developed for the rapidly developing global UAS industrial market where duplication is prevented, and cooperation is championed. To that end ISO / TC20 / SC16 has established liaison relationships with other international standards organizations to ensure continuity with UAS standards development. These liaisons include:

- Airport Council International (ACI)
- Aerospace and Defense Industries Association of Europe – Standardization (ASD-STAN)
- European Union Aviation Safety Agency (EASA)
- The European Organisation for Civil Aviation Equipment (EUROCAE)
- Institute of Electrical and Electronics Engineers, Inc (IEEE)
- Open Geospatial Consortium, Inc. (OGC)
- SAE International (SAE)
- ASTM International (ASTM)
- Global UTM Association (GUTMA)

The ISO TC20/SC16 work program has expanded since being established in 2014 to include eight Work Groups that includes leadership from six States: China, Germany, Japan, Republic of Korea, United Kingdom, and United States of America. The specific work areas include:

- General
  - Convener – Frank Fuchs, Germany
    Specifies general requirements for UAS for civil applications
- Product Manufacturing and Maintenance
  - Convener – Lance King, United States
    Specifies quality & safety requirements for components of UAS design and manufacturing process.
- Operations and Procedures
  - Convener – Robert Garbett, United Kingdom
    Details requirements for safe commercial UAS operations, vertiport standards, training standard and Advisory Group for Detect & Avoid.
- UAS Traffic Management
  - Convener – Okamoto Masahide, Japan
    Establishes standards and guidelines for UAS traffic management.
- Testing & Evaluation
  - Convener – Hyun-Young Chang, Republic of Korea
    Testing and evaluation of UAS for safety and quality of product

- UAS Sub-systems
  - Convener – Che Jiaxing, China
    Development of standards for UAS subsystems design and manufacturing process.
- Noise Measurements for UAS
  - Convener – Zhang Xin, China
    Noise Measurements for UAS) Joint Work Group with TC43 WG7
- Counter UAS
  - Convener – Mark Lupton, United Kingdom
    Counter UAS

The growing expansion of international UAS standards has touched other development areas that have an impact on emerging technology, including telecommunications, artificial intelligence, machine learning and data exchange.

Within ISO, the ISO/International Electrotechnical Commission (IEC) Joint Technical Committee (JTC) 1, Information Technology, is uniquely positioned as a singularly important organization within ISO related to standardization in the field of information technology. ISO/IEC JTC 1 has 43 Subcommittees, including Artificial Intelligence and Telecommunications and information exchange between systems. The ISO TC20 / SC16 UAS Committee enjoys a unique liaison relationship with both ISO/IEC JTC 1 Subcommittees with subject matter experts. To further enhance the liaison relationship between these two committees, ISO / IEC JTC 1 established Advisory Group 19 under the leadership of Mr. Lu Haiying for direct support of ISO TC20 / SC16's expanding UAS Committee standards development work plan. Mr. SHU Zhenjie, a member of the ISO TC20 SC16 leadership team is the TC 20/SC 16 representative to ISO/IEC JTC 1, Advisory Group 19.

Within the ICAO RPAS Section special attention is being made to bring international Standards Development Organizations (SDO) together to form a "Standards Roundtable" where RPAS technical standards may be discussed by SDO representatives related towards application for RPAS certification, airport/vertiport use, air traffic services, and use by CAA's. The Joint Authorities for Rulemaking on Unmanned Systems (JARUS) Industry Stakeholders Body (ISB) includes a Standards Community of Interest that continues to bring International SDO participation (ISO, ASTM, EUROCAE, SAE, RTCA) into JARUS's work group programmes, including Operations, Airworthiness, Safety Risk Management and Automation.

ISO standards are developed by international experts that describe the best way to achieve successful solutions for difficult challenges. Within ISO TC20 SC16 experts from 36 countries have joined together to develop world class voluntary standards for the safe operation of Remotely Piloted Aircraft Systems within all continents throughout the world.

ISO Technical Committee 20 - Subcommittee 16 is responsible for the "Standardization in the field of unmanned aircraft systems (UAS) including, but not limited to, classification, design, manufacture, operation, maintenance, and safety management of UAS operations".

Secretariat: ANSI, United States of America
Chair: John Walker
Manager: Chris Carnahan
https://www.iso.org/committee/5336224.html

John Walker
The Padina Group
USA

Chris Carnahan
Aerospace Industries Ass.
USA

FEATURE ARTICLE

The NAARIC Group

By Ron van de Leijgraaf
Founder & Chairman

NAARIC (National Aviation Authorities Regulation Implementation Coordination) is a voluntary group of governmental experts on unmanned aviation from a number of European Union Member States. The group was initiated in 2019 with the objective of establishing a platform for the common interpretation and harmonized implementation of European drone regulations at national level.

Currently Participating Countries
Austria
Belgium
Bulgaria
Cyprus
Denmark
Finland
France
Germany
Italy
Latvia
Luxembourg
Netherlands
Norway
Poland
Romania
Slovenia
Spain
Sweden
Switzerland
United Kingdom

Currently, the group is working on implementation aspects of the operational regulations (Commission Implementing Regulation (EU) 2019/947 and Commission Delegated Regulation (EU) 2019/945) and U-space regulation (Commission Implementing Regulations (EU) 2021/664, 665 and 666). Examples of topics that have been addressed are:

- A common approach to pilot training in the "Open" category; and
- Developing detailed requirements to be used with the implementation of SORA (Specific Operations Risk Assessment) in the "Specific" category.

On interpretation and implementation, NAARIC has established cooperation with EASA. Within this cooperation NAARIC seeks both advise from EASA, and provides inputs on issues that require attention or further clarification. Regarding issues on the "Open" and "Specific" categories, NAARIC will closely coordinate with the newly established EASA UAS Technical Body group (UAS.TeB).

The Benelux General Secretariat in Brussels provides the secretariat of the NAARIC group. NAARIC does not have a web site.

If interested, the regulatory authorities of the countries implementing the EU drone regulations can join NAARIC, and are invited to contact the author (**ron.vande.leijgraaf@minienw.nl**).

Ron van de Leijgraaf
Ministry of Infrastructure & Water Management
The Netherlands

FEATURE ARTICLE

Operations in the Maritime Environment

By Bruno Boucher
Nordic Unmanned, Norway

Nordic Unmanned ASA is a Norwegian RPAS operator founded in 2014 and owner of a LUC (EASA Light UAS Operator Certificate). It delivers flight services with a fleet of RPAS with a mass of 2 kg up to 200 kg in more than 20 countries. The company is listed on the Euronext stock exchange.

Our unique geographical situation in northern Europe, the experience of many of our staff in the domain of manned helicopter operations in the North Sea, and the number of employees with airline experience, provide a solid foundation to understand what it takes to be successful in delivering commercial RPAS operations in the maritime environment.

Below are some examples of RPAS missions, that have been carried out by Nordic Unmanned.

Cargo Delivery To Offshore Platform

Customer	Large Oil & Gas operator, Norway
Maritime environment	National & international waters
Cross Border Ops	No
Deployment base	Norway
RPAS used	S-100 - Schiebel, Austria
Payload(s)	EO & IR, cargo boxes
Operation:	
- Mission type:	BVLOS
- Flight period:	Daytime
- Distance covered:	>100 km
- Quantity of flights:	Multiple
- Quantity days flown:	Multiple
Applicable regulation	EU Drone Regulation
Applicable rules	National & EU - Customer safety rules - Customer emergency preparedness as part of Nordic Unmanned's ERP
Airspace integration	National, international
ATM assured by	Norwegian national ANSP

Oil Spill Inspection

Customer	European Union Organisation
In support of	Multiple EU maritime authorities
Maritime environment	National & international airspace
Deployment base	Oil spill emergency response vessels
RPAS used	Indigo 3 - Lockheed Martin, USA
Payload(s)	EO & IR
Operation:	
- Mission type:	VLOS & BVLOS
- Flight period:	Daytime
- Distance covered:	up to 20 km
- Quantity of flights:	Multiple
- Quantity days flown:	Multiple
Applicable regulation	EU Drone Regulation
Applicable rules	National & EU
Airspace integration	National authorities
ATM assured by	National ANSP

Ship Emission Monitoring

Customer	European Union Organisation

In support of	Maritime authorities of various countries
Maritime environment	National and international waters
Cross Border Ops	Yes
Deployment base	Land based
RPAS used	S-100 - Schiebel, Austria
Payload(s)	EO & IR, emissions sensor
Operation:	
- Mission type:	BVLOS
- Flight period:	Day and night
- Quantity flights:	Multiple
- Quantity days flown:	Multiple
Applicable regulation	EU Drone Regulation
Applicable rules	National & EU
Airspace integration	National and international
ATM assured by	Various national ANSP

Maritime Monitoring & Surveillance

Customer	European Union Organisation
In support of	Multiple countries
Maritime environment	National & international waters
Cross Border Ops	Yes
Deployment base	Various countries
RPAS used	Aerosonde - Textron Systems, USA
Payload(s)	EO & IR, SAR (Synthetic Aperture Radar)
Operation:	
- Mission type:	BVLOS
- Flight period:	Day and night
- Quantity flights:	Multiple
- Quantity days flown:	Multiple
Applicable regulation	EU Drone Regulation
Applicable rules	EU / National in various countries
Airspace integration	Cooperation between various countries
ATM assured by	Cooperation between various countries

Semi-submersible Crane Vessel (SSCV) Inspection

Customer	Vessel operator
Maritime environment	Norwegian national waters
Cross Border Ops	No
Deployment base	Norway
RPAS used	Staaker, Nordic Unmanned, Norway

Payload(s)	EO & IR, LiDAR
Operation:	
- Mission type:	VLOS
- Flight period:	Daytime
- Quantity flights:	Multiple
- Quantity days flown:	Multiple
Applicable regulation	EU Drone Regulation
Applicable rules	National & EU - Customer safety rules - Customer emergency preparedness as part of Nordic Unmanned's ERP
Airspace integration	National Norwegian rules
ATM assured by	Norwegian national ANSP

Challenges of Operations in Maritime Environments

Considerations in the following domains are of critical importance when planning maritime operations:

- Environmental Conditions
  - o Wind
    - High and gusty winds are more often present than during land-based operations requiring more accurate weather information and more robust RPAS.
  - o Humidity
    - High humidity, mostly saline and condensing, presents challenges to the design of the RPAS and increases the required maintenance and care to be provided to ensure continuous operations
  - o Temperature
    - Combined with high humidity and high wind, low temperatures will often create icing conditions that can compromise the safety of operations, if not detected or well managed.
  - o Visibility
    - The difference between temperature and Dew point is, more often than on land, very small and can create various types of fog that may remain in place for days at a time, affecting the visibility.
- Airspace (domestic and international)
  - o Maritime operations can be conducted in domestic airspace (within 12 nm of the coast), but also in international airspace

  - o Operations in international airspace that may also require flying across many borders and/or FIRs (Flight Information Regions), which requires that the operator masters regulations and operates in close cooperation with all stakeholders, especially during the planning of the activities.
- Other activities
  - o Co-existence with other airspace activities (helicopter traffic)
  - o Activities in maritime environments often involve big structures like oil & gas platforms that have specific constraints covering RPAS activities. Huge metallic structures with a high level of activities may cause magnetic interference, as well as radio interference, depending on what systems are active during the RPAS activities.
  - o Various military activities, especially above water bodies under international airspace, will affect maritime RPAS operations in many ways.
- Endurance
  - o Maritime operations typically involve long flights. Possibilities for a refuelling and/or battery recharging stop on the way are very limited.
  - o In the case of an impossibility to make it back to a safe landing area, at sea or on land, the options to interrupt a flight are typically limited to “safely” ditching the RPAS and its payloads in the water. This is an expensive and not very environmental-friendly option, which should be avoided.
- Reliability
  - o As for endurance, reliability is critical to ensure we can fly assets up to their expected life duration.
- Customer Requirements
  - o Maritime environment customers are used to work with commercial helicopter operators and have implemented over the years very effective processes and rules to ensure all stakeholders are cooperating effectively.
  - o Introducing RPAS services requires substantial knowledge of the customer’s activities (e.g. oil & gas industry, surveillance authorities), especially their specific regulatory frameworks in various countries and regions of the world.
  - o Customers will typically require that the RPAS and the RPAS operator demonstrate a high number of hours of operation in a similar maritime environment, before allowing any RPAS activities to take place.

Safety First

- Operations in maritime environments are always required to put safety as a first priority in all phases of the flight missions.
- Adhering to the customer’s safety approach in it’s field of activity and the applicable regulation is essential, in addition to adhering to the RPAS specific safety management, in order to have a complete picture of all potential risks and mitigations.
- Applying the SORA methodology is only an element of the safety management of RPAS operations in the maritime environment; it is complemented by other requirements (not only related to aviation), that need to add to our safety assessment.
- Emergency readiness includes not only the RPAS operator’s Emergency Response Plan (ERP), but also its integration with our customer’s emergency preparedness activities, which are typically more elaborated.

Experience in Managing Aviation Activities

- In all our deployments and discussions with customers and regulatory authorities, we saw the importance of having a deep understanding of all aviation related topics that go beyond the RPAS domain, in order to be able to effectively supply our RPAS services.
- These topics cover among others: airspace structure and management, procedures before, during and after flights, payload operations, understanding manned aviation rules and procedures, radio frequency coordination, crew training and scheduling, transport of dangerous goods, management of long term deployments, maintenance planning and execution, emergency preparedness, and all of those in multi-country deployment scenarios.
- Managing aviation activities means being expert in managing exceptions and unplanned events. This capability becomes even more important in maritime commercial activities, as it makes the difference

between a successful and profitable operations and an interrupted service, that will not meet the customer's expectations.

Teamwork

- Aviation learns from sharing experience and maritime environment operations are not different.
- Nordic Unmanned's experience shows that all stakeholders are willing to work together and make RPAS services introduction in maritime environment a safe and successful activity for all parties involved.

Conclusion

In conclusion, RPAS operations in the maritime environment have specific challenges and a lot of experience and aviation expertise is required from the RPAS operator in order to achieve successful deployments. If flying prototypes and low maturity systems may be acceptable for some land-based operations, it is definitely not suitable for commercial RPAS services in the demanding maritime environment.

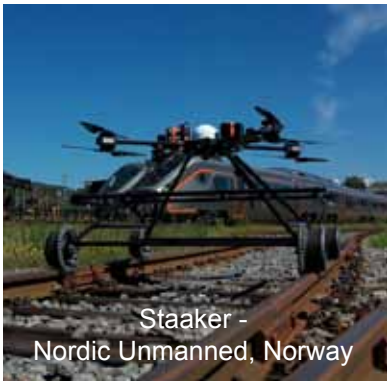
Nordic Unmanned has acquired a unique international experience in maritime operations and we are continuously expanding the types of services we are offering and delivering to our customers.

Bruno Boucher
Senior Vice-President
Nordic Unmanned
Norway
nordicunmanned.com

Examples of other drone missions conducted by Nordic Unmanned

Blood Transport

Sub-surface Mapping



Railway Track Inspection

Bridge Inspection

Security-related Operations

Perimetric & Industrial Site Monitoring

Drone Operations in Industrial Environments Case Studies

By Jean-Louis Weemaes
Skyebase, Belgium

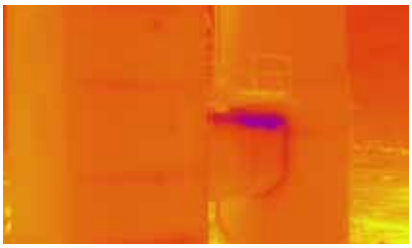
SkyeBase is a Belgian company that combines drones & robots and platform technology & AI for industrial asset inspections. The company is ISO9001:2015 and VCA Petrochemical certified. It was founded in 2020 as a total solutions company, starting with asset condition inspections, including the required proprietary AI-based data processing, and delivers actionable data for asset health management.

The company currently has 20 employees and focuses on performing drone & robot inspections for various industry sectors, including storage tank terminals, container terminals and critical infrastructure, with the purpose to increase safety, reduce ecological risks, as well as increase uptime and reduce maintenance costs.

The data capture takes place by means of inspections using various types of drones, robots (aerial, ground, water) and associated high-tech imaging and measurement equipment. The data processing takes place by means of I-Spect, the company's proprietary asset inspection platform, making use of artificial intelligence. The objective is to obtain crystal-clear insights into the condition of assets, permitting to take (preventive) maintenance & repair decisions.

The following case studies give an overview of the typical missions conducted by the the company.

Mission I
Electro-optical & thermal inspection of 2 coldboxes with a height of 65 metres.
Customer
Industrial gas production company
Drone
SB-01-M300 RTK - DJI, China
Goal
Detection of shortage of insulation material (consisting of granulates) causing cold losses. This can be visible from the outside (condensation, icing, etc).
End product
Report locating the detected defects by means of 3 types of images (zoom, high resolution and thermal) permitting targeted maintenance.



Payload: Zenmuse H20T - DJI, China			
Camera	Wide Angle	Zoom	Thermal
Sensor	1/2.3» CMOS 12 MP	1/1.7» CMOS 20 MP	Uncooled VOx Microbolometer
Lens	DFOV: 82.9° Focal length: 4.5 mm (equivalent: 24 mm) Aperture: f/2.8 Focus: 1 m to ∞	DFOV: 66.6°-4° Focal length: 6.83-119.94 mm (equivalent: 31.7-556.2 mm) Aperture: f/2.8-f/11 (normal) f/1.6-f/11 (night scene) Focus: 1 m to ∞ (wide) 8 m to ∞ (telephoto)	DFOV: 40.6° Focal length: 13.5 mm (equivalent: 58 mm) Aperture: f/1.0 Focus: 5 m to ∞
Zoom	-	23 x optical zoom 200 x digital zoom	8 x digital zoom

Mission II
Electro-optical inspection of a distillation column with 3 main pipes.
Customer
Industrial chemical company
Drone
SB-01-M300 RTK - DJI, China
Goal
Detection of damage & corrosion on the pipes, specifically welds, supports & joints.
End product
Report locating the detected defects by means images (zoom, high resolution) permitting targeted maintenance.

Payload Integrated into Drone by Manufacturer (Flyability, Switzerland)		
Camera Sensor	Electro-optical 1/2.3» CMOS Effective pixels: 12.3 MP low light optimised Video recording resolution: 4k Ultra HD: 3840 x 2160 at 30 fps Video streaming resolution: FHD: 1920 x 1080 at 30 fps, or SD 640 x 480 at 30 fps	Thermal Lepton:3.5 FLIR Video recording resolution: 160 x 120 at 9 fps Wave length: 8-14 µm
Lens	DFOV: 82.9° Focal length: 2.71	FOV: 56° x 42° Depth of field: 15 cm to ∞ Sensitivity (NEDT):<50 mk

Mission III
Electro-optical & thermal inspection of storage tanks (interior & exterior).
Customer
Waste treatment company
Drone
Elios 2 - Flyability, Switzerland
Goal
Inspection of storage tank walls inside the storage tanks.
Storage tank wall thickness measurements conducted from the outside.
End product
Report with a map of wall thickness measurements and defect annotations, permitting targeted maintenance & repair.

Inside view of storage tank

Jean-Louis Weemaes
CEO & Co-founder
Skyebase
Belgium
skyebase.be

M300 - DJI, China

Used for Missions I & II

Elios 2 - Flyability, Switzerland

Used for Mission III

UAS-related Training and Consultancy: Analysis of the Situation in Southern Italy

By Michele Fazio
Skyline Unmanned Systems, Italy

2013 has been defined the “year of drones”. Starting in 2013, many National Aviation Authorities started to define rules for the use of remote piloted aircraft systems (RPAS) in their respective countries, initially individually, and then collectively relative to creating a European Regulation.

Two services were developed in parallel in Italy, starting in 2013:
- The training of remote pilots for professional and leisure purposes;
- Consultancy relative to the writing of Flight Manuals, Operation Manuals, Technical Descriptions, Experimental Activity Reports, Safety Risk Assessments, Logbooks and related modules.

In the initial phase of the development of the UAS sector, the part relating to parallel services was characterized by an economic value higher than the cost of the device, creating the situation where users interested in using an RPAS for professional use with a commercial value of 250 Euro, had to spend about 2000 Euro* to obtain the relevant qualifications and authorizations.

In Italy, the training of remote pilots for UAS with a MTOM below 25 kg started in 2014 with a simple course of 33 hours with defined contents, enabling all scenarios. The number of hours selected for the training of RPAS pilots was derived from the syllabus of Light Sport Aircraft (LSA) Pilots. This kind of course was sold in Italy between 2000 Euros* in Northern Italy and about 500 Euro* in Southern Italy.

Considering the difference of nearly 100% between Northern Italy and Southern Italy (Lombardia Region Gross Domestic Product per habitant 38095,50 – Apulia Region GDP 18900,00 Euro), the higher cost of some courses in Northern Italy was also justified by the possibility of practical training relating to UAS with a take-off weight higher than 4 kg.

Considering the GDP parameter, it seemed a good approach to have a 900 Euro* course in Northern Italy and a 450 Euro* course in Southern Italy. However, in 2014 this situation created the interest with many aspiring pilots to go to Southern Italy to get the qualification, because the difference in cost between training in Northern Italy and Southern Italy compensated the purchase of the flight and the costs of accommodation.

One way to avoid this substantial difference in price could have been to bring the cost of the courses to an acceptable value, so as not to make travel justifiable. In 2014, a cost of 450 Euro* for Southern Italy and 700/800 Euro* for Northern Italy, plus the 33 hours training requirement was considered an acceptable price and to not induce aspiring pilots to consider travelling to the Southern Italy to obtain the qualifications.

The advantage of the approach adopted by Italian Civil Aviation Authority in 2014 was that the user attended only one course and had the elements to be able to carry out every operation in VLOS conditions, and it was at the discretion of the National Aeronautical Authority to request further training, depending on the authorized scenario.

Therefore, based on the 2014 scenario, the procedure that provided for compulsory training for professional drone activities and the choice to delegate leisure activity exclusively to areas outside inhabited zones seemed to be a good approach. Among other things, the Italian Civil Aviation Authority and the structures involved in the theoretical training managed to create a situation whereby «even if the theoretical training was not mandatory», the users registered en masse for the courses aimed at obtaining the title, even including users exclusively interested in following a course to increase their knowledge of the sector.

Theoretical training was not compulsory, as the regulation in force at the time implied that the operator had to contact a recognized authority «if he did not have the ability to train internally», making it clear that only the examination was mandatory.

In 2016, the Italian Civil Aviation Authority tried to structure the training, introducing new professionals such as the UAS Examiner, the Safety Adviser, the Practical Instructor, the Head of Training. This mechanism has favoured companies in Northern Italy, located in a more favourable territorial context, while disadvantaging companies in Southern Italy, which, in order to be sustainable, had to keep prices low.

In this phase, the cost of courses increased from 450 Euro for each pilot to 1400 Euro and then dropped again after about a couple of years to a cost of 450 Euro for pilot courses, but with tripled management costs.

The new approach provided implied a 16 hours theoretical course and 5 hours of practical training (30 missions of at least 10 minutes) for non-critical operations, alternating with 6 hours of autonomous practical training (36 missions of at least 10 minutes) and followed by 12 hours of theoretical course and 6 hours of practical training (36 missions of at least 10 minutes) for critical operations. At

Note:
* The amounts are indicative as an average value

this stage, the Italian Civil Aviation Authority neglected, in my opinion, the training of the UAS Examiners.

