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Abstract		
<p>JARUS WG-7 has been tasked with establishing a categorization scheme describing the level of regulatory involvement for the varying types of UAS and UAS operations. The categorisation concept, described in this paper, proposes the level of involvement of National Aviation Authorities in the issuance of Type Certificates, Operational Approvals and Certificates of Airworthiness for UAS.</p>		
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1 Purpose and Scope

1.1 Introduction

Across the entire world, Unmanned Aircraft Systems (UAS) operations are being introduced into all airspace at an exponential rate. The size and complexity of these aircraft and operations vary from small consumer toys flown in close proximity to the operator¹ to large aircraft operating far from a base station in airspace traditionally reserved for manned aircraft. Yet regulations of many nations have been slow to evolve to accommodate these new airspace entrants and control the risks they introduce into the airspace.

This document proposes a risk-based concept for performance-based regulations of UAS operations. **This concept is intended to inform the rulemaking authorities on future regulation of UAS operations and provide a baseline regulatory structure to allow technical and operational work efforts to define and standardize individual components of UAS operations.**

Section 1 describes the background, purpose, and scope of this document.

Section 2 describes the UAS operational categorization concept, the considerations and rationale for its use, and introduces the three categories of operation.

Section 3 describes Category A, low risk operations. It provides details on the approach and considerations for the category, a set of general parameters with rationale, a discussion on sub-categorization, and proposal for education and safety promotion for Category A operations.

Section 4 describes Category B, medium risk operations. It provides details on the approach and considerations for the category, details of the Authority involvement in the aircraft design and airworthiness/operational approval, and provisions for Safety Management Systems (SMS)/Continued Operational Safety (COS).

Section 5 describes Category C, high risk operations. It provides details on the approach and considerations for the category, details on the Authority involvement in the aircraft design and airworthiness/operational approval, and provisions for SMS/COS.

1.2 Background

In 2007, Joint Authorities for Rulemaking on Unmanned Systems (JARUS) was formed as a worldwide group of regulatory experts from the Authorities. Its purpose is to recommend a single set of technical, safety and operational requirements for all aspects linked to the safe operation of UAS.

JARUS's initial work plan included development of system safety guidance, certification specifications, and operational approval/pilot licensing. Within this work, there was an early acknowledgement by the JARUS members that many UAS operations posed significantly less risk than the manned aircraft the Authorities had traditionally regulated. These operations would need a level of regulator involvement which was more proportionate to this reduced level of risk, allowing for a more cost conscious regulatory burden while still controlling for the risk being introduced into the airspace and to the public. As the JARUS work planned expanded, the plenary documented the need to formalize an international consensus on the regulatory involvement in all UAS operations. The plenary created Work Group 7 (WG-7) and tasked them with this development.

¹ Operator: A person, organization or enterprise engaged in or offering to engage in an aircraft operation. The operator may or not be the pilot but is accountable for the operations.

In April 2015, JARUS WG-7 was officially chartered with establishing a categorization scheme describing the level of regulatory involvement for the varying types of UAS and UAS operations. The categorisation concept, described in this paper, proposes the level of involvement of National Aviation Authorities.

1.3 Purpose

This document proposes a risk-based concept for performance-based regulations of UAS operations. This concept is intended to inform the rulemaking authorities on future regulation of UAS operations and provide a baseline regulatory structure to allow technical and operational work efforts to define and standardize individual components of UAS operations.

The content of this document is not intended to be binding nor a singular document for the Authority to propose as regulation. Rather, it is a set of principles and proposed strategy which, when followed, will allow the Authority to properly set risk based proportionate UAS regulation within the context of any individual legal Authority.

It is recognized that societal values will influence the application of UAS regulations. The variance in societal norms, for instance between a conservative citizenry who may need little government regulation and oversight versus a risk-taking citizenry who may require stricter regulation and oversight, is a factor which hinders international agreement on specific aspects of regulation. However, this document provides for fundamental agreement on principals of safe operations of UAS.

This document is intended to be a living document throughout the duration of the controlling work group's charter.

1.4 Scope

This document provides a recommended UAS regulatory strategy for all operational environments. The regulatory strategy includes consideration for aircraft design, production, maintenance, operational approval, pilot competencies, regulatory enforcement, and safety promotion.

State/governmental operations are beyond the scope of this document.

Space operations are beyond the scope of this document. Suborbital operations will be encompassed in the scope of this document in the future.

2 Categorization

The size, performance and complexity of UAS are expected to vary significantly, as well as the variety and complexity of related operations. While it is expected that some UAS will conduct similar roles to manned aviation, the obvious divergence from the manned environment is that there is no pilot on board; hence traditional manned aviation regulatory philosophy may not be fit for purpose for UAS. The challenge therefore is to design a regulatory regime that allows the industry to develop while ensuring the other airspace users, critical infrastructure and people on the ground not exposed to undue risk. This must take into account the plethora of systems and roles that are envisaged.

2.1 Risk-Based Approach

The challenge for global aviation regulators is to establish proportionate methods and criteria for design, construction, production and operational approvals for UAS, where required for safe integration into airspace, such as non-prescriptive, performance-based regulatory approach.

