Académie de l'Air et de l'Espace
Air and Space Academy

3AF
La Société Savante de l'Aéronautique et de l'Espace

LES DOSSIERS

Present and future of CIVILIAN DRONES

AAE Dossier #40 2015 3AF Cahier #16

Present and Future of Civilian Drones

Following the conference organised by the Air and Space Academy (AAE) and French Aerospace Society (3AF) in Paris, 13-14 November 2014

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PLAN OF THE DOSSIER

FOREWORD

The Air and Space Academy (AAE) and the Association Aéronautique et Astronautique de France (French Aerospace Society, 3AF) endeavour to focus their attention and reflections on important issues linked to innovative development activities in air and space.

Today, for instance, technological progress has led to the design and manufacture of unmanned aircraft. In the military field, recent decades have witnessed the development and operational use of Unmanned Air Systems (UAS) or Remotely Piloted Aircraft Systems (RPAS) for Intelligence/Surveillance/Reconnaissance missions and even more recently, for weapon delivery. In the more recent civilian drone sector, the explosion of ideas has been impressive, with an exponential rise in the number of drone operators and missions. We now have the technological capacity to produce small RPAS that are cheap to buy and to run. This is inspiring a services market, often proposed by innovative young companies. The mayors of our cities and towns are purchasing aerial views of their area. Farmers can monitor their crops and define appropriate treatments. Infrastructure owners such as EDF, SNCF and GRT Gaz are envisaging using drones in an increasingly intensive way to inspect tracks, lines and bridges that are often difficult to access. For several years, television has been a major user of drones and now filmmakers are also starting to use these innovative systems.

This proliferation of drone applications may represent a potential hazard to people and goods and makes their integration into an already congested airspace very complicated.

So far, the number of accidents has been low and there have been few consequences, but the first serious accident is likely to hold back their expansion. Certification, regulation and safety authorities such as the French civil aviation authority DGAC, the Federal Aviation Administration (FAA) and the European Aviation Safety Agency (EASA) are of course aware of the criticality and urgency of this subject and are working on it. However, given the wide variety of vehicles and applications, it is tricky to implement measures to ensure safety without impeding the creative momentum of young companies.

This is the context behind the conference organised by AAE and 3AF on “Present and future of civilian RPAS”[1] on 13 and 14 November 2014 in the Paris DGAC auditorium, with live broadcast to “École Nationale de l’Aviation Civile” (ENAC) in Toulouse. The main aim of this two-day conference was to bring together key actors to confront and enrich viewpoints in order to achieve an integrated vision, bringing out areas for improvement and identifying actions required to help this “young” aeronautics sector to develop in a harmonious way.

This conference proved to be of great interest, with high attendance from an enthusiastic audience of varying backgrounds, including manufacturers, operators, end users, research organisations, public bodies and students, as well as representatives of the European (EASA) and American (FAA) civil aviation authorities. On behalf of AAE and 3AF, we would like to express our gratitude to the companies and organisations that supported the organisation of this conference: AG-Insurance, Airbus Defence & Space, Apave, Apsys, Bouygues Energies et Services, Dassault Systèmes, DGAC, ENAC, Excelium, FPDC, GRTgaz, La Réunion Aérienne, City of Toulouse, ONERA, Safran/Sagem, SNCF and Thales.

This meeting, gathering together the various stakeholders, provided a unique opportunity to identify key issues and avenues for progress in the development of these new systems in a way that will ensure a high level of safety to people and goods.

Common practice on the part of these two associations is to draw the benefits of such a rich, high quality conference and the many exchanges of information it encouraged by publishing a **recommendations dossier**.

This dossier not only takes into account the main lessons learned from the conference, but looks further, drawing on documents published in the meantime by the FAA and the European Commission according to three pillars: Regulation – Research – Society. Other presentations made at the International Civil Aviation Organization (ICAO) symposium from 23 to 25 March 2015[2] have also been taken into account. The subject of RPAS is ongoing, and the months and years to come will certainly bring new information.

The dossier only deals with “light” civilian drones used for professional purposes. Neither military UAVs, nor “recreational RPAS” are discussed. It contains recommendations to encourage the development of this promising branch.

1 Proceedings of the conference on “Present and Future of Civilian RPAS” www.academie-air-espace.com/upload/doc/ressources//rpas2014/proceedings.php

2 www.icao.int/Meetings/RPAS/Pages/RPAS-Symposium-Presentation.aspx

We would like to thank the members of the programme committee of the “Present and Future of Civilian RPAS” conference, especially its president Philippe Cazin, for their very hard work in preparing this conference and, under the coordination of Thierry Prunier, for their involvement during the first semester 2015 in order to prepare this document.

Philippe Couillard

President

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I EXECUTIVE SUMMARY

"**A new era for aviation**: Opening the aviation market to the civil use of remotely piloted aircraft systems in a safe and sustainable manner."

"Today Europe is taking a **decisive step towards the future of aviation**."

These sentences opened the 2014 Communication from the European Commission[3] and the declaration of the European community of drones[4] meeting in Riga in March 2015. To follow up on these declarations of intent, Europe is announcing a 2015 action plan with associated timeline to ensure that all conditions are met for the safe, sustainable emergence of innovative drone services.

According to the Riga declaration, the drones community is committed to working together based on the following principles:

"1. Drones need to be treated as new types of aircraft with proportionate rules based on the risk of each operation.
2. EU rules for the safe provision of drone services need to be developed now.
3. Technologies and standards need to be developed for the full integration of drones in the European airspace.
4. Public acceptance is key to the growth of drone services.
5. The operator of a drone is responsible for its use."

This dossier is fully in line with these principles and the following recommendations are intended to support this approach.

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3 Communication from the European Commission to the Parliament and the Council: www.ec.europa.eu/transport/modes/air/doc/com(2014)207_en.pdf

4 Under the Latvian Presidency of the Council of the European Union, meeting of European Commission representatives, civil aviation directors of the EU Member States, data protection authorities and leaders of manufacturing industry and service providers: www.ec.europa.eu/transport/modes/air/news/doc/2015-03-06-drones/2015-03-06-riga-declaration-drones.pdf

There are, and will continue to be, many **differing applications for civilian drones**, both now and in the coming years. Drones are proliferating and already involve a large number of players.

Thanks to their flexibility and ease of implementation, RPAS can offer many different kinds of **services**, either completely new or complementing/substituting for services provided by ground facilities, aircraft, helicopters, satellites and balloons. They can help to **produce more and better**, and in some cases **cheaper**.

These are the services expected by prime contractors, who require access to the final result of the acquisition/processing chain, including automatic diagnosis. The development and economic success of drones will depend on their ability to meet this demand.

Presently, the market is based essentially (80%) on photography and broadcasting, with drone-acquired shots used in most major TV programmes (nature, magazines, sports events ...), but it will evolve in the short term towards **providing data and diagnoses c**overing various areas such as:

- monitoring large networks (railways, oil and gas pipelines, power lines …);
- agriculture and the environment;
- diagnoses of the condition of buildings and civil engineering structures;
- mapping and monitoring construction sites, quarries and mines.

It is worth noting that almost all of these applications involve missions at very low altitude, i.e. less than 150 meters above ground level.

In France, since the publication of DGAC regulations in April 2012[5], **civilian drone market players** – prime contractors, aircraft manufacturers, RPAS manufacturers, operators, remote pilots, etc. – have been able to test a large number of applications. SMEs and large groups have thus been able to study and validate the use of drones in various areas, with experiments often leading to turnkey drone solutions (hardware/software/procedures). The French market has been growing very rapidly and in 2014 represented about 1,200 companies (often small or very small businesses), with a global turnover of between €10 M and €20 M (except recreational drones). This amount is still well below some 2012 market survey estimates due to structural reasons, inadequate investment capacity, or bad targeting.

The 2020 potential market could reach €180 M for France, €1,100 M for Europe and €10 billion worldwide, essentially for the monitoring of infrastructures and networks (35%), civil engineering (15%) and for the mines and oil industries (15%). To reach such a market, adequate regulations and operational rules should be set up.

5 www.legifrance.gouv.fr/jopdf/common/jo_pdf.jsp?numJO=0&dateJO=20120510&numTexte=9&pageDebut=08655&pageFin=08657
www.legifrance.gouv.fr/jopdf/common/jo_pdf.jsp?numJO=0&dateJO=20120510&numTexte=8&pageDebut=08643&pageFin=08655

Today, the major obstacle to development of the drone market lies in its extreme fragmentation into a large number of niches that have to meet multiple needs, requiring a wide variety of skills. These factors result in micro-contracts with narrow profit margins. Competition is high and profits are therefore low.

The market is also highly dependent on local, regional and national aspects, which run contrary to the requirements of competitiveness, safety and quality.

Consequently, some people are imagining an industrial organisation based around regional or franchised "agencies", or a three-player model whereby an industrial contractor acts as an intermediary between major industries and local and regional service providers.

The strong need for investment in drone systems, together with the technological sophistication required to comply with regulations, places a heavy financial burden on these relatively small players, further reducing profit margins. The main contractors are reluctant to sign multi-year contracts and investors are cautious, limiting their level of shareholding because of the low profit margins already mentioned. So this very young, fragile sector, exposed to international competition, lacks the necessary funding to achieve a solid industrial footing.

In order to promote growth in this sector, the French drone community has set up a "Conseil pour les drones civils" (national civilian drone council) as one of the plans contained in the report on "La Nouvelle France Industrielle" (New Industrial France, NFI[6]). This council, which comes under the authority of two French ministries, is chaired by the French Director for civil aviation. This initiative should be taken up in other countries to encourage European governments to significantly reinforce their support of research projects and start-ups and thus promote the development of new technologies and exports which are indispensable to the development of RPAS industry.

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Drones can cause **damage to third parties, persons and goods** (crash landings, air collisions, departures from planned working airspace). Failures may occur not only in the drone itself, but also in its remote control station and communication/navigation/surveillance systems as well as its air traffic management.

To **minimise these risks**, various operational measures and technical means can be implemented:

- check all components of the system before use;
- require certification or qualification of certain system components (especially control station and software);
- use protected data links;
- ensure automatic transmission of identification and localisation information;

6 www.economie.gouv.fr/nouvelle-france-industrielle

- organise airspace, informing all participants and providing flight separation services in some airspaces;
- equip drones and/or ground infrastructures (including remote control stations) with simple, cheap "detect and avoid" (D&A) systems;
- train and qualify remote pilots and operators;
- organise and broadcast the lessons learnt from feedback.

Significant **R&D efforts are essential** in order to qualify these procedures and resources, The Horizon 2020 programme[7], single EU Research and Innovation Programme (which includes SESAR[8]), should significantly increase the share of its budget devoted to drones. It should also urgently address the issue of drones flying at very low level, i.e. those carrying out most professional civilian missions.

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For professional drone operations to be safe, their remote pilots must have received appropriate **training**, both **theoretical and practical**. The syllabus should train them to fly a similar drone system to the one they will be using, in their specific field of activity, with the drone equipped with its real payload.

Should it be mandatory for all remote pilots to hold a **license**? Undoubtedly, in the case of risky operations; for very low-risk operations a training certificate might be enough.

Whatever the case, training is required and should take place in an **approved training school** with attested teaching proficiency, to ensure that candidates have the requisite level of knowledge and skills.

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In terms of **societal issues**, illegal intrusions and actions have already occurred, both in Europe and the United States. States must ensure that operators and remote drone pilots respect privacy and individual liberties and that they do not commit illegal actions, in particular flying over sensitive and/or protected sites.

Drone operators must therefore be insured and must declare their flight intentions before each mission, equip their vehicles with identification and localisation means and declare their list of their drones and flight paths after every mission.

At the same time, an organisation with the appropriate staff and resources should be set up to process this information and check, sanction, prevent, intercept and identify those responsible and seize their drones, with clear procedures as to decisions on the correct action to be taken.

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7 www.ec.europa.eu/programmes/horizon2020

8 www.sesarju.eu

In the field of **regulations**[9], France showed the example with its decrees of 2012. These authorise commercial flights according to four scenarios. Since then more than 1,200 operators have emerged and all are looking forward to the expansion of overflight conditions and operating airspaces.

Work is being carried out internationally to **harmonise and standardise conditions** (at least on a European level) for drone integration into airspaces frequented by other aircraft. DGAC and EASA approaches to regulations are consistent, taking the view that it is unacceptable for drone use to give rise to any uncontrolled risk.

In this respect, EASA issued a document[10] proposing three categories:

- an Open category, with low risks and no need for airworthiness approval, for flights below 150 m within sight of remote pilots;
- a Specific operation category, for operations with some risk, which will necessitate prior safety analysis;
- a Certified category, requiring traditional type rating for long-range flights with large, complex drones.

EASA must now prepare a draft regulatory framework and a practical regulatory proposal for the open category, for submission to the European Commission in December 2015.

In February 2015, FAA published a proposal to amend the regulation[11] concerning small drones weighing less than 25 kg. These proposals are more restrictive than those proposed by the DGAC – flying beyond visual line of sight is not allowed for instance – and remote pilots must obtain a UAV remote pilot certificate, renewable every two years by training centres approved by FAA.

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Drones are not routinely subject to **feedback from experience** reports, despite the fact that these exist in French legislation. Indeed, only a few dozen incidents have been recorded in the feedback from experience initiative set up by DGAC a year or two ago, the problem being that such reports can reveal confidential information on the operator and on the manufacturer’s product.

This situation needs to be improved, with a feedback from experience system that relies on several channels rather than just one. These channels must be easily accessible and offer direct, intuitive input.

9 For drones weighing under 150 kg

10 Concept of Operations for Drones: A risk based approach to regulation of unmanned aircraft: www. easa.europa.eu/system/files/dfu/204696_EASA_concept_drone_brochure_web.pdf

11 Small UAS Notice of Proposed Rulemaking (less than 55 lbs): www.faa.gov/regulations_policies/rulemaking/media/021515_suas_summary.pdf

To be accepted by operators and manufacturers, such processes must be user friendly and functional and it should be made clear that no information will be used against these players. Anonymity should not be considered an obstacle. In time, the process should cover technical failures as well as human errors and be designed accordingly.