Skyline has changed UAS Examiners approximately seven times. Often these Examiners had no aeronautical technical background and had obviously gained their expertise in the model aircraft world. The aspiring pilots were asked to conduct complex manoeuvers, but not so many questions were asked about the technical documentation and the compilation of technical forms. Skyline has had external UAS Examiners, a different approach from other Recognized Entities, which often had internal UAS Examiners.

The publication of the European Regulation 947/2019, limited to OPEN scenarios, has greatly reduced the profit margins in the UAS training business, culturally creating a trend where, unlike in 2014, even then the course was optional. In this case, users tend not to take courses, but to carry out the online exam directly. The simplicity of the questions asked also contributed to this aspect.

Furthermore, at the end of the transitional period, the OPEN scenarios will cover a large part of the training needs in the UAS sector. In fact, it is believed that there will be a decisive collapse relative to those who will decide to achieve STS qualifications, unless the police forces will begin to carry out serious checks on compliance with the provided distances, on the delimitation of areas and on the implementation of safety and mitigation measures on the ground (consider the OPEN A2 scenario and the application of the 1:1 rule for a flight at 120 meters AGL), and above all if public tenders will not make necessarily and compulsorily ask the possession of an STS qualification and related authorization mandatory.

A number of proposals that could boost the sector are:

1. The limitation of the OPEN category to natural persons (actually in Italy on the D-flight website there are companies accredited as OPEN operators);
2. The identification of 3 distinct qualifications for the OPEN category (A1, A2 and A3) and to not include A1 with A3;
3. To carry out the exams strictly at recognized entities, including A1 and A3 exams;
4. The redefinition of the planned programmes (for example insert “batteries” in the OPEN A3 program, considering that we are talking about UAS weighing up to 25 kg);
5. The theoretical training is provided with the same approach implemented in Italy for the courses on General and Specific High Risk Training** for Legislative Decree 81/08 (16 hrs for module, average cost 150 Euro* including final exam). This way, even considering a 100% difference in GDP from Northern to Southern Italy, the difference of about 100/150 Euro will not justify going to Southern Italy to follow the course there;
6. Mandatory STS scenario in public procurement;
7. The definition of trainer requirements (an approach similar to the Italian D.I. 06/03/2013 at a European Level is suggested)

The numbers reported concern a mixed trend between the two practical training centres of Montalto Dora (near Ivrea) and Toritto (near Bari).

In Italy, the history of consulting organisations begins in 2015. At that time, the Italian Civil Aviation Authority defined the possibility for some organisations to become accredited as approved Consulting Organizations. About 10 companies were authorised, but after about 12 months, the entire category was removed. Skyline was the sole company authorised by the Italian Aviation Authority in Southern Italy. These organisations were a lightweight form of Qualified Entities and their purpose was to collaborate with UAS Operators in defining the content of technical documentation to exercise the profession of UAS Operators (Flight Manuals, Operations Manual, Technical Description, Experimental Activities).

The cost of consultancy to support UAS operators in obtaining authorisation in critical scenarios started with a value of about 1200 Euro* per consultancy (excluding Italian Civil Aviation Authority costs) and then collapsed with the elimination of consultancy organisations and the publication of standardized fillable manuals from private companies and associations. This situation has effectively destroyed the sector and reduced investment opportunities.

A solution to give a new impetus to this sector could be the following. Considering that Recognized Entities already exist in Italy, it would seem inappropriate to create a new category for consulting organisations, but it would be a good approach to delegate them some privileges:

- The obligation of performing experimental activity for UAS Operators using UAS with a take-off weight of more than 4 kg at a Recognized Entity before starting the professional activity (also suggested for the OPEN A3 category);
- The obligation to draft the Operations Manual at a Recognized Entity for organisations with a number of employees greater than 3 (the Recognized Entity will become a supervisor);

Notes:

* The amounts are indicative of an average value

** It has been considered “General and Specific High Risk Training” exclusively for the number of hours, in Italy the General and Specific Risk training is divided in:

1) Low risk category (8 hours mandatory training minimum, UAS Operations have been included in this field);
2) Medium risk (12 hours mandatory training minimum);
3) High risk (16 hours mandatory training minimum).

16 hours are considered to be adequate to cover all topics of the OPEN category as reported in the Reg. EU 947/2019. The classification of the presumed risk level is based on the Italian ATECO, equivalent to NACE (Statistical Classification of Economic Activities in the European Community, or “Nomenclature statistique des activités économiques dans la Communauté européenne”).

- The obligation to define the Technical Manager and the definition of the requirements of the Technical Manager for UAS Operators with a number of employees greater than 3 (one pilot, three observers for example).

The quantity of 3 employees has been suggested, considering that a UAS operation involving more than 3 people requires more attention to defining the communication procedures and protocols.

In this way, the Recognized Entities will become a reference for the NAA, reducing the distance between those who practice the profession of UAS Operators and the legislator. The proposals presented in this article, combined with the description of the historical evolution of the UAS business in Southern Italy, serve to propose solutions deemed to improve business, in order to give a new impetus to the sector.

The author underlines that this article has tried to summarize situations of general nature, focusing on the OPEN category and STS Scenario for VLOS flight, which will most probably cover a high percentage of UAS operations. No in-depth analysis of specific training and of technical consultancy for not-standard scenarios has taken place.

Recognized Entities are invited to contribute with constructive proposals by joining United Systems Europe – **https://united-systems-europe.eu**

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FEATURE ARTICLE

Urban Air Mobility Takes Off
A Guide to the First Planned Services

By Philip Butterworth-Hayes
Unmanned Publications, UK

The first urban air mobility (UAM) commercial routes in Paris 2024 will be a 21km route from Saint Cyr and Issy-le-Moulineax to the west of the city and a 22 km route between Austerlitz and le Bourget to the west of the city, according to Groupe ADP, participating at the launch of the first European Advanced Air Mobility Testbed at Pontoise-Cormeilles Aerodrome, close to Paris, which was officially opened on November 10, 2022.

Photo: A. van Blijenburgh

The airport group is currently talking with aviation safety regulators on how these routes will be supported by additional landing facilities mid-point in the planned routes. Under the current plans, Volocopter's piloted electric vertical take-off and landing (eVTOL) aircraft VoloCity will fly these routes with a single passenger with hand-luggage and a fast turn-around between flights; during the turn-around, ground staff will replace the nine batteries every flight and the pilot will escort the arriving passenger to the terminal and then pick-up the new passenger and take him/her to the waiting aircraft.

Photo: A. van Blijenburgh

But it is highly likely that the public will not have to wait until 2024 to fly commercial eVTOL services.

The news in late October 2022 that LIFT Aircraft had signed a Letter of Intent (LOI) with the owners of Charm, one of the largest helicopter tour operators on the US East Coast of the USA, to offer sightseeing tours around New York from as early as 2023 in HEXA eVTOL aircraft has effectively set off the starter's pistol for the global urban and advanced air mobility industries. According to the company: "LIFT is launching a new concept in personal aviation - anyone will be able to learn to fly its semi-autonomous eVTOL aircraft in less than an hour, and then solo pilot the single seat, ultralight vehicle - no pilot's license required. Under FAA rules, flights are limited to uncongested flyover areas and uncontrolled airspace - so plans are in the works to develop LIFT vertiports along New York City's many waterfront areas that provide access to the "Class G", Visual Flight Rules (VFR) corridor that extends up to 1,300 feet around Manhattan. Unlike most eVTOL aircraft in development today, HEXA is already approved to fly under the FAA's Part 103 rules, and no pilot's license is required to fly for personal, non-commercial use."

Photo: A. van Blijenburgh

Very close observers of this industry will argue that the industry has already taken off. In July this year EHang performed sightseeing flights with passengers in Yantai, a coastal city in East China, as part of the autonomous air vehicle EHang 216 'World Flight Tour', with no pilot.

But LIFT is developing a more complex operation with vertiports and geo-fencing flight management systems to keep the aircraft confined to pre-defined flight areas and corridors – in other words, an entire UAM eco-system.

Sight-seeing is the one of the key drivers of initial UAM services. In 2021 September, EHang reached a cooperation agreement with China Eastern General Aviation, a helicopter service provider and airspace management company, for tourism flights in Malunshan Base, Linhai, Shenzhen. EHang eVTOL tourist services are also scheduled for the Guangdong-Hong Kong-Macao Greater Bay Area. Other early tourist flights planned include the Volocopter scenic circular path within the Marina Bay area (9km) of Singapore

Automatic Passenger Registration

Automatic Passenger Boarding Check

and a 6km hop around Jeju Island in Korea.

Most of the flights could take place in 2024 – depending on the speed of certification and the jury is still out on whether all the regulations and standards will be in place around issues such as pilot training, battery storage and fire protection, maintenance, airspace design and traffic management, to meet the business plans of industry. If they are not, it is possible the initial operations will be undertaken under some kind of exemption process.

While the initial sight-seeing routes are unlikely to be more than 10km in length, the point-to-point commercial services, such as that at Paris, are considerably longer. Leonardo and Aeroporti di Roma (AdR) want to launch the first commercial UAM operations in Italy between Fiumicino Airport and the city of Rome in 2024 – and this is a journey of around 30km. These longer services offer considerably more complex infrastructure planning and regulatory challenges – not the least because of the probable requirements by regulators to identify potential emergency landing sites beneath these routes, to support pioneering commercial operations of more than 10km. The first US commercial eVTOL point-to-point service is planned for 2025, with United Airlines connecting Manhattan and the Newark Liberty International Airport hub with Archer Aviation aircraft.

The world will have to wait until 2025 for fully competitive UAM eco-systems to develop. To coincide with EXPO 2025 EHang, Skydrive and Volocopter have all announced competing networks, linking downtown Osaka with the EXPO sites and other tourist services. The shortest of these is Skydrive's Osaka Universal Studios-Yumeshima island route (5km) and the longest is ANA/Joby's Osaka City Centre-Airport (40km).

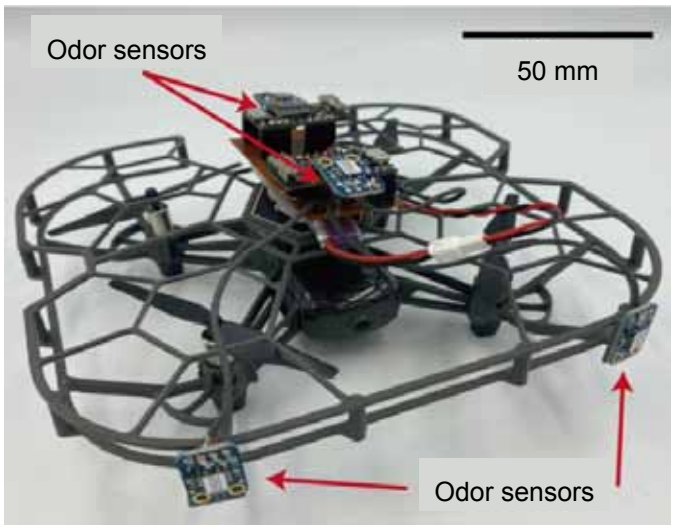
For more information on UAM/AAM routes & programmes please visit **https://www.globalairmobilitymarket.com**

Philip Butterworth-Hayes
Unmanned Productions
United Kingdom

Docking Station & Medical Delivery
Jedsy, Switzerland

Delivery Drone
Amazon 2 Mk 27 - Amazon, USA

Vineyard Spraying
AgroFly, Switzerland



Gas & odor detection - Osaka University, Softbank &
Tokyo Institute of Technology, Japan

Roof Spraying (moss & letchen eradication)
CleaningFly, France

Solar Panel Inspection
Fixar 007 - Fixar, Latvia

Palm Pruning & Treament
Todo Palmera, Spain

Drone Fitted with Chainsaw (tree pruning)
University of Hawai'i, USA


PROFESSIONAL
DRONE
OPERATIONS

PREAMBLE

Commentators and analysts in the field of non-military Unmanned Aircraft Systems (UAS) / Remotely Piloted Aircraft Systems (RPAS) / drones, as well as the relevant regulatory authorities and the press (specialized & general), make suppositions concerning the drone market (size, value, market sectors involved), as well as the flight operations actually taking place in these market sectors. Frequently, market sectors and flight missions get mixed up.

In many cases, these suppositions are not based on inputs received from qualified UAS/RPAS/drone operator community members. In addition, there are no commonly accepted definitions of the terms used to identify the UAS/RPAS/drone market sectors and flight operations, which adds to the confusion.

As a consequence, the information on the current & future drone markets that is getting out to industry (manufacturers & operators, as well as other service providers), potential drone service customers, investors, policy makers, regulatory authorities, standards producing organisations, as well as the general public, is not always accurate. In follow-up to an international survey on UAS operations conducted in 2018, the "Global UAS OPS" survey was conducted by Blyenburgh & Co (July - Dec. 2020) with the objective to contribute to correcting this situation. Those 2 surveys were based on an operation-centric approach (instead of drone-centric), and consequently did not make a distinction between unmanned aircraft (UA) based on their size, mass, airframe configuration, or type of propulsion. Many of the terms and explanations used in these 2 surveys are reflected in this lexicon. However, subsequent to considerable reflection and discussion, a number of the explanations in this current lexicon have been updated and improved.

AWARENESS CREATION

In the context of the aforementioned, as well as in light of the necessary general awareness creation efforts, that now have to be undertaken, this document proposes an identification and classification of the professional non-military drone market. This lexicon will also permit to highlight the very diverse societal benefits of drones and their job creation potential.

In order to permit all readers to obtain a clear understanding, this document includes a section on the basic terms used and the related explanations.

Furthermore, this document proposes:

- An updated segmentation of the non-military drone market into 25 application sectors (with respective explanations)
- An explication of the distinction between commercial and non-commercial drone flight operations performed in these market sectors (with respective explanations)
- An updated segmentation of flight mission purposes into 32 categories (with respective explanations) that can take place during commercial & non-commercial flight operations
- Explanations of the indicated market sectors and flight mission purposes

As the flight mission purpose defines the payload required to achieve its goal, and in order to be complete, a short overview of the payload categories is proposed. The payloads are split into 2 categories:

- Imaging payloads
- Non-Imaging payloads (sensing & non-sensing)

and examples in both categories are indicated.

This document also contains a section indicating the following for each of the 25 identified market sectors:

- The type of operator [commercial or non-commercial (corporate; governmental)]
- The location of the operation [open space or confined space (including GPS-denied & covered or partially enclosed spaces)]
- Type of flight (free flying or tethered)
- Flight envelopes (VLOS, EVLOS, BVLOS)
- Flight areas (over sparsely or densely populated areas)
- The possible flight missions

The final section in this publication supplies:

- The designation of the flight missions that can take place in each of the market sectors
- Practical examples of the these flight missions
- Photographs of selected flight mission purposes and dataset examples.

The objective of this holistic approach is to lay the foundation for an understanding of the professional drone market and its potential, in such a way, that it is comprehensible to all.

GENERAL INFORMATION

BASIC TERMS & EXPLANATIONS

Fig. 1 - Aircraft Types

AIRCRAFT	Lighter Than Air	Not Power Driven	Free Balloon	
			Captive Balloon	
		Power Driven	Airships	← Exist as RPAS
		Not Power Driven	Glider / Tethered Glider	← Exist as RPAS
			Kite	
	Heavier Than Air	Power Driven Tethered & Non-Tethered	Aeroplane: Landplane	← Exist as RPAS
			Aeroplane: Seaplane	← Exist as RPAS
			Aeroplane: Amphibian	← Exist as RPAS
			Rotorcraft: Gyroplane	← Exist as RPAS
			Rotorcraft: Helicopter	← Exist as RPAS
			Multicopter	← Exist as RPAS
			Ornithopter *(flapping wing)*	← Exist as RPAS

Fig. 2 - Current Drone Usage

Governmental	MUTUALIZATION	Military			✪
		Non-Military VLOS E-VLOS BVLOS RLOS B-RLOS	State Flights *Security-related*	Customs Police Border Guards Coast Guard	✪ ✪ ✪ ✪
			Not State Flights *Incl. Safety-related*	Civil Protection Fire Fighters National Mapping Agencies	◆ ◆ ◆
Non-Governmental		Commercial Air Transport *(Transport of Persons & Freight)* BVLOS RLOS B-RLOS		Scheduled Air Service Non-Scheduled Revenue Operations Non-Revenue Operations	◆
		General Aviation		Corporate Operations Flight Training / Instruction Pleasure *(private non-commercial)*	
		Aerial Work VLOS E-VLOS BVLOS RLOS B-RLOS		Commercial Non-Commercial *(incl. Corporate Ops)* Training / Instruction Other Miscellaneous	◆ ◆ ◆ ◆
		Leisure VLOS		Model Aircraft	○
				Recreational Drones	○
				Flying Toys	○

NON MILITARY OPERATIONS

Flight Operations	VLOS = Visual Line-of-Sight; E-VLOS = Extended VLOS; BVLOS = Beyond VLOS RLOS = Radio Line-of-Sight; B-RLOS = Beyond RLOS
Explanations	✪ **State Flights** ◆ Not State & Professional Flights ○ Leisure Flights

Fig. 3 - Professional Operations

AERIAL WORK	
Commercial & Non-Commercial *(Incl. Corporate Operations: Conducted by a corporate entity for its own purposes)* *An aircraft operation in which an aircraft is used for specialized (flight) services such as agriculture, construction, photography, surveying, observation & patrol, search & rescue, aerial advertisement, etc.* *(Chicago Convention, Annex 6 Part 1, Chapter 1.H9)*	
Flight Training / Instruction *(Commercial & Corporate operations)*	- **Duo** *(student instruction by licensed pilot)* - **Solo** *(unaided student flight)* - **Check** *(qualification verification of pilot license holder)*
Other Miscellaneous *(Commercial & Corporate operations)*	- **Test / Experimental** - **Demonstration** - **Ferry / Positioning** - **Air Show / Race**
COMMERCIAL AIR TRANSPORT **Commercial & Non-Commercial** (incl. Corporate)	- **Freight:** - **Internal Loads** *(inside the airframe)* - **External Loads** *(outside of the airframe)* - **Persons**

Fig. 4 - Professional Drone Market Sectors

The market sectors in which non-military drone applications (*commercial & non-commercial*) currently take place, or will probably take place in the future, are:

1 Aerial Photography, Audio-Visual Production
2 Agriculture, Fishery, Fish Farming, Forestry
3 Air Show / Racing
4 Aircraft System or Sub-system Prtion
5 Cinema & TV Industry & Media
6 Construction & Real Estate
7 Demonstration
8 Entertainment & Artistic Expression & Sport
9 Environmental Protection & Conservation
10 Ferry / Positioning
11 Flight Training / Instruction
12 Heritage Site & Historical Monument
13 Humantarian Aid
14 Insurance (Accident & Claim Investigation)
15 Maintenance
16 Mining & Exploration
17 News Gathering & Broadcasting
18 Policy Compliance & Obtaining Legal Proof
19 Public Services & Safety
20 Remote Operations - Non-Sensing
21 Remote Operations - Sensing
22 Research & Science
23 Security & Law Enforcement
24 Transport
25 Utility Companies (Public & Private)

Fig. 5 - Drone Flight Mission Purposes

The drone flight mission purposes of commercial & non-commercial operations in the market sectors indicated in Fig. 4 are classified as follows:

1 Advertising
2 Aerobatics, Special Effects & Sport
3 Aerial Photography & Film / Video
4 Broadcasting
5 Deterring
6 Dispensing
7 Exploration
8 Fire Fighting
9 Identification
10 Inspection
11 Localisation
12 Manipulation
13 Mapping
14 Measuring
15 Monitoring
16 Observation
17 Patrolling
18 Relief Flight
19 Search & Rescue
20 Security
21 Sensing
22 Sky Painting & Writing
23 Special Purpose
24 Spotting
25 Spraying
26 Surveillance
27 Surveying
28 Test / Experimental
29 Tracking
30 Transport - Goods
31 Transport - Persons
32 Validation

Drone Payloads

Payloads are elements installed on a drone that are not necessary for flight, but are carried for the purpose of achieving specific mission objectives.

Fig. 6 - Imaging Payloads

Elements on a drone that permit the capture of imagery (in some cases with simultaneous tracking) and the recording or transmission of such data. Imaging payloads (gimballed & non-gimballed) include, amongst others:

Corona Effect Imager
Digital Photo Camera
Digital Video Camera
Electric-Optical (EO)
Film Camera
Flash LiDAR
Hyperspectral
Infrared (IR)
Light Detection & Ranging (LiDAR)
Laser Scanner
Light Intensification
Line Scanner
Multi-Layer Laser
Multispectral - Optical
Multispectral - Thermal
Near Infrared
Radar
Radar - Ground Penetrating
Radar - Maritime
Solid State Photon Counter
Synthetic Aperture Radar

Fig. 7 - Sensing & Non-Sensing Payloads

Elements on a drone that permit the capture of non-imagery data and the recording or transmission of such data, as well as elements permitting to perform other non-sensing mission specific activities, include e.g.:

Sensing

Aerial pollution measurement
Anemometer
Atmospheric measurement
Bathymetric measurement
Electricmagnetic measurement
Emergency beacon detection
Frequency measurement
Gas detection
Geomagnetic measurement
Hydrography
Interferometry
Laser pointers
Location definition:
- Flora & fauna
- Object (moving & static)
- Person (moving & static)

Measurement system
Metal detector
Meteorological measurement
Microwave radiometer
Mineral detection
Moving target indicator
Odour detection
Particle measurement
Phenomena analysis
Radiation meter
Spectrometer
Telecommunication analysis
Ultrasonic analysis
Ultraviolet sensor

Non-Sensing

Cable stringing grip
Camera mounts
Communication relay
Data recording
Dispensing system (solids):
- Bulk (e.g. granulates, larvae, pollination agents, seeds)
- Other (e.g. seedlings)

Gimbal mount
Fire extinguishing system
Flame thrower (hornet & wasp nest eradication)
Floodlight
High pressure liquid dispenser (roof / wall cleaning)
Laser range finder
Loudspeaker / megaphone
Manipulating / robotic arm
Nets (drone interception)
Measurement probe / feeler
Payload imposed antennae
Perching grip
Spotlight
Spraying system (liquids for various purposes)
Suction Extractor (hornet & wasp nest control)
Water bombing system (large volume release)

FIG. 8a - BASIC TERMS & EXPLANATIONS

UAS / RPAS / Drone

The following terms and explanations are indicated in ICAO Circular 326.

Unmanned aircraft system (UAS) is an aircraft and its associated elements which are operated with no pilot on board.

Unmanned aircraft (UA) is any aircraft intended to be flown without a pilot on board is an unmanned aircraft. They can be remotely and fully controlled from another place (ground, another aircraft, space) or pre-programmed to conduct its flight without intervention.

Remotely-piloted aircraft system (RPAS) is a set of configurable elements consisting of a remotely-piloted aircraft (RPA), its associated remote pilot station(s), the required command and control links and any other system elements as may be required at any point during flight operation (e.g. launch & recovery systems).

Remotely piloted aircraft (RPA) is an aircraft where the flying pilot is not on board the aircraft. (Note: RPA is a subcategory of unmanned aircraft). It is piloted from a Remote Pilot Station and is expected to be integrated into the air traffic management system equally as manned aircraft [and,] real-time piloting control is provided by a licensed Remote Pilot.

Drone: In this document UAS and RPAS can be jointly referred to as drones, and UA and RPA (in the singular) can be referred as drone.

