Regulatory framework on the UAM operational concepts of the ASSURED-UAM project

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Abstract

Purpose – The purpose of this paper is to study the overall framework in which the Urban Air Mobility (UAM) deployment is expected to be implemented. Another aim of the study is to give a better overview on the current regulations and standards including the impact of the regulations on the industry, operations and cities.

Design/methodology/approach – This paper performs a literature review on the regulatory framework, which provides a clear view of the current regulations and standards. The review includes the insight into the details of possible international rules for the future, considering operations in the specific and certified categories. The impact and trends of current and future regulations are also presented.

Findings – The analysis described in this paper shows a strong upward trend in UAM technical and operational developments as well as further potential for a successful incorporation in city mobility concepts. This paper indicates the importance of the representatives of guideline development organizations, industry, agencies and other important players involved in the standard development process.

Practical implications – This section describes synthesis on the required level of safety for UAM operations as well as description on the impact of the regulations from different perspectives, including industry and certification of urban aircraft, operations and air traffic management, cities and the governance of the urban airspace and well as technology.

Originality/value – Barriers such as legislation do not allow the common UAM to be deployed. This paper studies the overall framework in which the UAM deployment is expected to be implemented.

Keywords UAM operations, UAV, Transportation, Regulation, Standards, Requirements

Paper type General review

Acronyms

AAM = Advanced Air Mobility;
ARMD = Aeronautics Research Mission Directorate;
ATM = Air Traffic Management;
ASD-STAN = AeroSpace and Defence Industries Association of Europe - Standardization;
ASTM = American Society for Testing and Materials;
CAA = Civil Aviation Authority;
D2D = Door to door;

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DDC = Dynamic Delegated Corridor;
DOA = Design Organisations Approvals;
EASA = European Union Aviation Safety Agency;
EUROCAE = European Organisation for Civil Aviation Equipment;
eVTOL = Electric Vertical Take-Off and Landing;
FAA = Federal Aviation Administration;
FDAL = Function Development Assurance Levels;
GNSS = Global Navigation Satellite System;
IoT = Internet of Things;
ISO = International Organisation for Standardisation;
ICAO = International Civil Aviation Organization;
MOA = Maintenance Organisation Approval;
MS = Member States;
MTOM = Maximum Take-Off Mass;
NASA = National Aeronautics and Space Administration;
PDRA = Predefined Risk Assessment;
POA = Production Organisations Approvals;
RTCA = Radio Technical Commission for Aeronautics;
SAE = Society of Automotive Engineers;
SAIL = Specific Assurance and Integrity Level;
SDP = Software Defined Protocol;
SESAR JU = The Single European Sky ATM Research Joint Undertaking;
SORA = Specific Operations Risk Assessment;
STS = Standard Scenario;
TC/RTC = Type Certificate/Restricted Type Certificate according to Part 21;
UAM = Urban Air Mobility;
UAS = Unmanned Aerial System;
UML = UAM Maturity Level;
USSP = U-Space Service Provider;
UTM = Unmanned Aircraft Systems Traffic Management; and
VTOL = Vertical Take-Off and Landing.

Introduction

ASSURED-UAM (Acceptance, Safety and SUstainability Recommendations for Efficient Deployment of Urban Air Mobility [UAM]) project is CSA funded under Horizon 2020 programme and aims at developing the set of solutions assuring integration of UAM with Air Traffic Management (ATM) and city structures without compromising UAM acceptability, safety or sustainability. The project is designed to provide knowledge and skills, cities with knowledge concerning deployment of UAM services and definition of necessary standards and recommendations assuring common acceptability, safety and sustainability within the integrated metropolitan transport system. According to common understanding, UAM refers to transportation by air within or between urban areas. The detailed meaning of the term is not officially defined. Examples of UAM definitions can be found in ATM Master Plan (European ATM Master Plan, 2020) or The Single European Sky ATM Research (SESAR) Programme. For the purpose of the ASSURED-UAM project, UAM is described as means of transport of people or goods enabling door-to-door (D2D) or near to D2D travel within or to densely populated urban areas. It relates to both manned and unmanned aircraft of different configurations.

