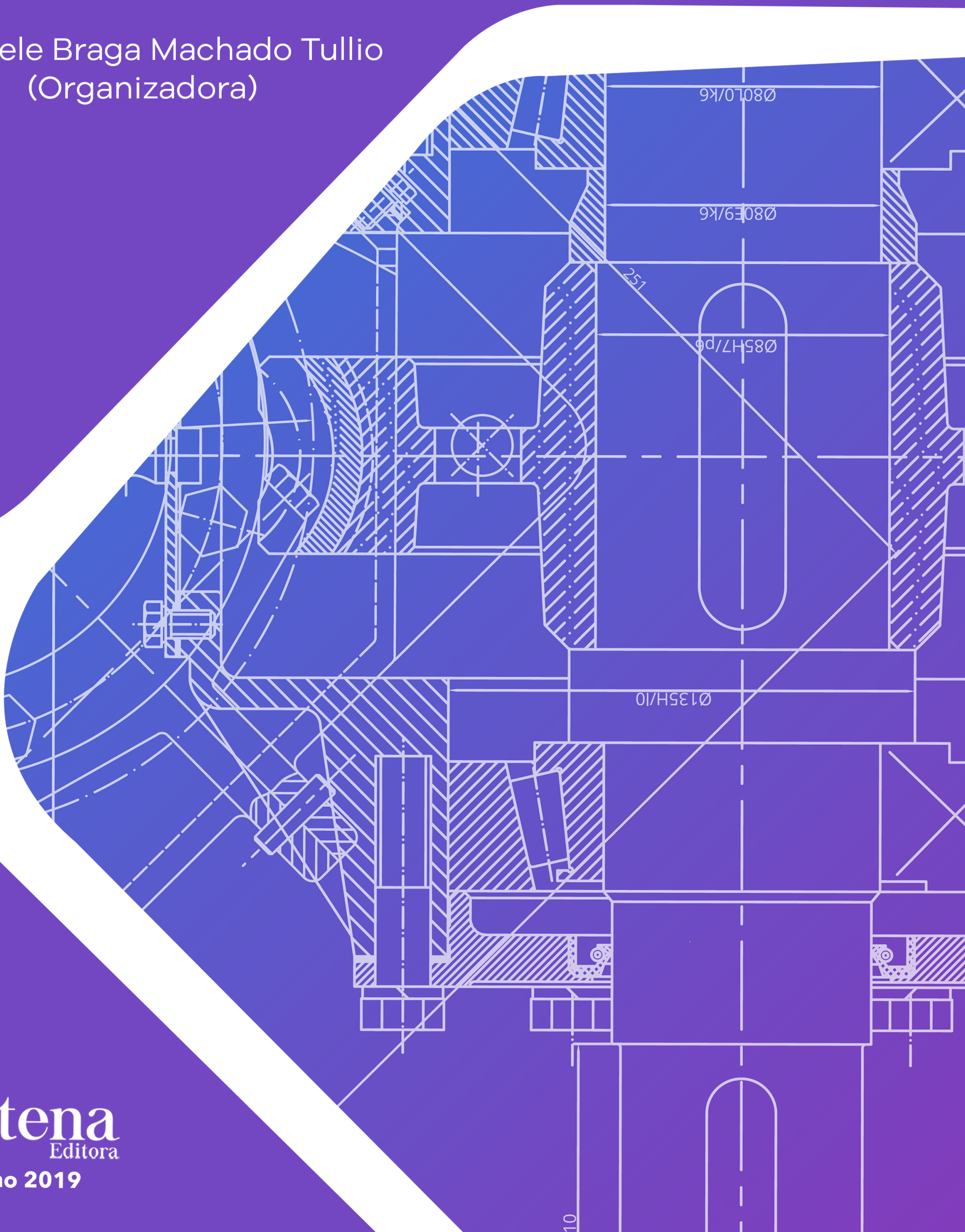
Pesquisa Científica e Inovação Tecnológica nas Engenharias 2

Franciele Braga Machado Tullio
(Organizadora)