It is envisaged that UAS may take on similar roles to manned aviation; the distinct, and somewhat obvious, difference of no pilot being on board the aircraft renders obsolete some of the more traditional methods utilized in the regulation of manned aviation. Furthermore, while the numbers of UAS types are limited at present, the predicted range of types, operating environment and performance of future systems require a flexible approach that regulators can adopt. The cornerstone of the categorisation scheme therefore is the adoption of a risk-based approach.

The potential to harm people on the ground harm other users of the airspace and cause damage to critical infrastructure are the predominant factors to consider in taking the risk-based approach. There are other risks that are not within the aviation regulators remit (e.g. privacy, security, etc.). Figure 1 details the risk areas to be considered. In considering these risks, the performance, operating environment and size of the UA need to be understood. For example, an UAS that is conducting surveys in the Arctic will require a wholly different approach to the same system being utilized over towns and cities.

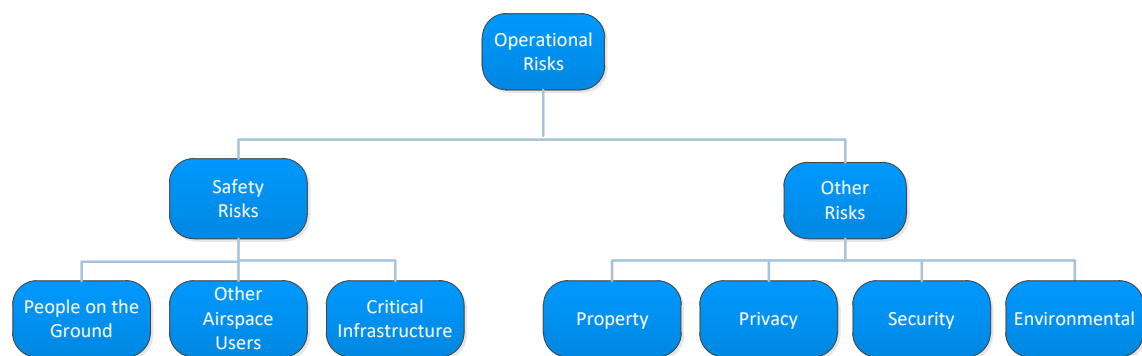


Figure 1: UAS Risk Considerations

2.2 Identification of Risks

2.2.1 Safety Risks

Safety, as defined by ICAO, is the state in which risks associated with aviation activities, related to, or in direct support of the operation of aircraft, are reduced and controlled to an acceptable level. Safety risks associated with UAS operations can be grouped according to

the victim parties. This includes people on the ground, other airspace users, and critical infrastructure.

2.2.1.1 *People on the ground*

A primary safety risk associated with UAS operations is harm to people on the ground. The victims could be participants who are directly or indirectly involved, or people not associated with the UAS operation.

Harm could result from a direct impact of the aircraft, a component of the aircraft, or its payload with people causing injury or death. This includes the harm resulting from post-crash explosion or fire. Harm could also result indirectly from the UAS. For example, a low flying UA could distract the driver of a motor vehicle causing an accident. Both direct and indirect harm to people on the ground could be accidental or purposeful. However, the safety risk is only associated with accidental harm. The risk of purposeful (wilful) harm is considered a security risk (see Paragraph 2.2.2.3).

2.2.1.2 *Other Airspace Users*

Another safety risk associated with UAS operations is harm to other airspace users. Other airspace users specifically address manned aircraft and include operations such as commercial aircraft operations, general aviation operations, suborbital and space vehicles.

Harm could result from a direct impact of the UA or component of the UA with another airspace user² causing damage to their property³, injury and/or loss of life. Harm to other airspace users could also result from proximity to the UA⁴. Evasive manoeuvring or turbulence caused by the UA could cause a manned aircraft to lose stability or become distracted and lose situational awareness to other air traffic or terrain.

2.2.1.3 *Critical Infrastructure*

The risk of damage or destruction of critical infrastructure is also a safety risk. Critical infrastructure can be described as the assets that are essential for the functioning of the society (for example, economy, security, health or public safety). It can include electrical power generation and distribution systems, communication systems, food and water supply, mining, production and distribution of energy resources (e.g. oil rigs, nuclear plants), as well as national transportation systems including land, maritime and aviation. Additional considerations need to be given to UAS operations which could pose a risk to such critical infrastructure before granting operational approvals.

Damage to critical infrastructure will be assessed on a national basis.

2.2.2 *Other Risks*

Other important risks associated with UAS operations are property, privacy, security, and environmental. These risks, while important for each Authority to consider in their own respects, are not of primary consideration in this classification scheme because they tend to deal more with cultural values which can vary so widely that consensus may not be easily reached.

2.2.2.1 *Property*

Operation of the UAS creates a potential for damage to property due to malfunctions or

² In traditional aviation, this is known as a mid-air collision defined as an accident where two aircraft come into contact with each other while both are in flight.

³ Property mentioned in this paragraph refers to aircraft (or other aerial vehicles) and payload in the air.