Note: *The abbreviations UAS, RPAS, UA and RPA are invariable (singular and plural are identical).*

NOTIFICATION

In compliance with ICAO directives, the terms "Unmanned Aerial Vehicle (UAV)" and "Remotely Piloted Vehicle (RPV)" are not recognized as accurate, and consequently **should no longer be used**.

UAS/RPAS/Drone Operator

Drone Operator is a company or organisation [non-governmental or governmental (non-military)] conducting, or planning to conduct, commercial or non-commercial flight operations with drones. (ICAO)

In the context of this document, the following classes of drone operators are recognized:

- Corporate Entity - Drone Manufacturer & Operator
- Corporate Entity - Drone Operator
- Corporate Entity - Flight School
- Corporate Entity - Research
- Corporate Entity - Test & Demo Site Management
- Governmental Entity - Drone Operator (non-military, including civil defence, coast guard, customs authoritities, emergency services, environmental agencies, fire brigades, police, infrastructure maintenance agencies)
- Governmental Entity - Research
- Academia / University
- Non-governmental organisation (NGO) (e.g. Red Cross, Doctors Without Borders, environmental protection groups, humanitarian aid groups).

RPAS Operator Certificate (ROC) (ICAO)

A certificate authorizing an Operator to carry out specified RPAS operations.

Aerial Work (ICAO)

An aircraft operation in which an aircraft is used for specialized services such as agriculture, construction, photography, surveying, observation, patrol, search and rescue, and aerial advertisement, etc. (ICAO definition).

Drone Flight Operations

In the context of this document non-military drone flight operations fall into two categories:

- Commercial: Flights carried out by companies for paying customers.
- Non-Commercial: Flights carried out by companies or organisations without external financial compensation from customers.

Non-commercial operations include Corporate Operations, which should be understood as: Flights carried out by companies or organisations to meet their own internal requirements.

Beyond visual line-of-sight (BVLOS) (ICAO)

An operation in which the Remote Pilot or RPA observer does not use visual reference to the remotely piloted aircraft in the conduct of flight.

Extended Visual Line Of Sight (EVLOS)

The Remote Pilot (RP) relies on one or more Remote Observers to keep the drone in visual line of sight at all times, relaying critical flight information via radio and assisting the RP in maintaining safe separation from other aircraft (manned or unmanned).

Visual line-of-sight (VLOS)

An operation in which the Remote Pilot (RP) or RPA Observer maintains direct unaided visual contact with the remotely piloted aircraft (RPA).

Remote Pilot (RP) (ICAO)

Remote Pilot is the person charged by the operator with duties essential to the operation of a remotely piloted aircraft and who manipulates the flight controls, as appropriate, during flight time.

Remote Pilot-in-Command (ICAO)

The Remote Pilot designated by the Operator as being in command and charged with the safe conduct of a flight.

Remote Piloted Aircraft Observer (ICAO)

A trained and competent person designated by the Operator who, by visual observation of the remotely piloted aircraft, assists the RP in the safe conduct of the flight.

FIG. 8b - BASIC TERMS & EXPLANATIONS

Flight Location

In the context of this document, two types of flight location are distinguished:

- Open Space — Flights taking place in the open air (outside of confined spaces)
- Confined Space — Flights taking place inside enclosed areas [e.g. buildings, greenhouses, mines, shafts, silos, ship (ballast) tanks, sport stadiums, storage tanks, structures, tunnels, warehouses], which may be GPS denied.

Standard (ICAO)

Any specification for physical characteristics, configuration, materiel, performance, personnel or procedure, the uniform application of which is recognized as necessary for the safety or regularity of international air navigation and to which Contracting States will conform in accordance with the Convention; in the event of impossibility of compliance, notification to the Council is compulsory under Article 38.

Recommended Practice (ICAO)

Any specification for physical characteristics, configuration, material, performance, personnel or procedure, the uniform application of which is recognized as desirable in the interests of safety, regularity or efficiency of international air navigation, and to which Contracting States will endeavour to conform in accordance with the Convention.

Geographical Zone

(Implementing Regulation (EU) 2020/639)

A UAS geographical zone is a portion of airspace established by the competent authority that facilitates, restricts or excludes UAS operations in order to address risks pertaining to safety, privacy, protection of personal data, security or the environment, arising from UAS operations.

In order to be compliant with the European regulation on drones, all EU member States are required to designate UAS geographical zones and publish them.

Note: A UAS geographical zone can consist of flight areas with varying population densities.

State of the Operator (ICAO)

The State in which the operator's principal place of business is located or, if there is no such place of business, the operator's permanent residence.

Flight Area

In the context of this document, two types of flight areas are distinguished:

- Sparsely populated
- Densely populated

Currently, there is no commonly accepted definition of these terms, eventhough they are referred to in various EASA documents. Nevertheless, in the context of this document, as a rule-of-thumb, ''densely populated zones'' will be understood as urban and discontinuous urban *(sub-urban)* areas, and all other areas will be considered as ''sparsely populated zones'' *(with various densities of population) (e.g. agricultural, forest & agroforestry, heterogeneous, natural vegetation, open spaces & water)*.

Confined Space

Space inside i.a.: buildings (*incl. sporting halls & stadiums*), encaged airspace volumes, mine galleries & shafts, ship holds & ballast tanks, structures (*ducts, greenhouses, hangars, pipelines, sewers, silos, storage tanks, tunnels, vaults, vessels*), underground reservoirs, well shafts.

Market Sectors & Flight Mission Purposes

Advertising ► Aerial Spectacles
► Drone swarms creating logos, names or client-specified forms or light shows
Intel's 50th Anniversary - Shooting Star system, Intel, USA

Advertising ► Banners
► Publicity banners installed on drone-mounted support
Madison,The Flying Billboard (Drone Aviary Project) - Superflux, UK

Advertising ► Banners
► Publicity banners slung beneath a a drone
Drone Adverts, UK

Advertising ► Banners
► Publicity banners towed behind a drone
Advertising Drone (developed for Annunzia) - CATUAV, Spain

Aerial Photography & Film / Video Footage ► Aerial Photographers
► Marriages, festivities, real-estate
AirButterflyDrone, Italy

Aerial Photography & Film / Video ► Cinema & TV Industry
► Producers - Feature films & series
Aerial Sky Works, Spain

Aerial Photography & Film / Video ► Publicity agencies
► Aerial imagery for advertising campaigns
WWF, International

Aerobatics, Special Effects & Sport ► Sport Trainers
► Athletic performance evaluation
Football practice - University of Charleston, USA

Aerobatics, Special Effects & Sport ► Air Show
► Aerial spectacle
Spilve Air Show - UgCS DDC (Drone Dance Controller), SPH Engineering, Latvia

Aerobatics, Special Effects & Sport ► Entertainment
► Circus / theatre act
Cirque du Soleil's Paramour on Broadway - Verity Studios, Switzerland

Aerobatics, Special Effects & Sport ► Entertainment
► Fashion show
2018 Milano Fashion Week - Dolce & Gabbana, Italy

Aerobatics, Special Effects & Sport ► Sport
► Drone racing
Drone Racing World Championship race track, Shenzhen, China (photo FAI/Marcus King)

Aerobatics, Special Effects & Sport ► Sport
► Drone soccer
A drone soccer arena - Drone Soccer, South Korea

Broadcasting ► News Gathering
► Journalistic purposes
2015 Nepal Earthquake - skyNEWS, UK

Broadcasting ► News Gathering
► Sporting event coverage
Sailing - Stef Vidéo, France

Deterring ► Public Service & Safety
► Chasing birds away from airports
RoBird - Aerium Analytics, Canada

FIG. 9 - DRONE MARKET SECTORS & EXPLANATIONS

Aerial Photography, Audio-Visual Production

Flight operations relative to the production of aerial imagery for educational & publicity & informational purposes.

Agriculture, Fishery, Fish Farming, Forestry

Flight operation relative to farming *(e.g. crop cultivation, lifestock breeding)*, inshore & offshore fishing, fish farming, tree cultivation.

Air Show / Competition / Racing

Flight operation carried out within the context of a public air show, sporting competition or drone race.

Aircraft System or Sub-system Production

Flight operations relative to the research, development and production of drone systems or sub-systems.

Cinema & TV Industry & Media

Flight operations for the cinema & TV industry, as well as floggers, relative to the production of feature & documentary films, the creation of special effects.

Construction & Real Estate

Flight operations for various purposes relative to all phases of construction and related promotional & sales activities. All applications except maintenance.

Demonstration

Flight operations carried out for regulatory (*certification*) authorities or potential customers.

Entertainment & Artistic Expression & Sport

Flight operations for public entertainment purposes, artistic expression, sporting events and drone races.

Environmental Protection & Conservation

Flight operations carried out with the purpose to contribute to maintaining or restoring the quality of the natural environment and protecting wildlife.

Ferry / Positioning

Delivery flights for the purpose of returning a drone to its base of operations, delivering a new drone from its place of manufacture to its customer, flying a drone from one base of operations to another, or flying a drone to or from a maintenance facility for repairs, overhaul or other work.

Flight Training / Instruction

Flight operations conducted by flight schools for the purpose of training/instruction of drone pilots (*Duo & Solo Flights*), qualification verification of pilot license holder (*Check Flights*) & flights conducted to maintain pilot competence.

Heritage Site & Historical Monument

Flight operations relative to the discovery, conservation, documentation & management of historical (incl. archaeological) sites & monuments.

Humantarian Aid

Flight operations carried out by or for international and non-governmental organisations (*NGOs*) within the context of natural & man-made disasters or emergency situations with the purpose to assist people in need.

Insurance (Accident & Claim Investigation)

Flight operations carried out by or for insurance companies.

Maintenance

Flight operations for maintenance purposes [*e.g. on aircraft hulls, buildings, critical infrastructure, industrial installations, offshore platforms, power plants, powerlines, pipelines, refineries, ships, solar & wind turbine farms*].

Mining & Exploration

Flight operations related to mining and quarry exploitation. All applications (*incl. exploration*), except maintenance.

News Gathering & Broadcasting

Flight operations carried out for journalistic purposes.

Policy Compliance & Obtaining Legal Proof

Flight missions conducted by or for international *(e.g. United Nation agencies, International Criminal Court)*, regional *[e.g. European Commission agencies (e.g. European Martitime Safety Agency, European Border & Coast Guard Agency)*, national governmental organisations, or by contractors for such organisations, to verify compliance with specific policies *(e.g. non-respect of ship emissions, agricultural or fishery policies)* and/or to obtain specific legal proof of non-compliance *(e.g. illegal fishing, illicit construction)* and/or obtain legal evidence *(e.g. detection of mass graves)*.

Public Services & Safety

Flight operations carried out by or for civil protection organisations, emergency services, fire brigades & firefighting services, public services *(incl. environ-mental, weather & health services)*, rescue services and utility companies, relative to safety of the general public.

Remote Operations - Non-Sensing

Flight operations with drones equipped with non-imaging payloads, or without any payload, for specific purposes.

Remote Operations - Sensing

Flight operations with drones equipped with imaging & non-imaging (*detection & measurement*) payloads for specific remote sensing purposes.

Research & Science

Flight operations conducted for private or public research or scientific purposes. Includes flight operations carried out for the purpose of testing, experimentation, or validation of new concepts and/or technologies for company internal assessment purposes.

Security & Law Enforcement

Flight operations carried out by or for municipal, regional or state authorities (*police, fire brigades, forensic experts, border guards, coast guard, customs, public health & safety*), harbour authorities, critical infrastrucure & sensitive industrial site management organisations.

Transport

Flight carried out for the carriage & delivery of freight (*incl. postage*) or persons.

Utilities (Public & Private)

Flight carried out by a corporate entity or governmental agency performing a public service which is subject to governmental regulation (*e.g. communications, gas & electricity distribution, railway network management, transportation, water distribtion & management, WIFI provision*). All applications, except maintenance.

Dispensing ► Agriculture
► Capsules (with useful insects/larvae)
Parabug - Parabug Australia, Australia

Dispensing ► Agriculture
► Pollination agents
Dropcopter - Dropcopter, USA

Dispensing ► Agriculture
► Seeds
Pouring rice seeds into JetSeed Granule System - XAG, China (PR)

Dispensing ► Forestry
► Seeds
Revegetating landslides areas trials - Taiwan's Forestry Bureau

Dispensing ► Public Services & Safety
► Flotation devices
Auxdron LFG - General Drones, Spain

Dispensing ► Security & Law Enforcement
► Crowd control devices
Tulpar T5-E - Tulpar Research Labs, Turkey

Exploration ► Mining & Exploration
► Mining industry
eBee - senseFly, Switzerland

Exploration ► Research & Science
► Archaeology
Iron-age settlement, located under centuries of vegetation - YellowScan, France

FIG. 10 - DRONE FLIGHT MISSION PURPOSES & EXPLANATIONS

Advertising

Drone swarms creating logos, names or client-specified forms, towing publicity banners, sky-writing, airships with publicity projected from inside on the inside of the external envelope, or publicity banners mounted on the outside of the airship envelope, or on a drone-mounted support.

Aerobatics, Special Effects & Sports

Flights for the cinema & TV industry, as well as for public entertainment and sporting purposes.

Aerial Photography & Film/Video

Production of aerial photography, film/video footage for the production of feature films, documentaries, advertisements/video clips, printed publications, news illustration on TV.

Broadcasting

Production of aerial film/video footage for news coverage *(real-time & deferred transmission)* on TV.

Deterring

Flight operation with the purpose to chase animals *(e.g. birds)* or eliminate insects from specific sites.

Dispensing

Aerial distribution of solids *(e.g. capsules, granulates, insects, pamphlets, pellets, powder, seedlings, seeds, other)*.

Exploration

The act of searching the earth's surface and sub-surface with the intent of finding minerals, oil or water, as well as finding sites with a specific interest *(e.g. archaeology)*.

Fire Fighting & Water Bombing

Flight carried out with the intent to extinguish a fire in a building, structure or installation, or to discharge large quantities of liquid on a forest fire with the intent to extinguish it or stop it from spreading.

Identification

The process of recognizing as being a certain person, animal, thing, vegetation or activity.

Inspection

Examination with the intent to find faults, errors, problems (disease), malfunctions or specific phenomena.

Localisation

Supplying the geographical coordinates of activities, equipment, errors, faults, flora, lifestock, malfunctions, metallic waste, persons, pollutants, structures, vegetation, wildlife, or specific phenomena.

Manipulation

The modification of the direction, or position, or the displacement, or the disruption, of an inert object.

Mapping

Process of creating a diagrammatic representation *(incl. 3D modelling, orthomasaic, digital models)*.

Measuring

The process of measuring using a particular standard *(e.g. ultrasonic non-distructive control)*.

Monitoring:

Observation on a regular basis over a period of time.

Observation

Examination of an activity, person, animal, group, area, vegetation, phenomena.

Patrolling

Searching for a specific activity, person(s), animal(s), group, object, vegetation or phenomena in a given area.

Relief Flight

Flight carried out for humanitarian purposes to transport relief supplies such as food, clothing, shelter, medical and other items during or after an emergency and/or disaster.

Search & Rescue

Looking for missing persons.

Security

Flights carried out to safeguard against unlawful acts

Sensing

Looking for & analysing or defining the geographical coordinates of phenomena *(incl. weather)* & transmitting or registering them.

Sky-Painting & Sky-Writing

Flight carried out by a swarm of drones or a single drone equipped with various types of lights and/or other devices *(e.g. smoke generators)* to create an aerial spectacle or message.

Special Purpose

Flights serving a specific purpose *[e.g. communication & WIFI relay; (tethered) aerial electricity generation]*

Spotting

Looking for an activity, animal, object, person, group, vegetation or phenomena & registering their geographical coordinates and/or counting them.

Spraying

The process of spreading liquid substances *[e.g. fertiliser, fungicide, insecticide, paint]*.

Surveillance

Close observation of an activity, person, animal, group, building/structure, site, area, vegetation or phenomena.

Surveying

Detailed inspection of a geo-referenced section of the earth's surface *(incl. structures)* with the purpose to study or measure altitudes, angles, distances, phenomena & structures flown over, and recording them.

Test / Evaluation

Ascertaining a capability, correct functioning or competence.

Tracking

The process of following something or someone.

Transport - Goods

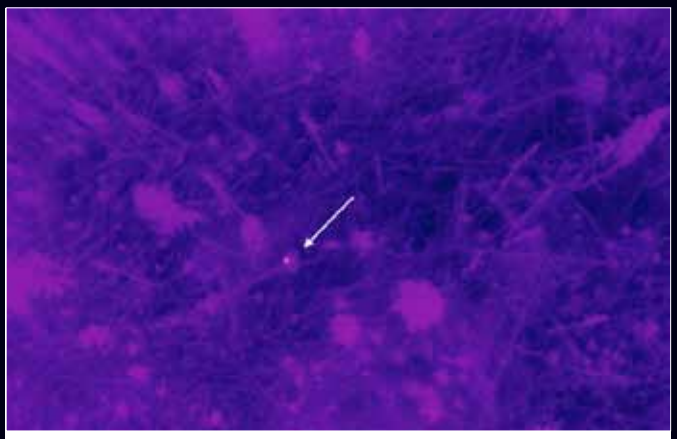
Flight carried out for the carriage & delivery of goods.

Transport - Persons

Flight carried out for the carriage & delivery of persons.

Validation

Confirmation by examination & provision of objective evidence that the particular requirements for a specific intended use are fulfilled or a specific competence has been acquired.



Fire Fighting ► Public Services & Safety ► Forest & wild fire
► Hotspot detection
Sarvus Unmanned Systems, Canada

Fire Fighting ► Public Services & Safety ► Urban fire ► Extinguishing
High-Rise Fire Fighting Drone
Chongqing Guofei General Aviation Equipment Manufacturing, China (PR)

Identification ► Agriculture
► Fungicide problems
Esca (grape disease) - Le Drone Vert, France

Identification ► Security & Law Enforcement
► Suspected criminals/pillagers/rioters
The Drone Surveillance System highlights violent individuals in red and neutral individuals in cyan
University of Cambridge, UK &
National Institute of Technology, India - Indian Institute of Science, India & IEEE, USA

Inspection ► Agriculture
► Bush / tree plantations in hilly / mountainous regions
Vineyards inspection - Instadrone, France

Inspection ► Agriculture
► Crop disease
Automatic detection of "Flavescence Dorée" (vine disease) - Novadem, France

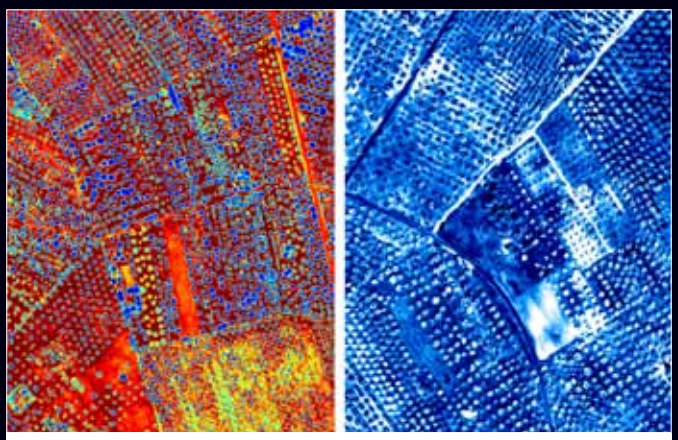
Inspection ► Agriculture
► Crop inventory / yield estimates
Yield estimation for citrus - Aerobotics, South Africa

Inspection ► Agriculture
► Irrigation monitoring
Valley Irrigation, USA

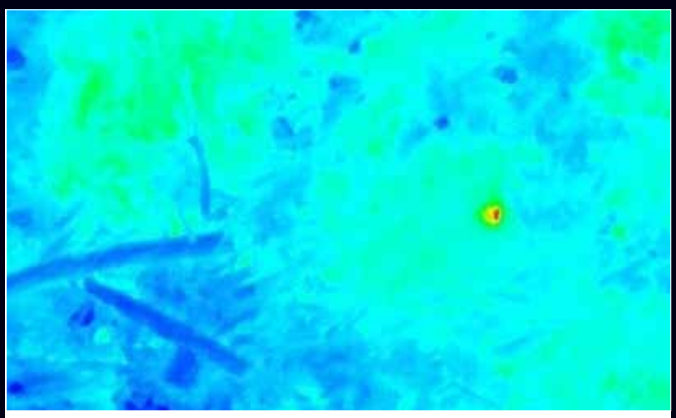
Fig. 11
Flight Missions per Market Sector

Market Sectors			
A	Aerial Photography & Audio-Visual Production	L	Heritage Site & Historical Monument
		M	Humantarian Aid
B	Agriculture, Fishery, Fish Farming, Forestry	N	Insurance (Accident & Claim Investigation)
C	Air Show / Competition, Racing	O	Maintenance
D	Aircraft System or Sub-system Production	P	Mining & Exploration
		Q	News Gathering & Broadcasting
E	Cinema & TV Industry & Media	R	Policy Compliance & Obtaining Legal Proof
F	Construction & Real Estate		
G	Demonstration	S	Public Services & Safety
H	Entertainment & Artistic Expression & Sport	T	Remote Operations - Non-Sensing
		U	Remote Operations - Sensing
I	Environmental Protection & Wildlife Conservation	V	Research & Science
		W	Security & Law Enforcement
J	Ferry / Positioning	X	Transport
K	Flight Training / Instruction	Y	Utility Companies (Public & Private)

	Flight Mission Purposes	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
1	Advertising	◆																			◆					
2	Aerial Photography & Film / Video	◆	◆			◆	◆			◆			◆	◆	◆	◆	◆	◆	◆	◆			◆	◆		◆
3	Aerobatics, Special Effects & Sport			◆					◆																	
4	Broadcasting					◆			◆									◆								
5	Deterring		◆				◆			◆						◆				◆						◆
6	Dispensing		◆							◆				◆						◆			◆	◆		
7	Exploration									◆			◆				◆						◆			
8	Fire Fighting																			◆				◆		◆
9	Identification		◆							◆			◆	◆		◆			◆				◆	◆		◆
10	Inspection		◆				◆			◆			◆	◆	◆	◆	◆			◆			◆	◆		◆
11	Localisation		◆				◆			◆			◆	◆	◆	◆	◆		◆	◆			◆	◆		◆
12	Manipulation															◆	◆				◆		◆	◆		
13	Mapping		◆				◆			◆			◆	◆	◆	◆	◆			◆			◆			◆
14	Measuring		◆							◆						◆	◆			◆			◆			
15	Monitoring		◆				◆			◆			◆			◆			◆	◆			◆	◆		◆
16	Observation	◆	◆			◆	◆			◆				◆	◆	◆	◆	◆	◆	◆			◆	◆		◆
17	Patrolling		◆							◆			◆	◆			◆		◆	◆			◆	◆		◆
18	Relief Flight													◆						◆						
19	Search & Rescue													◆						◆						
20	Security		◆				◆			◆			◆				◆		◆					◆		◆
21	Sensing									◆						◆				◆			◆			◆
22	Sky-Painting & Sky-Writing								◆											◆						
23	Special Purpose									◆	◆										◆	◆	◆			◆
24	Spotting		◆				◆			◆			◆	◆	◆	◆	◆		◆	◆			◆	◆		◆
25	Spraying		◆				◆			◆				◆		◆				◆						
26	Surveillance		◆				◆			◆			◆	◆		◆	◆	◆	◆	◆			◆	◆		◆
27	Surveying		◆				◆			◆			◆	◆	◆	◆	◆		◆	◆			◆			
28	Test / Evaluation				◆			◆				◆											◆			
29	Tracking		◆			◆			◆	◆													◆	◆		
30	Transport - Goods		◆											◆		◆	◆			◆	◆				◆	
31	Transport - Persons																								◆	
32	Validation				◆			◆				◆							◆				◆			