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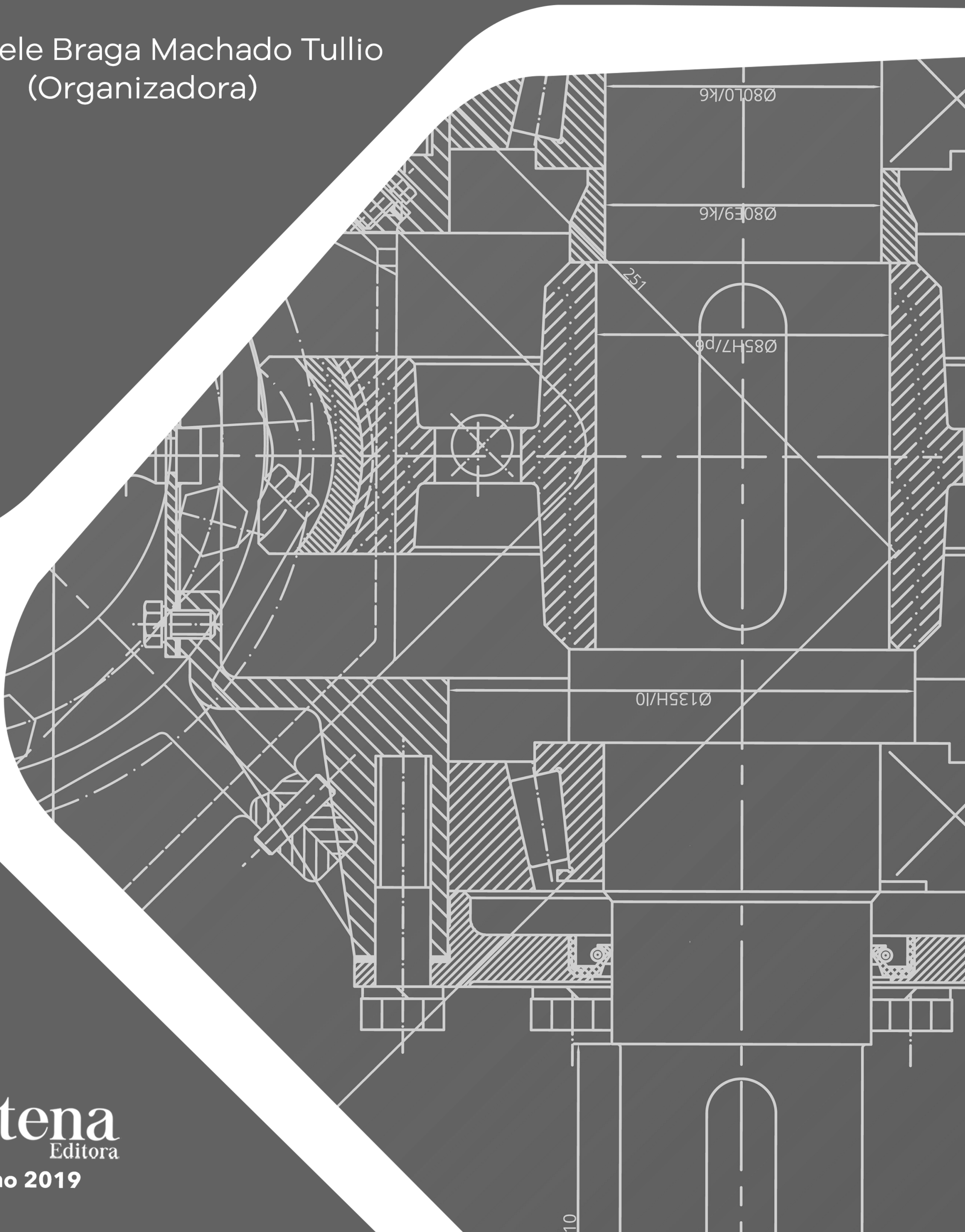

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APRESENTAÇÃO

A obra “Pesquisa Científica e Inovação Tecnológica nas Engenharias 2” contempla vinte e quatro capítulos em que os autores abordam pesquisas científicas e inovações tecnológicas aplicadas nas diversas áreas de engenharia.

Inovações tecnológicas são promovidas através dos resultados obtidos de pesquisas científicas, e visam permitir melhorias a sociedade através de seu uso nas engenharias.

A utilização racional de energia, consiste em utilizar de forma eficiente a energia para se obter determinado resultado. O estudo sobre novas fontes de energia, e o seu comportamento podem trazer benefícios ao meio ambiente e trazer progresso a diversos setores.

A aplicação de novas tecnologias pode permitir avanços em diversas áreas, como saúde, construção, meio ambiente, proporcionando melhorias na qualidade de vida de diversas comunidades.

Diante do exposto, almejamos que o leitor faça uso das pesquisas aqui apresentadas, permitindo uma reflexão sobre seu uso na promoção de desenvolvimento social e tecnológico.

Franciele Braga Machado Tullio

SUMÁRIO

CAPÍTULO 17

UNMANNED AIRCRAFT SYSTEMS AND AIRSPACE INTERFACES

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ABSTRACT: With the increasing global popularity of Unmanned Aerial Vehicles (UAV) for commercial, recreational and industrial purposes, millions of UAV are expected to be buzzing in the skies of the world's largest cities. A lower-cost, coupled with a growing demand for commercial services has led to an exponential growth of these vehicles. With air spaces and large urban centres already very congested, and limited, there is a concern to establish specific procedures, demarcated areas, corridors, and the need for an air traffic management system to allow UAVs to fly safely becomes more and more urgent. The purpose of this paper is to provide a broad and simplified understanding of the topic for the broader community that makes up the academic sector. It will have even more special meaning for transport researchers. Bringing the conceptual solutions already presented by experts for the future integration of so-called Unmanned Aircraft Systems (UAS) in unregulated airspace, it also offers studies on ways to manage UAS-specific airspace in segregated and their integration with segregated airspace. This work has practical, scientific, methodological, social and personal relevance. In practice, the results of this work could clarify the members of the Sector and even support decision making. Scientifically, it may also provide support for future academic research in the area.

KEYWORDS: Unmanned Aircraft System (UAS), UAS Traffic Management (UTM), Air Traffic Management (ATM), Airspace.

SISTEMAS DE AERONAVES NÃO-CONTROLADAS E INTERFACES DO ESPAÇO AÉREO

1 I INTRODUCTION

Since the completion of the work of the Special Committee on Future Air Navigation

Systems (FANS) in October 1993, the International Civil Aviation Organization (ICAO) has made significant progress in the development of material necessary for the planning, implementation, and operation of the Communications, Navigation and Surveillance/Air Traffic Management (CNS/ATM). ICAO Document 9750, which has been receiving scheduled and systematic implementation deadlines since then, establishes a Global Air Navigation Plan from 2016 to 2030 (ICAO, 2016).