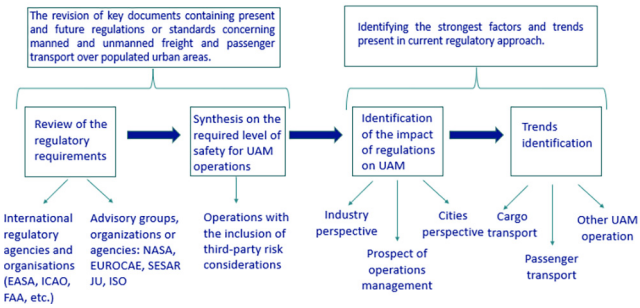
D2D transport of goods and people in a sense of UAV solutions in densely populated or even in urban environment is already regulated in the European Union (EU). Current legislation distinguishes operations for cargo, dangerous goods and people transportation. The main objective is to ensure safety for occupants, airspace users and especially for people and property on the ground. The most demanding certified category intended for the most sophisticated operations is furthermore regulated through additional standards and regulations addressing consistent parts of operation like the aircraft, necessary terrestrial infrastructure, operational aspects, etc., which usually require evidence supporting the safety status. However, the specific category intended for less demanding operations and not including the passenger transportation and transport of dangerous goods is more concentrated in operational manner so that only one authorisation is required. This authorisation is accessed for all aspects and based on risk assessments which are pre-defined or done by applicant.

The rapidly developing UAV technology needs new regulations; hence there is an urgent need for certification of urban aircraft. Modern cities dealing with disadvantages of current transportation models like growing traffic, environmental and noise pollution will need new solutions that should be human-friendly and must provide comfort to citizens. This is why manufacturers, commercial companies, development teams as well as public services representatives should consider hazards and impacts of UAM transportation and accordingly adapt necessary solutions for quick implementation and seamless certification. Present air traffic management model will have to evaluate to be able to integrate both manned and unmanned vehicles and to handle new concepts and models. This evaluation requires sustainable long-term development and will be done by technological and legislative measures. The entire evaluation process also requires engagement from governments and public services. All issues identified in this report clearly shows a trend towards UAM deployment and its integration with cities infrastructure. Depending on the region, the first actions to be introduced are expected between 2025 and 2035. Effective integration of Unmanned Aerial System (UAS) in the urban environment demands coordination and engagement of representatives of guideline development organizations, industry, agencies, government and other important players.

Methodological approach

The methodology of this analysis is presented in Figure 1. The main goal is to determine what regulations will exist in the future in relation to manned and unmanned freight and passenger transport over populated urban areas. This analysis is divided into two steps. The first step contains a review of documents from international regulatory agencies and organisations (European Union Aviation Safety Agency [EASA], International Civil Aviation Organization [ICAO], Federal Aviation Administration [FAA], etc.) and numerous advisory groups, organisations or agencies such as National Aeronautics and Space Administration [NASA], European Organisation for Civil Aviation Equipment

Figure 1 Methodological approach



[EUROCAE], The Single European Sky ATM Research Joint Undertaking [SESAR JU] and International Organisation for Standardisation [ISO] concerning approaches and visions related to regulation of different UAM forms. For the regulatory review, the collected information is divided into several topics, with information concerning UAM:

- risk assessment tools and safety models;
- requirements and specification for aircraft;
- ground station requirements;
- airfield and helipad requirements;
- operations;
- effective and flexible airspace management;
- noise and pollutant emissions;
- communication, navigation and surveillance; and
- roles and responsibilities of all parties that are identified and set out in above-mentioned documents.

This analysis also includes the synthesis on the required level of safety for UAM operations taking into account third-party risk issues, focusing mainly on transport operations involving dangerous goods or passenger transportation.

In the second step, the strongest factors and trends are identified, and three perspectives of impact of regulations on UAM are indicated and analysed:

- industry(vehicle) perspective;
- prospect of operations management; and
- cities perspective.