A feedback from experience website equivalent to those found in aerospace and sports federations should be set up.

II RECOMMENDATIONS

This paragraph lists only the key recommendations, referenced according to the chapters they appear in (e.g. 3.2 is the 2nd recommendation in chapter 3).

ON THE EUROPEAN DRONE SECTOR

- **Key recommendations 2.1, 3.1, 3.4 and 5.2:**
  Drone sector funding by European R&D programmes (H2020 and SESAR) should be increased to **at least €100 M over 5 years**. Priority should be given to small **drones flying at very low level (VLL) beyond visual line of sight (BVLOS),** i.e. those carrying out most potential missions. The European R&D programme H2020 should finance the development and experimentation of **simple, light, low-cost technology**, airborne and/or ground based, to reduce the risk of collision.
- **Key recommendations 2.2 and 5.1:**
  In order to help achieve a **harmonised European set of regulations**, the drone community should play an **active role** in the works of EASA, JARUS[12] and other standardisation bodies, by rapidly preparing input documents.
- **Key recommendation 3.5:**
  Civil aviation authorities should formalise their requirements on **remote pilot training** and the ways of monitoring training quality.
- **Key recommendation 4.4:**
  The European Union should require **insurance companies** in each member state to set up a **compensation fund.**

12 Joint Authorities for Rulemaking on Unmanned Systems: www.jarus-rpas.org

ON DRONE DESIGN AND REALISATION

► **Recommendations 2.3 and 3.3:**
European manufacturers should integrate **low-cost equipment** into their drones and **free** themselves from **foreign** acquisitions under export control. Equipment from the **automobile and telecommunications** industries should be taken into consideration. **Mobile telecom networks** (GSM, 3G, 4G) should be tested for air-ground-air communications and the identification and positioning of drones.

► **Recommendation 3.2:**
Drone manufacturers should examine **light, simple means and redundancies** to increase the safety of drones without increasing their costs.

► **Recommendation 4.1:**
Drone geographical data bases should contain information on **forbidden zones** (**geo-fencing**), and their post-processing should include privacy protection (**privacy by design**).

ON ENSURING PRIVACY AND SECURITY WITH RESPECT TO ILLEGAL ACTS

► **Recommendations 4.2, 4.3, 4.5 and 4.6:**
Drones should be equipped with **identification and localisation means.** This could be achieved by inserting an active chip. For each mission, the operator should declare its **flight intentions** on a public website, with **identification and flight path data.** Networked links should allow those in charge of security, as well as private individuals, to contact the operator of the drone. The decision might be taken to **track and intercept those responsible and/or neutralise the drone**.

ON FRENCH ACTIONS

► **Key Recommendations 2.4 and 2.5:**
The French “Conseil pour les drones civils” should **elaborate the roadmaps for the required technologies** and help obtain **public funds** for the development of the drone sector. The three aeronautics clusters should facilitate the **formation of consortia**, bringing together SMEs, laboratories/test centres, academies and major groups in the sector in order to meet calls for projects.

► **Recommendation 6.1:**
The “Fédération Professionnelle du Drone Civil” (French civilian drone federation – FPDC) should set up a **feedback from experience website** accessible to all professional users, along the lines of those existing in sports and aeronautical federations (FFA, FFAM,…), and should release regular safety information.

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1 POTENTIAL APPLICATIONS FOR CIVILIAN RPAS

"The future… is only the present to be set in order… Your task is not to foresee the future, but to enable it,"[1] as Antoine de Saint-Exupéry wrote.

1 Citadelle, Antoine de Saint-Exupéry, Ed. Gallimard, coll. NRF, 1948, chap. LVI, p167

Figure 1: EU Vision for drone integration © European Commission

This quote seems quite appropriate to the future of the civilian RPAS sector. Drones are proliferating rapidly worldwide and, as well as creating a huge “buzz”, are inspiring and stimulating developments and innovative uses all over the planet. A host of applications have already been catalogued, new ones are constantly emerging and it is difficult to predict with any precision how the sector will evolve in the future. The boundary between real and potential applications is so fast-moving that when we talk about “potential” applications, the chances are that they have already become real!

Slightly surprising is that neither **surveillance** nor **data gathering** immediately leap to people’s minds in relation to civilian RPAS. Yet this is the largest market and is both real and immediate, consisting mainly of photographs taken from the sky. On closer inspection, we can make a rough classification of these many different, sometimes highly complex applications, with varying potentials.

Audiovisual activities, the largest sector of activity, have spawned a large number of small, companies and freelancers specialised in specialised shots (these account for 90% of operators registered with the French civil aviation authority DGAC). None of the major French broadcasting groups (TF1, France Télévisions, Canal+, BFMTV, etc.) are specialists in this area, preferring to rely on external service providers. Paid per mission, or for a day’s filming, the turnover remains limited (a few hundred thousand euros for France Télévisions, a few millions euros at most for the whole of

Figure 2: Aerial view of the Versailles Palace and gardens
© ToucanWings - Creative Commons By Sa 3.0 - 018

France). The results though are often remarkable, with innovative, high quality shots enhancing programmes on heritage sites or other places of interest. The events and media sectors are also interested in images of concerts, festivals, marriages, etc. that produce the required “Wow!” effect. Regulations, whether aviation or labour laws, are not always respected. It is prohibited, for instance, to fly a drone over a crowd although CNN is successfully lobbying the US FAA to be granted an authorisation for this use. The effect on this sector can be felt the world over.

The **real estate** sector was quick to see the potential of RPAS. Estate agents find them extremely effective for taking photos that enhance the appeal of their products. For unsophisticated missions such as these, drones are generally equipped with mainstream camera equipment.

At the other end of the scale, in order to perform the obligatory thermal analysis of buildings for renovation, companies such as Bouygues or GDF-Suez (via GrDF) have been mapping facades and roofs with the aid of onboard thermal imaging cameras. Their ease of use, high quality and cost efficiency has led to an offer that largely meets expectations.

On similar lines, although with slightly differing applications, one might mention the **inspection of industrial sites**. For instance, EDF Energies Nouvelles has tested drones for examining solar panels in its major photovoltaic power plants, the aim being to check for defective cells that impact site profitability, and thus increase efficiency. Where a human agent takes at least several days to identify problem areas, a drone can give a comprehensive, precise, automatic diagnosis in a few

Figure 3: Thermal balance carried out for GrDF by a drone © Azurdrones 2014

Figure 4: Detection of anomalies in photovoltaic modules by aerial thermography © EDF ENR

minutes. Maintenance of an industrial site is a complex, costly operation that can sometimes bring production to a standstill; when the stakes are this high, an action of a few minutes can be counted in millions of euros. This applies for instance to blast furnaces, chimneys, formworks of nuclear plants, etc., where ease of use is another major argument since the intervention can be scheduled for a convenient slot instead of interrupting operations.

Industrial applications for large linear infrastructures are still limited but **network operators** (energy, transport, oil and gas, water, etc.) are showing great interest. Drones have already been used in desert regions or areas with no regulations (Alaska, Africa, the Gulf states…), essentially for surveillance of oil and gas pipelines. Their use in highly populated areas or dense air traffic routes is still complicated, at least within the framework of a relevant economic model. EDF (high voltage lines),

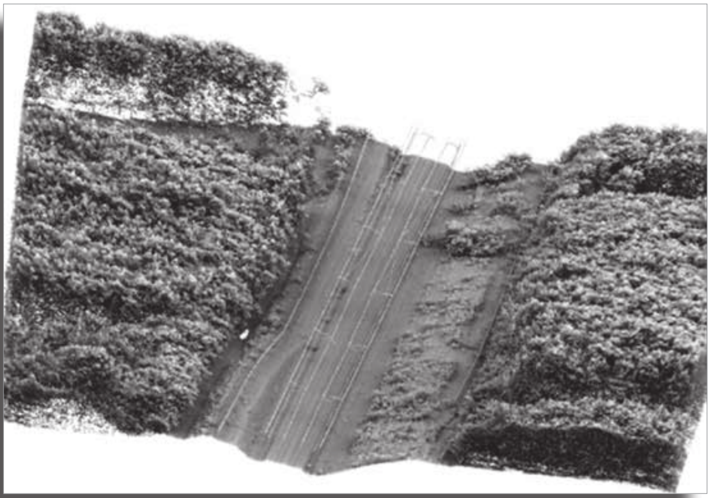

Figure 5: LIDAR point cloud © RIEGL/SNCF

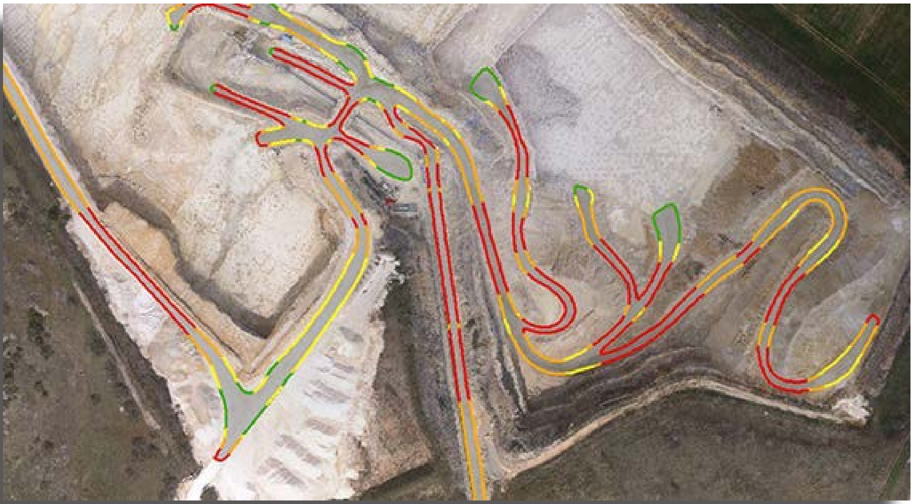

Figure 6: Analysis of quarry routes © Redbird

GRTgaz and SNCF (catenaries and railway lines) are endeavouring to find a solution that would meet requirements of reliability, safety and cost-effectiveness.

The **civil engineering** world has gone beyond the experimental stage and has implemented several remarkable applications for inspecting buildings and civil engineering structures (bridges, viaducts, dams, etc.), supervising mining projects and quarries and monitoring construction work. In this respect, Monnoyeur's association with RedBird is remarkable, optimising vehicular fleet management by analysing the changing level of risk as the engines move around a site, as well as reducing fuel consumption and calculating the volume of resources (drones can calculate volumes more quickly and accurately). In the case of mineral resources, significant savings can be made thanks to the reduced cost of data. At the heart of this application is **topographic measurement** and numerous turnkey solutions are proposed, such as the SenseFly eBee drone or Trimble's X100 drone.

Public works, mines and quarries probably constitute one of the most mature "industrial" sectors for civilian drones at the present time. In early 2015, following on from Monnoyeur-Caterpillar, the machinery manufacturer Komatsu announced a drone collaboration with the California startup Skycatch.

Potential applications also include digital mapping and land management.

The possibility of carrying heavier sensors such as LiDAR (manufactured by Riegl for instance) paves the way to new dense, ultra-precise measurements. Such data is sought by numerous players, particularly network managers, but also by the **research sector** for 3D reconstruction. In this way archaeologists can build up virtual constructions of historic sites (for instance in Peru, Jordan, ...). This type of information is also precious for monitoring natural risks, such as checking the

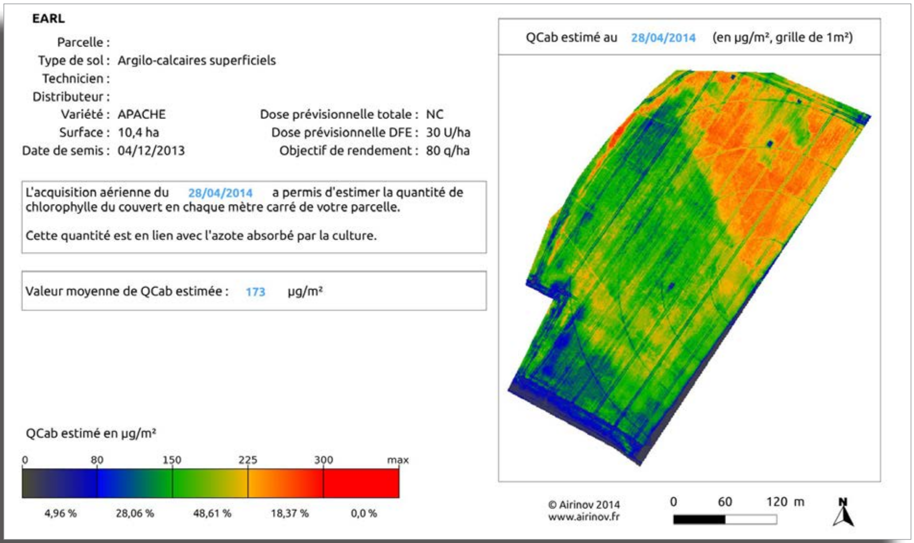

Figure 7: Measurement of quantity of chlorophyll in wheat or rapeseed biomass © Airinov

stability of dangerous slopes (for instance in French Guyana or China). In fact we are limited only by our own imagination! The data generated can meet an immediate need expressed by a client. Processed data that has been enhanced or combined with other sources of information can be of immense value to those who know how to exploit it. It can be used in original and complex ways. For instance, satellite images can be cross-referenced in real time to insurers' customer data bases to estimate the costs of a natural or industrial catastrophe (storms and hurricanes for example). The FAA authorised the insurance companies AIG, State FAA and USAA for instance to use drones for inspections following a disaster.