This document, from the leading world civil aviation body, determines all procedures to be adopted regarding air traffic services by member countries. To meet the requirements of this publication, the ICAO signatories elaborated their respective strategic projects. Just to name a few, the NextGen (USA's Next Generation Air Transportation System), the European Community's Single European Sky Air Traffic Management Program (SESAR), Japan's CARATS (Collaborative Actions for Renovation of Air Traffic Systems) and SIRIUS from Brazil. Regarding air traffic, and following airport operations, aviation's direction has been and will be short, entirely directed by these projects.

However, new challenges have grown, both in importance and quantity, in the ATM environment. One of the most significant challenges facing the airline sector today result from new systems in the airspace and refer to as Unmanned Aircraft Systems (UAS). Many useful civilian applications of UAS have been proposed such as commodity delivery, infrastructure surveillance, search and rescue, agricultural monitoring and various other uses. Currently, there is no established infrastructure to safely enable and manage the widespread use of airspace operations for low altitude UAS. These UAS operations will increasingly interact with some existing users, such as general aviation, helicopters, gliders, balloons, and even paratroopers. However, the safety of these operations should not be undermined by the introduction of new UAS operations (Belcastro et al., 2017).

There is a great deal of concern, especially in the substantial and diversified environment formed by the airline sector, regarding the current recommendations from the International Civil Aviation Organization (ICAO). What interferences can UAS cause in non-segregated airspaces?

This work is based on research nowadays conducted by academics and industry organisations and is advocated by the ICAO documents dealing with Future Air Navigation Systems (FANS). This new type of air traffic, although initially directed to segregated airspace, due to the diversity of uses that it has obtained, begins to have increasing needs to incorporate into non-segregated airspaces.

The Air Sector is made up of professionals from various backgrounds and fields. Many of the topics they deal with do so superficially because they are unaware of the subjects. In the case of UASs, and the airspace where they will evolve, it is essential for these professionals clearly to know the meaning of this type of aircraft and which airspace they can and should occupy. Of course, all air activities very shortly will have any interface with these unmanned or manned vehicles and the systems in place to ensure their operation. Thus, this scientific article seeks to bring in its content, in a compact form, a summary of what professionals in the sector need to know about this subject.

2 I LITERATURE REVIEW

2.1 UAS, UTM and RPAS

The designation UAS (Unmanned Aircraft System) refers to systems involving the movement of any air vehicle where there is no human operator on board. Such systems are composed of aircraft, ground support, air and communications infrastructure. The Remotely Piloted Aircraft System (RPAS) is a subcategory of this family. All those are UAS that have a human operator (or Remote Pilot - RP), which operates from a remote position (RPS) and constant control of the vehicle. This aircraft, called a Remotely Pilot Aircraft (RPA), was considered by ICAO as an aircraft, so it must comply with the rules set out in Annex 2 (ICAO, 2005), like any other aircraft. The term "system" refers typically to the complex nature of RPAS, where several components need to be coordinated, such as the command and control link between RP and RPA (Cordón et al., 2014).

Remotely controlled aircraft systems (RPAS) are a new component of the aviation system, which the International Civil Aviation Organization (ICAO), States and industry are working hard to understand, define and ultimately adapt to and integrate. Such systems have been developed by advanced knowledge specialists, especially in the area of aerospace technologies, thus offering many advances that can allow continuous improvement regarding aviation safety and efficiency. Integrating RPAS into non-segregated airspace is a long-term activity that can positively involve many stakeholders, and so add knowledge on a variety of topics such as:

a) Licensing and medical qualification of remote pilots;

b) Technologies to detect and avoid systems; frequency spectrum (including protection against unintentional or unlawful interference);

c) Separation patterns of other aircraft; and

d) Development of a robust regulatory framework.

As knowledge increases the challenges, the problem-solving become to be more complicated. Removing the pilot from the aircraft raises crucial technical and operational issues, the extent of which is being actively studied by the aviation community. To the extent that States and the aerospace industry are making progress in contributing to ICAO, they expect that information and data on the RPAS will begin to move forward rapidly.

Sustaining routine worldwide RPAS operations in a secure, harmonised and seamless manner comparable to manned activities is the primary objective and challenge of ICAO in addressing the RPAS issue. The Organization shall provide an international regulatory framework through Standards and Recommended Practices (SARPs), with support procedures for Air Navigation Services (PANS) and guidance materials. Above all, the introduction of RPAS in non-segregated airspace and aerodromes should in no way increase safety risks for manned aircraft (ICAO, 2015).

According to Kopardekar et al. (2016), when addressing the UAS increased demand for low-altitude, we should, through historical aviation experiences, have a systematic and organised concern, to ensure that these operations have both efficiency and safety. It is also necessary that we have systems installed to deal with high densities and a diverse mix of aircraft. Nowadays, gliders, general aviation, and helicopters operate in the uncontrolled low-altitude airspace. Thus, it becomes critical to accommodate new operators, safely, along with pre-existing users and in full operation. Many commercial UAS applications can operate within the visual line of sight (VLOS), such as cell phone tower inspection. However, many business UAS operators would like to fly their missions beyond the visual line of sight (BVLOS). So, they would have more significant economic gains, for example (Figure 1):

a) Pipeline inspection;

b) Electrical infrastructure; and

c) Deliveries.