In addition to this, the second part contains the trends that are described in terms of the implementation of UAM in our society considering the current regulations and standards with the focus on:

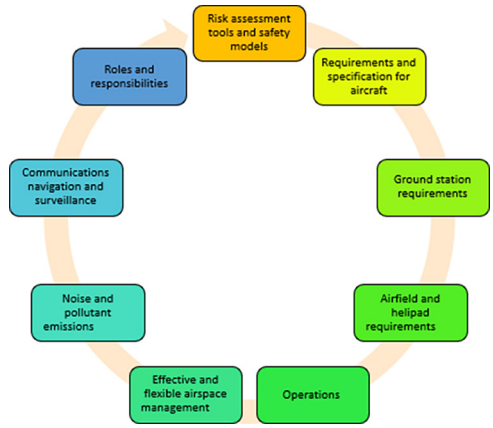
- cargo transport;
- passenger transport; and
- other UAM operation.

The second step ends with defining the main aspects that are most important and require the most effort to further facilitate the introduction of UAM.

Review of the regulatory requirements

The regulatory review covers the areas presented in Figure 2. This review considers operations in the specific and certified category including EU and international regulations and standards. It relates to manned and unmanned aircraft in different configurations.

Figure 2 Areas of the regulatory review



Risk assessment tools and safety models

Risk assessment tools and safety models can be used to support safety assessment, which can demonstrate its compliance with certain safety requirements. Laws and regulations on UAS in terms of risk assessment are at the stage of preparation; however, there are already EU norms that provide the legal basis for drones and the transport of passengers or dangerous goods.

European Union Drone Regulations

Under the 2015 EU Aviation Strategy, the European Commission, working closely with EASA has proposed a risk-based framework for all types of drone operations by developing the regulatory framework for Unmanned Aircraft Systems (UAS). Regulation (EU) 2018/1139 introduces a completely new regulations regarding unmanned aircraft: Commission Delegated Regulation (EU) 2019/945 defines requirements for the design and manufacture of UAS*;* EASA ED Decision 2019–021-R (Executive Director Decision 2019/021/R, 2019*)* and Commission Implementing Regulation (EU) 2019/947.

According to the regulation, an unmanned aircraft system must comply with operational limitations set out in the standard scenarios (STSs) of open category or in a predefined risk assessment (PDRA) which can be requested if the UAS operation meets a certain operational characterisation. Alternatively, operational limitations can be derived from Specific Operations Risk Assessment (SORA).

European Union manned aviation regulations

In accordance with the Commission Implementing Regulation (EU) 2019/947, unmanned aerial vehicle intended for the carriage of passengers and dangerous goods, have been classified as "certified**".** Therefore, unmanned aerial vehicle systems must fulfil the certification criteria that respond to the needs of manned aviation including:

- UAS designed and manufactured by certified organizations (DOA, POA);
- type certificate for UAS, Air Operator's Certificate (AOC) and the pilot license;
- Certified maintenance organisation (MOA) and technicians (Annex II to ED Decision 2020/002/R, 2020);
- fundamental requirements and recommended practices for airport design and operations, e.g. take-off and landing

(ICAO Annex 14 o the Convention on International Civil Aviation, Aerodromes, 2018).

Standards supporting regulations

Organisations and associations like AeroSpace and Defence Industries Association of Europe – Standard (ASD-STAN), ISO, Radio Technical Commission for Aeronautics (RTCA) and American Society for Testing and Materials (ASTM) are focused on developing and maintaining technical standards and best practises, which are available for:

- terminology related to UAS (ASTM F3341/F3341M – 20a, 2020);
- requirements for design, construction and testing procedure of fixed-wing aircraft (ASTM WK63678/ WK64619); and
- design and manufacture requirements for deployable parachutes of small unmanned aircraft (sUAS) (ASTM F3322 – 18, 2018).

Additionally, Advisory Circular (AC) of the Federal Aviation Administration (2012) (AC 150/5390–2 C – Heliport Design, 2012), provides standards for the design of heliports serving helicopters with single rotors.

NASA Aeronautics Research Mission Directorate (NASA, ARMD, 2021) plans to host an Advanced Air Mobility National Campaign series to promote public confidence in Advanced Air Mobility through bringing together some aircraft manufacturers and airspace service providers to identify the levels of safety assurance and airspace interoperability. NASA created the UAM Maturity Level (UML) scale to characterize levels and capabilities of UAM operations around urban areas.

