CONTINGENCY MANAGEMENT CONCEPT GENERATION FOR U-SPACE SYSTEM

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Abstract

Contingency management in aviation is a vital concept that ensures safety, security, and efficiency in operations. To fully benefit from the envisioned Advanced Air Mobility system, the need of a structured and system-wide contingency planning will be even more important since the air transportation system paradigm will shift into a highly automated system that includes high-density traffic. The complexity will increase considerably by enlarging the operations to the underserved urban areas. Therefore, the new system needs to provide a more agile, accessible, and flexible environment. In this paper, the need of a contingency management from a holistic approach is described and the base requirements to build such a system are defined by considering the roles and responsibilities of each stakeholder that are defined for the U-space system. Alongside the defined requirements, the tasks of the stakeholders and the expected main contingency sources are explained to have a better understanding of the system. The objective of this work is to provide the base guidelines that help to set appropriate actions by relevant stakeholder under an adverse condition which might compromise the safety and security of the operations within the air traffic network.

Introduction

Given the vision of an Advanced Air Mobility (AAM) concept, the current air transportation system is expected to transform into a more flexible, agile, and accessible system to all users and provide services to areas that are underserved or not served at all. Compared to the conventional air transportation system, the characteristics of numerous aspects of this new transportation system shall be much more diverse with operations in urban, suburban and rural areas, and supporting a wide range of platform types: fixed-wing/vertical takeoff and landing (VTOL), manned/unmanned, and various levels of autonomy. Many architectures are currently under discussion how this new system may interact and coexist with the conventional air traffic system supported by an air traffic control (ATC) authority, yet it remains undisputed that safety must be ensured at the same levels as is commonplace within the aeronautical sector. Nevertheless, the application of safety protocols to this diverse assortment of platforms and technologies is not straightforward. To make AAM a reality, there are various topics that have to be considered such as infrastructure, technology, regulations, social and environmental impact, safety, resiliency, and so forth. One of the most important challenges is to deal with off-nominal and disruptive events which can compromise the system to operate safely. Therefore, developing a proper contingency management concept for AAM and making it operable is one of the crucial steps to be taken to manage the expected or unexpected contingency and emergency situations.

In the existing concept of operations (ConOps) for urban air mobility (UAM) concepts across the world, contingency and emergency management procedures are discussed. The U-space ConOps, drafted by the EU CORUS project, defines contingency management process in a structured way and considers mitigation, contingency, and emergency stages separately. Moreover, it provides several contingency plans for certain operational cases to give an idea about contingency planning procedures [1]. NASA (National Aeronautics and Space Administration), partnered with the FAA (Federal Aviation Administration) and industry, describe the roles of the UAM stakeholders during operations through a couple of contingency scenarios in the UAM ConOps. Scenarios are about the drones that are non-conformant to the operational intent due to the performance issues and several external events and results with a safe continuation in the first scenario and forced landing in the second one [2]. In addition, the UATM ConOps for Australia investigates several contingency situations by considering on-board and

external issues such as change in vertiport destination due to technical or pilot induced failures, adverse weather, vertiport availability and so forth [3].

There are various studies that focus on the contingency management on operational activities under specific contingency cases. State estimation for unmanned aerial vehicles (UAV) using spherical simplex unscented Kalman filter in case of a contingency is demonstrated with a loss of GPS signal case by Hahn et al. [4]. Similarly, in case of a positional information loss, Pang et al. studied UAV trajectory estimation using extended Kalman filter and analyzed the comparison of the planned trajectories and estimated trajectories with various signal densities [5]. Terrain detection, self localization without GPS, and autonomous landing using machine vision for a rotorcraft UAV is presented by Theodore et al. [6]. Additionally, autonomous detection of safe landing zones to help a UAV to land quickly and safely as possible in case of an emergency is studied by Patterson et al. [7]. For efficient and safe Unmanned Aircraft System (UAS) operations within the existing airspace, Pang et al. proposed a general concept for airspace utilization and configuration by comparing different operational approaches to optimize complexity and flexibility of the airspace [8]. Zhou & Kwan developed a comprehensive contingency planning framework for loss of communication cases by considering all the aspects of loss of link contingency [9]. With the use of deep reinforcement learning, improvement of collision avoidance system using deep Q-network and its adaptation into the unmanned traffic is explored by Li et al. [10] and obstacle avoidance during operations using proximal policy optimization is provided by Hu et al. [11]. Grüter et al. worked on emergency flight planning of UAVs to a safe landing zone during an emergency situation by using Voronoi diagrams and selecting the most suitable path with dynamic programming [12]. Another approach for a pre-flight plan in case of an engine failure for fixed wing UAVs is introduced by Ayhan et al. which uses the A* search algorithm for finding the optimized trajectory to the safe landing areas [13]. Ortlieb et al. presented a work where they compute the large number of trajectories at offline phase [14], then select the proper options during online phase [15] in case of a contingency.