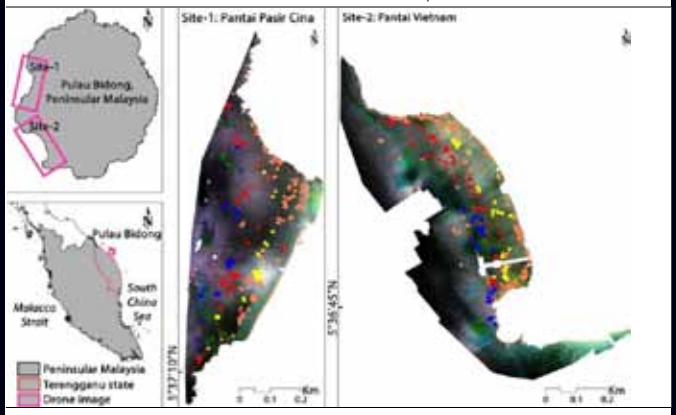


Inspection ► Agriculture ► Parasites infestation
Aerial hyperspectral images of olive orchards in a Xylella-infected region
P. Zarco Tejada, Joint Research Centre, European Commission



Inspection ► Environmental Protection & Conservation ► Biodiversity
Forest managers detect nightjars in thermal images to prevent workers from destroying nests (dark blue = downed trees, green = vegetation, yellow = nest, red = nightjar)
Natural Resources Wales, UK

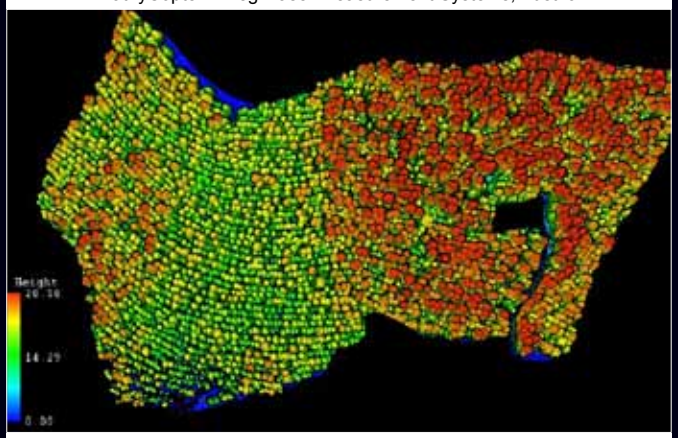
Inspection ► Environmental Protection & Conservation ► Coastal erosion ► Mangrove inspection
Replanting efforts become apparent - Marine Conservation Philippines



Inspection ► Environmental Protection & Conservation ► Ecological impact ► Reef degradation / growth
Institute of Oceanography and Environment (INOS), Universiti Malaysia Terengganu (UMT), Malaysia

Inspection ► Environmental Protection & Conservation ► Hydrography ► Bathymetric
BathyCopter - Riegl Laser Measurement Systems, Austria

Inspection ► Environmental Protection & Conservation ► Wildlife population density
Tern colony on an island (northwestern Australia) - Monash University, Australia



Inspection ► Forestry ► Inventory
Lidar Latinamerica, Chile

Inspection ► Forestry ► Parasites infestation
Defoliation of tree crowns (pine) due to bark beetle infestation - Micasense, USA

MARKET SECTORS & FLIGHT OPERATION CHARACTERISTICS

Inspection ► Heritage Sites & Historical monuments
► Erosion impact
Industrial SkyWorks, Canada

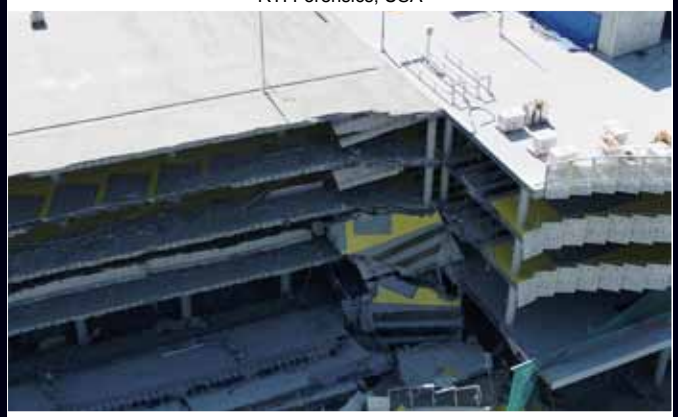
Inspection ► Heritage Sites & Historical monuments
► Post disaster
2016 Earthquake - CNVVF National Fire & Rescue Services, Italy

Inspection ► Humanitarian Aid
► Disaster response planning
Beirut explosion - GSCF (Groupe de Secours Catastrophe Français), France

Inspection ► Insurance
► Meteorological damage impact evaluation on: Infrastructure
Drone Malin, France

Inspection ► Insurance ► Post-accident / disaster
► Aircraft crash
RTI Forensics, USA

Inspection ► Insurance ► Post-accident/disaster
► Bridge collapse
Aftermath of Iowa Rail Bridge Collapse - Sioux County Sheriff, USA



Inspection ► Insurance ► Post-accident/disaster
► Building collapse
Inspection after collapse of parking garage at Eindhoven airport
Euro Drone Inspections, The Netherlands

Inspection ► Insurance ► Post-accident/disaster
► Industrial disaster
Fukushima Daiichi Nuclear Power Station - Air Photo Service, Japan

MARKET SECTORS - FLIGHT OPERATION CHARACTERISTICS

AERIAL PHOTOGRAPHY, AUDIO-VISUAL PROD.

Operator	**Commercial**		**Non-Commercial: - Corporate**
Location	**Open Space**		**Confined Spaces**
Flight	**Free-flying**		**Tethered**
Envelope	**VLOS**	**EVLOS**	**BVLOS**
Aera	**Sparsely populated**		**Densely Populated**
Flight Missions			
Advertising	Aerial Photography & Video		Observation

CINEMA & TV INDUSTRY & MEDIA

Operator	**Commercial**		**Non-Commrcial: - Corporate**
Location	**Open Space**		**Confined Spaces**
Flight	**Free-flying**		**Tethered**
Envelope	**VLOS**	**EVLOS**	**BVLOS**
Area	**Sparsely populated**		**Densely populated**
Flight Missions			
Aerial Photography Sport Coverage	Film / Video Observation		Special Effects Tracking

AGRICULTURE, FISHERY/FISH FARMING, FORESTRY

Operator	**Commercial**		**Non-Commercial: - Corporate**
Location	**Open Space**		
Flight	**Free-flying**		**Confined Spaces**
Envelope	**VLOS**	**EVLOS**	**BVLOS**
Area	**Sparsely populated**		
Flight Missions			
Aerial Photography & Video Dispensing Localisation Monitoring Security Surveillance Transport - Goods	Identification Mapping Observation Spotting Surveying		Deterring Inspection Measuring Patrolling Spraying Tracking

CONSTRUCTION & REAL ESTATE

Operator	**Commercial**		**Non-Commercial: - Corporate**
Location	**Open Space**		
Flight	**Free-flying**		
Envelope	**VLOS**	**EVLOS**	**BVLOS**
Area	**Sparsely populated**		**Densely populated**
Flight Missions			
Aerial Photography & Video Inspection Monitoring Spotting Surveying	Localisation Observation Spraying		Deterring Mapping Security Surveillance

AIR SHOW / RACING

Operator	**Commercial**		**Non-Commercial: - Corporate**
Location	**Open Space**		**Confined Spaces**
Flight	**Free-flying**		
Envelope	**VLOS**	**EVLOS**	**BVLOS**
Area	**Sparsely populated**		**Densely Populated**
Flight Missions			
Aerobatics	Racing		Sport

DEMONSTRATION

Operator			**Non-Commercial: - Corporate**
Location	**Open Space**		**Confined Space**
Flight	**Free-flying**		**Tethered**
Envelope	**VLOS**	**EVLOS**	**BVLOS**
Area	**Sparsely populated**		**Densely Populated**
Flight Missions			
Testing	Validation		

AIRCRAFT SYSTEM & SUB-SYSTEM PRODUCTION

Operator			**Non-Commercial: - Corporate**
Location	**Open Space**		**Confined Spaces**
Flight	**Free-flying**		**Tethered**
Envelope	**VLOS**	**EVLOS**	**BVLOS**
Area	**Sparsely populated**		
Flight Missions			
Testing	Validation		

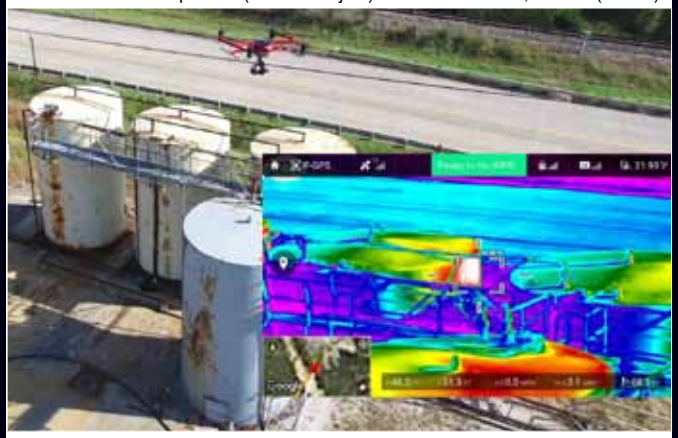
ENTERTAINMENT, ARTISTIC EXPRESSION & SPORT

Operator	**Commercial**		**Non-Commercial: - Corporate**
Location	**Open Space**		**Confined Spaces**
Flight	**Free-flying**		
Envelope	**VLOS**		
Area	**Sparsely populated**		**Densely populated**
Flight Missions			
Aerobatics Special Effects	Broadcasting Sport	Sky Painting Tracking	Sky Writing

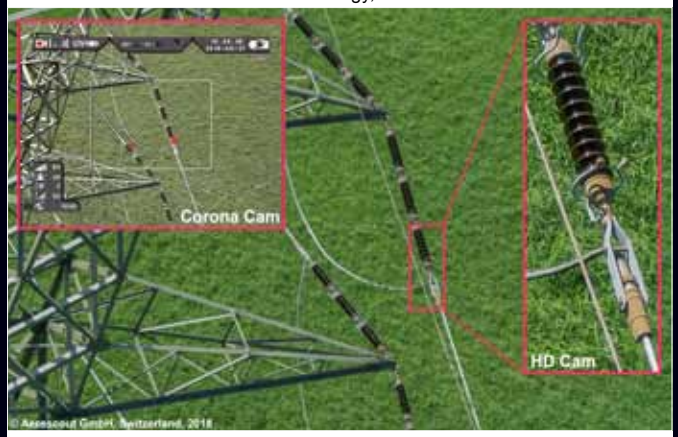
Inspection ► Insurance ► Post-accident/disaster
► Shipping accident
Inland Shipping Accident - Rijkswaterstaat, The Netherlands

Inspection ► Maintenance
► Aircraft hull exterior inspection
Airbus A350 hull inspection (Aircam Project) - BizLab Toulouse, France (Airbus)

Inspection ► Maintenance ► Industrial sites
► Chimneys
Force Technology, Denmark

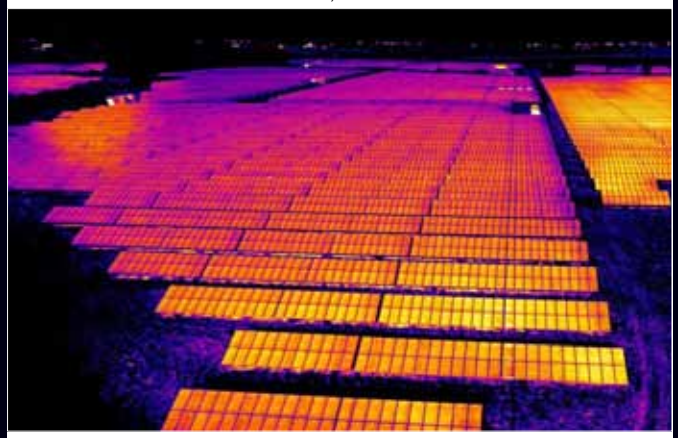


Inspection ► Maintenance ► Industrial sites
► Gas leaks
ICI, USA



Inspection ► Maintenance ► Industrial sites
► Power transmission cables
AeroScout, Switzerland

Inspection ► Maintenance ► Industrial sites
► Powerline pylons
Robot Aviation, Norway



Inspection ► Maintenance ► Industrial sites
► Solar panel farms
Flyway Drone, France

Inspection ► Maintenance ► Industrial sites
► Wind turbines
Sparrow Aerial, India

ENVIRONMENTAL PROTECTION & CONSERVATION

Operator	Commercial		Non-Commercial: - Public authorities - Corporate
Location	Open Space		
Flight	Free-flying		Tethered
Envelope	VLOS	EVLOS	BVLOS
Area	Sparsely populated		

Flight Missions

Aerial Photography & Film / Video		Deterring
Dispensing	Exploration	Identification
Inspection	Localisation	Mapping
Measuring	Monitoring	Observation
Patrolling	Security	Sensing
Special Purpose	Spotting	Spraying
Surveillance	Surveying	Tracking

HUMANITARIAN AID

Operator	Commercial		Non-Commercial: - Public Authorities - Humanitarian orgs
Location	Open Space		Confined Spaces
Flight	Free-flying		Tethered
Envelope	VLOS	EVLOS	BVLOS
Area	Sparsely populated		Densely Populated

Flight Missions

Aerial Photography & Video		Dispensing
Identification	Inspection	Localisation
Mapping	Observation	Patrolling
Relief Flight	Search & Rescue	Spotting
Spraying	Surveillance	Surveying
Transport - Goods		

FERRY / POSITIONING

Operator	Commercial		Non-Commercial: - Corporate
Location	Open Space		
Flight	Free-flying		
Envelope			BVLOS
Area	Sparsely populated		Densely Populated

Flight Mission

Deliverying a drone - Flying from A to B

INSURANCE (Accident & Claim Investigations)

Operator	Commercial		Non-Commercial: - Corporate
Location	Open Space		Confined Spaces
Flight	Free-flying		Tethered
Envelope	VLOS	EVLOS	BVLOS
Area	Sparsely populated		Densely Populated

Flight Missions

Aerial Photography & Video		Inspection
Localisation	Mapping	Observation
Spotting	Surveying	

FLIGHT TRAINING / INSTRUCTION

Operator	Commercial Private Person		Non-Commercial: - Corporate
Location	Open Space		Confined Spaces
Flight	Free-flying		Tethered
Envelope	VLOS	EVLOS	BVLOS
Area	Sparsely populated		

Flight Missions

Testing / Evaluation Validation

MAINTENANCE

Operator	Commercial		Non-Commercial: - Public authorities - Corporate
Location	Open Space		Confined Spaces
Flight	Free-flying		Tethered
Envelope	VLOS	EVLOS	BVLOS
Area	Sparsely populated		Densely Populated

Flight Missions

Aerial Photography & Video		Deterring
Identification	Inspection	Localisation
Manipulation	Mapping	Measuring
Monitoring	Observation	Sensing
Spotting	Spraying	Surveillance
Surveying	Transport - Goods	

HERITAGE SITE & HISTORICAL MONUMENT

Operator	Commercial		Non-Commercial: - Public Authorities - Corporate
Location	Open Space		Confined Spaces
Flight	Free-flying		Tethered
Envelope	VLOS	EVLOS	
Area	Sparsely populated		Densely Populated

Flight Missions

Aerial Photography & Video		Exploration
Identification	Inspection	Localisation
Mapping	Monitoring	Patrolling
Security	Spotting	Surveillance
Surveying		

MINING & EXPLORATION

Operator	Commercial		Non-Commercial: - Corporate
Location	Open Space		Confined Areas
Flight	Free-flying		Tethered
Envelope	VLOS	EVLOS	BVLOS
Area	Sparsely populated		

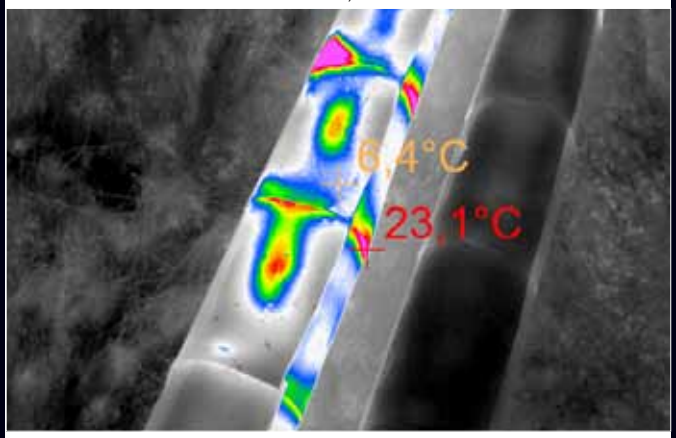
Flight Missions

Aerial Photography & Video		Exploration
Inspection	Localisation	Manipulation
Mapping	Measuring	Observation
Patrolling	Security	Spotting
Surveillance	Surveying	Transport – Goods

Inspection ► Maintenance ► Infrastructure
► Airport runway
Pavement Condition Index inspection - Canard Drone, Spain

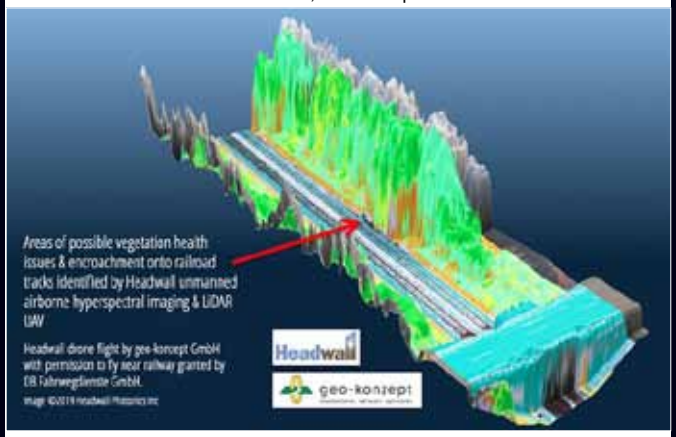
Inspection ► Maintenance ► Infrastructure
► Antennae
Sentera, USA

Inspection ► Maintenance ► Infrastructure
► Cranes
Ship to shore container crane - Kalmar, Finland



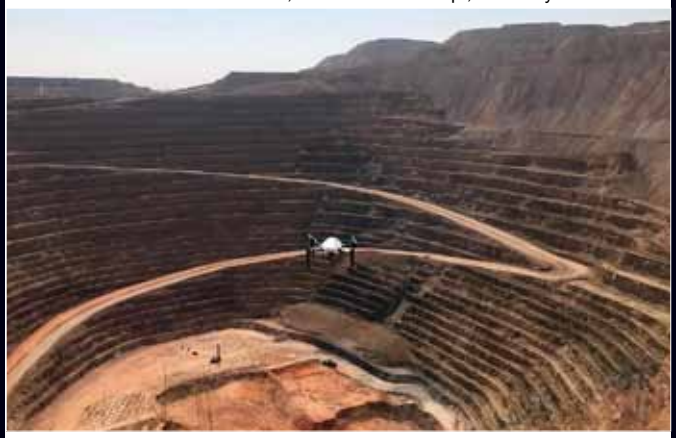
Inspection ► Maintenance ► Infrastructure
► Pipelines (exterior)
Workswell, Czech Republic

Inspection ► Maintenance ► Infrastructure
► Pipelines (interior)
Inspection of a pipe section - PowerFox, Australia



Inspection ► Maintenance ► Infrastructure
► Railway track surroundings
Headwall Photonics, USA & Geo Konzept, Germany

Inspection ► Maintenance ► Shipping
► Ship ballast tank
Drones for safety inspection of ships pass test - Technical University of Denmark



Inspection ► Mining & Exploration
► Highwall scanning
Skycatch, USA

NEWS GATHERING & BROADCASTING

Operator	**Commercial**		**Non-Commercial:** **- Corporate**
Location	**Open Space**		**Confined Spaces**
Flight	**Free-flying**		**Tethered**
Envelope	**VLOS**	**EVLOS**	**BVLOS**
Area	**Sparsely populated**		**Densely Populated**
Flight Missions			
Aerial Photography & Film/video			Broadcasting
Observation	Surveillance		

POLICY COMPLIANCE & OBTAINING LEGAL PROOF

Operator	**Commercial**		**Non-Commercial:** **- Public authorities** **- Corporate**
Location	**Open Space**		**Confined Spaces**
Flight	**Free-flying**		
Envelope	**VLOS**	**EVLOS**	**BVLOS**
Area	**Sparsely populated**		**Densely Populated**
Flight Missions			
Aerial Photography & Film/Video			Identification
Localisation	Monitoring		Observation
Patrolling	Security		Spotting
Surveillance	Surveying		Validation

PUBLIC SERVICES & SAFETY

Operator	**Commercial**		**Non-Commercial:** **- Public authorities** **- Corporate**
Location	**Open Space**		**Confined Spaces**
Flight	**Free-flying**		**Tethered**
Envelope	**VLOS**	**EVLOS**	**BVLOS**
Area	**Sparsely populated**		**Densely Populated**
Flight Missions			
Aerial Photography & Film/Video			Deterring
Dispensing	Fire Fighting		Inspection
Localisation	Mapping		Measuring
Monitoring	Observation		Patrolling
Relief Flight	Search & Rescue		Sensing
Sky Writing	Spotting		Spraying
Surveillance	Surveying		Transport – Goods

REMOTE OPERATIONS - NON-SENSING

Operator	**Commercial**		**Non-Commercial:** **- Corporate**
Location	**Open Space**		**Confined Spaces**
Flight	**Free-flying**		**Tethered**
Envelope	**VLOS**	**EVLOS**	**BVLOS**
Area	**Sparsely populated**		**Densely Populated**
Flight Missions			
Advertising	Manipulation		Special Purpose
Transport - Goods			

REMOTE OPERATIONS - SENSING

Operator	**Commercial**		**Non-Commercial:** **- Corporate**
Location	**Open Space**		**Confined Spaces**
Flight	**Free-flying**		**Tethered**
Envelope	**VLOS**	**EVLOS**	**BVLOS**
Area	**Sparsely populated**		**Densely Populated**
Flight Missions			
Special Purpose			

RESEARCH & SCIENCE

Operator	**Commercial**		**Non-Commercial:** **- Corporate**
Location	**Open Space**		**Confined Spaces**
Flight	**Free-flying**		**Tethered**
Envelope	**VLOS**	**EVLOS**	**BVLOS**
Area	**Sparsely populated**		**Densely Populated**
Flight Missions			
Photo & Video	Dispensing	Exploration	Identification
Inspection	Localisation	Manipulation	Mapping
Measuring	Monitoring	Observation	Patrolling
Sensing	Special Purpose	Spotting	Surveillance
Surveying	Test/Evaluation	Tracking	Validation