On slightly different lines, **agriculture** offers many applications including crop monitoring and agricultural spreading, although in a number of niches that are complicated to exploit in terms of market. Precision agriculture has used satellite imagery for some time and will now be able to complement or replace this with drone imagery. Drones have been spraying crops since the 1990s. Yamaha in Japan for instance has concentrated on this service for several years, making the brand and the country a civilian drone pioneer, but the ban on aerial spraying in Europe hampered the ambitions of the group. Farmers, cooperatives and seed companies are also looking for information to optimise the impact of fertilisers or pesticides, treat diseases more effectively and precisely calibrate optimum harvest dates. Every need has its own solution (information-sensor-vector). For example, measuring the diameters of broccoli on a plot of a few hectares in order to gauge when to harvest for optimum maturation of the whole plot is very different from detecting mildew on vine leaves in order to trigger curative, preventive treatment. One might mention in this respect the AIRINOV company that offers turnkey solutions dedicated to agriculture.

Drones are also used for instance in fisheries or for destroying Asian hornets' nests.

Loosely related to agriculture, the **environment** is an important market for civilian RPAS, which are already regularly used for accurate environmental monitoring of vulnerable areas (national parks, wetlands, pollution or erosion surveillance, etc.). The Urban Community of Bordeaux, the Island of Noirmoutier and the Arcachon basin called on drone technology in 2014 for such work. In April 2015, the Hydrotechnical Society of France organised a congress on RPAS for hydraulic and water services which specifically addressed questions of hydro-ecology, water stewardship, surveillance of civil infrastructures and water sciences[2] ...

Still on the drawing board, evolutionary delivery services are constantly in the headlines, mobilising R&D teams of the biggest companies. But other services could be provided by autonomous flying machines.

Parcel delivery has brought its share of announcements and its first tests. Amazon was keen to be first off the starting blocks with Amazon Prime Air, now launched in India. In March 2015, the FAA authorised Amazon to conduct experiments in the US. DHL made the first deliveries of its "Parcelcopter" service to the German island of Juist in 2014 (distance of 12 km flown over water, with Microdrones hardware). Google (X), the R&D division of the famous group, launched its "Project Wing" in

2 www.shf-hydro.org/176-1-manifestations-16.html

Figure 8: Drone delivery project © GeoPost, Atechsys

Australia, based on a hybrid wing equipped with a rope to set down a lightweight package (although the project is still being adapted after many technical difficulties). Recently the French post office, via its subsidiary GeoPost, operated a drone designed by Atechsys. More confidentially, UPS is also working on the subject.

Meal delivery is more about creating buzz than anything else: pizza (Domino's Pizza) and beer (Lakemaid) were delivered at the SuperBowl in 2013 for instance. Since then, several services have been offered around the world, with varying degrees of success: pizza in India and Russia, beer in South Africa (see Oppikoppi Beer on YouTube, with delivery by parachute), tacos (tacocopter in San Francisco), burritos (BurritoBomber), lobster (lobstercopter), sushi (YoSushi) in London, a simple table service with iTray! ... impossible to be exhaustive since anyone and everyone has tried out their pet idea which, relayed by local media, quickly spreads through the Internet. Delivery brings with it many societal and operational issues. Existing delivery activities in large cities, relying on fleets of trucks, vans, motor bikes and bicycles, give us some idea of the myriad of drones that would be circulating in the sky, all delivering one or two parcels per trip.

The possible contributions of drones to **emergency relief** include dropping food and rescue equipment into hostile areas and search and rescue of people in difficulties (particularly at sea or in mountainous or desert areas). Mobile defibrillators for instance have appeared in cities (a student project in Bordeaux, another in Belgium). The World Health Organisation (WHO has set up a partnership with a Greek start-up and the government of Bhutan to deliver drugs to remote areas. Other drones are used for searching for victims of natural disasters (forest fires, avalanches, volcanoes, tornadoes, hurricanes ...) or industrial catastrophes or accidents. Drones can also be used preventively, for example by triggering avalanches. Drones can be particularly useful in detecting and fighting fires, revealing toxic products or radiation, or indeed in **any case where their use eliminates or reduces human risk.** Firefighters can use them to evaluate the fire situation and locate persons hidden in a building or on rooftops. Many other specific applications can be imagined and will no doubt emerge in all these areas.

Apart from the audio-visual and data gathering sectors, a further market can today be found in the world of entertainment. The Puy du Fou, Disneyland and the Cirque du Soleil are already offering flying shows, new entertainment perspectives and a niche market. Imagination has no limits here and the Internet is full of examples from the world of music and the arts... Film studios are also joining in, especially Hollywood which is looking forward to a regulatory change from the FAA. One might note the New York City Drone Film Festival on 21 February 2015.

At the crossover between the events business and the entertainment industry (in its broadest sense), various applications relate to sporting and cultural events (championships, bicycle races, Olympic games, exhibitions, international fairs, universal expositions, etc.) whether regular or exceptional, movable or fixed, temporary or permanent. Indeed touristic, sporting and cultural aspects often overlap, in which case RPAS offer unparalleled advantages due to their capabilities, flexibility, versatility and low cost (e.g. Tour de France). However, this assumes that safety issues related to overflying drones have been resolved and authorisations or exemptions duly obtained.

Drones acting as mobile communications relays have potential applications in the area of radio broadcasting and **wireless communications**.

Still looking to the future, two giants are thinking of providing Internet access to the most isolated places on Earth:

- Facebook's Connectivity Lab, launched in August 2013, plans to fly UAVs the size of a Boeing 747 to an altitude of 20 000 m;
- Google X, having acquired Titan Aerospace and the Loon Project, will conduct experiments in New Mexico in 2015 with drones the size of seven Toyota Prius, weighing 5 to 6 t.

Drones can be used for scientific activities. We have already seen their uses in 3D reconstruction and archaeology but they are also used for studying the atmosphere, the land (geology), the oceans, the weather and the environment (including air quality measures, assessment of natural resources and detection of hydrocarbon or other pollutants).

Drones are or will be used in a wide variety of public interest missions under the control of the competent authorities, backing up the police and customs services as well as civil and maritime security. Such missions include maritime surveillance (sea

Figure 9: Improving internet provision in remote places © Titan Aerospace

routes, drug trafficking, illegal immigration, fishing), policing and law enforcement (inner city surveillance and demonstrations), surveillance of road traffic and the transport of hazardous materials, border surveillance, detection of illicit trafficking, monitoring and protection of wildlife, detection of forest fires…

Since “charity begins in the home”, we must not overlook the many existing and projected drone applications for aeronautics. These include airport monitoring (runways, infrastructures, birds ...), participation in many technological and operational developments such as the design, assessment, experimentation, validation and qualification of sensors, equipment, systems and scenarios, as well as remote pilot training and non-destructive testing of aircraft in inaccessible areas ...

Many still undreamed of applications will appear, all the more so since RPAS are easy to use and are evolving very rapidly in a highly transverse way, as indeed are the miniaturised technologies (sensors and other onboard systems), communication technologies and systems, digital processing methods and capabilities that equip them. For example, **connected objects, 3D printing and new communication solutions** herald ever faster, more numerous, seemingly limitless developments (the innovation cycle of a drones system is around four months). Brakes on this progress are both societal and technological, due to the fact that safety must be ensured and regulations adapted to rapidly evolving technologies.

“Drone perches” have even been imagined by designers Joe Sardo and Federico Bruni on roofs of buildings, with parking lots and battery chargers. Not so much an application as a system to facilitate drone integration and operations, these would

Figure 10: Dronairports © Yanko Design

increase effectiveness and safety, leading to a change of paradigm. Skysense is developing “charging pads” for this reason.

In a futuristic vision like the one presented at the conference, **autonomous systems** would be capable of **freight transportation** as described by John Lauber and even, albeit on a more remote horizon, **human transportation** (ONERA’s PPlane project was described by Claude Le Tallec, a projection of the future of civil aviation).

Drones may well also fly in swarms, sharing out tasks (a large drone to raise heavy parts, or many small drones handling smaller parts…). Close ties should be forged with robotics, a subject that is mobilising several academic centres (EPFL, UTC...). The Renault concept car, Kwid, present at the New Delhi Auto Expo, integrates a drone “Flying Companion” that offers a **steering aide** in a complex and evolving environment. This application also raises many ideas for the mobility of tomorrow.

To conclude, there are an abundance of highly varied applications for drones, with multiple combinations, facilitated by their intrinsic flexibility and versatility.

When compared to existing means, drones can offer a much larger range of services. They can play a completely new role or act as substitutes (for planes or helicopters), or they can work alongside planes, helicopters, satellites and balloons, etc. There are, and will continue to be in the coming years, a host of different applications for civilian drones. It is interesting to note that French RPAS players have been able to

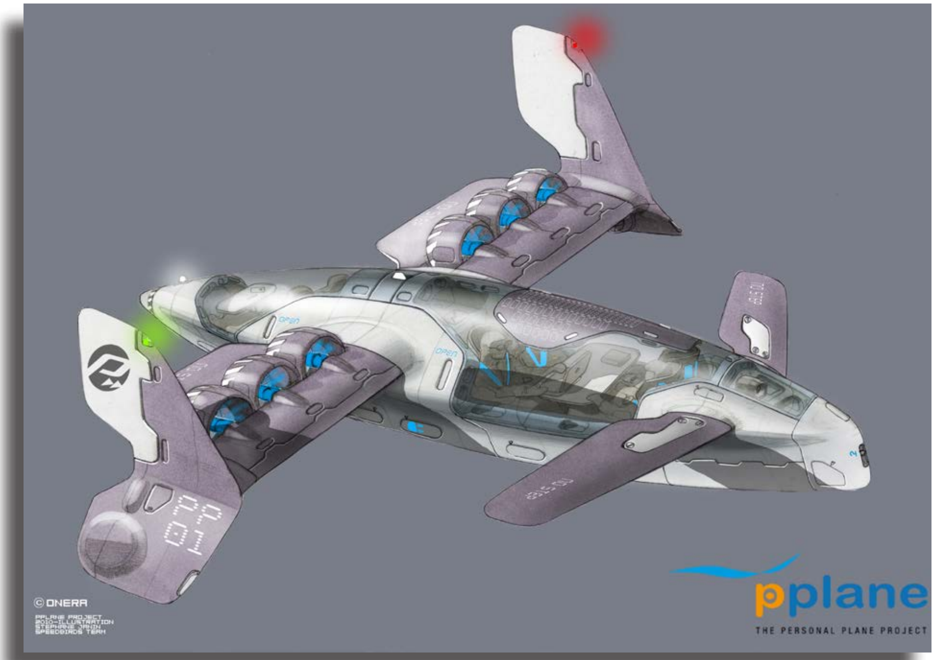

Figure 11: One of the concepts for the European PPlane
© Projet PPlane et Speedbirds Team

test a large number of applications since the DGAC regulations came into effect in April 2012. Drone specialists – SMEs or larger groups – have studied and often validated the use of drones for the media, public works, agriculture, network maintenance, safety, etc. In many cases, the experiments have led to the definition of comprehensive “drone solutions” (in terms of hardware, software and operating modes). Looking beyond the regulation side, this work on applications has helped give the France a head start that it must hold on to in order to support its industry.

Figure 12: Concept car Renault Kwid © Renault

2 PLAYERS AND MARKET

The civilian RPAS market is too young to benefit from in-depth economic studies based on stable comprehensive data. Attempts to measure the market are therefore still relatively empirical and this lack of reliable, collective measurements is a handicap to all players, whether clients, manufacturers or service providers.

2.1 PLAYERS IN THE CIVILIAN DRONE MARKET

Players in the civilian RPAS market are spread out along a value chain consisting of the following elements:

- data sought;
- sensor;
- measurements chain;
- drone system, carrying all or part of this sensor/measurements chain;
- sensor placement (to achieve the required measurement);
- drone definition (to correctly place the sensor in order to achieve the required measurement);
- data processing chain;
- processed data, ready for its final use;
- services necessary to achieve the mission (telecommunications, air traffic, meteorology).

The main players are:

- contractors;
- data users;
- manufacturers of sensors;
- suppliers of the measurements chain;
- manufacturers of air vehicles;
- manufacturers of drone systems, who assemble the drone, integrating the entire sensor/measurements chain and all equipment enabling its remote operation;

- operators of the sensor/measurements chain;
- drone operators, responsible for operating in compliance with safety regulations;
- remote pilots, with qualified expertise to enable proper operation of the drone;
- data processing providers;
- processed data managers, to transform the data into a marketable product or service for the user or the contractor.

Other players not directly members of the value chain also take part in the economic ecosystem of the civilian drone market:

- **external service providers**, in charge of:
  - telecommunications, navigation and surveillance,
  - air traffic management, including aeronautical information and air traffic control,
  - meteorological information,
  - information as to what is going on in the aerodromes;
- **training providers**, who qualify remote pilots and sensing/measurements operators;
- **insurers**.

Of course these players can actually be sorted into a more limited, “vertical” grouping and it is up to each player, depending on their particular strategy, to position themselves on this value chain according to their own varied spectrum of activities. Each type of player – from major industrial groupings to individual entrepreneurs – should stake out their position with regard to their competitors, contractors and customers.

Recently certain French players who had initially decided to position themselves “upstream” on the value chain (for example drone designer, producer and system operator) decided to move “downstream” (becoming drone system operator, processing provider and data manager), due mainly to market pressures, in a move that was inconsistent with their development needs and associated cash flow needs.

What would drive players to make such a shift in position, at the risk of undermining their structural sustainability?

Such a move can be traced back to a faulty initial judgement of the market or to prevailing operating conditions having changed faster than the player’s industrial model, altering its profitability margins, for example.

It could also be that the chosen industrial model was unsuitable for the civilian RPAS market. Perhaps there was a lack of operational aeronautical culture (in particular with respect to “best practices”) or a difficulty integrating the complex system of standards governing flying objects, subsystems, operators and operations.

The financial model of a company can also be inappropriate to the economic parameters of the market. The technological sophistication of even the most modest drone systems required to meet regulatory obligations, for instance, calls for high levels of investment. This can weigh heavily on the profit margins of civilian drone players who, in order to penetrate the services market, must compete with traditional, well-established alternatives that are already amortised and so ultra-competitive. Funding investment whilst operating on markets with narrow profit margins is a factor of tension, and thus of fragility.

Which players for which markets? Certain adjustments would seem necessary in order to ensure the economic development of the drone sector on the civilian market.