Automation of the contingency planning processes are also discussed through several researches. Pastor et al. present an architecture to automate the contingency actions onboard which focuses on taking proper actions by classifying the contingency situations [16]. Automation of the contingency management and its integration into the unmanned aircraft systems are discussed through Usach et al.'s study [17]. Furthermore, Ippolito et al. presented an architecture for the autonomy of the controls of the vehicles to provide automation for both nominal and off-nominal cases and presented results both from simulations and flight tests [18], [19]. Model-based onboard contingency planning system is introduced to make autonomous in-flight system diagnosis and tested over couple of cases which are related to component failure, by Schumann et al. [20]. Teomitzi and Schmidt proposed an integrated contingency management framework, defined requirements needed for proper contingency strategies from operational perspective, and tested their framework through a simulation environment [21]. Wing and Levitt presented the digital flight rules concept that enables the automation in airspace system that increases both safety and flexibility in air traffic [22]. Last but not least, instead of a rule-based approach, the intelligent contingency management concept is introduced for UAM by Gregory et al. [23]. Intelligent contingency management concept claims that the vehicles have to be aware of their situation and capabilities, surroundings, and make decisions accordingly during operations to handle also the unexpected situations since it is hard to know each and every contingency case beforehand. As a continuation of this work, Campbell Jr. et al. discussed the possible approaches for dynamic vehicle assessment which is one of the important parts of the intelligent contingency management framework [24].

Authors from Boeing Research & Technology - Europe have studied the development and testing of advanced communication, navigation, and surveillance (CNS) technologies to handle various tactical contingencies in the Galician SkyWay project. There were multiple objectives of the project in-line with the afore-mentioned studies in which specific technological solutions for preventing the contingency outcomes were developed, and automated, onboard solutions were also developed. The novelties in this project were primarily an integrated set of solutions which were compatible with ATC protocols and communications during flights based on operational impact analysis, trajectory replanning and risk

assessment, and drone-centered on-board contingency management concept. The Contingency Manager architecture was designed to be scalable to handle an increasing number of operational requirements, constraints and performance criteria. Nevertheless, only a single aircraft's onboard contingencies were considered such as loss of separation, loss of engine, loss of global navigation satellite system (GNSS), loss of power, loss of ownership, loss of link, and possible any concurrent combinations of such contingencies. Details of this study can be found in [25] which include descriptions of actual flight testing of this implementation. Moreover, contingency scenarios within the project are tested through the developed simulator [26]. The SkyWay project creates the basis for defining the requirements needed for the much broader contingency management development considered here and inspires the studies conducted under the Air Mobility Urban – Large Experimental Demonstrations (AMU-LED) project in terms of analyzing the feasibility and development of a system wide contingency management strategies for the future AAM system. A contingency management methodology with holistic approach both for strategic and tactical level, that considers all the U-space partners and their roles is currently being studied and shall be developed with the AMU-LED project by the authors.

The mentioned studies handle the problem mostly from an operational perspective which is very useful for on-board solutions where the traffic density is low. However, these approaches might not work well when the complexity of the environment increases. For example, high-density operations are expected in the AAM system. Those operations are envisioned to share the same airspace which will be supported by the U-space ecosystem. U-space ecosystem has various roles and responsibilities which provide numerous services to the users. In addition, while providing such system, higher levels of automation is also expected to be achieved. Therefore, a more structured, system wide contingency management strategy has to be adopted including responsible stakeholders by considering strategic and tactical levels of the procedures. In this study, the minimum requirements that are crucial and must be satisfied to define a comprehensive contingency management and to obtain a reliable AAM system, are investigated. The requirements should be established upon safety, security, and efficiency aspects by considering operations, UAS Traffic Management (UTM) functions, system stakeholders, and the operational environment.