Fig. 1. Examples of UAV operation in urban and non-urban areas.

Unmanned Aircraft System (UAS) Traffic Management (UTM). Source: NASA, 2018.

To be able to accommodate all equipped operations (VLOS and BLVOS) safely UAS in low-altitude airspace, systematic and growing studies are needed to contemplate future diversity. NASA, envisioning this potential future, and based on decades of research and experience in air traffic management research and development, has already begun an investigation on UAS Traffic Management (UTM).

According to NASA's website (2018), many civilian and population-facilitating applications have been brought in by UAS. In the future, we should need to deploy UTM for low altitude airspace. There, many variables can be considered; perhaps it is even possible to leverage existing concepts of vehicle separation. Such as the road system, lanes, stop signs, rules, and lights that are now adopted for vehicle traffic on the ground. Thus, NASA is researching prototype technologies for a UTM system to enable safe and efficient low-altitude operations and further develop airspace integration requirements. For this, it has a great legacy of work in air traffic management for manned aircraft.

2.2 Methodologies

To facilitate the understanding, the methodology of Case Study, more precisely a Multiple Case Study, was adopted for the preparation of the article, which will allow us to present some analysis and solutions already performed at the international level.

However, to illustrate the article, it is interesting to highlight one of the most applicable methodologies in studies and implementation of processes such as the one studied. The characteristics of the Aviation Sector and, more particularly, of air traffic control services, always recommend collaborative actions. And the Collaborative Decision-Making (CDM), now widely adopted by ICAO, is a recommended process to be applied by managers and stakeholders in this process.

2.2.1 Multiple Case Study

- **Use of case-study type research:**

For Yin (2010), the use of a case study as a research method in various situations has the purpose of bringing to the knowledge individual, group, organisational, social, political and related phenomena. The differentiated need for case studies arises from the desire to understand complex social aspects as it allows researchers to retain the holistic and meaningful characteristics of real-life events. The case study is preferred when:

a) The type of research question is of the form "how" and "why";

b) When the control that the researcher has about the events is very reduced; or

c) When the temporal focus is on contemporary aspects and within the context of real life.

- **Multiple case study:**

According to Yin (2010), case studies can cover multiple cases and then draw a unique set of cross-case solutions. The same author considers that in some areas, multiple case studies have been considered a different "methodology" than single case studies. It presents the advantages and disadvantages of the single case study:

a) As a positive fact believes that the evidence of the multiple case study is often found more vigorous, being then the study seen as more robust; and

b) As for disadvantages observes that the multiple case study cannot use for analyses that deal with critical, unusual, rare and revealing cases, typical of being studied as single cases and the fact that it may require more resources and time that the unique situation.

It also indicates, within the multiple case study, the use of case replication logic, citing that cases should be carefully selected, so that they can: predicting similar results (a literal replication); or produce contradictory results, but for predictable reasons (a theoretical replication).

2.2.2 Collaborative Decision-Making (CDM)

Whenever people involved in any decision-making process need to choose between alternative actions, as Stakeholders involved in collaborative decision-making processes, they should keep in mind that often the alternatives supporting the information presented are inadequate to defend or explain the recommended actions. Thus, the priority in making a decision is to establish the identification of decision-makers and stakeholders in the process; such action may reduce a possible disagreement on definition, requirements, goals, and criteria of the problem (Baker et al., 2001).

According to ICAO documentation (DOC 9971) dealing with the subject (ICAO, 2014), collaborative decision making (CDM) defines a process focused on how to decide on a course of action articulated between two or more community members. Through this process, members of the ATM community share information related to that decision, interact, establish everyday choices and apply the approach and principles of decision making. The overall purpose of the process is to improve the performance of the ATM system while balancing the needs of individual members of the ATM community.

CDM Features:

a) The CDM is a support process always applied to other activities, such as demand/capacity balancing, and can be used throughout the timeline of strategic planning activities (for example, infrastructure investments) to operations in real-time;

b) CDM is not a goal leading but a way to achieve the performance objectives of the processes it supports. These performance objectives are expected to be agreed upon collaboratively;

c) While sharing information is an essential element for the CDM, such sharing is not sufficient to fully realise the CDM and achieve its objectives;

d) To ensure that collaborative decisions are made expeditiously and equitably, the CDM also requires pre-defined and agreed on procedures and rules;

e) The CDM ensures that decisions are made transparently by the best available information, as provided by the participants at the right time and in a precise manner;

f) The development and operation of a CDM process follow some typical phases:

- Identification of the need to carry out a CDM;
- CDM analysis;
- CDM specification and verification;
- The case of CDM performance;
- Implementation and validation of the CDM; and
- The operation, maintenance and improvement of CDM (continuous).

Thus, CDM is one of the adequate processes for the studies, decision-making processes and implementation of the factors necessary for the operation of these new members of the Air Sector. In fact, such a sector is a systematic use of this process.

3 I UNMANNED OPERATIONS

Several countries have advanced studies regarding the operation of UAV. We will present here: the vision of the international civil aviation regulator (ICAO); from SESAR, which define, develops and deploys solutions to modernising air traffic management in Europe; and from FAA, sharing with NASA an advanced stage of development in UAS / UTM research.