SECURITY & LAW INFORCEMENT

Operator	**Commercial**		**Non-Commercial:** **- Public authorities** **- Judiciary**
Location	**Open Space**		**Confined Spaces**
Flight	**Free-flying**		**Tethered**
Envelope	**VLOS**	**EVLOS**	**BVLOS**
Area	**Sparsely populated**		**Densely Populated**
Flight Missions			
Photo & Video	Dispensing	Identification	Inspection
Localisation	Manipulation	Monitoring	Observation
Patrolling	Security	Spotting	Surveillance
Tracking			

TRANSPORT

Operator	**Commercial**		**Non-Commercial:** **- Corporate**
Location	**Open Space**		
Flight	**Free-flying**		
Envelope			**BVLOS**
Area	**Sparsely populated**		**Densely Populated**
Flight Missions			
Transport - Goods			Transport - Persons

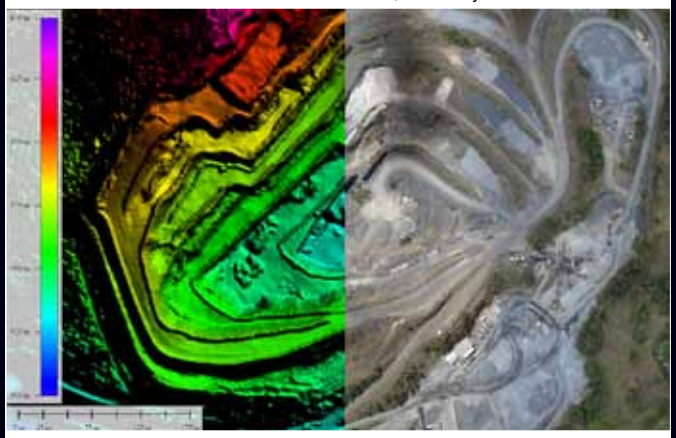
UTILITY COMPANIES (Public & Private)

Operator	**Commercial**		**Non-Commercial:** **- Corporate**
Location	**Open Space**		**Confined Spaces**
Flight	**Free-flying**		**Tethered**
Envelope	**VLOS**	**EVLOS**	**BVLOS**
Area	**Sparsely populated**		**Densely Populated**
Flight Missions			
Photo & Video	Deterring	Fire Fighting	Identification
Inspection	Localisation	Mapping	Monitoring
Observation	Patrolling	Security	Sensing
Special Purpose	Spotting	Surveillance	

Inspection ► Mining & Exploration
► Mine tunnels
Elios 2 - Flyability, Switzerland

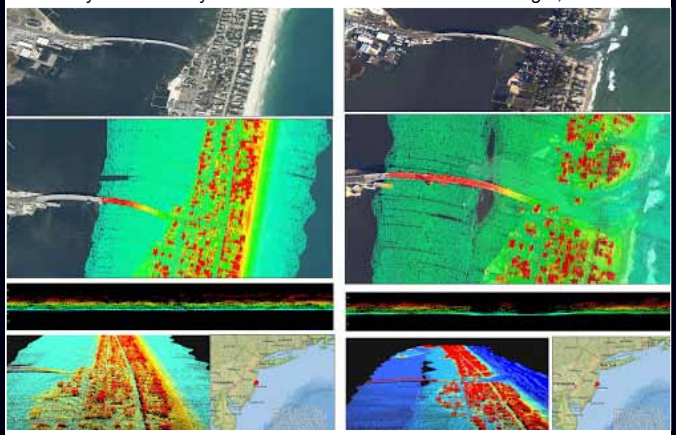
Inspection ► Mining & Exploration
► Flare stacks
Schröter Höhen Technik, Germany

Inspection ► Mining & Exploration ► Offshore platform
► Corrossion
Cyberhawk, UK



Inspection ► Mining & Exploration
► Quarries
Quarry drone survey converted to CAD format - AirBorn Insight, Australia

Inspection ► Public Services & Safety
► Post disaster - Natural (earth quake)
OnyxStar XENA-8F - Altigator, Belgium



Inspection ► Public Services & Safety ► Post disaster - Natural (hurricane)
Changes caused by hurricane Sandy in the region around Mantoloking Bridge
CCOM/JHC University of New Hampshire, USA

Inspection ► Public Services & Safety
► Post disaster - Natural (tsunami)
Team Rubicon, Australia - for National Board For Disaster Mgt, Indonesia

Inspection ► Security & Law Enforcement
► Illegal logging
Asociación para la Conservación de la Cuenca Amazónica (ACCA), Peru

FLIGHT MISSIONS IN EACH MARKET SECTOR

EXAMPLES

Localisation ► Environmental Protection & Conservation
► Anti-poaching
Kruger National Park, South Africa

Localisation ► Environmental Protection & Conservation
► Bird nesting detection
National Audubon Society, USA

Localisation ► Environmental Protection & Conservation
► Coastal erosion
Septentrio, Belgium

Localisation ► Environmental Protection & Conservation
► Underground metallic waste
EM61Lite - Geonics, Canada

Localisation ► Mining & Exploration
► Detection of ferrous & non-ferrous metals
GFDAS, Chile

Localisation ► Public Services & Safety
► UXO detection
Manta - Mine Kafon, The Netherlands

Manipulation ► Maintenance
► Remote repair
Flugroboter - DLR, Germany

Manipulation ► Security & Law Enforcement
► UXO clearance (disruptor)
Protector - Steelrock Technologies, UK

FLIGHT MISSION PURPOSES - EXAMPLES

Advertising

Remote Operations - Non-Sensing
- Aerial Spectacles:
  - Drone swarm equipped with lights creating logos, names or client-specified forms (open & confined spaces)
- Banners:
  - Publicity banner (incl. LED screen) mounted on the outside of the external envelope of an airship;
  - Publicity banner (incl. LED screen) mounted on a drone-carried support
  - Publicity banner slung beneath a drone
  - Publicity banner towed behind a drone
- Projection:
  - Airship with publicity projected from the inside of the airship on the interior of the airship envelope

Sky Writing
- Drones creating written aerial messages using smoke generators

Aerial Photography & Film / Video

Aerial Photographers:
- Marriages, festivities, real-estate

Cinema & TV Industry:
- Production - Adventure show
- Production - Documentary
- Production - Feature film & series
- Production - Educational film

Environmental Protection & Conservation:
- Production - Documentary
- Production - Educational film

Publicity Agencies:
- Aerial imagery for advertising campaigns

Sport Training:
- Athletic performance evaluation (interior & exterior)

Aerobatics, Special Effects & Sport

Air Show:
- Aerial spectacle
- Aerobatic show

Artistic Expression
- Aerial show by an artist
- 2D & 3D painting on horizontal & vertical support surfaces

Cinema & TV Industry:
- Aerial view
- Aircraft special effects
- Pilot's view

Entertainment:
- Fashion show animation
- Acts in circus, night club, stadium, theatre

Sport:
- Drone racing
- Drone soccer

Broadcasting

News Gathering
- Journalistic purposes
- Television industry:
  - News coverage (direct transmission & recorded)
  - Public spectacles (e.g. national celebration, pop festival; rock concert)
  - Sporting event coverage

Deterring

Agriculture:
- Protecting high value crops from birds & insects

Environmental Protection & Conservation:
- Preventing birds from nesting on construction sites (which in some countries would oblige construction activities to be halted)
- Chasing birds from industrial waste retention ponds
- Wildlife management

Environmental (Sanitary):
- Chasing birds away from garbage dumps & aesthetically sensitive sites (buildings, golf courses, monuments, structures)
- Chasing migratory birds from urban areas

Public Service & Safety:
- Chasing birds away from airports

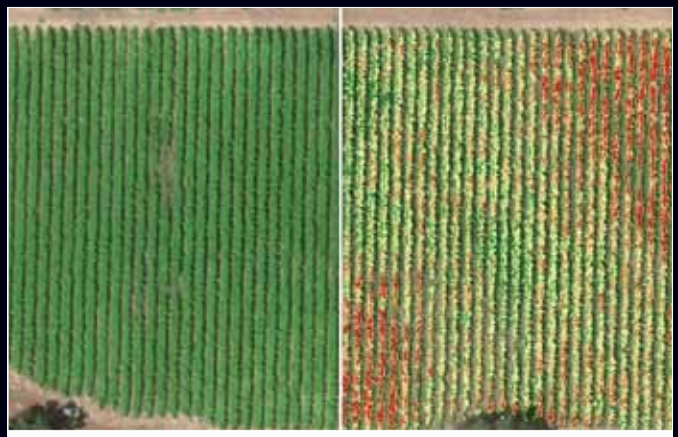
Dispensing

Agriculture:
- Capsules (with useful insects / larvae),
- Fertilizer granulates
- Seedlings
- Pollination agents
- Seeds

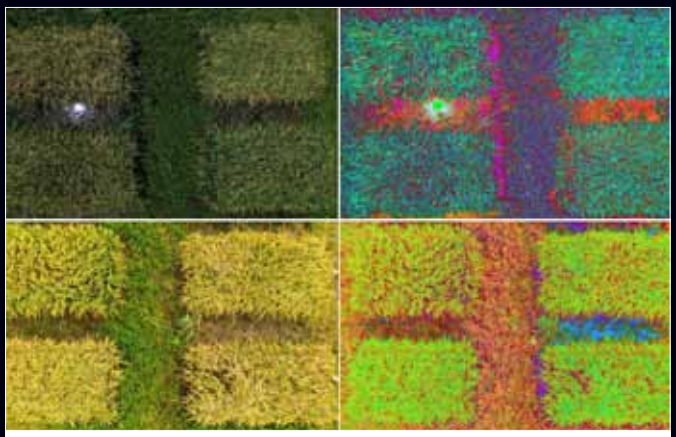
Forestry:
- Incendiary devices (to create anti-fire corridors to avoid wild fires from spreading)
- Fertilizer granulates
- Pollination agents
- Seeding vessels (seeds with moisture, nutrient, pest deterrent)
- Seedlings / Saplings (incl. in wetlands)
- Seeds

Public Services & Safety:
- Anti-leakage sealants (for dams)
- Flotation device (for swimmers in distress)
- Pamphlets

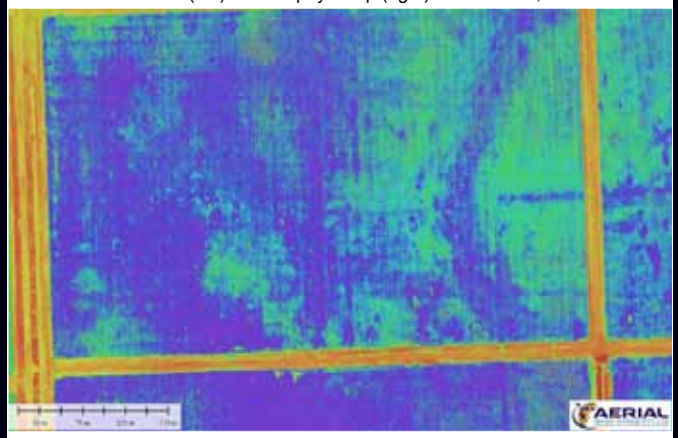
Security & Law Enforcement:
- Crowd control devices
- Pamphlets



Mapping ► Agriculture
► Chlorophyll content
RGB color (left) / Chlorophyll map (right) - Micasense, USA

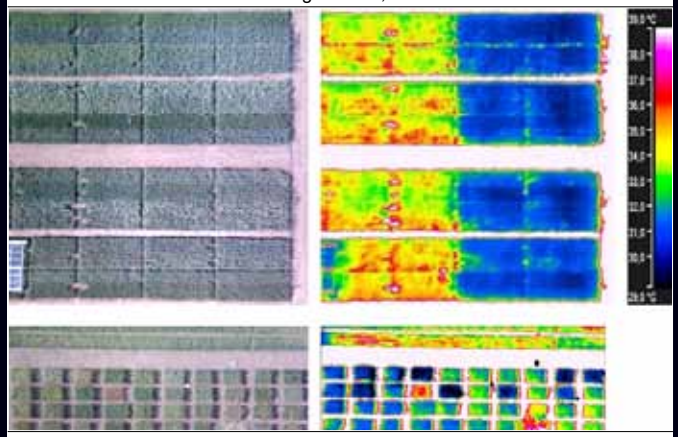


Mapping ► Agriculture ► Diseased crops
Rice sheath blight (electro-optical & multispectral sensors)
Fujian Agriculture and Forestry University, China (PR)



Mapping ► Agriculture
► Normalised difference vegetation index (NDVI) maps
Aerial Image Works, Australia

Mapping ► Agriculture
► Nutrient deficiencies
Nitrogen content map - JOUAV, China (PR)



Mapping ► Agriculture
► Water stress or excess evaluation
Thermography map - Workswell, Czech Republic

Mapping ► Construction & Real Estate
► Preconstruction planning
Aerial map with projected building in 3D on top - Wingtra, Switzerland

Mapping ► Forestry
► Forest management
Forest Manager - OpenForests, Germany

Mapping ► Heritage Site & Historical Monument
► 3D modelling
Minaret of Jam (Afghanistan) - Iconem, France

Exploration

Mining & Exploration:
- Mining industry
- Oil & gas industry
- Quarries

Research & Science:
- Archaeology

Fire Fighting

Public Services & Safety:
- Forest & wild fire:
  - Dispensing incendiary devices to create fire retention corridors
  - Extinguishing
  - Hotspot detection
  - Identification
  - Inspection
  - Localisation
  - Measuring
  - Monitoring
  - Observation
  - Patrolling
  - Post fire inspection
  - Spotting
  - Surveillance
  - Surveying
  - Water bombing
- Industrial (incl. Seveso & CBRN classified) site fire:
  - Extinguishing
  - Hotspot detection
  - Identification
  - Inspection (incl. post-fire)
  - Localisation
  - Monitoring
  - Observation
  - Surveillance
- Non-urban [building (incl. high-rises) & structure] fire:
  - Extinguishing
  - Hotspot detection
  - Identification
  - Inspection (incl. post-fire)
  - Localisation
  - Monitoring
  - Observation
  - Surveillance
- Urban fire [building (incl. high-rises) & structures]:
  - Extinguishing
  - Hotspot detection
  - Identification
  - Inspection (incl. post-fire)
  - Localisation
  - Monitoring
  - Observation
  - Surveillance

Identification

Agriculture:
- Crop damage (meteorological & pests)
- Crop disease
- Fungicide problems
- Insect/parasite infestation

Forestry:
- Disease
- Insect / parasite infestation

Security & Law Enforcement:
- Suspected criminals / pillagers / rioters

Wildlife Conservation:
- Unauthorized settlement detection

Inspection

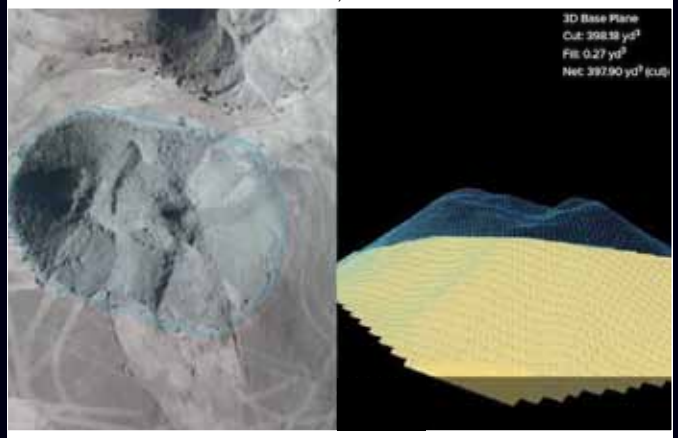
Agriculture:
- Bush / tree plantations in hilly / mountainous regions
- Conformity with agricultural policy
- Cultivated areas:
  - Bio-mass evaluation
  - Crop disease
  - Crop growth vigour
  - Crop health
  - Crop inventory / yield estimates
  - Crop maturity
  - Crop yield
  - Irrigation monitoring
  - Irrigation system leaks
  - Invasive vegetation (irrigation canals, ditches, water reservoirs)
  - Nutrient sufficiency
  - Parasite infestation
  - Pasture grass mass evaluation
  - Seedling growth density
  - Selective harvesting
  - Soil erosion evaluation
  - Soil moisture
  - Terraced rice paddies & vineyards
  - Water leaks (pumps & pumping stations)
  - Weed growth / infestation
  - Wildlife / pest impact
- Fence inspection

Construction & Real Estate:
- Building facade
- Compliance with regulations
- Construction site safety conditions
- Isolation effectiveness

Environmental Protection & Conservation:
- Atmospheric measurements (e.g. ozone, aerial pollution)
- Biodiversity
- Climate change impact:
  - Maritime (iceberg & sea ice flow)
  - Terrestrial (glacier, ice cap, river ice flow)
- Coastal erosion:
  - Mangrove inspection
  - Reef island inspection
- Ecological impact:
  - Reef degradation / growth
- Emission control:
  - Terrestrial (e.g. industrial emissions)
  - Maritime (e.g. ship emissions)

Mapping ► Mining & Exploration
► 3D Modelling
Aero3D, Poland

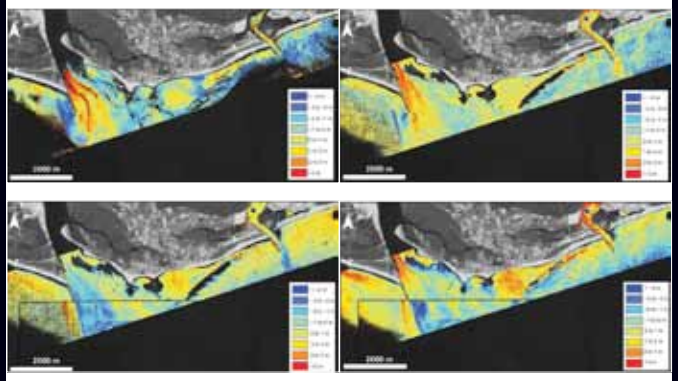
Mapping ► Mining & Exploration
► 3D Modelling
Autonomy Level 2 - Emesent, Australia



Measuring ► Mining & Exploration
► Volumetric
Stockpile inventory - Sitescan, 3D Robotics, USA

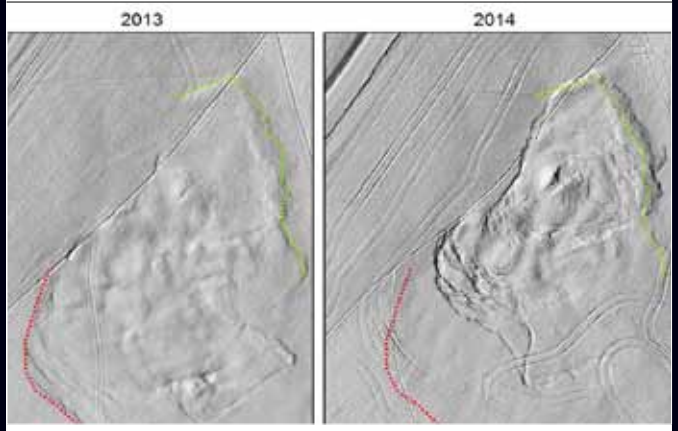
Measuring ► Maintenance
► Instrument Landing System measurements
OnyxStar ATLAS - Altigator, Belgium

Monitoring ► Agriculture
► Life stock
Folio3 Software, USA



Monitoring ► Environmental Protection & Conservation ► Hydrography
► Bathymetric
Bathymetries of the Guadiana Estuary mouth on successive dates
University of Vigo, Spain

Monitoring ► Environmental Protection & Conservation
► Pollution (aerial, maritime, terrestrial)
Camcopter S-100 monitoring ship sulphur emissions for EMSA - Schiebel, Austria



Monitoring ► Environmental Protection & Conservation
► Soil erosion
Wageningen University & Research, The Netherlands

- Hydrography:
  - Bathymetric
  - Turbidity
- Invasive algae (coastal areas & inland waterways)
- Invasive animal species detection
- Invasive plant species [(irrigation / water management) canals, ditches, lakes]
- Pollution impact
- Sandbank shifting
- Wildlife population density

Forestry:
- Cultivation-related:
  - Biodiversity
  - Carbon sequestration
  - Disease
  - Inventory (tree count & height; volumetric)
  - Parasite infestation
  - Seedling growth density
  - Soil erosion
  - Soil moisture
  - Species recognition
  - Tree canopy analysis
  - Tree growth vigour
  - Tree health
  - Tree maturity
  - Water leaks (irrigation piping)
  - Weed growth
  - Wildlife / pest impact
  - Wildfire damage assessment
- Meteorological damage impact (drought, hail, hurricane, icing, lightning, mud-slides, rain, snow, storms, temperature, tornados, tsunami, wind)
- Post natural disaster (drought, drainage, earth quake, flooding, forest fire, hurricane, mud/land slide, storm, tornado, tsunami, volcano eruption)
- Taking stock:
  - Counting of life stock
  - Counting of wildlife
  - Identification of diseased animals (in herds) - by means of temperature comparison

Heritage Sites & Historical Monuments:
- Archaeological site search
- Erosion impact
- Pollution impact
- Post disaster

Humanitarian Aid:
- Disaster response planning

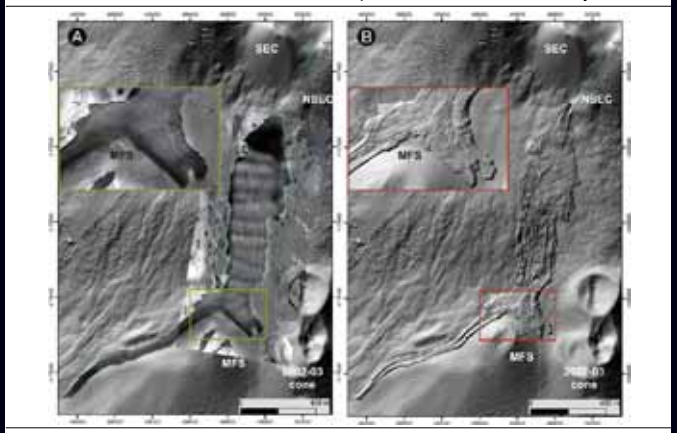
Insurance:
- Meteorological (drought, flood, hail, hurricane, icing, lightning, rain, snow, temperature, tornado, wind) damage impact evaluation on:
  - Buildings
  - Crops & farmland
  - Infrastructure
  - Nature conservation sites
  - Structures
- Post-accident / disaster:
  - Aircraft crash
  - Bridge or building collapse
  - Explosion
  - Fire site [urban (building, structure), non-urban (farmland, forest, industrial site, building & structure]
  - Industrial disaster
  - Maritime accident
  - Road accident
  - Railway accident
  - Shipping accident

Maintenance:
- Aircraft hull exterior inspection
  - Impact results (hail, lightning)
  - Painted surfaces
- Construction:
  - Solar panel inspection
  - Thermal isolation inspection
- Industrial sites:
  - Chimneys (*interior & exterior*)
  - Cooling towers
  - Drydocks (locks, sidewalls)
  - Flare stacks
  - Gas transport pipes
  - Holding tanks (*interior & experior*)
  - Offshore platforms & oil rigs
  - Pipelines (various purposes)
  - Power transmission cables
  - Powerline pylons (isolators; invasive moss/lichen growth)
  - Powerline surroundings (invasive vegetation growth)
  - Sink holes
  - Solar panel farms (bird droppings; diminished panel functionality)
  - Storage tanks (*interior & exterior*)
  - Storm drains
  - Warehouses (inventory inspection - *indoor & outdoor*)
  - Wind turbines (blades)
- Infrastructure:
  - Airport runways
  - Antennae
  - Breakwaters
  - Bridges
  - Cranes
  - Dams
  - Dikes
  - Harbour quay walls
  - High power cables
  - Mobile network towers
  - Piers
  - Pipelines (*interior & exterior*)
  - Railway tracks & ballast beds
  - Railway track surroundings (invasive vegetation growth)
  - Roads & highways
  - Street light assets
  - Transmission (repeater) towers
  - Tunnels (*confined area*)
- Shipping:
  - Fuel tanks (*confined area*)
  - Ship ballast tank (*confined area*)
  - Ship hull
  - Ship- & barge-based crane
  - Tanker ships (cargo holding tanks)(*confined area*)