The rest of the paper is structured as follows. In the Problem Statement Section, the current studies for contingency management concept are discussed, and the need of a system-wide framework is addressed. Requirements for the Contingency Management of AAM Section explores the base requirements that are needed to define such a system by considering all of the stakeholders of the U-space system and the possible contingency sources. Finally, the Conclusion and Discussion Section summarizes how the defined minimum requirements can be detailed and used to build the envisioned contingency management framework and discusses the next steps that should be taken.

Problem Statement

Contingency management concept is about providing high level safety and security to a system while considering efficiency at the same time, which makes it a very crucial concept. There are many applications of contingency planning in various industries. Yet, questions such as how a contingency shall be defined, how contingency situations shall be handled, remain open to discuss for the envisioned AAM system.

The objective of contingency management is to bring benefits to the system such as assuring safety and security, building confidence, and providing reliability, resiliency and robustness, etc. From the AAM perspective, it is not clear what parts of the system must be considered while developing a contingency planning concept. There are many studies that handle specific failures or off-nominal situations from an operational perspective with various solutions. Yet, the sufficiency of the operational studies to constitute system-wide contingency strategies is still questionable due to the extent of the AAM contingency planning and is still an open issue. For AAM to be operable, questions regarding the scope of the contingency management have to be cleared. It has to be defined if the operations are enough to be focused on in terms of providing solutions to the off-nominal situations or failures and contingency situations on-ground with each and every stakeholder shall be considered as well and be

included into the system-wide problem solving as they each form part of the system.

The contingency management planning process can also be separated into strategic and tactical phases. The strategic phase is about improving the procedures and the design by analyzing the whole system. The aim is to have a more robust and resilient structure that can tolerate failures and non-nominal situations. For example, being single-failure tolerant where the system design conceives that one stakeholder may take over from another when it is not able to provide a vital service due to a contingency and thereby system continuity can be maintained. On the other hand, the tactical phase is the one where the required measures are analyzed and provided. The purpose is to contain and mitigate a contingency situation in the best manner during operations and, if possible, to lead back the individual flights or system to the nominal operations.

Safety and security are the most important terms that have to be satisfied to see AAM in our everyday life. Thus, the extent of the contingency management concept has to be discussed and defined clearly to cover and be valid for the whole AAM system.
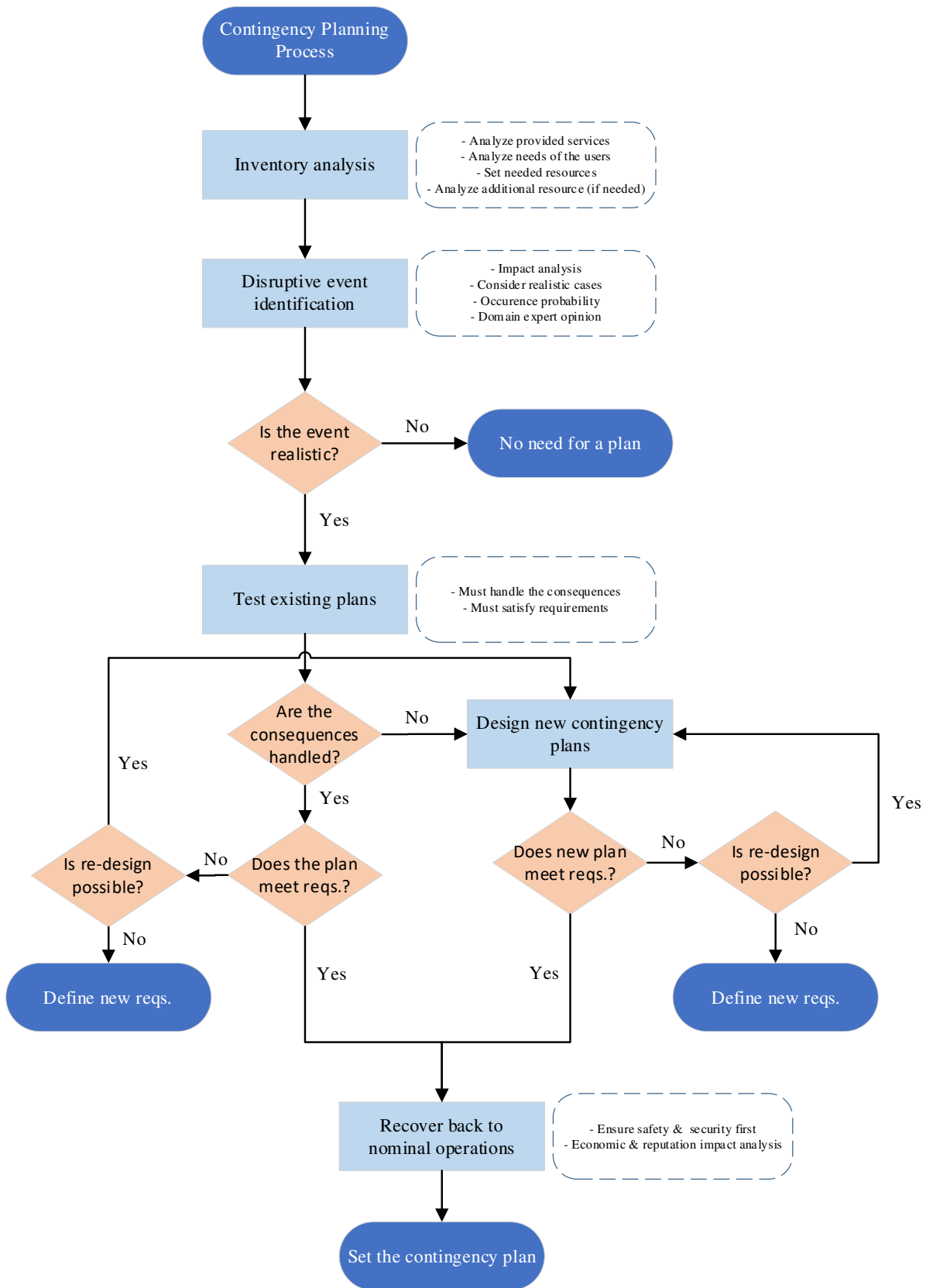
Generic Solution Framework