3.1 ICAO Overview

As one of the actions taken by ICAO to discipline unmanned aircraft operations, as well as to concentrate some documents already dispatched, in the year 2015 was published the Document 10019 - AN/507, Manual on Remotely Piloted Aircraft Systems (RPAS) (ICAO, 2015). Manual highlighted remotely piloted aircraft are a type of unmanned aircraft. All unmanned, remotely piloted, fully autonomous or combination aircraft are subject to the provisions of Article 8 of the Convention on International Civil Aviation (Doc 7300), signed in Chicago on December 7, 1944, and amended by the ICAO Assembly. Inside we can see the same standards that a lot of years ago:

- The development of the legal framework for international civil aviation began with the Paris Convention of 13 October 1919, and subsequently, the Protocol of 15 June 1929 amending the Paris Convention refers to aircraft without a pilot in a paragraph of "Article 15" as follows:
    - *"No aircraft of a Contracting State capable of being taken without a pilot shall, except by special authorisation, fly without a pilot over the territory of another Contracting State."*
- The Chicago Convention of December 7, 1944, replaced the Paris Convention, "Article 8" of the Chicago Convention entitled "Non-Pilot Aircraft" provides that:
    - *"No aircraft capable of flying without a pilot shall be taken without a pilot over the territory of a Contracting State without the special permission of that State and by the terms of such authorisation. Each Contracting State undertakes to ensure that the flight of such aircraft without a pilot in areas open to civilian aircraft must be controlled in such a way as to avoid danger to civil aircraft".*

Also, according to the Convention (Article 12), the Command Pilot is responsible for the operation of the aircraft by air rules, as well as for the authority over the aircraft while in command. This responsibility is real for a pilot on board or even flying remotely.

Currently, for evolution in non-segregated airspace, ICAO has specific procedures only for remotely piloted aircraft (RPAS). Such methods are very similar to those adopted by conventional aircraft with pilots on board. Some restrictions apply in order always to preserve the safety of other traffic and aviation, where aviation operates in general (ICAO, 2015).

Regarding the evolution of other UAS, mainly in segregated airspace, ICAO has been conducting studies, gathering working groups and organising seminars on the subject, such as the Second Global Remotely Piloted Aircraft Systems Symposium (RPAS 2017) held from September 19 to 21, 2017 at the headquarters in Montréal, Canada.

But ICAO's most significant challenge lies in UAS Traffic Management (UTM) that, undoubtedly, will be one of the most vital subjects for the Air Sector in the coming years. In the last seminars, UTM issue has been treated as a fact and with a demand that grows exponentially. There is a glimpse of a future in which this small equipment, which, today under 25 kg and flying in air spaces that do not exceed 400 ft, will have increased participation in the regular life of the cities. In this way, we need to have specific rules for pilotage, self-separation and, above all, the creation of particular airspaces, corridors, forms of separation, etc. Many systems are already being developed by software companies, especially those already working with air traffic management systems. The specificity of this airspace needs to have an exact geographic database and lies in the fundamental premise that all the so-called UAVs are equipped with anti-collision systems. Such facts are already present in all the works that are currently being developed.

3.2 SESAR Overview

In Europe, SESAR JU works the UAS / RPAS operation. According to "Demonstrating RPAS integration in the European" (SESAR JU, 2016), SESAR is the technological pillar of the Single European Sky, which defines, develops and deploys solutions to modernising air traffic management in Europe.

The SESAR JU also works closely with staff associations, regulators and airport operators. According to SESAR JU, UAS is an acronym for Unmanned Aerial Systems (SESAR Joint Undertaking, 2016), where the Unmanned Aerial Vehicle (UAV) is the airborne component. There are two more fundamental airborne components:

a) Remotely piloted aircraft systems (RPAS), a class of UAS which has a pilot operating the remotely piloted aircraft (RPA) from a ground-control station (GCS); and

b) UAS with no remote pilot, or autonomous air vehicles. The term ‘drone’, substantially a nonprofessional's name, refers to all types of UAS.

3.2.1 RPAS

The European ATM Master Plan (SESAR JU, 2015) considers that emerging technology RPAS, formerly operated primarily by military organisations, is increasingly used today by private means in non-commercial, or even commercial operations and, In government (non-military) operations. This technological advance will be a great driver of industrial competitiveness, in addition to promoting entrepreneurship and creating new businesses.

The RPAS, by themselves, are already multiple systems and composed of a great diversity of equipment. To supply the manufacturers of RPAs there is also a wide range of enabling technologies such as telemetry, energy, communication, etc. Research and development of the UAVs industry, aiming to operationalize its operations, will have a significant impact on manned aviation, positively influencing actors such as environmental impacts, safety, and efficiency of air operations. The

Master Plan also reinforces alignment with ICAO principles, whose fundamental belief is that the RPAS should be treated similarly to manned aircraft, with due regard to the operating recommendations for remote crews. They must comply with aviation regulations and recommended levels of safety, and should not affect current airspace user operations when integrating with ATM systems.

Thus, the behaviour of the remote crew must be equivalent to manned aviation, meeting the requirements of the Air Traffic Control Bodies that apply to the class of airspace where they are operating. Accompanying all the evolution of operational concepts, gradually implemented by SESAR, the RPAS shall be designed, constructed, operated and maintained in such a way that the risk to persons in the ground and, as well as to other users of the airspace, remains within regulatory standards. The European Commission is working on this primary objective, as well as on developing a robust regulatory framework to allow UAVs to operate in the European Union scenario.