2.2 THE MARKET FOR CIVILIAN RPAS PLAYERS

The market for civilian RPAS is highly fragmented in terms of needs, functioning rather as an agglomeration of individual niches. In 2012, market research carried out internally by Airbus in France identified nearly a hundred niche markets for larger drones of all shapes and sizes. These were classified into ten market segments according to types of operation, along the lines of the application categories listed in Chapter 1: agriculture, network monitoring, civil protection, civil engineering, environment, telecommunications, photography and cinema, etc.

These applications generate a variety of activities:

- photography, cartography, topography and modelling;
- surveillance, detection, sampling and measurement, technical inspection and monitoring;
- spraying/treatment;
- crisis management, establishment of photographic evidence;
- support for search and rescue operations.

This study put the potential 2014 market value for all segments in France at an estimated recurring value of €100 million. Part of this sum is unattainable because of disparities between technical solutions and regulations. The lion's share of this market (50-60%) is made up of the requirements of the major networks. However, for technical reasons, current drone systems are as yet incapable of performing these particular tasks in a routine way, indeed few of them are even ready for such tasks experimentally. The actual active market is therefore much lower than the above estimate and a look at the financial results of all players in France reveals a probable turnover in 2014 of between 10 and 20 million euros. Moreover, these results come from a very large number of micro-contracts, with between 5,000 and 20,000 euros charged for most common services. We are clearly far removed from a contractual model capable of fuelling dynamic, sustainable development of the sector, with multi-year contracts from large clients on a broad range of services. No contract of this type yet exists in France, although the SNCF recently launched an invitation to tender on this basis.

Taking into account the economic growth index of each country in the European Union, the potential European market is put at approximately €665 million. Given certain growth areas in this market in coming decades (e.g. maintenance of offshore wind farms, which will mature by 2025), it seems reasonable to predict an annual average growth rate of 10% for the next two decades. This would lead to a total European market of just over one billion euros by 2020, which is the estimated date of regulatory maturity of the drone sector and therefore, of an active market, fully exploiting its potential. This market represents over ten thousand jobs, mainly in medium, small and micro businesses.

On the basis of this structural analysis of the French and European market, we can roughly classify “export” markets according to factors of similarity as follows:

- the US and Canada;
- South America;
- the Mediterranean countries;
- Sub-Saharan and Central Africa;
- South Africa and the Indian Ocean islands;
- the Near and Middle East;
- India;
- Russia;
- Asia (excluding China, Japan, South Korea);
- Japan and South Korea;
- China.

This market could represent 10 billion euros by 2020 but the fact that it is split into niches calling on a variety of trades, together with its heavy reliance on national regulations and locally based economic activity, will restrict the profitability of services offered, resulting in narrow margins.

This would argue in favour of an industrial organisation based on regional “agencies” or franchises with a transverse contractual structure, or alternatively for a model involving three players: an industrial prime contractor mobilising major contractors and local or regional service providers.

Before planning to expand its export side, French players must first establish their viability on the home territory, which means improving their market effectiveness rate.

Players' access to a healthy, sustainable market can be further limited by demands as to competitiveness, safety and quality.

Ways of coping with demands linked to **competitiveness**	Ways of coping with demands linked to **safety**	Ways of coping with demands linked to **quality**
Low-cost sensors Low hourly wages Existing avionics Low-cost drones Long endurance drones Low-cost maintenance Open source software Mainstream technologies Local operations Tolerance to weather Intensive operations Multi-year contracts SME-type cost structure	Reliable drones Certification of company processes Mature technologies Compliance with regulatory framework Specific insurance Airworthiness Financial strength Trained, qualified personnel	Contractual conditions High performance sensors Effective maintenance High-performance drones Measurement methods Compatible software Recognised quality system Trained, qualified personnel

- How can one expect to hire trained, qualified personnel on a low wage?
- How can one find drones that are high performance, reliable and with long endurance, but cheap at the same time?
- What company possesses strong financial standing, an adequate ceiling of responsibility and total regulatory conformity while preserving an SME-type cost structure?
- How can one use open source software and at the same time meet the development constraints of certifiable software?
- etc.

One solution might be to introduce a third party which would play the role of both contractor (providing clients with guarantees of financial standing and sustainability) and risk bearer (supporting innovation and quality for service providers). The French industry and market are both well suited to this type of arrangement because of the numbers and profiles of current players.

Considered in this manner, the available market in 2020 could be estimated as follows:

	Segmentation	France	Europe
Infrastructures/networks	35%	€62 M	€385 M
Civil engineering	15%	€27 M	€165 M
Mining and oil industries	15%	€27 M	€165 M
Agriculture, forestry, fisheries	5%	€9 M	€55 M
Civil protection	5%	€9 M	€55 M
Chemical, biological and nuclear safety	5%	€9 M	€55 M
Environment, meteorology, wildlife	5%	€9 M	€55 M
Telecommunications	5%	€9 M	€55 M
Law enforcement and public safety	5%	€9 M	€55 M
Cinema, photography, publicity, recreational, communication	5%	€9 M	€55 M
Total available market	**100%**	**€179 M**	**€1,100 M**

As an illustration, a French firm wishing to acquire 50% of its national market and 20% of the European market by 2020, for all applications, would be aiming for a sales turnover of approximately 275 million euros, for which it would need approximately 1,100 employees.

By the end of 2014, almost 1,200 civilian drone companies had registered with the French authorities; representing approximately 3,000 jobs, most of them recently created, this confirms the fragmentation described above. The idea of an intermediary structure previously mentioned would help capture more of the potential market and avoid an impoverishment of stakeholders, often ending with a cessation of activities.

Given, on the one hand, the high potential of drones for socio-economic development and, on the other hand the investment needs that are crucial for this development, together with certain aspects specific to drones outlined above, it is vital that European and EU political powers/bodies (both executive and legislative) provide robust economic and financial support to the entire industry (R&D projects, start-ups, developing technologies and exports, etc.).

2.3 RECOMMENDATIONS

In terms of the economic dynamics of the civilian drone market, the recommendations are as follows:

► **Key Recommendation 2:1:**
The European Commission and Member States should provide **strong support to the whole sector** (R&D projects, technology development, start-ups, exports, etc.). Funding of the drone sector by European R&D programmes H2020 and SESAR should be raised to at least **€100 M** over 5 years. Priority should be given to small drones flying at very low level (VLL) beyond visual line of sight (BVLOS), i.e. those carrying out most of the potential missions.

► **Key Recommendation 2:2:**
In order to help achieve a **harmonised European set of regulations** meeting users' needs, the drone community should play an **active role** in the works of EASA, JARUS[3] and other standardisation bodies, by rapidly preparing input documents.

► **Recommendation 2.3:**
European drone manufacturers should integrate **low-cost equipment** into their drones (sensors, autopilots, datalink, engines, batteries) and free themselves from **foreign** acquisitions under export control. Equipment from **car and telecom industries** should be considered.

► **Key Recommendation 2.4:**
The French "Conseil pour les drones civils" should elaborate the **roadmaps for the required technologies** and help obtain **public funds** for the **development of the drone sector.**

► **Recommendation 2.5:**
The three aeronautics clusters[4] should facilitate the formation of **consortia**, bringing together SMEs, laboratories/test centres, academies and major groups in the sector in order to meet calls for projects.

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3 Joint Authorities for Rulemaking on Unmanned Systems. www.jarus-rpas.org

4 Aerospace Valley www.aerospace-valley.com
ASTech www.pole-astech.org/site/pages/index.php
Pegase www.pole-pegase.com

3 TECHNICAL AND OPERATIONAL RISKS

This chapter discusses the risks potentially arising from drone activities, more specifically relating to incidents or accidents that may cause damage to third parties, people and goods. The operational risk of abandoning mission is not considered because this falls under the operator's responsibility. Aspects related to violations of privacy and the use of drones for malicious or illegal acts are covered in Chapter 4.

3.1 RISK CLASSIFICATION

1) If a drone performs a crash landing, uncontrolled by the remote pilot or by the drone itself, it can damage itself as well as third parties, persons and property. Such crashes are usually due to systems failure, collision with fixed obstacles (or birds) or weather phenomena (turbulence, icing, urban high winds, visibility...).
2) **Collision** with another aircraft, manned or unmanned, can cause damage to the other aircraft and its occupants and to the drone itself, as well as to goods or people in the subsequent crash landing.
3) A **controlled crash**, while posing a risk to the drone itself, can prevent third party damage. It can be activated by the remote pilot, autonomously by the drone or by an authority.
4) **Exiting the authorised manoeuvring airspace** or loss of communication or visibility are secondary risks because they do not necessarily lead to damages, provided that **degraded modes** can be put in place (emergency landing, controlled crash or automatic return to a designated place or starting point).

3.2 TECHNICAL RISKS AND FAILURES

Technical risks refer to failures of the following elements:

1) the vehicle itself: its structure, propulsive system, energy, autopilot and avionics, including software;
2) the flying system (remote control) and its associated software and/or the error(s) of its remote pilot;
3) its Communication-Navigation-Surveillance systems (CNS):
   - command and control communications (C2link) and voice links (air-ground-air and air traffic control): risk of loss and interference, jamming or full takeover of the link by an intruder,
   - navigation systems: loss or corruption of the satellite navigation function, whether GPS or Galileo in the future,
   - the surveillance system that positions the drone on the ground: loss of one of the previous two features,
   - autonomous collision avoidance systems such as “detect and avoid” designed to avoid collision with manned aircraft;
4) air traffic services, which must contribute to preventing collisions.

3.3 HOW TO REDUCE TECHNICAL AND OPERATIONAL RISKS?

Risks must be reduced using measures and means that are proportionate and appropriate to the risk in question. The type of risk depends on the drone mission, the airspace within which it is operating (overflown population, segregated area or not, medium or very low altitude...) and the vehicle itself (weight, speed, kinetic energy). A quantitative analysis if possible should be conducted in each case and compared with an accepted risk level (see Appendix 1).

Risk limitation relies on drone design, quality of hardware and operation, remote pilot training (§3.5) and relevant regulations (see Chapter 5), with the inclusion of an appropriate safety management system containing effective feedback from experience (see Chapter 6).

What resources and technical/operational measures are needed to effectively limit identified risks?

1) **For the drone and its control station**, this can range from a simple equipment check before every flight to certification of the whole system including vehicle, control station and data link.

   Software, whether onboard or in the control station, is playing a more and more important role in RPAS systems. How can one ensure the necessary safety level when development teams are unfamiliar with aviation standards? How best to manage configurations and updates?

Human factors must be taken into account in designing **control stations** in order to minimise the risk of interpreting and handling errors.

2) **Command and control data links** (C2Link) require protected frequencies, authentication and encryption of control information. Frequency management is an important point, as highlighted in EASA's Concept of Operations for Drones: "The harmonisation of regulations and availability of spectrum is fundamental to the success of drones. Spectrum decisions are taken in the ITU (International Telecommunication Union). The continuation of the active coordination of Member States already existing in the European Aeronautical Spectrum Frequency Consultation Group (ASFCG) is strongly recommended so that Europe speaks with a single voice and the necessary spectrum is allocated to drone operations".

   Is it necessary to use specifically aeronautical networks for **communications**? Would it not be possible to use the internet (c.f. MACH7[5], FlightRadar24) for fixed connections? For ground to air links, the mobile cellular network could provide good cover especially at low altitude, although with the risk of lack of continuity of service (c.f. LATAS[6]).

3) Identification and positioning information should be systematically transmitted to the operator and broadcast to other players, either directly (ADS-B – Automatic Dependent Surveillance – Broadcast) or via operator and land networks. See Recommendation 3.3.

4) The **air traffic management system** must be capable of managing conflicts and preventing collisions between aircraft by organising the airspace, keeping players informed and providing flight separation in certain areas, based on CNS and a shared information system (aeronautical, meteorological).

   - In controlled areas of class A, B, C or D, air traffic services should deal with drone flights in the same way as instrument flight, maintaining connection with remote pilots.

     Specific issues involved in integrating drones into controlled airspaces include communications between air control and remote pilots, the defining of contracts and the conduct of drones when in degraded mode. Procedures should be defined and negotiated with air traffic control services. Similarly, the drone will need to meet common flying rules in order to be managed by air traffic control services. These rules will need to be standardised on a national, European and global level.

5 www.mach7.com/mach-7-drone

6 www.flylatas.com

- In uncontrolled or segregated areas, separation will be the responsibility of the remote pilot – either in direct line of sight or by means of the information at their disposal – or of the drone itself, using "Detect and Avoid" systems.
  The current military system of **restricted airspace**, although dynamic – restrictions apply to shifting zones according to the unfolding of the mission -, cannot be a solution in the presence of a multiplicity of drones.
- For effective air traffic management, information on drone missions and whatever segregated areas may have been attributed to them should be sent to all players. This should be facilitated by the transmission of identification and positioning information suggested above, as well as the submission of flight intention and/or flight plans (see recommendations 4.3 and 4.5).
- It is necessary to set up and update in real time a database of prohibited airspaces to be avoided either manually by the remote pilot, or automatically by the drone according to a previously programmed flight plan.
  These systems will require a large amount of **data**, particularly aeronautical and air traffic information. How can one ensure this information is up to date and accurate?

5) "**Detect and Avoid**" (D&A) systems will be used for co-operative planes, broadcasting their identification, position and speed (c.f. §3.4.2.)
   Vision sensors and systems will need to be developed for drones operating out of the operator's line of sight so as to resolve conflicts and avoid obstacles and collisions with non-cooperative aircraft (i.e. not broadcasting their position).
6) Remote pilot training and qualification can require a licence in certain cases (see §3.5). Operators must be qualified and a safety management system set up in accordance with the risks (see Chapter 6 Feedback from experience).
7) Systems must be developed to detect, identify and neutralise any drones (including non-cooperative) breaking the rules, as defined in the call for tenders of the French research agency (ANR) in December 2014.
8) Solutions can be provided by professional organisations, independent service providers or State bodies.