Contingency management is one of the most important concepts in U-space structure for flights to operate safely. The contingency planning concept must be applicable, integrated, flexible, adaptable to the environment, always open to offer new strategies in detail and define needed resources under adverse situations while ensuring the required safety and efficiency within the system.

The current approaches to develop contingency plans for AAM are mostly operation-centric and for some cases they focus on specific contingency situations. Applications in ATM, on the other hand, can be beneficial as a starting point since they adopt a more holistic approach. Contingency planning guidelines for the air navigation services which are defined by EUROCONTROL [27], represent the contingency planning approach from ATM perspective. According to those guidelines, the planning process starts with the inventory analysis to set the needed resources. The provided services to the users, the needs of the users, the required resources, and the additional inventory needed in case of a contingency have to be extensively analyzed. As a

second step, the events that can cause a disruption in the system must be identified. The considered disruptive events and their impacts to the operations have to be examined to decide if they really have an impact on nominal operations and are realistic enough to be considered as a contingency for the system or the system can survive without taking any major actions for them. Analysis on how likely the occurrence of the event and if it has links to trigger the other disruptive events can be conducted to decide whether the faced event is realistic or not. Additionally, domain experts' opinion can be consulted for the cases that are not faced before. For the third step, the available contingency strategies must be tested to see if the existing plans are appropriate and sufficient for the faced contingency situation or not. The analysis can be done simply by checking if the existing contingency plans are able to handle the consequences of a contingency and can satisfy the defined requirements. If they do not suffice, the development of new plans or change in the existing plans must be considered by assessing that specific situation and defining new requirements accordingly. Lastly, measures have to be taken for operations to recover and keep on track after the safety and security requirements are met. For doing that, after the safety and security of the system is ensured, impact assessment from economic and reputation aspects should be conducted as well. That general planning structure can be useful for implementing in U-space system but all the stakeholders must be taken into consideration while doing such a structured planning. The representation of the discussed structure is given as in Figure 1.

As explained in the Introduction Section, there are several researches that focused on contingency management and planning. Yet, those studies mostly centered around solving one portion of the planning process with specific scenarios or developing concepts from an operational or mission-based point of view. EUROCONTROL's generic process approach of contingency planning provides a good basis to develop a holistic approach for AAM. However, new requirements have to be defined and tasks of the stakeholders have to be set with respect to the AAM system for developing a structured contingency planning and possibly customizing the generic solution framework for AAM. Therefore, to build contingency strategies that considers the whole AAM system and provides a safe and efficient environment, the base requirements have to be explored.