In the document Demonstrating RPAS integration in the European aviation system (SESAR JU, 2016), a promising new chapter in aviation history is being opened, since these types of equipment can fly close to the ground and obstacles. The unmanned systems can work in all kinds of dangerous conditions, which would be hazardous to traditional aviation. It is estimated that by 2050 there will be around 7 million RPAS for the leisure of the population in operation throughout Europe and a fleet of 400,000 RPAS that would offer essential services throughout the agricultural sector, energy, e-commerce and public sectors.

According to the "UAS Roadmap" that is part of the SESAR Master Plan (SESAR JU, 2015), the UAV market will represent EUR 10 billion annually by 2035 and, over EUR 15 billion annually by 2050. This market will have enormous potential for Europe and its global competitiveness.

Aiming to evolve in the concepts and operability of the RPAS, in 2013, SESAR JU launched nine SESAR demonstration projects to see how the RPAS could be operated safely within unsegregated airspace using existing technologies. To explore the integration of RPAS into real operational environments and identify possible operational, technological and regulatory gaps over two years, operators, manufacturers, ANSPs and regulatory authorities worked on this project. Its primary purpose was to analyse the level of RPAS operations possible, using current technology, within the current regulatory and operational environment. These demonstrations were intended to signal areas that needed additional research and development. In general, compared to small general aviation aircraft, operating in an air traffic control (ATC) environment was not perceived significant in RPAS behaviour. However, positively, several technical, operational and safety and security issues were identified. These are subjects that must be intensely worked out before full integration:

a) Definition of a harmonised and well-established civil regulatory and certification system by the required certification authorities;

b) Implementation of policies and procedures on how the ATC should interact with the RPAS to ensure efficient operations and meet security level requirements;

c) Detection and evasion (D & A) capability by European aircraft qualification requirements;

d) Reliable command and control links must be developed in conjunction with contingency procedures in case of failure and implemented in a protected spectrum range; and

e) Specific training and licensing for RPAS pilots.

The RPAS is changing the landscape of aviation, and this change is happening at a speed and scale we have never seen before. This market has the potential to generate significant and far-reaching value for Europe. Thus SESAR is concerned with producing specific solutions for collision avoidance RPAS, surface management and integration with IFR traffic and the safe and secure integration of RPAS alongside existing conventional aircraft.

3.2.2 UAS

As for the use of other UAS in unmanaged or low-altitude airspace and urban areas, through the document Blue Print U-space (SESAR JU, 2017), SESAR presents the vision of the European Union on the subject. This document qualifies this airspace as U-space and considers that:

a) It allows complex operations of high-level automation UAVs to occur in all types of operating environments, including urban areas;

b) It must be flexible enough to encourage innovation and support the development of new enterprises;

c) It will facilitate the overall growth of the European UAVs services market;

d) It contributes to ensuring that the privacy of citizens is respected;

e) It will allow a better approach to issues related to safety and security (including cyber-security) and resilience (including failure mode management); and

f) It facilitates processes to minimise environmental impacts.

They present a holistic view of U-space, as a set of new services and specific procedures, which are designed to support safe, efficient and secure access to airspace for a large number of UAVs. Such services would primarily depend on a high automation level of functions, both in the terrestrial environment and onboard the

UAV itself. Thus, this U-space would have an integrated structure to support routine operations and should have an appropriate interface to interact with the ATM systems when necessary.

It is evident that U-space, although it is a great organiser and facilitator for UAV flights at low altitude and in urban airspaces, which should represent the vast majority of its occupation, is not considered as a fixed volume of space air, exclusive, segregated and destined for the private use of such vehicles.

3.3 FAA Overview

The Association of Unmanned Vehicle Systems International (AUVSI), has published a report, The Economic Impact of Unmanned Aircraft Systems (AUVSI, 2013), which shows the economic benefits attached to UAS integration in the United States. The work shows the expectancy to have enormous economic and job creation impacts. These impacts have been demonstrated to be due to direct, indirect and induced effects of total spending in UAS development. The AUSVI forecast for the period 2015-2025 is as follows:

a) UAS integration is expected to contribute US$ 82.1 billion to the nation's economy by agriculture, public safety, and other activities;

b) 103,776 new jobs will be created, with 844,741 job years worked over the period;

c) UAS integration is expected to contribute US$ 75.6 billion to the economy.

Aiming to address the systematic challenges facing the National Airspace System (NAS), the Federal Aviation Administration (FAA) and the National Aeronautics and Space Administration (NASA) share a long history of collaboration. Add to that the knowledge and experience of managing the FAA's air transport network to NASA's advanced research, analysis and development capabilities. Federal Aviation Administration (FAA) and National Aeronautics and Space Administration (NASA), given the complex nature of the challenges, both organisations have developed processes and structured documents to move forward together efficiently. This fact is now being repeated with the creation of Research Transition Teams aiming to deepen in UAS / UTM studies (FAA, 2016).

In presenting the UTM Concept of Operations (CONOPS) from the NASA / FAA workgroup, Kopardekar et al. (2016) report that with the growth of UAS operations, the tendency beginning to access areas that were initially used only by general aviation aircraft, helicopters, gliders, balloons, and paratroopers. The introduction of the new UAS operations cannot reduce the safety of these already existing traditional operations. Moreover, there are some difficulties developing a CONOPS to accommodate a broad mix of UAS. The initial focus of NASA's research was the development of a concept of operations that defines how these operations could be safely accommodated in the low-altitude airspace. Today, uncontrolled airspace (technically known as Class G airspace) is regulated, but it is not controlled, that is, air traffic services are not provided to anyone flying in that portion of the airspace. Thus, this lack of requirements, procedures, and support functions for evolution in these airspaces is the most significant obstacle for UAS operations to occur on a large scale.