Mining & Exploration:
- Elevator shaft (*confined area*)
- Highwall scanning (open pit mining)
- Power transmission cables
- Mine tunnels (*confined area*)
- Offshore platform
- Flare stacks
- Corrossion
- Post blasting
- Quarries

Monitoring ► Fish Farming
► Fish holding pens
Illustration of the ARTIFEX concept - SINTEF Ocean, Norway

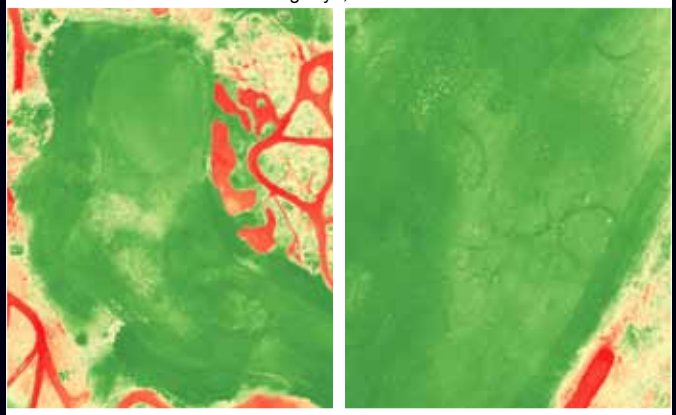
Monitoring ► Fish Farming
► Oyster farms
Oyster park surveillance in Arcachon basin (France) - Drone Protect System, France



Monitoring ► Research & Science ► Volcanos
Active lava flow on Mt. Etna (Italy), during the 2017 eruption
Istituto Nazionale di Geofisica e Vulcanologia, Italy

Monitoring ► Security & Law Enforcement
► Border (maritime & terrestrial) control
Airboxer - HighEye, The Netherlands

Monitoring ► Security & Law Enforcement
► Traffic control
Busy city intersection - DataFromSky, Czech Republic



Observation ► Construction & Real Estate ► Grass status on golf courses
Left: NDVI processing reveals low turf vigor on the approach
Right: Multispectral analysis locating fairy ring fungi
Black Sky, USA

Observation ► Insurance
► Disaster impact
Dronotec, France

Observation ► Public Services & Safety
► Beach water (swimmers)
Little Ripper LifeSaver - Ripper Corp., Australia

Public Services & Safety:
- Aircraft crash
- Buildings & structures
- Disease infected areas
- Elevator shafts (*confined area*)
- Industrial accident
- Infrastructure
- Maritime accident – inshore (incl. harbours)
- Maritime accident – offshore
- Post disaster – Natural (avalanche, earth quake, flash flood, flooding, forest fire, hurricane, mud/land slide, storm, tornado, tsunami, volcano eruption)
- Post disaster – Not Natural (chemical or nuclear accident)
- Railway accident
- Road / highway accident
- Sewers (*confined area*)
- Urban post-fire site
- Waterway accident (lakes, rivers & canals)

Security & Law Enforcement:
- Agriculture policy compliance
- Illicit crop cultivation
- Illicit fishing
- Illicit logging
- Illicit landfills & garbage / waste dumps
- Perimetric surveillance
- Post man-made disaster (industrial mishap, civil war, revolution, war)
- Pre-intervention situational evaluation
- Treaty compliance

Localisation

Agriculture:
- Crop damage (meteorological & pest causes)
- Crop maturity localisation (selective harvesting)
- Defining where to fertilise
- Defining where to use fungicide
- Defining where to use insecticide
- Early stage detection of diseases & pests
- Recovering lost life stock

Construction:
- Structural faults (cracks, rust)

Environmental Protection & Conservation:
- Anti-poaching
- Bird nest detection (in context of plough planning)
- Coastal erosion
- Insects / parasite infestation
- Natural methane emission
- Soil erosion
- Underground metallic waste
- Vegetation disease
- Very young animals detection prior to harvesting
- Weed growth
- Wildlife

Fishery:
- High value fish (school) detection

Fish Farming:
- Algae detection
- Pollutant detection

Forestry:
- Geo-tagging log piles

Heritage Site & Historical Monument Management:
- Non-intrusive delimitation archaeology sites

Maintenance:
- Aircraft fuselage dents & cracks
- Dike cladding status
- Dams (cracks)
- Fencing (repair requirements)
- Irrigation systems
- Pipelines
- Powerlines (invasive vegetation)
- Railway track ballast bed sagging
- Railway tracks (invasive vegetation)
- Roads & highways (repair requirements)
- Solar panel farms (repair requirements)

Mining & Exploration:
- Detection of ferrous & non-ferrous metals

Policy Compliance & Obtaining Legal Proof
- Caches of illegal goods
- Illegal construction
- Illegal crops & illegal crop cultivation
- Illegal garbage dump
- Individual human remains & unmakred (mass) graves
- Pollutant discharge (liquid):
  - Coastal waters
  - Harbours
  - Inland waters
  - Maritime
- Pollutant discharge (atmospheric)
  - Terrestrial (industrial emissions)
  - Maritime (ship emissions)

Public Services & Safety (coastal, maritime & terrestrial):
- Injured persons (incl. mobile telephone)
- Gas leaks
- Missing persons
- Unexploded ordnance (UXO) detection

Utility Companies:
- Hotspot detection on power transmission cables
- Lichen on power transmission cable insulators
- Pipeline - Leak detection (gas & liquids)
- Pipeline - Illegal tapping

Manipulation

Environmental Protection & conservation
- Installation of bird diverters on powerlines
- Surface water sampling

Maintenance:
- Remote repair

Mining & Exploration
- Taking samples

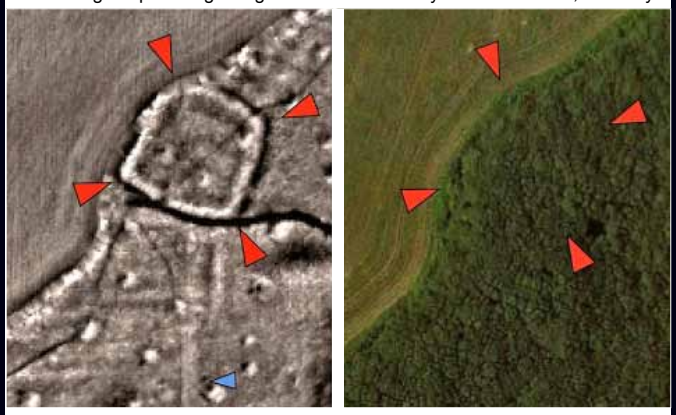
Public Services & Safety
- Eradication of hornet & wasp nests

Security & Law Enforcement
- Unexploded ordnance (UXO) clearance

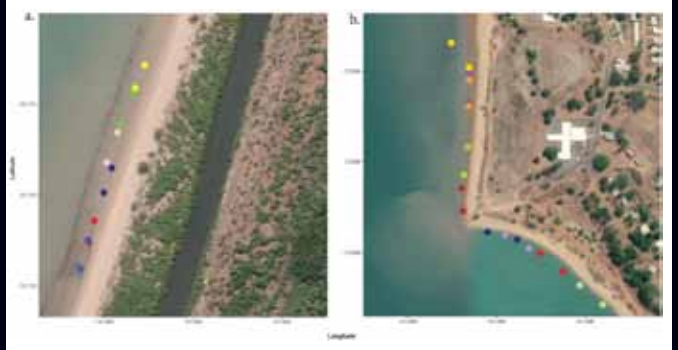
Observation ► Public Services & Safety
► Public gatherings
Cyber Drone Guarding, France

Patrolling ► Agriculture
► Weed growth/infestation
Bermudagrass patches growing in inter-rows of a vineyard - Microdrones, Germany

Patrolling ► Environmental Protection & Conservation
► Wildlife management
Avy, The Netherlands



Patrolling ► Heritage Site & Historical Monument
► Search for & discovery of archaeological sites
Probable Iron Age or Roman enclosed settlement (red arrows) and associated field system (blue arrow) revealed by LiDAR data - University of Exeter, UK



Patrolling ► Public Services & Safety
► Toxic jellyfish detection
Box jellyfish in Australia - Universita degli Studi di Genova, Italy (© 2020 Rowley et al.)

Relief Flight ► Humanitarian Aid
► Emergency supplies
Flyox I - Singular Aircraft, Spain

Relief Flight ► Humanitarian Aid
► Emergency supplies
MiniFreighter 8/500FW - Wings For Aid, The Netherlands

Search & Rescue ► Public Services & Safety ► Terrestrial
► Mountainous areas
Rega drone - Rega, Switzerland

Mapping
(incl. photogrammetry & orthomaps)

Agriculture:
- 3D topographic modelling
- Chlorophyll content
- Crop damage (meteorological & pest causes)
- Diseased crops
- Environmental heterogeneity models
- Field delineation
- Hydrographic
- Irrigation control
- Leaf area index (LAI) maps
- Normalised difference vegetation index (NDVI) maps
- Nutrient deficiencies
- Parasite control
- Pest control
- Photochemical reflectance index (PRI) maps
- Re-seeding
- Selective fertilizing
- Selective harvesting
- Selective insecticide spraying
- Selective irrigation
- Soil density & composition assessment
- Water stress or excess evaluation
- Weed pressure mapping

Construction & Real Estate:
- Building information modelling (BIM)
- Preconstruction planning
- Progress reporting
- (Re)construction planning
- Topographic survey (digital surface models & digital terrain models)
- Tree-growth delineation
- 3D modelling (inside buildings & building exteriors)

Fishery:
- Coastal habitat mapping (during low tide)

Forestry:
- Forest management
- Illicit encroachment
- Operational planning

Heritage Site & Historical Monument:
- 3D modelling

Humanitarian Aid
- Post disaster awareness creation & pre-intervention planning

Maintenance
- Aircraft fuselage (impacts, dents & cracks)
- Tunnels (*confined area*)
- Underground infrastructure

Mining & Exploration:
- 3D Modelling (open air pits & mine shafts)
- Highwall scanning (open pit mining)
- Progress reporting
- Topographic

Public Services & Safety
- Cadastral services (urban & non-urban)
- Coastlines
- Post disaster (earth quake, flash flood, flood, forest fire, hurricane, mud slide, tsunami, volcano eruption)
- Waste water & pollutant retention ponds
- Water courses (rivers, streams, torrents) & lakes
- Water retention lakes, ponds & reservoirs

Measuring

Agriculture
- Biomass, crop growth rate, crop height
- Blossoms per fruit tree
- Crop growth vigour
- Fruit growth vigour
- Harvest volume estimation

Construction
- Excavation depth
- Thermal isolation

Environmental Protection & Conservation:
- Coastal erosion
- Deforestation
- Ground water
- Ice caps & glaciers & icebergs
- Hydrography
  - Bathymetric
  - Turbidity
- Ozone levels
- Salt water infiltration
- Snow cap
- Pollution

Forestry:
- Tree height, volume, inventory
- Volumetric (harvested logs)
- Weather forecasting (temperature, humidity, wind)

Maintenance:
- Instrument Landing System (ILS) measurements (airports)

Mining & Exploration:
- Hygrometric
- Slope angles (open pit mining)
- Slope height (open pit mining)
- Volumetric (gravel, sand)

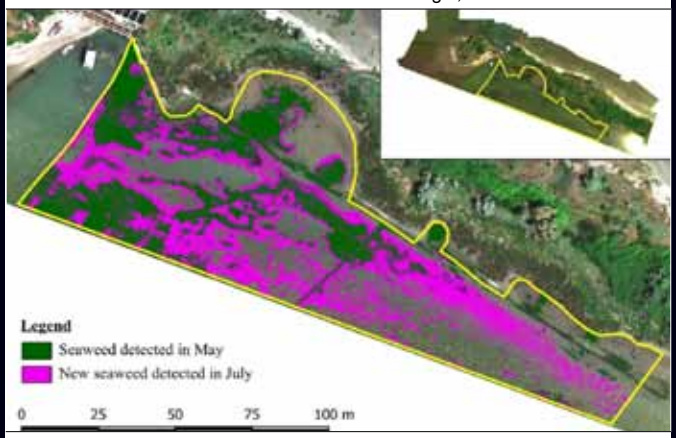
Public Services & Safety:
- Aerial emissions
- Climate change/environmental impact
- Contamination
- Gas & odor
- Pollutant impact
- Water retention lakes & reservoirs

Research & Science
- Drifting pack ice (drift, size, volumetric)
- Dune (drift)
- Glacier displacement (glacier velocity flow)
- Glacier & iceberg (size, volumetric)
- Pack ice (drift)
- Sandbank (drift)
- Sea ice floe (size, volumetric)

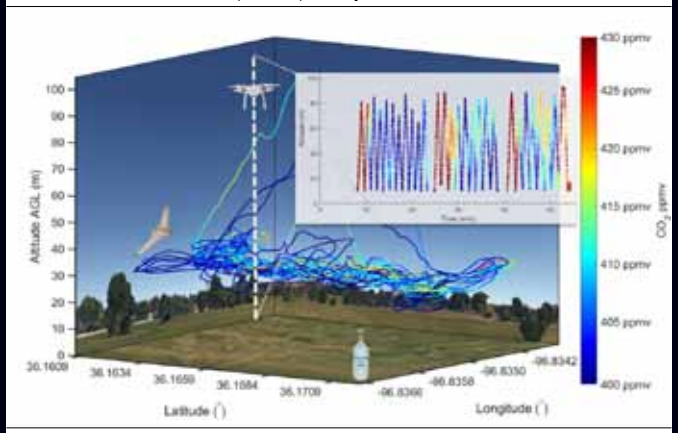
Security ► Policy Compliance & Obtaining Legal Proof
► Refugee camp over-watch
Sayam Forage refugee camp in Niger - UNHCR, International

Security ► Security & Law Enforcement
► Critical infrastructure over-watch
Ouranos Beta - Dronétix Technologie, France

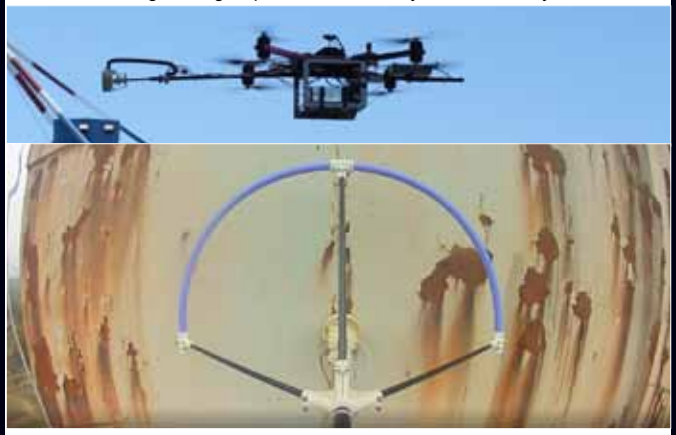
Security ► Security & Law Enforcement
► Harbour facility over-watch
Dunkirk harbour (France) - Skeyetech, Azur Drone, France



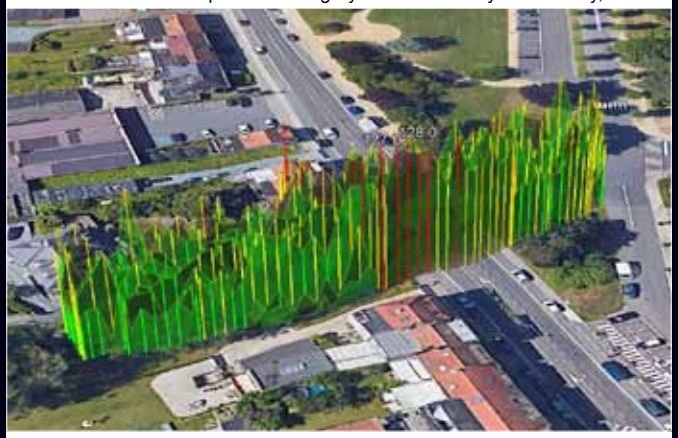
Sensing ► Environmental Protection & Conservation ► Algae proliferation
Multispectral imaging of submerged seaweed in shallow water
Engineering Department, University of Ferrara, Italy



Sensing ► Environmental Protection & Conservation
► Atmospheric measurement & analysis
Researchers Develop Gas Sensing System - University of Kentucky, USA



Sensing ► Maintenance
►Ultrasonic measurements (metal & paint thickness)
Pilgrim Technology, France



Sensing ► Research & Science
►Methane level verification
Outskirts of Brussels (Belgium) - Skyebase, Belgium

Sky Painting & Sky Writing ► Entertainment & Artistic Expression ► Aerial spectacles
Drone Show For XiangTan Shop in ChangSha
ZhiYun Hunan & HighGreat & ZeroTech, China (PR)

Monitoring

Agriculture:
- Farm equipment & machinery & facilities
- Irrigation
- Life stock
- Soil erosion
- Soil moisure level

Environmental Protection & Conservation:
- Anti-poaching
- Evaluation of ecological / ecosystem impact
- Glacier, iceberg, ice cap degradation / growth
- Hydrography:
  - Bathymetric
  - Turbidity
- Iceberg & maritime ice flow
- Invasive algae
- Invasive plant growth
- Plankton drift / flow / presence
- Pollution (aerial, maritime, terrestrial)
- Salt water seepage into coastal land areas
- Soil erosion
- Wildlife (protected species)

Fish Farming:
- Fish holding pens
- Oyster farms
- Algae proliferation

Heritage Site & Historical Monument Management:
- Evaluation of environmental & pollutant impact

Meteorology:
- Atmospheric sensing
- Climate change impact:
  - Glacier
  - Ice cap

Oceanography:
- Ice floe & icebergs

Public Services & Safety:
- Forest fires
- Building & structure fires
- Industrial zone fires & other mishaps

Research & Science
- Volcanos

Security & Law Enforcement:
- Anti-terrorism
- Border (maritime & terrestrial) control
- Critical infrastructure
- Crowd control (hostile; non-hostile)
- Fishery control
- Illicit activity in natural parks/nature reserves
- Illicit ship bilge venting
- Illicit crop cultivation
- Illicit cargo
- Immigration control
- Perimeter security
- Sensitive site
- Shipping lane
- Traffic control

Observation

Agriculture:
- Bio-mass
- Crop growth vigour
- Crop health
- Crop maturity
- Crop disease
- Irrigation
- Invasive vegetation (irrigation canals & ditches)
- Parasites infestation
- Nutrient sufficiency
- Pasture grass mass
- Seedling growth density
- Soil erosion
- Soil moisture content
- Terraced rice paddies & vineyards
- Weed growth / infestation
- Wildlife / pest impact

Construction & Real Estate:
- Construction site awareness
- Grass status on golf courses

Environmental Protection & Conservation:
- Climate change impact
- Coastal erosion
- Desertification
- Dune shifting
- Ecological impact
- Invasive algae
- Invasive vegetation
- Pollution impact

Humanitarian Aid:
- Disaster impact
- Pre-intervention planning

Insurance:
- Disaster impact
- Meteorological damage impact

Maintenance:
- Disaster impact
- Meteorological damage impact

Mining & Exploration:
- Accident impact

News Gathering & Broadcasting:
- Situational awareness (of reporter)

Policy Compliance & Obtaining Legal Proof:
- Situational awareness

Public Services & Safety:
- Beach water (anti-shark)
- Beach water (swimmers)
- Public gatherings (music festivals; sporting events)

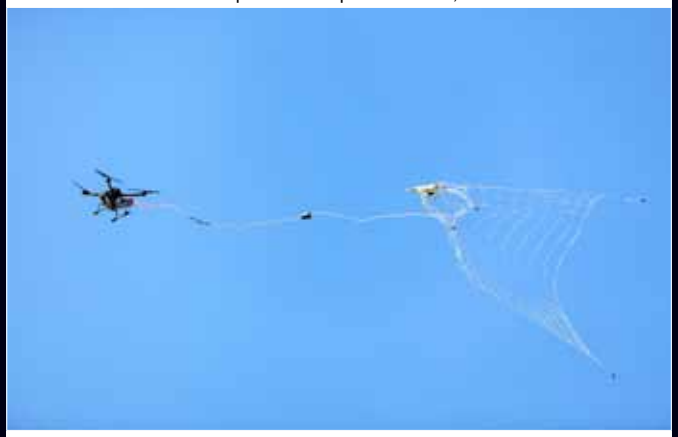
Research & Science:
- Climate change impact
- Coastal erosion
- Desertification
- Ecological impact
- Pollution impact
- Volcanos

Sky Painting & Sky Writing ► Public Services & Safety
► Message to the general public
Ministry of Land, Infrastructure and Transport (MOLIT), South Korea

Special Purpose ► Communication Companies
► Communication rely
Zephyr - Airbus, France

Special Purpose ► Environmental Protection & Conservation
► Water analysis
Water Sampler V2.0 - Sphere Drones, Australia

Special Purpose ► Public Services & Safety
► Eradication of pests
Flame Thrower - Blue Sky Rescue, China (PR)



Special Purpose ► Security & Law Enforcement
► Interception of hostile/illicit drone
DroneCatcher - Delft Dynamics,The Netherlands

Special Purpose ► Security & Law Enforcement
► Public address system
Mavic 2 Enterprise - DJI, China (PR)

Spotting ► Construction & Real Estate
► Construction errors
Skydrone, France

Spotting ► Environmental Protection & Conservation
► Driftnet
Sea Sheperd Global, International

Security & Law Enforcement:
- Crowd control
- Public demonstrations

Utility Companies (Public & Private):
- Accident impact
- Pre-intervention planning
- Situational awareness

Patrolling

Agriculture:
- Crop growth vigour
- Crop health
- Crop maturity
- Crop disease
- Invasive vegetation
- Parasites infestation
- Seedling growth density
- Soil erosion
- Soil moisture
- Weed growth/infestation
- Wildlife / pest impact

Environmental Protection & Conservation:
- Anti-poaching
- Pollutant detection
- Wildlife management

Heritage Site & Historical Monument:
- Search for & discovery of archaeological sites

Humanitarian Aid:
- Search for survivors (post disaster)

Mining & Exploration:
- Perimeter security

Policy Compliance & Obtaining Legal Proof:
- Illicit construction control
- Illicit crop cultivation
- Search for mass graves

Public Services & Safety:
- Beach water oversight (swimmers in distress; shark / toxic jelly fish threat)
- Coastal water oversight (surfers in distress)
- Search for missing persons
- Search for escaped (dangerous) animal

Research & Science:
- Climate change impact
- Coastal erosion
- Desertification
- Ecological impact
- Pollution impact

Security & Law Enforcement:
- Anti-poaching
- Anti-terrorism
- Border (maritime & terrestrial) control
- Critical infrastructure
- Crowd control (hostile; non-hostile)
- Fishery control
- Illicit activity in natural parks/nature reserves
- Illicit ship bilge venting
- Illicit crop cultivation
- Illicit cargo
- Immigration control
- Perimeter security
- Sensitive site
- Shipping lane
- Traffic control