3.4 NECESSARY RESEARCH AND DEVELOPMENT

Drones must be made safer if we are to prevent the two main feared events:

- drone crash-landing on people;
- a drone collision with another aircraft.

This dossier does not aim to make a comprehensive inventory of R&D work in progress in France and Europe, indeed this would be too difficult. Accordingly, the following is only a partial view of the subject.

In France, although the civil aviation authority DGAC has not funded any project as such, certain projects have been supported by the aeronautical competitiveness clusters (Pegase, Aerospace Valley, ASTECH) which are partly financed by the national research agency ANR or the single inter-ministry funding agency FUI.

Research is spread over a large number of organisations: ONERA, "grandes écoles" such as ISAE and ENAC, universities, CNRS within its robotics research group, major aeronautics companies (Airbus, Thales, Safran-Sagem, ...) as well as small businesses (DeltaDrone, DelairTech ...).

These studies relate to the aircraft itself, its control station, avionics, integration into airspace, sensors and applications, in particular data processing.

It should be noted that certain research is of a dual civil-military nature.

At European level, the framework programmes (FP) have funded a number of projects in a patchwork manner.

In 2013 SESAR JU initiated nine 2-year demonstration projects mainly dealing with the integration of **medium-sized drones into controlled airspace**. These include real-time simulations and real experiments in flight.

For the coming five years (2015-2020), European drone activities are dealt with exclusively by the SESAR programme 2020, currently under definition. This programme comprises the 14 activities identified in the "Roadmap of the European Commission of June 2013" which remains a reference[7]. SESAR is thus developing a detailed R&D programme for integrating drones into airspace, which should be published in summer 2015. But, in the short term, most drone missions will be performed at very low altitude in uncontrolled airspace: equipment and procedures must thus be developed that are adapted to this type of mission. Aspects such as airworthiness are not taken into consideration. The operational concept and ATM (Air Traffic Management) master plan will also be modified to take account of drones, as well as dealing with general aviation and helicopters which had not been included in the first SESAR1 phase.

► **Key Recommendation 3.1:**
Priority should be given in **R&D** programmes to the sector comprising **small, very low-flying drones**, which carry out the majority of missions. In particular, the case of drones flying beyond visual line of sight (BVLOS) must be addressed. Moreover, industrialists participating in SESAR, primarily the large aeronautical firms, must take into account the place occupied by SMEs and their particular needs.

7 Roadmap for the integration of civil Remotely-Piloted Aircraft Systems into the European Aviation System: www.ec.europa.eu/growth/sectors/aeronautics/

3.4.1 Preventing drone crash landings

The risk of a drone falling on a person can be mitigated by respecting safer principles when constructing drones aimed at carrying out missions over people and in urban areas.

► **Recommendation 3.2:**
Drone manufacturers should examine **light, simple means and redundancies** to increase the **safety of drones** without **increasing their costs**.

3.4.2 Communications at very low altitude

Communications between the ground and the air vehicle are very important and underpin all aspects linked to control and command, identification and positioning. The supply of specific coverage for very low altitudes would be difficult and extremely expensive.

The use of existing mobile phone networks would seem worth considering because of their extensive low-altitude coverage and miniature components developed at low cost. Their SIM cards could for example be used to identify the operator. The low speed of drones should ensure that they are compatible with cellular networks.

► **Recommendation 3.3:**
The use of **mobile telecom networks** (GSM, 3G, 4G), enhanced with performance and safety analyses and security measures, should be tested for air-ground-air **communications** as well as drone **identification and positioning**.

3.4.3 Detect and Avoid (D & A) functions

It is not easy to restrict airspace for operational use of drones.

It remains to be seen as to whether the idea of asking all users of the airspace to be cooperative is workable. This might be applicable to controlled airspace but would be difficult to apply where there is no existing requirement as to equipment. Indeed, current users of this airspace would be likely to react negatively to a new requirement caused by the arrival of drones. Small, low-flying drones should not necessarily be compelled to have cooperative means.

Vision sensors and conflict avoidance systems will need to be developed for drones operating out of the operator's line of sight so as to resolve conflicts and avoid obstacles and collisions with non-cooperative aircraft (i.e. not broadcasting their position).

Components such as sensors developed for the automobile industry could facilitate these developments.

► **Key Recommendation 3.4:**
The European R&D programme H2020 should finance the **development and experimentation of simple, light, low-cost technology, airborne and/or ground based, to reduce the risk of collision**, especially for very low-flying drones.

3.5 TRAINING

The safety of professional drone operations depends on their remote pilots having received appropriate training, both theoretical and practical. If one takes the example of pilot training for manned aircraft (planes, sailplanes, helicopters), such a course should be set up in several stages:

- The **theoretical module** should teach remote pilots the functioning of the various drone systems, especially those where any in-flight failure could have serious consequences for the aircraft and its environment, on the ground or in the air. To limit the consequences of such feared events, existing regulations defining flight requirements should be fully assimilated. Finally, since the drone is flying through airspace, the remote pilot must learn to comply with the set of rules applying to flying vehicles which define, in particular, the various classes and types of airspaces and the conditions for entering them. Candidates must also know how to obtain information on airspace from aeronautical charts or appropriate data servers.
- Once candidate pilots have acquired this theoretical information and their level of knowledge has been tested, they must follow a **practical training** course comprising two phases: a course in drone handling and another in performing the specific activities linked to the application.
- This **remote pilot training** should be carried out on a drone system similar to the one the remote pilot will have to use professionally. This system could be simplified, however, provided that all controls and flight control information remain identical. Part of this training programme could be performed on a simulator as long as the virtual control station was identical to the real operational station.
- **Training in particular activities** must be done using the same type of drone as the one to be operated, equipped with its real payload. The remote pilot student will only progress from the practical flight training phase to the specific training course once they have demonstrated their ability to fly the drone and manage the main critical situations. The authorisation to carry out specific activities in a professional manner should only be issued to the student pilot at the end of a skill testing flight.

Nonetheless, the question of who does what in this process remains to be defined. The theoretical training course should take place in an approved training school with verified teaching skills, either in a dedicated site (classroom training) or by correspondence (including the Internet). This training institute will have a duty to validate candidates' knowledge and skills level. Its organisation and the teaching skills of its trainers should be checked regularly, either by an air safety authority, or by an accredited organisation thereof.

The practical training module should also take place in a training institute, at least for the initial flight training. This course should use a drone similar to the one to be used professionally by the remote pilot. If the drone to be operated is series-built, the practical piloting training scheme should be put together by the manufacturer and adhered to by the training institute. If the future drone has been built by the remote pilot candidate, the course will have to be defined with the training institute and be carried out where possible on this particular drone.

Training for a specific activity will depend on the particularities of this activity. The syllabus for this training programme must be defined by the drone operator and followed by the remote pilot candidate. For certain common activities like surveillance, institutes will be able to develop generic training schemes for each type of activity.

An important issue here is the question of a **licence** for remote RPAS pilots. Given the low level of associated risks, a licence would not appear necessary for very light-weight drones (<2 kg), flying above the countryside, outside inhabited areas, at a height of under 150 m. But a licence should be obligatory for drones weighing over 25 kg, or between 2 and 25 kg, flying at a height of over 150 m, above an inhabited zone or beyond visual line of sight of remote pilots, i.e. for operations representing a high level of risk. For flights in controlled airspace where permanent radio contact with air traffic controllers is required, the course should include training in radiotelephony.

Minimal medical skills should also be defined and checked for remote pilot candidates who will need to control drones within sight and detect and avoid obstacles and other aircraft in flight. The terms governing licence renewal and extension should also be defined on the basis of rules pertaining to traditional aircraft pilots.

Training remote drone pilots is very important for flight safety.

► **Key Recommendation 3.5:**
Civil aviation authorities should formalise training requirements for **remote pilots** as well as the various ways of monitoring the effectiveness of such training (accreditation of courses, theoretical and practical tests).

► **Recommendation 3.6:**
For high-risk operations, the remote pilot should hold a **licence** delivered either by the civil aviation safety authorities or by an accredited organisation. For very low-risk operations a training certificate might be enough.

► **Recommendation 3.7:**
It is important to train remote pilots of drones carrying out professional activities. All training in view of issuance of an attestation should be carried out within **approved training schools, accredited** by the civil aviation safety authorities or a recognised body on the basis of standards that should be **harmonised** if possible on a European level, thus ensuring **mutual recognition** between EU Member States.

4 Societal risks

Societal risks consist of violations of privacy and the use of drones for malicious and illegal acts.

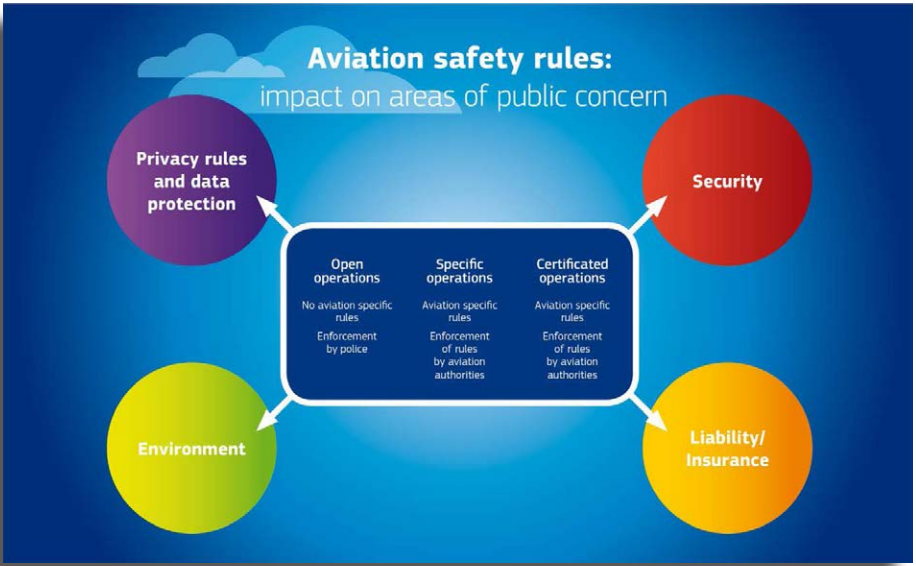

Figure 13: EU Vision for drone integration © European Commission

Malicious acts include hijacking, jamming or hacking a drone as well as illegal acts such as flying over a prohibited area (nuclear power plant, military zone, urban district), non-authorised freight transport (drugs, to a prison, over a border) or privacy violations (photo or theft of personal data) as well as terrorist actions.

4.1. LESSONS LEARNED FROM THE AAE/3AF CONFERENCE

The two aspects tackled at the conference were respect for privacy, dealt with by Edouard Geffray, secretary general of French data protection authority CNIL, and insurance issues, which were raised in a debate with the floor.

Edouard Geffray declared that:

“The very rapid expansion in civil drone usage is game-changing and demands regulation, to preserve not only aviation safety but also privacy, personal data and law and order.

Although the issues are now well-known (video-protection, photos or audio recordings by third parties...) and legislation has already been passed to protect privacy and personal data and regulate video surveillance, this protective framework was not designed for the new risks posed by drones, which mainly involve violations of personal and public freedoms.

CNIL does not intend to fall into the trap of technophobia by artificially setting protection of privacy against innovation, but rather wishes to contribute to building a stable, predictable, legal framework. It is working on this with the various players, in a strategy known as ‘privacy by design’ that aims to identify risks as far upstream as possible in order to trace the necessary red lines while preserving freedom for innovation.”

The goal is not to impose technologies but to persuade manufacturers and professional operators to take privacy issues into consideration in their hardware, data management system (storage and diffusion in particular) and onsite acquisition protocol (zones of exclusion). In this way CNIL aims to restrict and sanction excesses by supporting innovation without hampering players. The profession would be well advised to integrate this aspect in order to ensure public acceptance.

Edouard Geffray continued: “For example, it is difficult to inform people in advance about images or information relating to them that are collected by these discrete mobile devices. One of the possibilities envisaged is to inform the public after the event by providing (on an Internet site or as open data) a list of drones having flown over a site. This would make it possible to identify air traffic and would enable plaintiffs to assert their rights.

It would also seem necessary to strengthen cooperation between the various monitoring bodies (DGAC, CNIL, judicial system).

Finally, given this explosion in drone use, it is urgent to launch a collective, preventive information campaign, for example by massively diffusing practical information on best practices and applicable laws.”

On the final point, in late 2014 the DGAC issued a fact sheet, the "ten commandments,"[8] summarising best practices to be observed by any drone owner.

With regard to insurance, it was submitted that the operator should logically be the responsible party and should therefore take out an insurance. If the operator is not insured, the third party victim may then turn to the manufacturer, on the grounds of a hidden defect for instance.

Insurers currently lack the necessary data to estimate risks and are therefore not in a position to propose an insurance that would meet operators' needs. Moreover, the drone sector must find investors to help finance these rather expensive products: a professional drone can cost several tens of thousands of euros or more. Perhaps one solution consists of leasing these machines to be able to start operating immediately; and of course where there is leasing there is insurance. For the moment, however, there exists no drone leasing offer complete with insurance.

4.2 THE EUROPEAN COMMISSION APPROACH

4.2.1 Protecting the fundamental rights of citizens

At the conference, Thierry Buttin brought out the following elements:

"We have a 1995 directive on the issue of respect for privacy and we have launched a study on data protection with regard to drones. The second avenue we are exploring is the consultation of Article 29, i.e. bringing together all European data protection agencies to issue an opinion in early 2015 on drone technology and the question of respect for privacy and data protection. We are conducting this action jointly with the Directorate-General for Justice and Consumers (DG JUST).

Regarding privacy and data protection, our study focuses mainly on commercial applications. It shows that it is not necessary to change existing regulations, with the proviso that this regulation is currently undergoing modification. We are integrating the current modifications, which are important for the field of drones in that they introduce the concepts of so-called "privacy by design" and impact assessment on data protection. No modification of legislation then, but an enhanced dialogue between the aviation and data protection authorities. This aspect varies greatly from one country to another with certain countries having difficulty communicating, which can be problematic. There is a need for training and informing stakeholders and developing 'soft law', i.e. protocols on transparency, drone identification, and methodologies on data protection and privacy impact assessment.