There are some differences between manned aviation and UAS operations (Table 1):

a) There is no pilot onboard UAS who may detect and avoid other vehicles;

b) There is a wide range of performance characteristics, which are new and still unknown in UAS;

c) UAS often do not have a load capacity capable of carrying heavy or energy-intensive equipment;

d) The requirements for UAS and separation standards are very different from those required for the operation of traditional aircraft. The most significant risk is to the people and assets on the ground and manned aviation, unlike civil manned aviation UAS may fly very close to each other under certain circumstances. Because of their different performance characteristics, like their susceptibility to wind due to low mass, UAS operations have additional information needs to safely operate in environments that are rarely used by traditional aviation; and

e) The density of activities in the airspace could easily be several orders of magnitude higher than in manned operations.

MANNED	UNMANNED
Pilot on board	No pilot on board
Known performance characteristics	A wide range of performance characteristics of new and yet unknown
Generally, have carrying capacity and energy-intensive equipment	Generally, they have no massive carrying capacity and energy-intensive equipment
Requirements and separation acccording ICAO standards	Requirements and separation standards are very different from those required for the operation of traditional aircraft
The density of operations according to ICAO standards	The density of operations in the airspace could easily be several orders of magnitude higher than in manned operations

Table 1. Operational differences between manned and UAV. Source: Kopardekar et al., 2016.

4 I CONCLUSION

With the increasing global popularity of UAV for commercial, recreational and industrial purposes, millions of UAV are expected to be buzzing in the skies of the world's largest cities. A lower-cost, coupled with the growing demand for commercial services has led to the exponential growth of these vehicles. With air spaces and large urban centres already very congested, and limited, there is a concern to establish specific procedures, demarcated areas, corridors, and the need for an air traffic management system to allow UAVs to fly safely becomes more and more urgent.

Many UTM projects on the development, of management systems, based on pre-established road-like low-altitude air routes, are including the possible use of stop signs at convergences. The Nanyang Technological University (NTU) of Singapore, are studying ways to allow hundreds of UAV to fly efficiently and safely simultaneously. The aim is to develop a traffic management system for UAV consisting of designated air-lanes and blocks, similar to how cars on the roads have traffic lights and lanes.

Advanced technologies that will be developed include smart and safe routing, detect-and-avoid systems, and traffic management to coordinate air traffic. It is evident what the UAVs' paths in urban centres should be (Fig 2, green line), even with stop signs (Figure 2, interrupted red line mixed with a green line). The airspace marked with lilac (Figure 2) represents the areas where demarcated geographical fences are established and, in an automated way, will prevent the entrance of the UAVs. These cannot be flown unless expressly authorised, such as military installations, prisons, flammable product industries, power distribution lines, etc.

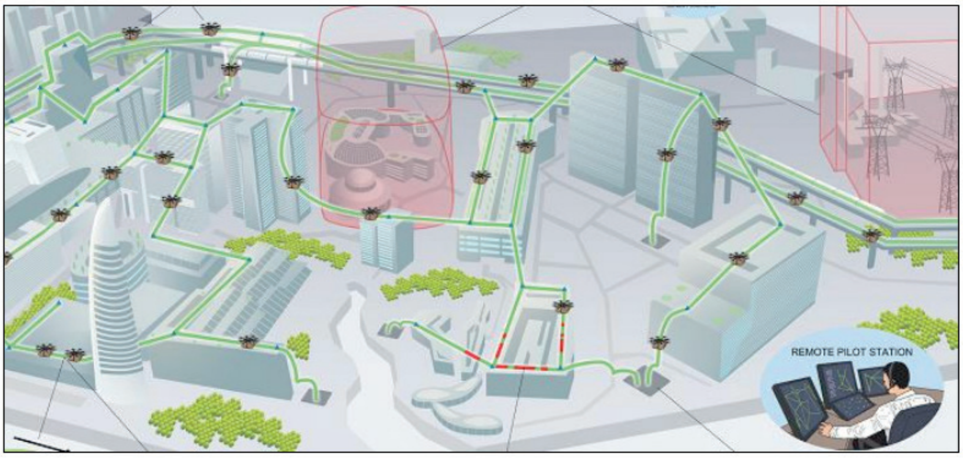

Fig. 2. Nanyang Technological University, Singapore (NTU Singapore).

Traffic Management of Unmanned Aircraft Systems solution. Source: NTU, 2017.

The advanced technologies that will be developed include intelligent and safe routing, detection and evasion systems, and traffic management to coordinate air traffic. Within this technological package, safety systems such as geographic fences to determine areas where flights are prohibited as well as efficient collision avoidance systems between the UAV are indispensable. All these improvements require a perfect security system to prevent cyber-attacks, which, given the high demand envisaged, would cause urban and air chaos should it occur.

Several other countries, in addition to the USA and those of the European Union, are pursuing studies to establish safe and efficient procedures for the operation of UAS, as well as some associations, have also created, which bring together regulators, industry, academics, and finally several industry stakeholders.