Utility Companies:
- Railways (invasive vegetation control)

Relief Flight

Humanitarian Aid:
- Blood units
- Emergency supplies
- Medical supplies
- Vaccines

Public Services & Safety:
- Blood units
- Emergency supplies
- Medical supplies
- Vaccines

Search & Rescue

Public Services & Safety:
- Coastal areas (beach lifeguards/swimmers in distress)
- Inland waterways
- Maritime:
  - Man-over-board
- Terrestrial
  - Forested areas
  - Open areas
  - Mountainous areas (incl. avalanche victims)
  - Urban areas

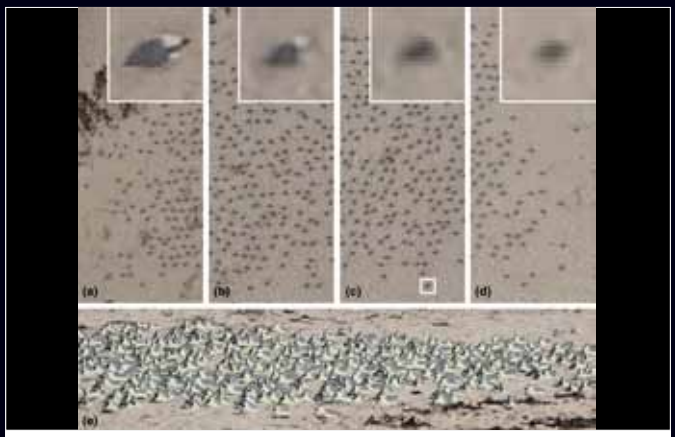
Security

Environmental Protection & Conservation:
- Anti-poaching (detecting & localizing + identifying culprits)
- Nature reserve - Detecting illicit intrusion
- Poacher tracking

Heritage Site & Historical Monument
- Break & entry detection
- Detecting acts of vandalism
- Perimeter patrol

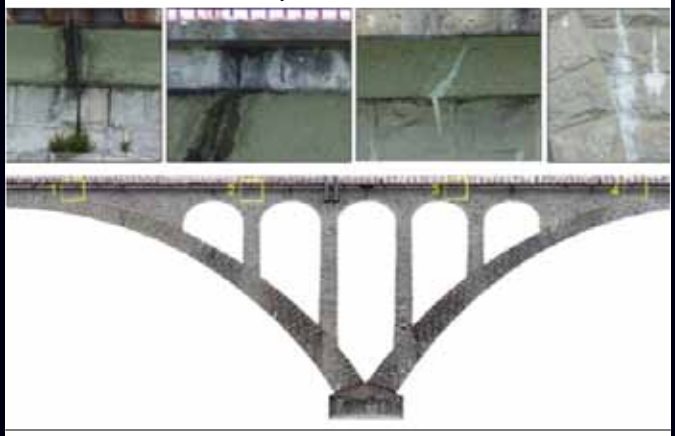
Policy Compliance & Obtaining Legal Proof
- Illicit construction
- Refugee camp over-watch

Security & Law Enforcement:
- Airport perimeter over-watch
- Boats with illegal immigrants or illegal cargo (detecting & localizing + identifying culprits)
- Crime scene awareness
- Crime suspect tracking
- Criminal activity detection
- Critical infrastructure over-watch
- Crowd & demonstration control
- Crowd counting
- Customs authority controlled areas over-watch
- Demonstration over-watch



Spotting ► Environmental Protection & Conservation ► Wildlife counting
Seabird colony compared with the ground counter's viewpoint
University of Adelaide, Australia

Spotting ► Industry
► Stock check/inventory in large warehouses
Eyesee, France



Spotting ► Maintenance ► Cracks
► Bridges
Drones Imaging, France

Spotting ► Maintenance ► Cracks
► Dams
EasyInspect, Denmark

Spotting ► Security & Law Enforcement
► Boats with illegal immigrants or illegal cargo
Migrant boat crossing the English Channel - AR5, Tekever, Portugal (for EMSA)

Spotting ► Security & Law Enforcement
► Illicit crop cultivation on public/private land
Cannabis cultivation spotting with infrared camera - West Midlands Police, UK

Spraying ► Agriculture
► Fertiliser
Volodrone - Volocopter, Germany

Spraying ► Construction ► Mortar coatings
Ornamental coating with clay-based mortars in Brussels (Belgium)
MuDD Architects, France

- Harbour facilities
- Hazmat response planning
- Illicit cultivation of crops in nature reserve (detecting & localizing + identifying culprits)
- Illicit cultivation of crops on public land (detecting & localizing + identifying culprits)
- Illicit fishing activity (detecting & localizing + identifying culprits)
- Illicit logging activity (detecting & localizing + identifying culprits)
- Illicit mining (detecting & localizing + identifying culprits)
- Industrial site perimeter
- Intervention over-watch
- Intervention planning
- Looter & vandal detection & identification
- Missing person search
- Plunder prevention
- Preliminary information gathering (prior to intervention)
- Public gathering (music festivals; public events; sporting events) overwatch
- Refugee camp over-watch
- Restricted access area over-watch
- Riot control
- Unexploded ordnance (UXO)

Sensing

Environmental Protection & Conservation:
- Algae proliferation
- Atmospheric measurement & analysis
- Odor detection
- Weather analysis

Maintenance:
- Chemical corrosion
- Holding tank corrosion analysis
- Tanker ship holds & ship ballast tanks
- Ultrasonic measurements (metal & paint thickness)

Public Services & Safety:
- Atmospheric measurement & analysis
- Toxic cloud analysis

Remote Operations - Sensing
- Water samples
- Ultrasonic measurements (metal & paint thickness)

Research & Science:
- Experimentation
- Methane level verification

Utility Companies
- Atmospheric measurement & analysis

Sky-Painting & Sky-Writing

Advertising:
- Drone swarms creating client-specified logos, names or forms
- Drone using smoke generator to create aerial words

Entertainment & Artistic Expression:
- Aerial spectacles

Public Services & Safety:
- Message to the general public - Drone swarms creating government messages to the general public (e.g. health warnings)

Special Purpose

Artistic Expression:
- Long exposure photos of flying drone(s)

Communication Companies:
- Communication rely
- WIFI relay

Environmental Protection & Conservation:
- Sea mammal tagging
- Wildlife tagging
- Water analysis (inland & coastal)

Public Services & Safety:
- Emergency regional telephone connectivity
- Eradication of pests (e.g. hornet & wasp nests, mosquitos)

Remote Operations - Non-Sensing:
- Sample taking

Security & Law Enforcement:
- Interception of hostile / illicit drone (with net, electronic or other means)
- Public address system

Utility Companies:
- Tethered aerial electricity generation

Spotting

Agriculture:
- Crop growth vigour
- Crop health
- Crop maturity
- Crop disease
- Diseased cattle
- Invasive vegetation
- Parasite infestation
- Pest investation
- Seedling growth density
- Soil erosion
- Soil moisture
- Weed growth / infestation
- Wildlife (damage by)

Construction & Real Estate:
- Construction errors
- Environmental damage
- Intruder detection
- Meteorological impact/damage
- Perimeter fence damage

Environmental Protection & Conservation:
- Diseased vegetation
- Hydrographic anomolies
- Salt water penetration into arable land
- Traces of poaching
- Young animals & bird nests in fields to be harvested
- Wildlife counting (terrestrial & maritime)

Spraying ► Construction
► Paint
Spray Painting Drone (PoC) - Apellix, USA

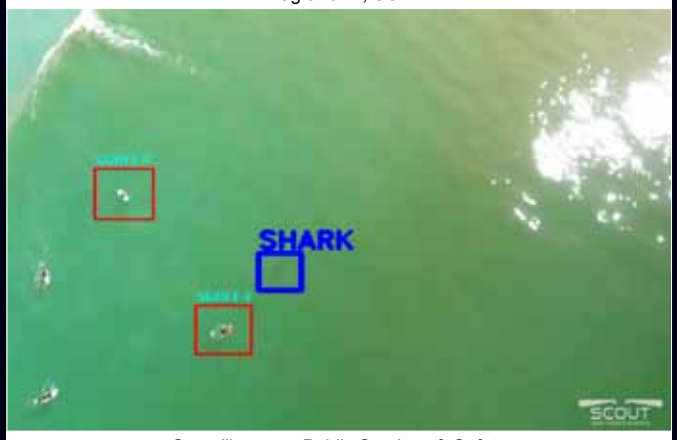
Spraying ► Humanitarian Aid
► Locust control
Desert locust control in East Africa - Centre for Agricultural Bioscience International, UK

Spraying ► Humanitarian Aid
► Mosquito control
Anti-Malaria Drone - Dutch Malaria Foundation, The Netherlands

Spraying ► Public Services & Safety
► Virus control
Hercule 20 - Drone Volt, France

Spraying ► Public Services & Safety
► Virus control
EagleHawk, USA

Surveillance ► Heritage Site & Historical Monument
► Site over-watch
Delair, France



Surveillance ► Public Services & Safety
► Beach waters
Scout Aerial, Australia

Surveying ► Insurance
► Post-disaster assessment
Morandi Bridge collapse (Italy) - eBee X, senseFly, Switzerland

Heritage Site & Historical Monument:
- Earthquake damage
- Erosion
- Illicit exploration
- Pollution damage

Humanitarian Aid:
- Post (natural) disaster action:
  - Human activity
  - Survivors (trapped)

Industry:
- Stock check / inventory in large warehouses

Maintenance:
- Concrete cancer / spalling / crumbling
- Corrossion on:
  - Ballast tanks (inside ships)
  - Bridges
  - Cranes
  - Offshore platforms
  - Pilings
  - Pipelines
  - Pylons
  - Ships
  - Storage tanks
  - Transmission towers
- Cracks:
  - Bridges
  - Cooling towers
  - Dams
  - Wind turbine blades
- Deformities (metallic structures & pipes)

Mining & Exploration:
- Charges (not having exploded)
- Corrossion on:
  - Elevator rigging
  - Oil rigs
  - Offshore platforms
  - Pipes & pipelines
- Retainment pond overflows

Policy Compliance & Obtaining Legal Proof:
- Illicit cultivation of crops in nature reserve
- Illicit logging activity
- Illicit mining

Public Services & Safety:
- Lifeguards:
  - Swimmers / surfers in distress

Research & Science:
- Environmental impact
- Iceberg
- Meteorological impact/damage
- Pack ice
- Pollution impact
- Raptor nestings

Security & Law Enforcement:
- Boats with illegal immigrants or illegal cargo
- Illicit construction
- Illicit crop cultivation on public or private land
- Illicit crop cultivation in nature reserve
- Illicit fishing activity
- Illicit logging activity
- Illicit mining

Utility Companies
- Corrossion
- Cracks & concrete cancer / spalling / crumbling
- Environmental damage
- Intruder detection
- Meteorological impact/damage
- Perimeter fence damage

Spraying

Agriculture:
- Fertiliser (wide area & selective)
- Fungicide (precision farming)
- Herbicides (wide area & selective)
- Insecticide (wide area & selective)
- Water (precision & selective irrigation)

Construction:
- Anti-corrosion (metallic structures)
- Mortar coatings
- Paint
- Pressure cleaning (building façades, roofs, windows)

Environmental Protection & Conservation:
- Locust control

Humanitarian Aid:
- Locust control
- Mosquito (malaria & dengue) control
- Virus control (public area)

Public Service & Safety:
- Holy water dispersion over pilgrims (India)
- Hornet & wasp nest eradication
- Mosquito (malaria & dengue) control
- Virus control (public area, sport stadium)

Surveillance

Agriculture:
- Climatic impact assessment
- Infestation impact assessment (birds, insects, vermin)
- Invasive vegetation (weeds) impact
- Plow planning
- Seedling growth
- Vegetation disease

Construction & Real Estate:
- Climatic impact assessment (golf course)

Environmental Protection & Conservation:
- Animal behavior:
  - Coastal waters (sea mammals)
  - Terrestrial (endangered species, wildlife herds)
- Desertification encroachment
- Nesting sites
- Pollution impact (on ecosystem) assessment

Heritage Site & Historical Monument:
- Site over-watch
- Situational awareness

Surveying ► Maintenance
► Breakwater repair assessment
The port of Scheveningen, The Hague - CDR International, The Netherlands

Tracking ► Security & Law Enforcement ► Criminal suspects
Daytona Beach police use drone to help catch roof-climbing burglar suspect
Daytona Beach Police Department, USA

Transport - Goods ► Medical
► Blood platelets / Blood units
Zip - Zipline, USA

Transport - Goods ► Medical
► Medical supplies (e.g. defribillators)
Ambulance Drone - TU Delft, The Netherlands

Transport - Persons ► Transport - Persons
► Air ambulance
Volocity ADAC Field Test Air Rescue (begin in 2023) - Volocopter, Germany

Transport - Persons ► Transport - Persons
► Air taxi
CityAirbus - Airbus Helicopters, France

Validation ► Flight Schools
► Duo flight: Student pilot instruction by licensed pilot
Belgian Drone School, Belgium

Validation ► Industry ► Product certification demonstration witness
► Rescue boat (drop test)
Pilgrim Technology, France

Humanitarian Aid:
- Post-disaster situational awareness (towns & villages)
- Pre-intervention planning

Policy Compliance & Obtaining Legal Proof:
- Situational awareness

Public Services & Safety:
- Beach waters (anti-shark)
- Post-disaster situational awareness (towns & villages; infrastructure)
- Pre-intervention planning
- Swimmer & surfer safety

Research & Science:
- Climatic impact assessment
- Desertification encroachment
- Pollution impact assessment

Security & Law Enforcement:
- Crowd over-watch
- Perimeter security
- Restricted site over-watch
- Situational awareness

Utility Companies:
- Post-disaster situational awareness
- Pre-intervention planning (post disaster)

Surveying

Agriculture & Forestry:
- Erosion assessment

Construction & Real Estate:
- Pre-construction planning

Heritage Site & Historical Monument:
- Pre- & post restauration
- Pre-excavation planning

Insurance:
- Post-disaster assessment

Maintenance:
- Breakwater repair assessment
- Dike re-cladding planning
- Road & highway repair planning

Mining & Exploration:
- Pre-excavation planning

Remote Sensing: Bathymetric (coastal areas, canals, lakes, ponds, rivers)

Public Services & Safety:
- Cadastral services (urban & non-urban)
- Post-disaster assessment

Test / Evaluation

Industry:
- Unmanned aircraft (UA) / drone (flight performance, incl. take-off/launch & landing/recovery)
- Unmanned aircraft system (UAS) / drone system performance
- Payload for UA / drone
- Sub-systems for UAS / drone system
- U-Space/UTM/UAM systems

Tracking

Agriculture:
- Life stock tracking & counting

Cinema & TV Industry
- Aerial film footage / video of moving persons & vehicles (terrestrial, maritime, aerial)

Environmental Protection & Conservation:
- Wildlife (transponder) tracking & counting

Research & Science:
- Wildlife (transponder) tracking & counting

Security & Law Enforcement:
- Criminal suspects

Sport
- Aerial film footage / video of moving atheletes & racing vehicles (e.g. cars, boats)

Transport – Goods

Construction
- Structure element positioning

Distribution & Courier Service:
- Consumer goods

Forestry:
- Critical spare parts
- Log transport

Industry:
- Critical spare parts

Medical:
- Blood platelets
- Blood units
- Emergency supplies
- Medical supplies (e.g. defribillators)
- Organs
- Vaccines & medicine

Mining & Exploration:
- Critical spare parts

Public Services & Safety:
- Emergency supplies (civil protection)
- Explosives (avalanche control)
- Postal delivery to remote areas

Remote Operations – Non-Sensing:
- Harbour service & shipping documents to/from ships (customs; harbour authorities, logistics)
- Remittance of power transmission cable lead lines (to string cables)

Transport – Cargo:
- Courier/parcel delivery (incl. shore/ship & ship/shore)
- Large volume (containerized)
- Large volume (underslung bulk) (e.g. logs)
- Remittance of towing cable lead lines (tug boats)
- Powerline (replacement) stringing

Beach Surveillance + Search & Rescue
▶ Public Services & Safety
KNRM, The Netherlands

Railway bridge Inspection
▶ Maintenance
Rijkswaterstaat, The Netherlands

Orchard Spraying
▶ Agriculture
VITO, Belgium

Post Flood Area Observation
▶ Public Services & Safety
Rijkswaterstaat, The Netherlands

Powerline Inspection
▶ Maintenance
Robot Aviation, Norway

Fireball Hopper (to create controlled burns) to contain forest fires
▶ Forestry & ▶ Public Services & Safety
Ignis by Drone Amplified, USA

Drone for aircraft fuselage inspection
▶ Maintenance
Mainblades, The Netherlands

Inspection
▶ Mining & Exploration
UDH, South Africa

Transport – Persons

- Air taxi
- Air ambulance

Validation

Industry:

- Flight Schools:
  - Duo flight: Student pilot instruction by licensed pilot
  - Solo flight: Unaided student flight
  - Check flight: Pilot qualification examination
  - Flight to maintain flight competence (unaided)
- Product calibration:
  - Electronic Terrain and Obstacle Data (E-TOD)
  - Radar
- Product certification:
  - Anti-drone system
  - Unmanned aircraft (UA) / drone
  - Unmanned aircraft system (UAS) / drone system
- Product certification demonstration witness:
  - Liferaft (drop test)
  - Man-over-board boat (drop test)
  - Rescue boat (drop test)
  - Other
- Product certification process:
  - Industrial plant
  - Ship
- Product development:
  - Aircraft-related matters (incl. proof of concept & prototype)
  - Flight-related matters
  - Payload performance
  - System-related matters
  - Technology performance
  - U-space / UTM / UAM systems

Policy Compliance & Obtaining Legal Proof:

- Agricultural policy compliance
- Emission limit compliance:
  - Harbours (ships)
  - Territorial waters (ships)
  - Terrestrial (production & processing facilities)
- European Commission agencies (e.g. EMSA)
- International organisations (e.g. UN)
- Judiciary (incl. International Criminal Court)


THE
DRONE
ECOSYSTEM

INTRODUCTION

In the context of promoting general awareness, this publication proposes a description of the unmanned aircraft system (UAS) ecosystem. The objective is to indicate the wide variety of stakeholders that are (or should be) part of this community, and to improve comprehension of the far-reaching economic impact this community may have in the future, as well as it's job creation potential. De facto, this document will hopefully draw attention to the necessity of coordination and cooperation between the ecosystem stakeholders, and the importance of education at all levels, in order to unlock the UAS market.

THE UNMANNED AIRCRAFT SYSTEMS (UAS) ECOSYSTEM

The UAS ecosystem can be understood as the community of companies and organisations (private & public) interacting with one another and involved, directly or indirectly, with conducting UAS operations and making them safe, compliant with the applicable regulations (incl. privacy, data protection, security), sustainable, and societally acceptable, on a national, European and international level.

The UAS Ecosystem Constituents

In this publication, the UAS ecosystem is considered to consist of the following stakeholder groups:

Products

Aircraft
Ground-based Elements
Communications
Software
Critical Components
Air Traffic Management
Training Simulators
Counter-UAS Systems

Services

Education-related
Airspace Information & Management
Infrastructure-related
Operators:
- Commercial
- Non-Commercial (incl. Corporate)
- Public

Operations-related
Producer- / Product-related

Additional Stakeholders

Aeromodelists
Sport, Competition & Racing
Interest Groups
General Aviation
Research Organisations
Innovation Hubbs
Knowledge Centres
Standard Producing Organisations
Traditional Transport
Consortia - Subsidized by the EU & SESAR JU
Consortia - Nationally subsidized
Public Entities:
- National
- Regional
- International Organisations
- Inter-governmental Organisations

Flight Mission Customers

General & Specialized Press

Additional Information

In order to be explicit, this sections contains multiple examples of the following :

Flight Mission Purposes

End-Customers of UAS-Supplied Services

PRODUCTS PER SYSTEM ELEMENT

System Types	**Manually operated, automatic (preprogrammed) and autonomous:** **- Unmanned Aircraft (UA) System (UAS) - Incl. Optionally Piloted Aircraft (OPA)** **- Remotely Piloted Aircraft (RPA) System (RPAS)**

System Elements	AIRCRAFT	GROUND-BASED	COMMUNICATION	SOFTWARE

AIRCRAFT	Aeroplane, rotorcraft (helicopter & gyroplane), multicopter, glider, dirigible, ornithopter, tethered glider (incl. amphibian & hybrid air/ground types) of all sizes for operations in the open air & in confined spaces
Airframe Elements	◆ *Fuselage* ◆ *Wing & Winglet* ◆ *Tail* ◆ *Boom* ◆ *Cowling* ◆ *Fan duct* ◆ *Fuel tank / bladder* ◆ *Landing gear* ◆ *Nacelle* ◆ *Airframe protection cage* ◆ *Rotor shroud* ◆ *Internal cargo rack / dispenser* ◆ *Tilting mechanism (i.a. engine, fan duct, motor, wing)* ◆ *Storage / transport container*
Propulsion	◆ *Engine (thermal)* ◆ *Motor (electric)* ◆ *Turbine* ◆ *Hybrid* ◆ *Other power unit* ◆ *Engine starter* ◆ *Exhaust & Muffler* ◆ *Propeller* ◆ *Rotor*
Energy	◆ *Batteries* ◆ *Energy storage* ◆ *Energy transmission* ◆ *Fuel cell / cartridge (i.a. hydrogen, butane, propane)* ◆ *Solar cell array / sheeting*
Flight Control	◆ *Accelerometer* ◆ Actuator ◆ *Autopilot* ◆ *Avionics/flight management (sensor & processor)/operational control-related* ◆ *C3-related (incl. interfaces)* ◆ *Engine control unit (ECU)* ◆ *Flight performance sensors (e.g. altimeter, fuel & power consumption, pitot, temperature)* ◆ *Geo-referencing* ◆ *Global navigation satellite system (GNSS) receivers* ◆ *GNSS-denied navigation system* ◆ *Gyroscope* ◆ *Inertial measurement unit (IMU)* ◆ *Inertial navigatuion system (INS)* ◆ *Magnetometer* ◆ *Navigation-related* ◆ *Power management unit (PMU* ◆ *Servo* ◆ *Situtional awareness (incl. Detect & Avoid, obstacle avoidance)* ◆ *Transponder*
Sub-system	◆ *Antenna* ◆ *De-icing & anti-icing* ◆ *Flight recorder* ◆ *Gyro-stabilized platform* ◆ *Lights - Landing/Position* ◆ *Perching grip* ◆ *Pod (various applications)* ◆ *Recovery (airbag, parachute)* ◆ *Cargo sling & release unit* ◆ *E-identification* ◆ *Radiation shielding* ◆ *Weather radar*
Sub-assembly	◆ *Cable harness* ◆ *Cables & connectors*
Payloads - Imaging	◆ *Corona effect imager* ◆ *Digital photo camera* ◆ *Digital video camera* ◆ *Electric-optical (EO)* ◆ *Film camera* ◆ *Flash Light Detection & Ranging (F-LiDAR)* ◆ *Hyperspectral* ◆ *Infrared (IR)* ◆ *Light detection & ranging (LiDAR)* ◆ *Laser scanner* ◆ *Light intensification* ◆ *Line scanner* ◆ *Multi-layer laser* ◆ *Multispectral - Optical* ◆ *Multispectral - Thermal* ◆ *Near infrared* ◆ *Radar [incl. ground penetrating, maritime & synthetic aperture radar (SAR)]* ◆ *Solid state photon counter* ◆ *Related gimbals & imager mounts* ◆ *Video encoder* ◆ *Video processor*
Payloads - Non-Imaging	**Measurement** ◆ *Anemometer* ◆ *Atmospheric pollutants (i.a. SOx, NOx)* ◆ *Bathymetric* ◆ *Electromagnetic* ◆ *Frequency analysis* ◆ *Geo-magnetic* ◆ *Interferometry* ◆ *Laser range finder* ◆ *Meteorological* ◆ *Microwave radio-meter* ◆ *Particle analysis* ◆ *Phenomena analysis* ◆ *Radiation meter* ◆ *Spectrometer* ◆ *Ultrasonic* ◆ *Ultraviolet* ◆ *Other*