To conclude, we intend to issue legislation and it is important that we receive feedback from stakeholders, particularly on aspects we might miss. We have initiated discussions [...] with the Directorate-General for Mobility and Transport (DG MOVE)

8 Rules for use of a recreational drone: www.developpement-durable.gouv.fr/IMG/pdf/Drone-_Notice_securite.pdf

on issues related to the CE marking because, even if an entire class of drones operating in certain areas does not generate specific risks, we must provide consumers with minimum guarantees. The second avenue for reflection we have also recently launched concerns the instruction leaflet. The Australians, for example, have fairly clear instructions. We must follow their example. Some member states are preparing similar initiatives. We would like to generalise this approach at European level, but we must find the appropriate legal basis to do so".

According to §3.4 of the Communication of the European Commission 2014 0207[9] "the opening of the aviation market to RPAS would need to involve an assessment of measures necessary to ensure the respect for fundamental rights and the data protection and privacy requirements. The privacy situation would need continuous monitoring by the competent authorities including the national data protection supervisory authorities."

4.2.2 Guaranteeing civil liability and insurance

Thierry Buttin added:

"Looking beyond safety regulations, a few words on insurance and questions of civil liability. We have a regulation from 2004 and we commissioned a joint study with DG MOVE on civil liability and insurances[10]. This study, recently completed, reveals rather different approaches to responsibility within the EU, although these do not seem to be an obstacle to market development. The concept of responsibility should be clarified, creating jurisprudence. The 2004 'insurance' regulation applies to drones. At this stage, the study shows that no change is necessary because operators insure themselves against civil liability at levels higher than minimum regulatory thresholds. This insurance market is developing, despite very little data, but if claims multiply and premiums soar, a real problem of level of responsibility is likely to arise. We will continue to monitor this aspect.

The other question is whether or not a compensation fund is needed, as for uninsured vehicles. We know that there are a number of illegal uses for drones and that accidents can occur with people who have no insurance, so we would appreciate this issue being considered by the profession."

4.2.3 Ensuring security with respect to unlawful actions

According to §3.3 of the Communication from the European Commission 2014 0207:

"RPAS are not immune to potential unlawful actions. Potentially, RPAS could be used as weapons, the navigation or communication system signals of other RPAS could be jammed or ground control stations hijacked.

9 www.eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52014DC0207

10 Third-Party Liability and Insurance Requirements of RPAS. www.ec.europa.eu/growth/sectors/aeronautics/rpas/index_en.htm

The information needed to manage 4D trajectories in the future air traffic management system and to remotely control an aircraft will need to be communicated and shared in real time by different aviation operators to optimize the performance of the system. Addressing security vulnerabilities in information and communication are therefore essential elements of the ATM Master Plan[11], of which RPAS will become an integral part. The identified security requirements will then need to be translated into legal obligations for all relevant players, such as the air navigation service provider, RPAS operator or telecom service provider, under the oversight of the competent authorities.

Action 3: The Commission will ensure that security aspects are covered in the operations of RPAS to avoid unlawful interference, so that manufacturers and operators can take the appropriate security mitigating measures."

According to the Riga declaration: "Drones also pose potential security risks. The design of drones can and should take into account those risks by using methods such as cyber-defence or geofencing. However, the malicious use of drones cannot be entirely prevented by design or operational restrictions. It is the task of the national police and justice systems to address those risks."

4.3 RECOMMENDATIONS

Implementing measures related to societal aspects comes under national responsibility. Taking into account the CNIL proposals and European Commission guidelines, the recommendations are as follows.

To protect the fundamental rights of citizens

- **Recommendation 4.1:**
  Drone geographical data bases should contain information on forbidden zones (**geo-fencing**), and their post-processing should include privacy protection (**privacy by design**).
- **Recommendation 4.2:**
  Drones should be equipped with **identification and positioning means** that are compatible at a European level. This could be an active chip.
- **Recommendation 4.3:**
  Each operator should provide information (on a website or open data portal) on their drone **missions** with their **username** and **trajectories**, thereby making it possible for air movements to be identified and for plaintiffs to assert their rights.

11 www.atmmasterplan.eu

To guarantee civil liability and insurance

► **Key Recommendation 4.4:**
The European Union should require **insurance companies** in each member state to set up a **compensation fund** to underwrite damages caused by uninsured drones.

To ensure security with respect to unlawful actions

► **Recommendation 4.5:**
Before each mission, operators should **declare their flight intentions** (airspace to be used, timetable, flight path, etc.). This information would be collected by operators on a specific website and made freely available to all.

Setting up monitoring controls

In order to prevent drone users from performing unlawful acts on sensitive and/or protected sites, society through its public administration should ensure that an organisation is set up to manage such information and monitor, punish, prevent, intercept and neutralise where necessary, with clear procedures on local decisions as to such and such an action.

This monitoring organisation would have a broad mandate to carry out missions similar to the national and local police forces and judiciary for road and aircraft surveillance. It would clearly need to dispose of adequate means for these missions.

In all cases where the regulation has been transgressed, the sanction should be extremely dissuasive. Indeed, aside from the threat to human lives, such illegal usage also penalises professional users complying with the rules, with the possibility of blanket ban being placed on drones in certain places for instance.

Penalties laid down in the civil aviation or other codes should be actively applied to remote pilots and operators of drones infringing the law.

States must be responsible for **ensuring legal use of civil drones.**

► **Recommendation 4.6:**
Networked links should allow those in charge of security, as well as private individuals, to contact the remote pilot and/or the owner of the drone. If they do not respond, a penalty could be applied. As exists for traditional aircraft, and according to the situation, the decision might be taken to **track and intercept those responsible and/or neutralise the drone.**
These devices remain to be set up. It should be noted that the SGDSN (French secretariat-general for national defence and security) has already initiated action by identifying a set of such systems; a tender is underway for their development.

5 Regulations

Figure 14: EU Vision for drone integration © European Commission

5.1 INTRODUCTION

Unlike manned aircraft, RPAS have no persons onboard, so it is not a question of ensuring their safety but that of third parties on the ground or in the air.

The organisations in charge of safety regulations for drones are the same as for manned aircraft: the International Civil Aviation Organization (ICAO) at an international level, the European Commission and the European Aviation Safety Agency (EASA) in Europe, and the different national civil aviation authorities.

At the AAE/3AF conference, Koen De Vos of the European Commission's DG MOVE reiterated the role of the various European stakeholders:

- "The highest layer is at European Commission, European Council and European Parliament level. The Commission can propose something which can be adopted by Council and Parliament at European level. They are the legislator. The Commission can propose, they have to adopt.
- The second layer is EASA. EASA is to prepare rules of implementation.
- The third layer is Industry. It has a very important role to play. They have the possibility of setting industry standards. And they must, of course, ensure the compatibility of those standards with the different layers."

French civil aviation authority DGAC played a pioneering role for the question on drones with an initial set of regulations for France as early as 2012; indeed Europe is rather more advanced in this area than the United States.

At the ICAO symposium on Remotely Piloted Aircraft Systems (RPAS)[12] on 23 to 25 March 2015, the United States and Europe showed their intention to take action.

5.2 DGAC APPROACH

In his introduction to the AAE/3AF conference, Patrick Gandil, French director general for civil aviation, explained the approach adopted by the DGAC:

"From the outset, DGAC focused on evolvable regulations in order to adapt to the diversity of drone families, from military drones right through to recreational drones, which have a somewhat different operational mode to model planes. These regulations apply to civil drones of all sizes, which does not make the task any easier, and since the activity is young and developing fast, evolvability is the only solution. This current state of regulations can therefore change."

5.2.1 Goals

- To enable the development and consolidation of the primary segment of activity – i.e. light drones of a few kilogrammes, for simple missions – while respecting fundamental rules: ensuring the safety of persons and goods on the ground and of other aircraft, guaranteeing fair access to airspace and airport infrastructures for all users.
- To enable controlled, progressive evolution towards increasingly complex cases.
- To promote and structure research and development.

12 www.icao.int/meetings/rpas/Pages/default.aspx

5.2.2 Classification into four scenarios

In line with regulatory principles and requirements, the DGAC has established a classification comprising four scenarios:

- “Scenario S1: recreational drones which are the continuation of model aircraft, flying only within line of sight and far from anything that could be dangerous;
- Scenario S2: simple professional drones mainly designed to take aerial photographs;
- Scenario S3: activities in urban zones, flying only within line of sight, requiring a handbook and specific authorisations for the particular type of activity as well as appropriate training;
- Scenario S4: the most complex scenario, for activities out of the remote pilot’s line of sight, at a relatively long distance, limited to very low altitudes (to benefit from natural separation with aircraft flying at higher altitudes) and to light drones of less than 2 kg, in compliance with certification conditions on avian collisions with aircraft.

The drones used must be equipped with a device to inform the remote pilot of the altitude of the flight, another device guaranteeing return to the ground in the event of the drone exiting a pre-set safety perimeter and a plate identifying the operator.

All remote pilots must hold a theoretical pilot’s licence. In the case of the S4 scenario, they must have a full licence. The operator is responsible for ensuring that the remote pilot has the necessary practical skills.

Operators must declare any event that might have endangered the safety of third parties. In addition they must submit an annual report.

In terms of danger, there is a risk of colliding with a plane or of crash landing in a busy place. The danger level is low because these are light machines, but it is real nonetheless. This is why these rules, part of a broader set of regulations, must be complied with. This aspect is fundamental because if the situation is not controlled, drones will be subject to cumbersome regulations that could hamper their activity.”

These regulatory provisions were well received. In the space of two years, over 1,200 operators have submitted their handbooks and have been authorised to operate, mainly within the framework of S1 (within line of sight, at a very short distance) and S3 (within line of sight, in urban zones). The DGAC is currently working on an adjustment to these scenarios so that they better match real operational needs. This is being carried out in liaison with the other stakeholders and according to an iterative experimental process.

5.2.3 Looking ahead

As we have seen, the DGAC has developed a progressive, evolving approach to regulation, which has enabled real development of the market; such methods should

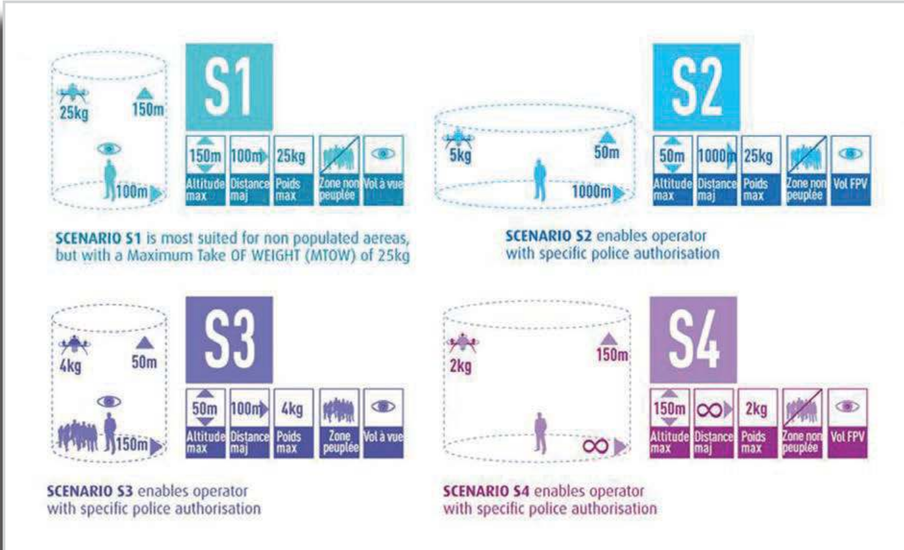

Figure 15: The four DGAC drone scenarios © DGAC

be adopted locally, taking into account real missions, operational conditions and needs, which can vary from one country to another.

On the other end of the scale, an international approach should be taken to **harmonising standards** (at least on a European level) for drone integration into airspaces frequented by other aircraft. DGAC supports studies and research in these areas and favours a progressive approach, implementing successive stages of increasing complexity. Integration into a controlled airspace with co-operative aircraft and an air traffic control service is undoubtedly simpler than integration into uncontrolled airspace for instance. Finally, care must be taken, once such regulation has been elaborated, not to extrapolate it to the simplest cases.

Patrick Gandil concluded: “The new frontier is that of instrument flying of drones. Visual flying of drones in open airspaces is not for tomorrow, indeed I am not sure I wish to see it happen, but flying in airspaces containing only planes in controlled flight, i.e. class A airspace in France, must be possible. We have the technologies but the regulations remain to be elaborated. It is the new frontier, but I think that one of the future evolutions in regulation will tackle this issue.

The world of drones reaps benefits from the efforts of all players, with the European Commission – DG MOVE and DG GROW – and EASA, with JU SESAR (Joint Undertaking on Single European Sky ATM Research) launching research in this field. And on the other side of the Atlantic, the FAA and the NTSB. We have also initiated actions to support industrial development and have inserted the drone roadmap, adopted a few months ago, into the roadmaps of the great technological programmes of the future; this should give us the means to develop this activity.”

5.3 THE EUROPEAN APPROACH

5.3.1 The process

Comprehensive information is available on the Remotely Piloted Aircraft Systems (RPAS)[13] section on the website of the EC Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs (DG GROW). As stated by Thierry Buttin at the AAE-3AF conference, European strategy is summarised in a communication of 8 April 2014:

"The strategy is founded on three pillars: regulations, research and market. In terms of regulations, the theoretical limit for the moment is 150 kg, a limit that we must extend, and I hope the Commission will make a proposal in 2015 to this effect. The integration issue has a sizeable research and development component: The first part of this is entrusted to EASA and the second to SESAR JU and involves development of technologies to enable drone insertion. The definition phase, which involves amending the work programme, is underway and will be completed by January 2015. We will then have a clear work programme for drone integration."

Eric Sivel (Deputy Director Rulemaking, EASA) outlined the instructions of the Commission:

"On a regulatory level, the Commission sets a number of priorities for EASA.