Figure 1. Generic Solution Framework for Contingency Planning

U-space Stakeholders

Operations within the U-space are conducted by the collaboration of tasks between its stakeholders. To be able to define the requirements of a system-wide contingency planning, the tasks of every stakeholder have to be analyzed. These stakeholders can be named as service providers, drones, operators, vertiports/airports, passengers, other users of the U-space, and regulatory authorities. The safety and efficiency of the U-space operations are highly dependent to that cooperation. This paper focuses on the U-space ConOps [1] and makes relevant adaptations to the specific AMU-LED ConOps [28] in terms of defining the roles and responsibilities of the considered stakeholders. The general structure of the considered system is illustrated in Figure 2.
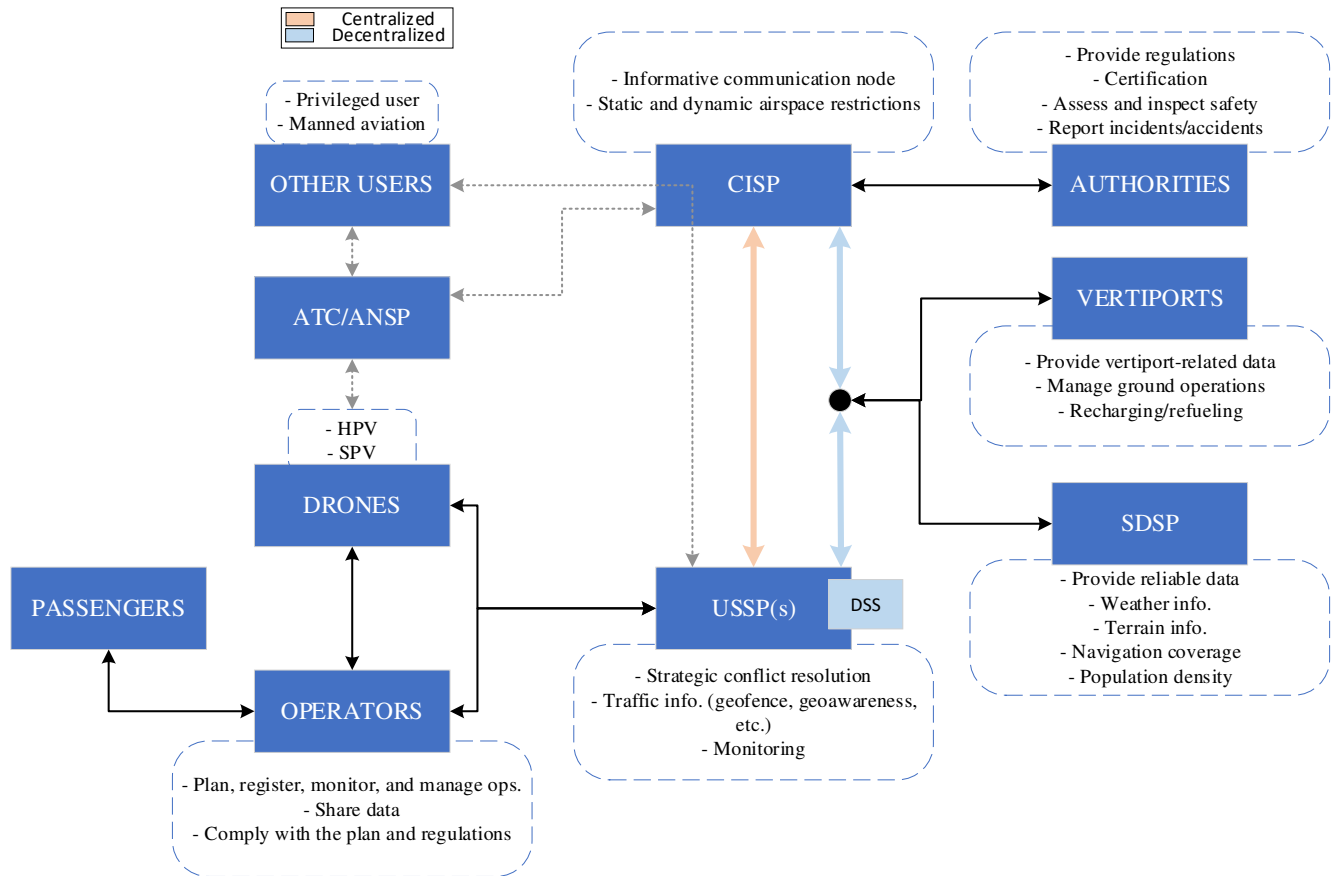
Figure 2. General U-space System Architecture from AMU-LED Perspective [28]