The Global UTM Association through the document UAS Traffic Management Architecture (High-Level Architecture Document) considers that the UTM Concept is a complex system in which several stakeholders contribute to guarantee the level of security required of UAS operations. Therefore, it defines UTM as being a system composed of interested parties which interact collaboratively with technical systems. They must comply with existing regulations to maintain safe separation with other unmanned aircraft and users of ATM systems, when necessary, in addition to providing an efficient and orderly flow of traffic. It is a technical implementation, which includes software, the infrastructure required for the execution of the software and operation of the UAVs themselves. It is possible to provide distinguished services that may be through public or restricted interfaces. The UTM concept is comprehensive as it considers all types of UAS operations in the very low-level airspace, from simple remotely piloted aircraft systems (RPAS) to complex autonomous operations (UTMA, 2017).

The full potential of RPAS is an integral part of the aviation system. It requires the elaboration of adequate regulations, to maintain the highest possible and uniform the level of safety. There is a definite need for close coordination between R & D activities and the regulatory framework, which will allow newly validated technologies to be translated into legal instruments, industry standards, and what is indispensable, the development of transparent and didactic guidance material. Integrating RPAS into all types of airspace will undoubtedly occur gradually (Figure 3).

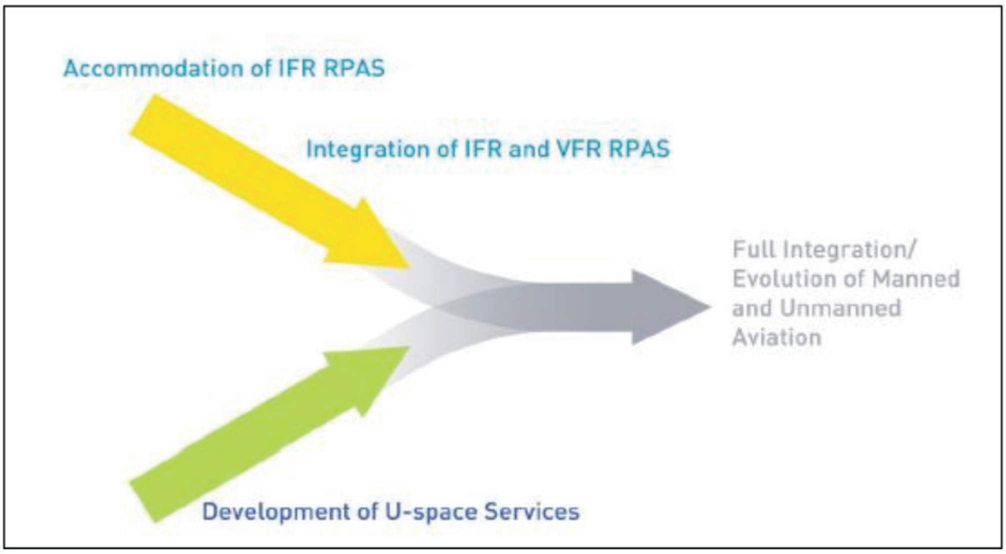

Fig. 3. Full integration between manned and Unmanned Aviation.

Source: SESAR JU, 2016.

This integration will evolve with the support of technology and regulation, more so with the progress of social acceptance. Not yet mature and adequately standardised are all the critical technologies needed to support RPAS flights in non-segregated airspace. We need to focus today on the research regarding aspects of detection and prevention of collisions, as well as on the performance of command and control systems - a priority for achieving integration with the IFR operations of the RPAS in controlled airspace (SESAR JU, 2015).

5 I FINAL REMARKS

There are many different ways to characterise the various operating environments. To discuss the UTM CONOPS scope, we are distinguishing the operational environment, especially about interactions with controlled aircraft. In this respect, we can see that there are at least three different operating environments within the airspace system:

a) UAS operations **within uncontrolled airspace**: in this environment, no interaction with controlled air traffic shall occur with UAS operations outside controlled airspace operations. However, UAS shares airspace with other users, such as general aviation aircraft, helicopters, gliders, balloons, and parachutists;

b) UAS operations **within controlled airspace**, but separate from controlled air traffic. As there is a need for UAS to operate close to airports and within controlled airspace, segregated areas may be created within controlled airspace that may be made available for UAS operations. These may be transitional tunnels or airspace blocks made available depending on the particular current configurations of each airport and airspace, obeying the criteria related to controlled airspace operations;

c) UAS operations integrated **into controlled air traffic flows**. When UAS is into controlled air traffic flows, they must behave precisely like traditional aviation and meet all currently established requirements for operations in controlled airspace classes. The requirements for this type of UAS integration have been developed over the last few years and are listed in the respective documents.

By the current scenario, it is clear that the advent of the so-called UAVs is something irreversible and that its use will grow exponentially. It is of high public interest, as it is urban equipment that provides social well-being. It is a new means of transporting cargo and also passengers. The diversity of uses that grows over time make it a significant discovery regarding transportation in general in recent decades.

With the growth that has taken place, it is urgent to develop the necessary means to support and protect these air vehicles. Both the RPAS and the aircraft that evolve in all types of airspace and, what is a new fact and much relevant, protection of the population and vehicles in the ground, considering the low altitudes that they evolve.

We have seen that the regulation for the evolution of RPAS in controlled airspace is already at a high level of development under the leadership of ICAO. Nowadays, the most significant challenge is the implementation of a system for the organisation and control of spaces where small and medium-sized UAV are evolving in areas below 400 ft.

It is fundamental for those who are part of the airline sector to have an understanding of what is happening today with this segment and the actions that are beginning to give support for its organisation and control.

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