- Firstly, regulations should be based on performance and risks. There is no question of prescriptive rules.
- Secondly, the global organisation JARUS (Joint Authorities for Rulemaking on Unmanned Systems) should be used and their studies exploited as a basis for work.
- Thirdly, EASA should translate these draft regulations into European regulations. Depending on the limits of European jurisdiction, some of these JARUS proposals might be translated into national regulations."

5.3.2 The EASA "Concept of operations"

Since the conference, EASA published a document "Concept of Operations for Drones: A risk based approach to regulation of unmanned aircraft," on 12 March 2015. This document proposes a classification into three categories.

Category A: "Open category"

For this, very low-risk category, there are no approval requirements as regard airworthiness or operators and no mandatory training for remote pilots. It covers recreational model aircraft as well as commercial operations.

Drones must fly at low altitude (less than 500 ft AGL= Above Ground Level), in the pilot's line of sight (up to 500 m), away from reserved zones.

13 www.ec.europa.eu/growth/sectors/aeronautics/rpas/index_en.htm

Figure 16: EASA drone concept of operations © EASA

Any risk to people on the ground is reduced by using aircraft with low kinetic energy and by establishing minimum distances from people on the ground. In addition, it is advisable to respect a maximum weight limit for operations in residential areas. Flights over crowds are prohibited, but flights over persons not related to the operation are allowed in cities or inhabited areas.

Category B: "Specific operation category"

This category covers operations where there is an element of risk, which must be reduced by increasing operational limitations, enhancing equipment and requiring personnel to have a higher level of competence.

The operator must conduct a safety analysis, taking into account the drone's mass and speed, the class of airspace it is flying in, the presence or not of persons and the operational complexity of the mission, including the flight rules observed (VFR/IFR). Operations close to crowds could be accepted, in particular, provided that the drone is equipped with additional features (procedures in the event of Command and Control (C2) data-link loss for instance or devices limiting force of impact such as parachutes) as well as suitable operating procedures.

Category C: "Certified category"

The boundary between the "certified" and the "specific operation" categories remains permeable at this stage, but could depend on considerations based on kinetic energy as well as the type and complexity of operations, particularly in terms of autonomy.

For this certified category, a traditional **Type Certificate** will be required, with each drone requiring environmental certification, an individual certificate of airworthiness and an individual noise certificate.

Flights in this certified category will generally be executed by large, complex drones, in BVLOS (Beyond Visual Line of Sight). The Command and Control (C2) data link must have a protected aeronautical bandwidth.

5.3.3 The future of the European process

The European Commission confirmed this regulatory approach at the Riga Conference (6 March 2015) with the "Declaration on Remotely Piloted Aircraft" and at the Montreal ICAO conference (23-25 March 2015). EASA must now:

- publish by mid-2015 a regulatory framework and propose concrete regulations for the open category for consultation by stakeholders according to the usual NPA consultation process (Notice Proposal for Approval);
- prepare a draft regulatory framework and a practical regulatory proposal for the open category, for submission to the European Commission in December 2015.

5.4 THE FAA APPROACH

As announced by Catherine Lang in her presentation at the AAE/3AF conference, the FAA published a document entitled "Small UAS[14] Notice of Proposed Rulemaking (NPRM)"[15] on 23 February 2015. In compliance with its usual consultation process, the FAA issued this regulatory amendment proposal in order to adopt specific rules enabling the use of small UAS (RPAS or drones in EU terminology) in US airspace. Comments on this proposal could be addressed to the FAA until 24 April 2015.

The FAA lists examples of applications made possible by this regulation and the main applicable provisions.

These proposals are more restrictive than those implemented by the DGAC (flying beyond visual line of sight is not permitted for instance), remote pilots must obtain a UAS pilot certificate, renewable every two years, and training centres must be approved by the FAA.

5.5 ORIENTATION AND FUTURE NEEDS

Patrick Gandil added: "We are driven by major companies such as France's railway operator SNCF, which has chosen drones to monitor its network and which is therefore strongly motivating both industry and regulators to make this possible. But we could also mention electricity and gas companies EDF, GDF and ERDF. These

14 weighing less than 55 pounds

15 www.faa.gov/uas/nprm

are not aeronautic manufacturers but industries expecting a service and they are very demanding as to the conditions of this service."

These large network operators are today interested in cases not covered by the four DGAC scenarios. They wish to test out drone operation with an autonomy of several hours and a few hundred kilometres (therefore well out of sight), flying at very low altitude, with a payload weighing a few dozen kilograms in the form of sophisticated sensors. It is clear that for these cases, there is a high risk to third parties in the event of loss of control (crash or departure from protected airspace). Safety demonstrations guaranteeing the proper functioning and adequate management of failures must therefore be particularly robust, whilst maintaining operational precautions (types of airspace authorised or areas overflown). A step must be taken in the direction of category B ("specific operation") systems: compliance with preconditions enhanced by the calculation of likelihood of breakdown and assessment of the gravity of the consequences, determination of acceptable occurrence/gravity ratios and demonstrations linked to analysis, calculation or tests. The nature and extent of these conditions are under discussion. Similar work could be launched with the major building contractors, with differing constraints, requiring in particular the possibility of operating in urban areas while affecting inhabitants as little as possible.

In the cases evoked above, protection to other aircraft is essentially provided by the fact that these drones are flown in almost segregated airspaces, into which other aircraft do not normally enter, or which are the subject of specific operation protocols with other users. Widespread development of drones and the possibility of their being used for new missions will require amendments to category C (certified), which is why many studies are devoted to integrating drones into controlled airspace, or into uncontrolled airspaces used by other aircraft, particularly general aviation. It is no longer a question here of dealing with breakdowns but of approving systems to guarantee conflict management and collision avoidance in these airspaces; such systems would need to be at least as effective as those in force for manned aircraft and would have to be acceptable in the eyes of other users and air traffic control services. The requirements and methods characteristic of certified traditional aviation will undoubtedly resurface here.

5.6 RECOMMENDATIONS FOR A HARMONISED EUROPEAN APPROACH TO REGULATIONS

DGAC and EASA approaches to regulations are consistent, taking the view that it is unacceptable to allow drones to give rise to an uncontrolled risk, and that the application of regulations elaborated for aviation is neither justified nor viable from an economic point of view.

France recently decided to set up a civilian drone council (Conseil pour les drones civils, CDC) under the joint authority of the Ministry of Economy and the Ministry of

Ecology, Sustainable Development and Energy, and the development of civilian drones is included in the plans for a New Industrial France (NFI).

► **Key Recommendation 5.1:**
In order to help achieve a harmonised European set of regulations, the drone community should play an active role in the works of EASA, JARUS and other standardisation bodies, by rapidly preparing input documents.

► **Key Recommendation 5.2:**
A strong need exists for aerial work on linear infrastructures (up to several hundred kilometres) or very large sites. Based on experiments underway, priority should be given to establishing a harmonised European set of regulations allowing the routine use of drones at an altitude and a distance from the remote pilot that is compatible with needs expressed.

6 Feedback from experience

6.1 GENERAL PRINCIPLES

One of the main levers for improving safety is feedback from experience. It helps us to understand failures, learn from mistakes and detect precursors to malfunctions, helping prevent them.

It traditionally involves collecting and processing information on accidents and incidents, indeed on any event that, without constituting an actual incident, may hold elements useful for safety.

Aviation authorities thus first set up obligatory declaration systems (e.g. European regulation EU 996/2010 – soon to be modified by the provisions of regulation EU 376/2014); they then organise the corresponding information, supplementing it if necessary by voluntary reports going beyond the scope of obligatory declarations, before putting in place the tools necessary to act on these declarations. These tools include investigations carried out by civil aviation accident investigation bodies into the most serious accidents and incidents, as well as analyses of the whole set of data. The various stakeholders (manufacturers, operators, etc.) are also encouraged (or required) to organise their own internal system of collection and analysis.

Feedback from experience is especially critical for drones in that they represent a new, rapidly expanding category requiring a particularly strong regulatory base.

Such feedback processes are described in Appendix 2.

6.2 APPLICATION TO DRONES

Drone incidents may or may not be subject to the requirements of **incident** reporting, depending on the scenario. Incident reporting would clearly improve safety but the fact that specific drone regulations are often still in gestation or under development means that they are not usually subject to the general provisions mentioned above.

However, they may be subject to special measures. French regulations stipulate for instance that drone operators must declare to the authority “any event that could have jeopardised the safety of others” and must also set up “an operational incident tracking system”, making an annual report consisting of “a summary of the problems encountered within the framework of airworthiness monitoring”. It should be noted though that the feedback from experience system developed by the DGAC, containing confidential information about operators and manufacturing materials which cannot therefore be made public, was used to report only a few dozen incidents over a couple of years, and therefore does not seem to hold the solution.

6.3 HOW TO ORGANISE A SPECIFIC FEEDBACK SYSTEM FOR DRONES?

Feedback from experience initiatives must be based on the following principles:

- a feedback programme must rely on several complementary feedback channels rather than just one;
- according to the nature of the events or the information, those who wish to share their experience thus have the choice of using the channel that appears most relevant to them;
- to be attractive, the feedback channels envisaged must be adapted to the culture and practices of those who are to use them. These channels must be easily accessible and offer direct, intuitive input. The flexibility of use procured by the Internet is invaluable;
- to be accepted by operators and manufacturers, such processes must be user friendly and functional and it should be made clear that no action will be taken against those who volunteer information. Except in the case of serious accidents, anonymity should not be considered an obstacle. A good way to raise interest is to create a feedback loop by which all stakeholders have access to publications containing the key feedback received. Participants would be able to find their contribution there and the experiences listed could benefit all players;
- to be exploitable, the information collected must be relevant, i.e. it must help identify and understand failure modes leading to accidents. It is thus important to define from the outset the kind of accidents that need to be avoided as a priority (feared events) as well as the “barriers” that are intended to provide protection from these accidents;
- lastly, feedback from experience must cover human errors as well as technical failures and be designed accordingly, particularly with regard to human errors, which are always more difficult to elicit and yet essential for preventive purposes.

► **Recommendation 6.1:**
The "Fédération Professionnelle du Drone Civil" (French civilian drone federation – FPDC) should set up a **feedback from experience website** accessible to all professional users, along the lines of those existing in sports and aeronautical federations (FFA, FFAM,…), and should release regular safety information.

6.4 EXAMPLE OF INDEPENDENT CHANNEL FOR FEEDBACK FROM EXPERIENCE

On the site of the French Aeronautics Federation (FFA)[16], one finds this reference to feedback from experience:

"Feedback from experience aims to collect testimonies provided voluntarily by users that describe situations and events related to the use of an aircraft.

- Direct facts relating to an accident or incident are subject to special regulatory treatment and are therefore excluded.
- By detecting weaknesses and failures or by highlighting positive facts in this way, feedback from experience contributes to improving flight safety. The FFA guarantees anonymity.
- You can contact the team in charge of the feedback from experience at the following address, a pilot will call you back: contactrex@ff-aero.fr."

Examples

No	Flight date	Category	Title	Start of description	Detailed description
298	11/01/15	Vigilance	THE AP DOESN'T DO EVERYTHING	After leaving the aerodrome of Aix Les Milles bef...	Consult
297	20/02/15	Flight envelope	STATE OF THE RUNWAY	Training flight in sector then return to…	Consult
296	17/02/15	*Omission, Inattention, Forgetfulness*	REMINDER OF INSTRUCTIONS	At night-time on a busy airport, from the a...	Consult
295	31/01/15	Procedures	FAILURE OF LIGHT IN NIGHT FLIGHT	Failure of light in final phase of NVF instructional flight...	Consult
294	14/12/14	Procedure	ASSISTANCE DURING RADIO FAILURE	This flight took place with a pupil and a FE; flight …	Consult

16 www.ffa-aero.fr

APPENDIX 1: RISK ASSESSMENT

Risk assessment must be based on a qualitative and quantitative analysis according to a definition of the safety goals for the type of drone and mission under consideration.

a) Risk for persons on the ground

As indicated in the 3AF document distributed at the time of the AAE/3AF conference, various studies have been carried out into this aspect including those of EASA, JARUS and Eurocae, as well as the military authorities. In her presentation, Bernadette Veye dit Chareton put forward the following equation:

The number of deaths per flying hour (N) is equal to the lethal surface of the drone (S) multiplied by the density of the population overflown (De) and by the probability of a catastrophic event per flight hour (P):

$$N = S*De*P$$

A goal of 10^{-6} victims per flight hour is considered to be equivalent to the US statistics for military aircraft accidents. In this case, the goal to be reached for P is: probability of catastrophic event P = N/S/De:

Lethal surface	1 m^2	10 m^2	100 m^2
Density			
Stadium (1 person per m^2)	10^{-6}	10^{-7}	10^{-8}
Very busy street 1/10 m^2	10^{-5}	10^{-6}	10^{-7}
Park – beach 1/100 m^2	10^{-4}	10^{-5}	10^{-6}
Quiet street 1/1000 m^2	10^{-3}	10^{-4}	10^{-5}
Countryside – field 1/10000 m^2	10^{-2}	10^{-3}	10^{-4}

b) Risk of collision

To assess the risks of mid-air collision, it is necessary to factor in the structure of the traffic, its horizontal and vertical distribution. If this information is not available, an initial approach would be to consider that the aircraft is flying randomly but in a straight line. A model similar to the model for gases was put forward by Bob Machol (1979).