Specific conditions for unmanned aircraft systems

This section addresses the Specific Conditions for Unmanned Aircraft Systems found in regulations and reports from EASA, SESAR, the European Union (EU), ISO, ASTM and NASA.

EASA

In the Special Condition for Light Unmanned Aircraft Systems – Medium Risk published by EASA (EASA, SC-Light UAS, 2020), the authority outlines the airworthiness specifications for UA operated in the specific category focusing on Specific Assurance and Integrity Level (SAIL III and IV, medium risk). These technical requirements are applicable for future UAS projects for which TC/RTC is applied. This was supplemented with additional guidance on the expected design verification process of aircraft within above-mentioned SAIL levels (EASA, 2021).

In November 2021, EASA published the Opinion report (Opinion 05/2019, 2019), which includes some introduction of two new Parts in the Annex to Commission Delegated Regulation (EU) 2019/945, including the technical requirements that UAS needs to meet to be operated in the STSs, and establishing two new UAS classes – C5 and C6. STS is an operation described in EU regulation. Till now, two STSs have been published (STS 1 and STS 2). Both of them require the use of a drone with class identification label C5 or C6, respectively.

Regarding Vertical Take-Off and Landing (VTOL), EASA published the Proposed Means of Compliance with the Special Condition VTOL (SC-VTOL, 2020), where a complete set of technical specifications in the form of a Special Condition for VTOL aircraft was developed. Additionally, Function Development Assurance Levels (FDAL) recognises the ARP4754A/ED-79A document (SAE International, 2011) as an acceptable guideline.

European Union

Regulation 2018/1139 establishes the specific conditions for the design, production and maintenance of unmanned aircraft and their equipment. These requirements also apply to personnel and organizations involved in those activities. This regulation also establishes the conditions and procedures for issuing, maintaining, amending, limiting, suspending, or revoking the certificates, or for making declarations.

Commission Implementing Regulation (EU) 2019/947 established requirements for the registration of UAS operators as well as of certified UAS.

The Single European Sky Air Traffic Management Research Joint Undertaking

SJU published report (SESAR JU, 2020), which provides an overview of recommendations and requirements for all of drone activities The document mentions that in case of remote identification and e-identification services, drones should be able to broadcast their remote identification, which enables operators or nearby authorities to receive the necessary information.

International Organisation for Standardisation

The published report of ISO *(ISO/DIS 21384-2)*, concerning the requirements for ensuring the safety and quality of the design and manufacture of UAS, establishes the requirements for UAS equipment and components.

ASTM International has published three relevant standardization reports regarding aircraft required specification:

- ASTM F3201-16, concerning standard practice for ensuring dependability of software used in UAS (ASTM F3201-16, 2016) and providing the core requirements for airworthiness certification of lightweight (UAS) or for certain Civil Aviation Authority (CAA) operational approvals using risk-based categories.
- The standard specification and airworthiness requirements for design, construction and verification of fixed-wing UAS (ASTM F3341/F3341M-20a, 2020).
- ASTM F3322-18 report on the requirements for deployable parachutes osUAS (ASTM F3322-18, 2018).

Ground station requirements

Regulation regarding ground station requirements can be currently found in three different sources:

- In May 2020, EASA addressed the topic in the regulation titled: "Proposed Means of Compliance with the Special Condition VTOL" (SC- VTOL, 2020).
- In December 2020, EASA addressed this topic in the regulation titled: "Special Condition for Light Unmanned Aircraft Systems - Medium Risk" (EASA, SC-Light UAS, 2020).
- In 2019, SEA International defined a set of standards application layer interfaces called "JAUS Unmanned Ground Vehicle" (SAE, AS6091, 2019).

Airfield and helipad requirements

Regulation regarding airfield and helipad requirements can be currently retrieved from two different sources.

1 ASTM International:

Report on New Specification for Vertiport Design (WK59317), establishing the requirements for the planning, design and establishment of vertiports intended to for the service of small VTOL aircraft.