Service providers are responsible to provide service access to the eligible operators. The provided services can be examined by considering each type of service provider. U-space service provider (USSP) is responsible to assist on operational plan preparation, optimization, and processing, to provide strategic or dynamic geofence, geo-awareness, network identification, flight registration assistance and authorization, risk analysis, and emergency management. Most importantly, tactical and strategic deconfliction tasks are also assigned to USSPs.

Common information service provider (CISP) works as an informative communication node of the system, collects all the relevant data, makes sure if the data is accurate, has enough quality and integrity, and provides them to the stakeholders of the system. CISP provides also static and dynamic restrictions for the airspace, certified USSPs list, and sets the requirements for the U-space. For the centralized approach, CISPs work as a direct communication channel between USSPs where the information flow related to the flights, traffic, and flight conformance is

provided. For the decentralized concept, discovery and synchronization service (DSS) is planned to be used on each USSP for communicating with CISP, to avoid bilateral connections. Functions such as ensuring the separation of the general/civil aviation and unmanned traffic within the U-space, providing situational awareness to the specific airspace users, and acting in a contingency or emergency situation collaborating with the USSPs, are assigned to the airspace navigation service provider (ANSP). Mainly, ANSPs are expected to coordinate the manned and unmanned traffic interactions. Lastly, supplemental data service provider (SDSP) is responsible for the provision of proper supplemental data such as weather information, ground and terrain data, navigation and communication coverage information, population density of the flown area, and so forth. SDSPs are also responsible from the accuracy and reliability of the provided data and its update procedures.

Drone operators are in charge of the performance of the individual drone operations. The planning, registering, monitoring, and managing the operations from start to end by considering the regulations and constraints and sharing data with U-space stakeholders at all times, are all under drone operators' responsibility. Basically, a drone operator in unmanned aerial systems has the same tasks as an airliner in civil aviation.

In vertiports, responsibilities such as management of the boarding procedures of the passengers, recharging or refueling the drones, management of the ground operations, providing safety and security around vertiports, are on vertiport operators. They also undertake duties such as guiding the vertiport users under severe weather and providing information to the stakeholders upon vertiport availability (for landing/takeoff, chargers, parking, etc.) by considering the capacity limits.

Drones' and PICs' (or supervisors for fully autonomous systems) main task is to operate with respect to the flight plan in a safe and secure way. Drones have to comply with their certificates and have to be maintained regularly or repaired and overhauled if it is needed. PICs, on the other hand, have to monitor and execute the flight and modify the route if there is a need depending on the provided real-time information such as adverse weather or dynamic geofence.

For the U-space environment, general aviation users have to be aware of the surrounding unmanned air traffic and are responsible to stick with their operational boundaries. They must comply with the defined rules within the shared airspace at all times.

Passengers must be aware of the safety and security requirements at all times. They are responsible to act accordingly and comply with the rules before, after, and during the requested service.

Authorities are the entities that provide regulations, certification, and prepare appropriate environment for the coordination of the other U-space partners. Specifically, they define the no-fly zones, record activities, assess and inspect the safety of the system, report incidents and accidents, and so on.

The described roles and responsibilities of some of the partners are open to the other relevant partners to take over the process and to provide a continuous service. Yet, a proper, strategic planning has to be done for that to prevent the interruption of the whole traffic due to a failure in one of the tasks of a stakeholder.