Payloads - Non-Imaging	**Detection** • *Cell phone location* • *Emergency beacon* • *Gas (i.a. methane, CO^2)* • *Metal* • *Mineral* • *Moving target* • *Odour* • *Pollutants (i.a. atmospheric)* • *Hydrography* • *Location identification [flora, fauna, object, person (moving & static)]* **Other** • *Cable stringing grip & release* • *Data recorder* • *Cargo pod & release (incl. parachute)* • *Communication relay* • *Dispensing system (bulk: granulates, larvae, pollination agents, seeds)* • *Dispensing system (other: i.a. bird diverter, seedling)* • *Fire extinguishing system* • *Flame thrower (pest eradication)* • *Flood light* • *High pressure spraying system (roof, structure & wall cleaning)* • *Laser pointer* • *Loudspeaker* • *Manipulator / robotic arm + grab / grip* • *Rangefinder* • *Measurement probe* • *Megaphone* • *Net (aerial drone interception)* • *Radio direction finder* • *Spotlight* • *Spraying system (liquids - all purposes)* • *Suction extractor (hornet & wasp nest control)* • *Tagging system (animals)* • *Waterbombing (large volume liquid release)*
GROUND-BASED	• *Remote pilot station & related sub-systems* • *Data storage* • *Homing / docking station* • *Self-charging pad* • *Automated cargo loading & unloading* • *Tethering system* • *Landing grid* • *Launch system (launcher)* • *Recovery system (arresting net & cable)* • *Transport & storage cases*
Infrastructure	• *Aerodrome* • *Charging station* • *Droneport* • *Navigation & surveillance aid* • *Vertiport*
COMMUNICATION	*All types (incl. satellite)* • *Anti-jamming* • *Anti-spoofing* • *Antenna* • *Command, Control, Communication (C3)* • *Telemetry* • *Tracking* • *Transponder*
SOFTWARE	• *Autopilot* • *Data & image processing & analytics* • *Flight planning & control* • *Fleet management & MRO* • *Geo-caging & referencing* • *Health monitoring* • *Payload control & target tracking* • *Performance-based navigation tools* • *Position precision enhancement* • *Safety risk assessment* • *Simulator (virtual, augmented & mixed reality)* • *Traffic management tools* • *Training & examination* • *Artificial intelligence (AI) (all relevant applications)*
CRITICAL COMPONENTS	• *Circuit board* • *Electronic card* • *Electronic chip* • *Micro-processor* • *Semi-conductor*
TRAFFIC MANAGEMENT	Hardware & software • *Aeronautical information service* • *Air navigation service (ANS)* • *Air traffic management (ATM)* • *Common information service (CIS)* • *Urban air mobility (UAM) service* • *U-space service (USS)* • *Unmanned traffic management (UTM)*
TRAINING SIMULATOR	Hardware & software (*incl. AI, virtual, augmented & mixed reality)*
COUNTER-UAS SYSTEM	Hardware & software • **Types** [*i.a. ground-based (static & mobile), hand-held, UAS-based]* • **Counter-measures** *[detection, classification, identification, localisation, tracking, control take-over, incapacitation (i.a. C2 or GNSS jamming), interception, neutralisation, remote pilot localisation]* • **Application sectors** Military, homeland security, corporate

SERVICES

Educational-related

- Approved Training Organisation (ATO)
- Centres of learning (*academy, university & technical school*)
- Examination & licence granting organisation
- Manuals & tutorials [*i.a. operational; user instruction; maintenance & repair & overhaul (MRO); spare parts; exploded views*]
- Subject matter experts (*i.a. cybersecurity, data protection, examination, frequency, human factors, insurance, privacy, training*)
- Training (*theoretical & qualification*) (*remote pilots, remote system operators & instructors*)
- Training site (*practical flight instruction*)

Airspace Information & Management

- Aeronautical information service provider
- ANSP - Air navigation service provider
- ATM - Air traffic management provider
- CIS - Common information services provider
- UAM - Urban air mobility service provider
- USSP - U-space service provider
- U-Space Coordinator

Infrastructure-related (*Ground-based*)

- Aerodrome, droneport & vertiport
- GNSS-related
- Ground-based Detect & Avoid
- Security-related surveillance (public & private)
- Telecommunication-related
- Navigation-related & GNSS augmentation

UAS Operations

- Commercial & non-commercial (incl. public) flight operations with UAS.

Operations-related

- Compliance attesting
- Communication service providers (*incl. mobile telephone & satellite link service providers*)
- Designated Entities
- Global Navigation Satellite System (GNSS) service providers *(e.g. Galileo, GPS)*
- Image & data processing & analytics
- Law firm / legal opinion
- Qualified Entity (QE)
- Recognized Assessment Entity *(national & EU level)*
- Safety Risk Assessment & Mitigation
- Subject matter experts (*i.a. cybersecurity, data protection, frequency, human factors, insurance, privacy, regulatory matters, training*)

Producer / Product-related

- Clusters (*technology & industry*)
- Consultancy & think tank
- Design, Engineering & Prototyping
- Distributor (*of products*)
- Maintenance, repair & overhaul (MRO)
- Evaluation & Certification; Notified Body
- Rental & leasing organisations
- Subject matter experts (*i.a. cybersecurity, data protection, frequency, human factors, insurance, privacy*)
- Test & demonstration site

FIGHT MISSION SERVICES SUPPLIED BY UAS OPERATORS

UAS Operator: A company or organisation [*non-governmental, governmental (non-military & military), municipal*] conducting, or planning to conduct, commercial or non-commercial flight operations with UAS.

Commercial

Innovative aerial services & innovative transport services *(incl. freight & passenger)* carried out by companies for paying customers.
(see "Market Sectors" & "Mission Purposes")

Non-commercial

Innovative aerial services & innovative transport services (*incl. freight & passenger*) carried out by companies or organisations without external financial compensation from customers.
(see "Market Sectors" & "Mission Purposes")

Corporate Operation

Innovative aerial services & innovative transport services (*incl. freight & passenger*) carried out by companies or organisations to meet their own internal needs.
(see "Market Sectors" & "Mission Purposes")

Public Operation

Innovative aerial services & innovative transport services (i.a. *Police, fire brigade, coast guard, customs authority, civil security, disaster response, emergency management, forestry service, government executivce agency, military, environmental service, wild life protection service, etc*). (see "Mission Purposes")

Note: Flight missions can be conducted by **remote pilots**, or **remote system controllers** of fully automated and autonomous UAS (*mission oversight*).

FLIGHT MISSION SERVICE CUSTOMERS

Public & private entities in the below-indicated market sectors (*see explanations on page 83*) commercially contracting for the below-indicated flight missions (*see explanations on page 85*), or conducting these flight missions for their own benefit (corporate), or for non-commerical reasons (incl. operations by non-military public entities).

Market Sectors

- **A** Aerial Photography, Audio-Visual Production
- **B** Agriculture, Fishery, Fish Farming, Forestry
- **C** Air Show / Competition / Racing
- **D** Aircraft System or Sub-system Production
- **E** Cinema & TV Industry & Media
- **F** Construction & Real Estate
- **G** Demonstration
- **H** Entertainment & Artistic Expression & Sport
- **I** Environmental Protection & Conservation
- **J** Ferry / Positioning
- **K** Flight Training / Instruction
- **L** Heritage Site & Historical Monument
- **M** Humantarian Aid
- **N** Insurance (*Accident & Claim Investigation*)
- **O** Maintenance
- **P** Mining & Exploration
- **Q** News Gathering & Broadcasting
- **R** Policy Compliance & Obtaining Legal Proof
- **S** Public Services & Safety
- **T** Remote Operations - Non-Sensing
- **U** Remote Operations - Sensing (*Imaging & Non-imaging*)
- **V** Research & Science
- **W** Security & Law Enforcement
- **X** Transport
- **Y** Utilities (*Public & Private*)

	Mission Purposes	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
1	Advertising	◆																			◆					
2	Aerial Photography & Film / Video	◆	◆			◆	◆			◆			◆	◆	◆	◆	◆	◆	◆	◆			◆	◆		◆
3	Aerobatics, Special Effects & Sport			◆					◆																	
4	Broadcasting					◆			◆									◆								
5	Deterring		◆				◆			◆						◆				◆						◆
6	Dispensing		◆							◆				◆						◆			◆	◆		
7	Exploration									◆			◆				◆						◆			
8	Fire Fighting																			◆				◆		◆
9	Identification		◆							◆			◆	◆		◆			◆				◆	◆		◆
10	Inspection		◆				◆			◆			◆	◆	◆	◆	◆			◆			◆	◆		◆
11	Localisation		◆				◆			◆			◆	◆	◆	◆	◆		◆	◆			◆	◆		◆
12	Manipulation															◆	◆				◆		◆	◆		
13	Mapping		◆				◆			◆			◆	◆	◆	◆	◆			◆			◆			◆
14	Measuring		◆							◆						◆	◆			◆			◆			
15	Monitoring		◆				◆			◆			◆			◆			◆	◆			◆	◆		◆
16	Observation	◆	◆			◆	◆			◆				◆	◆	◆	◆	◆	◆	◆			◆	◆		◆
17	Patrolling		◆							◆			◆	◆			◆		◆	◆			◆	◆		◆
18	Relief Flight													◆						◆						
19	Search & Rescue													◆						◆						
20	Security		◆				◆			◆			◆				◆		◆					◆		◆
21	Sensing									◆						◆				◆			◆			◆
22	Sky-Painting & Sky-Writing								◆											◆						
23	Special Purpose									◆	◆										◆	◆	◆			◆
24	Spotting		◆				◆			◆			◆	◆	◆	◆	◆		◆	◆			◆	◆		◆
25	Spraying		◆				◆			◆				◆		◆				◆						
26	Surveillance		◆				◆			◆			◆	◆		◆	◆	◆	◆	◆			◆	◆		◆
27	Surveying		◆				◆			◆			◆	◆	◆	◆	◆		◆	◆			◆			
28	Test / Evaluation				◆			◆				◆											◆			
29	Tracking		◆			◆			◆	◆													◆	◆		
30	Transport - Goods		◆											◆		◆	◆			◆	◆				◆	
31	Transport - Persons																								◆	
32	Validation				◆			◆				◆							◆				◆			

ADDITIONAL STAKEHOLDERS

PRIVATE SECTOR

Aeromodelisme

Sport, Competition & Racing

- Club
- Association
- Federation

Interest Group *(national, European, international)*

- Association
- Centre of Excellence
- Civil Drone Council (*& equivalent*)
- Federation
- Foundation
- Union

General Aviation *(manned aviation)*

- Sport / Recreational
- Aerial Work
- Business Aviation

Research Organisation

- Private
- Public Private

Innovation Hub

Knowledge Centre

- Technical Vocational School
- Academy
- University

Standard Producing Organisation (SPO)

- National
- European
- International

Traditional Transport / Mobility

Air, Road, Rail, Maritime, Waterways, Space

Consortia - Subsidized by the EU & SESAR

Consortia - Nationally Subsidized

General & Specialized Press

- National (incl. television)
- International (incl. television)
- Information blogs
- Social media (incl. floggers)

PUBLIC SECTOR

Public Entity

- **National**
  - Ministry, i.a.:
    - Agriculture & Fishery
    - Defence
    - Economy & Finance
    - Education, Culture & Sport
    - Environment
    - Finance
    - Foreign Affairs
    - Health & Welfare
    - Industry, Innovation & Trade
    - Infrastructure
    - Interior
    - Justice & Security
    - Science & Innovation
    - Social Affairs & Employment
    - Transport & Mobility
  - Governmental Agency
  - Regional Entities (e.g. département, Länder, province, region)
  - Municipality
  - Economic and industrial development organisation
  - Research organisation
- **Regional**
  - European Commission (Directorate Generals)
  - EU Institutions & Bodies
- **International Organisation**
  - International Civil Aviation Organization (ICAO)
  - Organisation for Economic Co-operation and Development (OECD)
  - United Nations (UN)
  - UN Agencies
- **Inter-governmental Organisation**
  - EUROCONTROL
  - Joint Authorities for Rulemaking on Unmanned Systems (JARUS)
  - National Aviation Authority Regulatory Implementation Coordination (NAARIC)

END-CUSTOMERS (Recipients/Users of UAS-Supplied Data & Other Services) *(incl. Corporate Operations)* - EXAMPLES

Note: Corporate operators conduct flight missions for the benefit of the their own company or organisation.

Academic & Science - Research

Agronomy
Anthropology
Archeology
Atmospheric
Biology
Botany *(flora & habitat)*
Climatology
Earth Sciences
Ecology
Environmental *(incl. ice cap, ice flow, iceberg, glacier)*
Geography
Geology
Heritage Site & Historical Site Conservation
Meteorology
Oceanography
Zoology *(fauna & habitat, incl. marine mammals)*

Agriculture

Crop Farmer *(individual)*
Crop Farmer *(company)*
Crop Farmer *(cooperative)*
Fish Farm Management
Fishing Ship Operator
Forestry Management
Game/Wildlife Reserve Management
Greenhouse Operator
Livestock Management

Assessment - Compliance/Maintenance

Building Owners
Conformity Compliance Assessment Entities
Home Owners
Industrial Facility Owners
Infrastructure Management

Communication

Mobile Telephone Network Management
Satellite Communication Network Management
Television Broadcasters

Construction - Contractors

Architectural & Engineering
Airfield Runway
Building & Construction Work
City / Town District
Civil Engineering Work
Communication Towers
Construction Site Preparation Work
Historical Site & Monument Restoration/Conservation
Industrial Facilities
Infrastructure *(incl. bridges, breakwaters, canals, dams, dikes, harbours, highways, locks, railroads, roads, tunnels, wind farms)*
Irrigation Network
Pipeline Network
Planning & Zoning
Powerline Network *(incl. cable stringing)*
Railroad
Reclaimed Land *(dredgers)*
Renovation, Addition & Alteration Works
Residential Areas
Site Exploration *(preconstruction)*, Inspection & Mapping
Site Security
Water Transport & Sewage

Energy - Management / Maintenance / Security

Aerial Electricity Producer
Electricity Distributor
Electricity Producer *(coal & gas)*
Electricity Producer *(nuclear)*
Electricity Producer *(renewable energy):*
- Solar Farm
- Wind Farm *(offshore)*
- Wind Farm *(onshore)*

Offshore Facility
Oil & Gas Pipeline Network
Oil and Gas Exploration
Oil and Gas Storage
Oil Refinery
Site Security

Exploration

Crude Petroleum
Ferrous Ores
Natural Gas
Water
Other

Geographic Information Service (GIS) Customers

Industrial Facility

Inspection & Maintenance
Site Security
Storage Tank Maintenance

Infrastructure - Management / Maintenance

Aerodrome
Bridge
Cable Car
Canal & Waterway
Crane
Dam
Dike & Breakwater
Harbour
Highway, Street & Road Network
Irrigation Network
Railway Network
Sewage Network
Telecommunication Tower Network
Tunnel

Insurance

Accident Investigation
Claim Investigation
Risk Evaluation

Justice & Juridical

Arbitration & Conciliation Services
International Criminal Court
National Courts

Media

Advertising Agency
Cinema Industry *(aerial views & special effects)*
Entertainment *(aerial shows, aerobatics)*
Floggers
News Agency
Publishers
TV Broadcasting

Mining & Quarrying

Exploration
Pit Wall Inspection
Shaft Inspection
Site Management
Site Security
Volumetrics

Non-Governmental Organisation (NGO)

Disaster Relief
Environmental Protection
Humanitarian Aid

Pipeline Operator

Natural Gas
Oil
Water

Policy Compliance

EU Agencies
International Criminal Court
National Governmental Agencies
UN Agencies

Public Safety

Avalanch Patrol & Control
Beach & Coastal Water Patrol
Border Patrol
Civil Defence
Civil Protection
Emergency Service
Fire Brigade & Firefighting Service
Health Service
Rescue Service
Search & Rescue

Public Service

Cadaster
Environmental Conservation
Environmental Protection
Mapping Agency
Meteorology
National Historical Monument Conservation
National Park / Nature Reserve
Rural Land Planning
Sewage Network Management / Maintenance
Urban Planning

Railroad Operator

Construction
Maintenance

Real Estate

Building Project Development
Maintenance
Planning & Construction Oversight
Private Security

Security & Law Enforcement

Critical Infrastructure Management
Harbour Authority
Municipal Authority
Nature Reserve & Anti-poaching
Police Operations
Regional Authority
Security Service Company
Sensitive Industrial Site
State Authority
Wildlife Protection Authority

Shipping

Bilge & Tank Inspection
Dredgers
Maintenance & Repair
Ship-to-shore & Shore-to-ship Courier Service
Shipping Company
Support Services *(incl. logistics)*
Tugboat Operator

Transport & Delivery

Aerial Last Mile Delivery Service *(Meal & Beverage)*
Aerial Taxi Operation Management
Air Transport - Freight - Nonscheduled
(urban, suburban, national, international)
Air Transport - Freight - Scheduled
(urban, suburban, national, international)
Air Transport - Persons - Nonscheduled
(urban, suburban, national, international)
Air Transport - Persons - Scheduled
(urban, suburban, national, international)
Aircraft *(hull)* Maintenance Management
Airport Beacon *(PAPI, ILS)* Calibration
Airport Runway Inspection
Airport Wildlife Management
Highway & Road Network Management / Maintenance
Postal & Air Courier *(letters & parcels)* Service
Railway Network Management / Maintenance

Transport & Delivery (Health-related)

Ambulance Service
Defilabrator Delivery Service
Hospital-to-hospital *(blood & organs)*
Hospital-to-hospital *(patients)*
Medicine / Vaccine Delivery Service

OVERVIEW OF THE DRONE ECOSYSTEM

PRODUCTS

Airborne

- Airframe
- Propulsion
- Energy
- Flight Control
- Sub-System
- Sub-Assembly
- Payload - Imaging
- Payload - Measurement
- Payload - Detection
- Payload - Other
- Recovery system
- Transport & storage case

Ground-Based

- Pilot Station
- Homing/docking station
- Self-charging pad
- Auto cargo loading & unloading
- Tethering system
- Launch & recovery systems
- Transport & storage

Ground Infrastructure

- Aerodrome
- Droneport
- Vertiport
- Charging station
- Navigation & surveillance aids

Communication (incl. satellite)

Command, Control & Communications
- Telemetry
- Antenna
- Tracking system
- Transponder
- Anti-jamming
- Anti-spoofing

Software (*incl. AI*)

Training Simulator & Tools

Counter-UAS

- Ground-based
- Mobile
- Handheld
- UAS-based

SERVICES

Education-related

- Approved Training Org. (ATO)
- Centres of Learning (*technical schools, academy, university*)
- Examination org.
- Manuals & tutorials
- Training (*theoretical & practical*)
- Training site

Infrastructure Operators

- Aerodrome
- Droneport
- Vertiport
- Ground-based Detect & Avoid
- Navigation-related
- GNSS precision augmentation
- Security-related
- surveillance
- Communication-related

Producer & Product-related

Cluster (*technology & industry*)
- Consultancy & think tank
- Design, engineering & prototyping
- Maintenance, repair, overhaul
- Distributor
- Notified Boby
- Rental organisation
- Subject matter expert
- Test & demo site

Standard Prod. Orgs

- Industry group
- National org.
- European org.
- International org.

Press

- General
- Specialized
- TV
- Info blogs
- Social Media

Financial

- Banks
- VCs
- Investment Companies

OPS-RELATED SERVICES

UAS Operators

- Commercial
- Non-Commercial (*incl. Corporate*)
- Public Entity (*non-military*)
- Public Entity (*military*)

Traffic Info & Management

- Aeronautical info
- Air navigation (ANSP)
- Air traffic management (ATM)
- Common info service (CIS)
- Urban air mobility (UAM)
- U-space service (USSP)
- Unmanned traffic management (UTM)
- U-space coordinator

Operations-related

- Compliance attesting
- Communication provider
- Data Protection & Privacy
- Designated Entity
- Insurance
- Legal assistance
- GNSS provider
- Qualified Entity
- Recognized Assessment Entity
- Safety risk assessment

End-product-related

- Image processing
- Data interpretation

END-CUSTOMERS

Market Sectors

Non-Military

- Aerial Photography, Audio-Visual Production
- Agriculture, Fishery, Fish Farming, Forestry
- Air Show / Racing
- Aircraft System & Sub-system Production
- Cinema, TV Industry & Media
- Construction & Real Estate
- Demonstration
- Entertainment, Artistic Expression & Sport
- Environmental Protection & Conservation
- Ferry / Positioning
- Flight Training & Instruction
- Heritage Site & Historical Monument
- Humantarian Aid
- Insurance (Accident & Claim Investigation)
- Maintenance
- Mining & Exploration
- News Gathering & Broadcasting
- Policy Compliance & Obtaining Legal Proof
- Public Services & Safety
- Remote Ops - Non-Sensing
- Remote Ops - Sensing
- Research & Science
- Security & Law Enforcement
- Transport
- Utilities (*Public & Private*)

Military

Mission Purpose

Non-Military

- Advertising
- Aerobatics, Special Effects & Sport
- Aerial Photography & Film / Video
- Broadcasting
- Deterring
- Dispensing
- Exploration
- Fire Fighting
- Identification
- Inspection
- Localisation
- Manipulation
- Mapping
- Measuring
- Monitoring
- Observation
- Patrolling
- Relief Flight
- Search & Rescue
- Security
- Sensing
- Sky Painting & Sky Writing
- Special Purpose
- Spotting
- Spraying
- Surveillance
- Surveying
- Test / Experimental
- Tracking
- Transport - Goods
- Transport - Persons
- Validation

Military

ADDITIONAL STAKEHOLDERS

Private Sector

Aeromodelism

Sport, Competition, Racing

Interest Group

Association
Ctre of Excellence
Civil Drone Council
Federation
Foundation
Union

General Aviation

Sport & Recreation
Aerial Work
Business Aviation

Research Organisation

Private Public/Private

Innovation Hub

Knowledge Centre

Technical School
Academy University

Transport & Mobility

Air Road Rail
Maritime Space

Consortia (subsidized)

EU SESAR JU
National Regional

Public Sector

National

Ministry

Governmental Agency
Regional Entity
Municipality
Economic Development Organisation
Military

Research Organisation

Regional

European Commission
EU Agency
European Parliament

International

ICAO OECD
UN UN agency

Inter-governmental

EUROCONTROL
JARUS NAARIC

Knowledge Centres

Technical School
Academy University

General Press

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PROFESSIONAL DRONE OPERATIONS

With & For
The International Drone Community

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