2 The EU:

- The EU addresses requirements for airfield and helipad in Regulation (EU) 2018/1139. In this regulation, the following articles are relevant:
  - Article 34 – Aerodrome certification.
  - Article 35 – Safety related aerodrome equipment.
  - Article 36 – Implementing acts as regards aerodromes and safety-related aerodrome equipment.
  - Article 38 – Protection of aerodrome surroundings.
  - Article 62 – Certification, oversight and enforcement.
  - Article 79 – Certification of Safety-Related Aerodrome Equipment.

Operations

3 SESAR JU, 2020, describes a number of U-space services. EASA will publish new regulation, where the following functions will be prescribed as mandatory in the first phase of implementation. Following must be available in all MSs by January 2023:

- network identification;
- geo-awareness; and
- flight authorisation.

4 The SESAR JU, in accordance with the ATM Master Plan (European ATM Master Plan, 2020) is to provide the EU with a high-performance air traffic control infrastructure, enabling more direct trips using less fuel and fewer delays by 2040.

5 The European Commission (Commission of the European Communities, 2008) defines a more sustainable and better performing aviation in Europe as one of the mail goals of The Single European Sky (SES). The new generation European air traffic management system (Regulation [EC] No. 219/2007) has set up the SESAR ATM research programme, which aims to improve ATM performance by modernising and harmonising Europe's ATM systems through the definition, development, validation and deployment of innovative technological and operational ATM solutions.

Airspace management and flexible use of airspace

1 The Dynamic Delegated Corridors (DDCs) concept (The MITRE Corporation, 2019) is aimed at enabling the UAM aircraft to operate in busy airspace by defining specific corridors, and to empower procedural separation from conventional aircraft. The concept also defines a set of rules and procedures to help coordinate the flow of traffic in the corridor. DDC uses a set of established procedures and rules to determine the airspace volume used by aircraft to fly.

2 SESAR JU, 2020, describes a number of U-Space services. One of them is geo-awareness, which can be extended to geo-fencing. A geo-awareness service will provide to UAS operators:

- information on the applicable operational conditions and airspace constraints;
- UAS geographical zones; and
- dynamic airspace restrictions that temporarily limit the U-Space airspace.

3 ISO (ISO/DIS 23629-7) provides a data model with the necessary attributes for flexible airspace management.

Environment, noise and emissions

Environment, noise and emission regulations are addressed in European regulations and FAA guidance material.

- The Commission Implementing Regulation (EU) 2019/947 states that "Unmanned aircraft noise and emissions should be minimized as far as possible taking into account the operating conditions and various specific characteristics of individual MSs, such as the population density, where noise and emissions are of concern".
- FAA (AC 150/5390-2C - Heliport Design, 2012) provides guidelines and implementing instructions for Helipads to consider environmental impacts.
- NASA (NASA, ARMD, 2021) is planning to gather the vehicle noise data, which can help in determining future regulations and standards for noise pollution.

Communication, navigation and surveillance

- EASA's Special Conditions for Light UAS (EASA, SC-Light UAS, 2020) address communication, navigation and surveillance requirements as demands focusing on link performance, performance monitoring and link security.
- Commission Implementing Regulation (EU) 2021/664 states that all manned aviation that is operating in non-controlled airspace must communicate their position to U-Space service providers (USSPs).

Several regulations and standards apply:

- Regulation (EU) 2018/1139 on general ATM/ANS systems specifies requirements for all aviation CNS systems.
- ISO/DIS 21384-2 gives requirements for C2 link in terms of: antenna module design, data features, reliability requirements and security requirements.
- SAE International (SAE AS 5669A JAUS/SDP) specifies layers of communication data for the flow of messages defined by the Joint Architecture for Unmanned Systems (JAUS) or other Software Defined Protocols (SDP). This document also defines the formats and protocols used for communication between compliant entities for all supported link-layer protocols and media.

- SAE International (AS5669A, 2019) also describes a SDP as an application data interface for communicating between software elements;
- JAUS Core Service Set AS5710A provides a set of application layer interfaces and the means for software entities in unmanned system to coordinate their activities, e.g. functionality of the underlying communication transport layer, mechanism for automatic messaging and connection liveness between communicating components.
- SAE International (SAE6857, 2018) provides Recommended Practice as technical requirements for a terrestrial-based Position Navigation and Timing (PNT) system to improve vehicle positioning/navigation solutions and ensure critical infrastructure security, complementing GNSS technologies.