Contingency Hazards

The nature of UAM implies a range of new possible contingencies. Those adverse conditions can affect the system in various ways and bring the operations to a standstill. Therefore, to analyze the root causes of the disruptions in operations, the contingency hazards can be classified into five categories as it is shown in the Figure 3; technical failures, human-related failures, data-related issues, infrastructure-based failures, and environmental events.
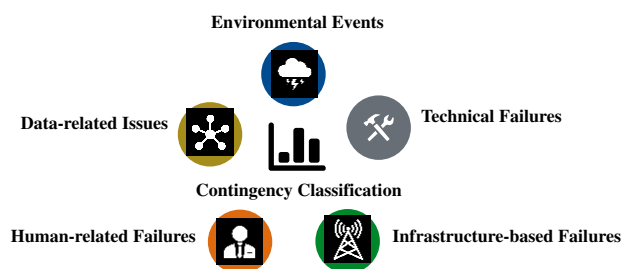
Figure 3. Contingency Hazard Categorization

Technical failures, can be described as physical failures on systems of any of the U-space stakeholders especially on drones and service providers. Loss of link (command and telemetry), GPS failure,

navigation degradation, camera failures, engine and power failures, loss of payload, structural component failure are some of the technical failure examples that can be given.

Human-related failures, are the failures based on human performance on U-space system which includes pilot and ground personnel performances, and passenger awareness. Distractions on pilot in command (PIC) or any of the personnel, medical issues, perception and decision errors can be named as some of the human-related failures.

Data-related issues, are the problems that are faced at the data flow within the system. It is a very important issue due to the considered autonomous nature of the U-space. Data-related issues can rise with cyberattacks or providing inaccurate/delayed data (e.g. providing faulty/delayed geofence data, inaccurate weather, terrain data).

Infrastructure-based failures, represent the issues that are mostly related to vertiports. Vertiport unavailability, surface contamination, debris that can affect take-off or landing can be given as some of the vertiport related issues. Additionally, failure of infrastructures for UTM system to operate safely such as CNS and information management systems (INS) can be considered as well.

Environmental events, define the adverse environmental effects that lead to a contingency situation. Those events can vary, e.g. adverse weather conditions, volcano eruptions, air pollution, bird strikes.

Base Requirements for the Contingency Management of AAM

Every part of the AAM system must be taken into consideration to develop a system-wide contingency management framework. Thus, to achieve this holistic approach in U-space, the minimum requirements have to be defined. In this section, we covered the U-space stakeholders' tasks and main contingency sources to generate a preliminary/representative list of requirements towards a comprehensive capture of the system essentials, associated to each key U-space stakeholder.

To take a first step in providing system-wide contingency strategies for AAM, needs of the system have to be defined. We proposed base requirements by

evaluating the undergoing research on contingency management for AAM and manned aviation, considering the structure within the ConOps., and by defining the needs to achieve such a system. The base requirements that are explored under this study are considered for each stakeholder separately, which are operators, service providers, drones, public, vertiports, passengers, and authorities.

Minimum requirements for the operators, their validations, and the possible verification processes can be listed as in the Table 1.

Table 1. Requirements for Operators

Operators		
Requirements	**Justification**	**V&V**
The adequacy of the contingency procedures (CPs) must be ensured through flight tests and simulations	To see if CPs are applicable and enough to resolve contingency situations	Analysis / Simulation of CPs / Tests
PICs/Supervisors must be trained properly for performing CPs	To see if PICs are capable of executing CPs. If not to make them proficient to execute CPs	Trainings / Tests for PICs
PICs/Supervisors must monitor the contingency process and step in if it is needed	To increase the safety level since PICs/Supervisors will have the control	Tests for PICs/Supervisors
Flights must be followed to see if it's conforming to the plan and situational awareness must be viewed	To not interrupt the U-space traffic and to see if everything is going as planned	Analysis / Simulation environment to observe flights
CPs must comply with general aviation and manned aviation regulations in shared airspace	To not interrupt and endanger the general aviation traffic in shared airspace	Analysis / Simulation to observe the traffic behavior

Base requirements for the service providers, why those requirements are needed, and the general idea about how they can get verified are given in the Table 2.