If N is the number of mobiles in in a volume of surface A and heigth FL, where Sh is the horizontal surface, Sv the vertical section and Vr the average absolute relative speed of the mobile, then the probability λ of collision per hour of flight is:

$$\lambda=N2*|Vr|*Sh*Sv/(A*FL)$$

Examples:

(1) N drones flying in a surface A of 100 m * 100 m = 10 000 m^2, below 50 m (FL=50)

$$Sh = 1\ m^2\ Sv= 0.2\ m^2\ Vr= 10\ m/s = 36\ km/h$$

$$\lambda = N2*1*0.2*10/500,000$$

For N=2, $\lambda = 1.6*10^{-5}$/s i.e. **0.0057 collision/h**

For N=10, $\lambda = 100*2/500,000 = 4*10^{-4}$/s i.e. **0.144 collision/h**

2) Drone and light aircraft (Cesna 172 = 11 m span, length 8 m, height 3 m)

Na planes and Nd drones in a volume of 1000 m * 1000 m = 106 m^2, below 150 m

$$Sah = 80\ m^2;\ Sav = 30\ m^2;$$

$$Vam = 180\ km/h\ \text{i.e.}\ 180,000/3,600 = 50\ m/s,\ Vr = 25\ m/s$$

$$\lambda = Nd*Na*(Vm/^2)*(Sah +Sdh)/2*(Sav+Sdv)/2/A/FL$$

For a drone/private plane pair Na=Nd=1

$$25 * (80+1)/2*(30+0,2)/2/106/150 = 0.5.10^{-4}/s$$

i.e. 0.18 collision/flight hour, but the plane remains less than 20 seconds in this volume, and during these 20 seconds the probability is then 10^{-3}.

This figure can be compared to collisions between light aircraft and birds. Although birds do see and seek to avoid aircraft.

This highlights the importance of:

- general aviation having access to information on the presence of drones;
- remote pilots of drones in visual line of sight (VLOS) watching carefully for the possible presence of aircraft in their manoeuvring volume;
- drones not being flown near aerodromes;
- Detect & Avoid devices being implemented in airspaces with uncontrolled planes.

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APPENDIX 2: SOME EXAMPLES OF FEEDBACK FROM EXPERIENCE IN CIVIL AIR TRANSPORT

General and recreational aviation

The “Recueil d’événements confidentiel” (confidential collection of events: REC) was created by BEA in 2000 in conjunction with the DGAC and general and leisure aviation users’ associations[17].This system offered all pilots, mechanics and controllers the possibility of drawing up a report on any unusual situation they had experienced, with no repercussions, and to send it to the REC by paper or email. On receiving this account, the REC agent would make contact by telephone with the author to obtain any additional information and to discuss the event with them. The report was then inserted into the REC database deleting all personal data or information enabling direct identification of the event. The original report was then returned to the author. The REC kept no copy of the report, thus ensuring full confidentiality for the author.

The REC database was then used to produce “REC Info”, a 4-page publication assembling several stories illustrating a particular safety theme. This leaflet was distributed free to flying clubs, flight schools, administrations, etc. and was intended to raise awareness within the aviation community as to specific issues.

Voluntary experience feedback systems like this provide lessons and interesting reflections on human error and individual and collective behaviour. It should be noted that the REC operating mode did not allow for the use of safety investigation techniques (at the heart of the BEA mission) such as: technical examinations, complementary research on data or testimonies. Because of this, reports often remained subjective. They did however provide, and continue to provide, precious teaching materials.

In autumn 2010, BEA set up a working group to define a successor to the REC system. This working group associated DGAC, IASA (International Aviation Safety Assessment) and CNFAS (French commission for aeronautical and sport federations).

The system chosen was baptised REX (Return on EXperience). It was organised by the principal federations and has been accessible on their websites since September 2011: FFA (French aeronautical federation); FFVV (French gliding federation);

17 www.bea.aero/fr/publications/rec-info/rec-rex.php

FFPLUM (French ULM federation); FFG (French rotorcraft federation); FFP (French parachuting federation); RSA (Air sports network).

Commercial civil aviation

Accident investigations carried out by investigation agencies are an important source of vital information, but the accent is placed on the processes that enable work on precursors, i.e. events with no consequences.

The example below presents the various channels set up in a number of airlines with their advantages, constraints and limitations.

Pilots' REX reports are sent directly by the Internet via tablet applications developed by airlines.

The Aviation Herald site (http://avherald.com/) also gives an idea of "live" incident analyses through a forum.

Experience Feedback Process

Type of feedback (sources), advantages, constraints and limitations.

ASR (Air Safety Report):

Written report dedicated to flight safety available to pilots to report any type of event relating to flight safety. The drafting of an ASR is often obligatory. Between 500 and 600 ASRs are written per month within Air France.

- Very broad coverage of events.
- Pre-set format shared with other companies and easy to exploit.
- Powerful data base used in real time and in networking.
- Simplicity of data exchange with the outside.
- Less information received when the crew's performance may be in question.
- Certain events, accident precursors on the scale of an airline carrying out nearly a thousand flights per day, are not perceived as such and are not reported.

Systematic flight data analysis (FDA).

All flight data is processed. A hundred anonymous communications are transmitted to crews per year.

- Objectivity of recorded data.
- Possibility of statistics.
- Good comprehension of events provided that the crew co-operates in the analysis (recorded flight data cannot alone explain the decisions and actions of crew members).
- Trust and co-operation of crews and also management.
- Quality of flight recorders (older generation aircraft have few parameters).
- Difficulties in the analysis of automation-related defects.

CSR (Cabin Safety Report)

The equivalent of ASR for events concerning the cabin and the perceptions of cabin attendants and passengers.

- Provides a useful, effective supplement to the ASR, facilitates event analysis and processing.
- Very useful for certain aspects concerning perceived safety (cabin crew and passengers).
- Without the ASR it is sometimes difficult to gauge the importance of the cabin events reported.
- Less information provided when the crew's performance may be in question.

Anonymous feedback (REX)

Spontaneous, optional, anonymous reports. Reports are permanently de-identified after contact with the author if the latter so desire. Between 150 and 200 reports per year.

- Enables collection of less visible aspects of certain events.
- Enables human errors to be analysed more effectively.
- Reinforces the links between prevention services and crews.
- Trust and co-operation of crews and also management.
- Subjectivity of reports.
- No exploitable statistics.

Surveys

Surveys can be carried out on all or part of a group of people.

- Good solution for "low visibility" events.
- Positive impact on prevention (crews engage by responding).
- Supplements analysis.
- Very limited number of surveys per year (maximum 3?).
- Low number of answers usually (15%) not a disadvantage.
- In general, impossible to get in touch with respondents.

Inter-airline feedback from experience

This goes on through working groups such as IRM (incident review meeting) during which volunteer airlines share their most significant incidents.

Working groups focusing on flight analysis also exist. Report analyses issued by accident investigation offices worldwide belong to this family of exploitable feedback from experience.

- Very effective for compiling serious events that are rare on the scale of a single airline.
- Direct access to the result of an analysis and the recommendations.

- Questions: Can this happen to us? What protections do we have? Are they in place? Are they effective? Can they be reinforced?
- Trust between airline and person in charge of accident prevention.
- Risk of negative media coverage is an important constraint for certain events.
- incidents and their analyses should be examined within the context of each different airline culture. The role played by these is difficult to assess.

External monitoring for flight safety

This consists of trawling recognised publications and websites to identify events that can be exploited within the airline. Such monitoring is structured by fields of risks. The processing goes on through simple publications and a case study type process.

- Very low cost.
- Large variety of scenarios.
- Processing on the basis of a “case study” with questions similar to the inter airline feedback: Can this happen to us? What protections do we have? Are they properly in place? Are they effective? How can they be reinforced?
- Not always reliable sources.
- Intellectual honesty is essential, reasoned answers to questions.
- Need for familiarisation with human factors in order to accept the “generic” aspect of certain types of errors and to take account of them in operations.

“Info Share” type forum in the US

A twice-yearly meeting over three days between the principal stakeholders to pool safety issues and organise a network dedicated to risk management.

- Players meet together and subjects are dealt with in a more crosscutting way.
- Promotes network contacts and exchanges on safety issues.
- Very high level of participation.
- Requires resources and good organisation.
- Requires a commitment to confidentiality on the part of all the participants.
- No report. Sharing of presentations possible with formal agreement from the authors.

GLOSSARY

3AF	Association aéronautique et astronautique de France, *French Aerospace Society*
AAE	*Académie de l'air et de l'espace, Air and Space Academy*
ADS-B	*Automatic Dependant Surveillance – Broadcast*
AESA	Agence européenne de la sécurité aérienne
AGL	*Above Ground Level*
ATC	*Air Traffic Control*
ATM	*Air Traffic Management*
ASD	*AeroSpace and Defence Industries Association of Europe*
BVLOS	*Beyond Visual Line of Sight*
CIEEMG	Commission interministérielle pour l'étude des exportations de matériel de guerre (trouve pas dans le texte)
CNIL	Commission nationale de l'informatique et des libertés, *French data protection authority*
CNS	Communication Navigation Surveillance
C2	*Command and Control*
D&A	*Detect and Avoid*, détecter et éviter
DGAC	Direction générale de l'aviation civile, *French civil aviation authority*
EAR	*Export Administration Regulations*
EASA	*European Aviation Safety Agency*
ENAC	École nationale de l'aviation civile
ETI	Entreprise de taille intermédiaire
EU	*European Union*
FAA	*Federal Aviation Administration*
FFA	Fédération française d'aviation
FPDC	Fédération professionnelle du drone civil
GNSS	*Global Navigation Satellite System*
ICAO	*International Civilian Aviation Organization*
IFR	*Instrument Flight Rules*
ITAR	*International Traffic in Arms Regulations*
JARUS	*Joint Authorities for Rulemaking on Unmanned Systems*
JU SESAR	*Joint Undertaking on Single European Sky ATM Research*
LATAS	*Low Altitude Tracking and Avoidance System*

LiDAR	*Light Detection And Ranging*
MTCR	*Missile Technology Control Regime*
NFI	Nouvelle France industrielle
NPA	*Notice Proposal for Approval*
NPRM	*Notice of Proposed RuleMaking*
NTSB	*National Transportation Safety Board*
OACI	Organisation de l'aviation civile internationale
PA	Pilote automatique
PME	Petite et moyenne entreprise
R/D	Recherche / développement, *Research and Development*
REX	Retour d'expérience
RPAS	*Remotely Piloted Aircraft System*
SME	*Small and medium enterprise*
TPE	Très petite entreprise
UAS	*Unmanned Aircraft System*
UE	Union européenne
VFR	*Visual Flight Rules*

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THE AIR AND SPACE ACADEMY (AAE)

Established in 1983 in Toulouse on the initiative of André Turcat, the aims of AAE (Air and Space Academy) are the following: "To encourage the development of high quality scientific, technical, cultural and human actions in the realms of Air and Space, promote knowledge in these areas and constitute a focal point for activities."

AAE's eminent membership is co-opted via an elaborate system of patronage and elections so as to promote high level reflection on vital issues. Embracing a broader European dimension in 2007, AAE integrated its European members as Fellows, thus guaranteeing a European and international focus to all of its studies. AAE members hold or have held important responsibilities in their fields and represent the many different facets of air and space activities: pilots, astronauts, scientists, engineers, doctors, industrialists, lawyers, journalists, writers and artists work together and constitute a valuable pool of knowledge.

Members are allocated to sections according to types of activity and interests:

I. Scientific knowledge of air and space

II. Applied science and technology of air and space

III. Human presence and activities in air and space

IV. Ethics, law, sociology and economy of air and space

V. History, literature and arts of air and space

Ad hoc commissions are set up in order to study specific, crosscutting topics. There are four permanent commissions, others exist only for the time required to deal with a particular issue.

On their own initiative, or at the request of an official body, the sections and commissions carry out multidisciplinary studies on essential issues, often leading to the organisation of various types of events (conferences, forums, lectures, training courses …) aimed at bringing together the relevant stakeholders and encouraging an exchange of ideas. Such meetings are also the opportunity to maintain constructive relations with international aerospace institutions and companies.

Following these events, AAE publishes proceedings which serve as a basis for the elaboration of recommendations published either in the form of "Opinions" or more in-depth "Dossiers". AAE publications are widely disseminated to key industrial and political stakeholders and are also available, along with a host of other resources including a regular Newsletter, on the AAE website.

Five sessions are held annually in French and other European cities with the aim of encouraging an exchange of ideas on key issues and taking collective decisions as to future actions. The final session of the year, a public plenary session, traditionally takes place in Toulouse Town Hall. At this plenary session in November, AAE awards prizes and medals aimed at giving international recognition to persons who have made some vital contribution to the fields of air and space.

AAE's partners include public and private organisations, educational establishments, companies, etc. Our partners are invited to all sessions, exhibitions, colloquia and other events and receive all our publications. Over and above the financial and material support they provide, our partners constitute an essential link with the realities of the aerospace world and thus contribute to enriching our reflections. In return, AAE has a duty to objectivity in its deliberations and uses the interface of its wide network of members and associated institutions to encourage suggestions from its partners as to future areas of study.

THE FRENCH AEROSPACE SOCIETY (3AF)

French aerospace society 3AF is a learned society with the following missions:

- to bring together persons and organisations involved in the sciences and technology of aeronautics and astronautics, whether professionally or out of a curiosity and enthusiasm for these areas;
- to distinguish those of its members who constitute topmost specialists on an international level;
- to promote networking between members of whatever speciality, particularly young people;
- to build up a major pool of specialised resources;
- to constitute a platform for members to promote their point of view and their work;
- to represent its members in all contacts with other French or foreign scientific and technical societies or aerospace federations.

3AF's activity is mainly related to industry and research and more specifically to the aeronautics, space and other hi-tech industries. 3AF also has close connections with French state bodies.

However, it offers a distinct approach to the development and diffusion of ideas: that of a learned society.

By providing such means of expression to its members - whether they are engineers, technicians, research scientists or students - 3AF helps promote their work, viewpoints, achievements or ambitions.

The Air and Space Academy (AAE) and the Association Aéronautique et Astronautique de France (French Aerospace Society, 3AF) endeavour to focus their attention and reflections on important issues linked to innovative development activities in air and space.

This is the context behind the conference organised by AAE and 3AF on "Present and future of civilian RPAS" on 13 and 14 November 2014 in the Paris DGAC auditorium.

This dossier not only takes into account the main lessons learned from the conference, but looks further, drawing on documents published in the meantime by the Federal Aviation Administration (FAA) and the European Commission. In particular, it contains recommendations on the European and French drone sectors, on drone design and realisation, including specific needs linked to development and experimentation, and on ensuring privacy and security with respect to illegal acts.

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