Roles and responsibilities

New regulation on U-Space in 2021, which will enter into force on 26 January 2023, will identify requirements for the roles of the UAS operator and USSP within the context of U-Space. Roles for registration services as well as for accident and incident reporting can be found in the new regulations. Moreover, the Commission Implementing Regulation (EU) 2019/947 identifies roles for manufacturers and distributors of unmanned aircraft systems. Requirements for process manufacturing software are specified by ASTM (ASTM F3201 - 16, 2016).

Synthesis on target of safety level

This part provides a synthesis on the review of regulatory requirements, as presented in the paragraphs above and focusses on the available tools for safety risk management and required level of safety for UAM operations with the inclusion of third-party risk considerations.

Urban Air Mobility operations for transporting humans and/or dangerous goods

Such operations are to be certified in accordance with traditional manned aviation certification principles, including certified design, production and maintenance organizations as well as certified operator organizations, pilots and certificated aircraft. Some deviations are made to cater so as to take account of the specificity of UAM operations without a pilot on board. This concerns specificities on aircraft requirements in which the target levels of safety can vary depending on the number of persons on board. Ground station considerations, take-off and landing area aspects, traffic management and flexible use of airspace, communication, navigation as well as surveillance measures have also been introduced. Thus, the safety recommendations resulting from UAM operations rules, ensures the safety of other airspace users and occupant safety only. This may be attributed to the rationale that when they are protected from impacts with the ground, third parties on the ground are also protected.

Other Urban Air Mobility operations

The SORA is a process to perform risk evaluation for UAS operations, including some UAM operations, with the exception of transporting humans and/or dangerous goods. The risks identified through this process are to be mitigated to an acceptable level and explicitly including third-party risks in the notion of air and ground risk.

The STS and PDRA approaches are basically pre-performed SORA processes where the STS are fixed and the PDRA provides some level of flexibility. It targets to mitigate air and ground risks to an acceptable level. On this matter, it builds on industry standards.

In summary, current legal requirements for UAM are divided into those relating to the transport of people and/or dangerous goods and those relating to the rest of operations. The first one is designed to ensure passengers' and other users' safety, while the second is to ensure the safety of (uninvolved) people and property on the ground. Besides, the elements of operations performed in the certified category (such as airplane, ground station and vertiport) are regulated by a variety of regulations and are related to the need of defining a minimum level of security. The specific category is also regulated in an operational centric manner, meaning that only one permission to fly is required, which addresses all aspects in one. These are based on risk assessments that are pre-defined or done by the applicant and evaluated by the competent authority. These are also assessed mostly subjectively, as the minimum level of security has not yet been ensured.

Impact of regulations on Urban Air Mobility – different perspective

Industry perspective

As there is still not a market for UAM that would require certification of urban aircraft and the technology is still advancing rapidly and in an unpredictable way, the regulative documents that concern VTOL and electric (eVTOL) usage are still in the "specific condition phase". Despite that, dynamics of the development of UAM solutions is increasing because of the compelling need to ease the existing transportation systems in the world's developing megacities. The risks and impacts of UAM transportation must be investigated for a seamless certification and quick implementation of these solutions in urban space.

Operations perspective

The present air traffic management system must, of course, evolve to incorporate the UAM innovative concepts and models by changing existing policies and procedures. Both the EU and the US are working to regulate the unmanned air traffic market via encouraging appropriate legislation, supporting experimentation through "*ad hoc*" regulations, focusing on new technologies – i.e. autonomous and/or aerial and connected mobility – and implementing new policies as well as creating innovative business services in the field of monitoring, security and logistics.

The Single European Sky programme aims to improve ATM performance by modernising air traffic systems through new technological and operational solutions. Meanwhile, in the US, NASA is working on the "Advance Air Mobility (AAM) National Campaign" program (e.g. NC-1 for 2022) to accelerate the development of safe and frequent flight operations.

Both programmes and soon new developed technological solutions will have impact on air traffic management, U-Space services, infrastructure and risk management.