Table 2. Requirements for Service Providers

Service Providers		
Requirements	**Justification**	**V&V**
Required data (weather, terrain, etc.) must be provided at all times	To provide situational awareness and keep the system updated with recent info.	Work on similar systems as general aviation / Tests
If the provided data is insufficient/inaccurate, proper forecasts must be made available for operators and PICs	To provide situational awareness and keep the system updated with recent info.	Simulation / Work on similar systems as general aviation / Tests
Traffic information must be provided accurately	To provide situational awareness and keep	Work on similar systems as

to/from all the traffic users and U-Space stakeholders	the system updated with recent info.	general aviation / Tests
CPs must be conducted by considering the capacity limits of airspace	To prevent other risks and not increase conflictions by taking actions not considering capacity	Analysis / Simulation
In case of LOC of a drone, trajectory estimation and possible trajectory deviations must be predicted	To assess the risk to other U-space users and take actions accordingly	Simulation / Models can be developed for estimation
The system must have redundant back-up systems to provide and keep user data all the time	To keep the system updated all the time and feed with recent information	Work on similar systems as general aviation / Tests
Special line that is not open for interruptions must be used to communicate with third parties in case of an emergency	To provide safe contact channel with third parties immediately in case of an emergency	Work on similar systems as general aviation / Tests
CPs must be cooperative with other U-space users	To ensure all the users are in safe situation and provide the best solution possible	Analysis / Simulation to observe the system

Defined minimum requirements for the drones to build contingency strategies upon, their purposes, and the possible verification methods can be given as in the Table 3.

Table 3. Requirements for Drones

Drones		
Requirements	Justification	V&V
The drones must have redundant back-up systems (if applicable) for providing data all the time	To keep the drones updated all the time and feed with recent information	Work on similar systems as general aviation / Tests
Regular maintenance on drones must be followed to ensure safety	To capture the failures on drones and ensure safety	Structural tests, etc.
Drones must comply with their certification	To prevent unexpected situations	Vehicle tests / compare with certification

For the sake of public environment and acceptance, base requirements, their validations, and the possible verification processes are defined as in the Table 4.

Table 4. Requirements for Public

Public		
Requirements	Justification	V&V
All the CPs must be developed by considering ground risks, urban areas. Plans	To not endanger the urban areas	Simulation / Tests

must be prepared with safe distances		
In case of an emergency, possible crash sites must be predicted and third parties must be contacted immediately to evacuate the area	To not endanger the urban areas and to be ready for a possible crash	Simulation / Tests

Minimum requirements for the vertiports, their validations, and the possible verification processes are given in the Table 5.

Table 5. Requirements for Vertiports

Vertiports		
Requirements	Justification	V&V
Vertiports must be prepared/controlled before and after flights for providing safe take-off/landing	To provide safety in vertiport operations - Similarity argument (airports)	Preparation tests for take-offs / landings
Safety instructions must be prepared for Vertiport users (passengers, UAV operators, etc.)	To set rules for Vertiport users to increase safety - Similarity argument (airports)	Tests

Minimum requirements for the passengers can be listed as in the Table 6.

Table 6. Requirements for Passengers

Passengers		
Requirements	Justification	V&V
Passengers must comply with the defined safety rules and procedures	To raise awareness of passengers in terms of safety - Similarity argument (general aviation)	Tests

Lastly, base requirements for the authorities, their validations, and the possible verification processes are defined in the Table 7.

Table 7. Requirements for Authorities

Authorities		
Requirements	Justification	V&V
Regulations must be set for shared airspace (in case of a contingency)	For proper functioning - Similarity argument (general aviation)	Regulations / Work on similar systems as general aviation
Regulations must be prepared for U-space	For proper functioning - Similarity argument (general aviation)	Regulations / Work on similar systems as general aviation
PIC trainings must be under control	For proper functioning -	Work on similar systems

	Similarity argument (general aviation)	as general aviation
Assess and inspect all the stakeholders' performances	For proper functioning	Work on similar systems as general aviation

Conclusion and Discussion

In this paper we proposed the minimum requirements that are needed to build a holistic approach for contingency management in envisioned AAM concept. Those requirements can be utilized as a guide to generate proper measures for off-nominal situations that can be faced during operations by considering the tasks of each and every stakeholder within the system. The generated measures can be detailed such as in case of a contingency what needs to be done by which partner and how, which stakeholder needs to communicate with which stakeholder, and so forth.

As a future work, we will study on a matching-based contingency planning system where each and every task of every stakeholder are matched with all of the contingency sources that can be faced to extract and set logical contingency cases and plans for every situation and provide solutions to them step by step, under the AMU-LED project. After extracting all the scenarios possible, we will work on to solve them with algorithmic approaches, as well as performing the required validation and verification activities.

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