Cities perspective

To regulate UAM impact on cities and regions across the EU, the Manifesto on the Multilevel Governance of the Urban Sky (Hamilton, 2018) is analysed. In the context of U-Space's multilevel governance and implementation of flexible and decentralized policies, it is imperative that UAM Initiative Cities Community (UIC2) members request the cities and regions to be one of the competent authorities in the governance of urban airspace. Their role must be explicitly acknowledged and referenced in the prospective U-Space legislative clauses of MSs.

In specific, the UIC2 members request that Prosecution of infringements of the public use of urban airspace over a city/region remains a local task, but first and foremost, the most important issue is that cities/regions play a decisive role:

- for allowing the operation of UAM services of public interest (e.g. future public transport, postal-services, emergency services) in alignment with the needs and preferences of their citizens;
- in establishing to what extent UAM/U-Space operations can be conducted in their territories;
- where UAM/U-Space flight operations are permitted in their territories (e.g. geofencing, day-/night-time restrictions, noise and visual abatements); and
- where take-off and landing sites are planned to be built.

Conclusion

One of the most crucial issues in providing UAM transportation for consumer use is certification, mostly focused on design, initial airworthiness and continuing airworthiness. There have been recent promising developments in Europe in the area of certification that will enable a regulatory framework for the safe operation and certification of air taxi and electric VTOL (eVTOL) in Europe. The statistics data certainly indicate on a large gap in safety between commercial air transport and light aircraft (Lineberger and Hussain, 2019). No significant progress in terms of safety and reliability will result in a large and exceptional number of incidents that will negatively affect the perception of security and the acceptance of UAM in the field of digitization and automation. The main identified trends are focused on:

- Development of vehicle and infrastructure-related technologies enabling safe, efficient and sustainable deployment and operation of the systems.
- Definition of the appropriate regulatory framework (certification, initial and continuing airworthiness) ensuring crucial from the point of view of UAM safe, efficient, sustainable and affordable operation of the system.
- Regulations and standards for UTM systems integration with ATM concerning flights management and sharing common airspace.
- Avoiding adverse weather conditions and implementation of geo-awareness and geo-fencing technologies in integrated UTM/ATM airspace (e.g. assuring separation from prohibited areas like airspace around the airport).
- Operational standards for aircraft intended to operate in UTM system (about performance and equipment, both for manned and relating to performance and equipment for manned and UAM).
- Regulations concerning AI procedures in case of appearance unintended, unexpected situation (covering risk mitigation and occurrence severity minimization/optimization).
- Providing with regulations for 5G and beyond and the ability to communicate effectively with all airspace users.
- Technical requirements for IoT devices distributed both on the ground (vertiports, airports) and in the air (UAS).
- Implementation of algorithmic governance to assure efficient air transport management as well as integration with other modes of transport.
- Enabling near real-time airspace and traffic management (covering sustainability issues aviation forecasting predicting future demand, as well as emergency, military or other public service operations as well as priority actions in emergency, military or other public utility operations by implementation of regulations for flexible UTM airspace.
- Integration of airports, vertiports or airfields, enabling safe and efficient automatic approach, landing, take-off as well as reconfiguration (including capabilities and limitations).

According to the estimates of experts of the X-Team Consortium (Lineberger and Hussain, 2019), 2035 is the earliest possible date for the introduction of UAM tests of unmanned passenger operations for all types of air vehicles. Convertible VTOL configurations are expected to enter the market within the feasible timeframe, because they are considered as the most complex configurations. Providing safe electrification of small aviation, introducing new vertical take-off and landing aircraft and development technologies and enabling safe and weather-resilient operations in the urban environment (covering all phases of flight) will be the main technological trends.

According to NASA, assuming the regulations and policies are in place, UAM is likely to be a commercially viable market for air metro services by 2028. [Regulation (UE), 2021].

The study identified a clear trend towards UAM technical and operational developments as well as further integration in city mobility concepts. The first introductions are expected between 2025 and 2035 depending on the region and are already being addressed by a wide variety of organisations and associations for the development of rules and regulations. Effective integration of UAVs in the urban space requires involvement in the development of commitment to developing standards covering a wide range of issues. That is the crucial task for all representatives of guideline development organizations, industry, agencies and other important players on the aviation market.

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