⁴ In traditional aviation, this is known as a near mid-air collision defined as an incident associated with the operation of an aircraft in which the possibility of a collision occurs.

human error. To encourage the UAS operator to follow proper rules for operations, the Authority could implement measures such as restricting operations over private property and/or require some form of insurance to operate the UAS over property.

2.2.2.2 Privacy

An additional risk associated with UAS is that of privacy. UAS, primarily because of their ability to be uniquely small and remotely operated, combined with advancements in camera, video, and audio technologies provide a new means for surveillance activities. A common feature of small UAS is a camera or video recorder payload with either on-board storage or the ability to stream the content to the operator or third party. This means of surveillance is a disrupting factor to any real or perceived sense of privacy.

UAS operations present a threat to personal privacy which can be defined as the ability of an individual to hide their activity and express themselves selectively. Environments or structures meant to seclude people can be uniquely neutralized or penetrated by UAS. Privacy of groupings of people or of third parties is similarly at risk.

This risk of privacy due to UAS operations can be managed by regulations via operational limitations, limitations on design, or, in extreme instances, outright bans on UAS usage. However, because cultures place differing values on privacy, its effect on regulating UAS operations is excluded from the categorization scheme presented in the next section.

2.2.2.3 Security

There is a potential security risk associated with UAS operations although security has not been considered as part of the categorization work. Security risks differ from the safety risk described in the earlier section because they are defined against the motives of people who are directly or indirectly involved, or people not associated with the UAS operation. These are risks associated with motives of deliberate, malicious intentions. In direct involvement, a pilot can purposefully fly the UA with intentions of harm to persons or property by controlled flight crash landing, through deliberate interference/distraction (e.g. distraction of motor vehicle operator(s)), or through carriage of harmful items (e.g. munitions, chemicals). Indirect involvement includes instances of 3rd party takeover of UAS (e.g. cyber threats) where control of the UA is either temporarily or permanently taken from the pilot. The routine outcome to this event would be loss of the UA. There is also additional risk that UA which was overtaken would be used purposefully to crash into people/property on the ground, and other aircraft and airspace users. However, because cultures place differing values on security, its effect on the regulating UAS operations is excluded from the categorization scheme presented in the next section.

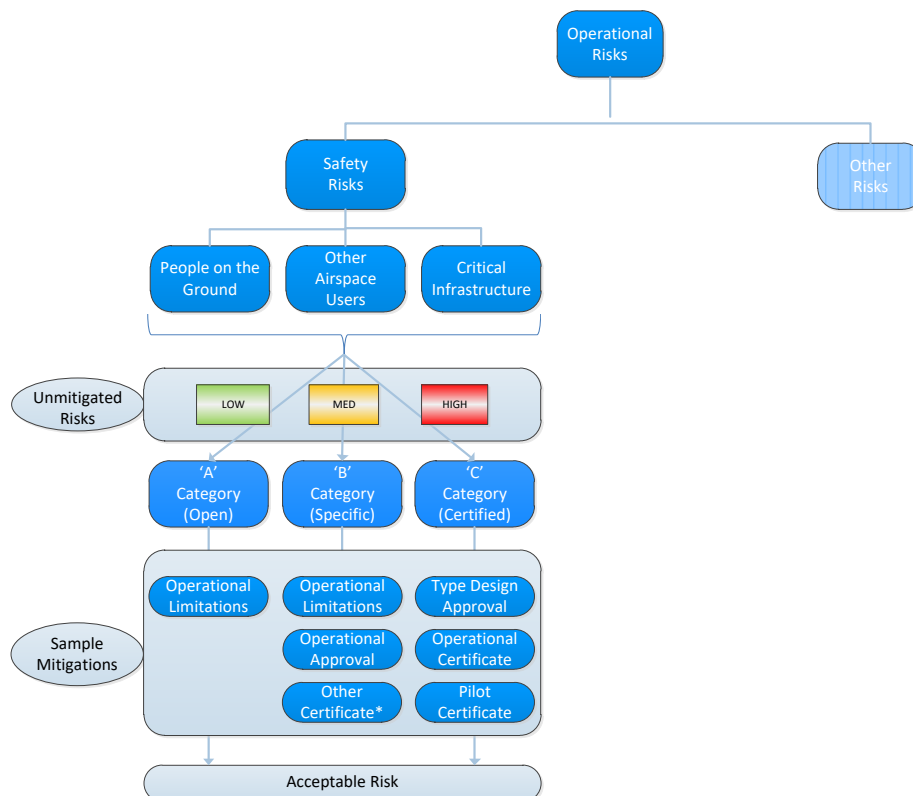
2.2.2.4 Environmental

UAS operations pose an environmental risk, which is an actual or potential threat of adverse effects on living organisms and the environment by emissions, wastes, noise, etc. Environmental risks can be local or national. Nations may desire to protect sensitive and/or fragile local settings, e.g. national parks, housing developments, from ambient noise or other emissions created by UAS operations. National environmental strategies also look to protect against ambient noise or emissions, but instead target comprehensive national outputs. These environmental risks may be managed by airspace restrictions and/or design requirements to contain noise or emissions.

Priorities on environmental issues vary widely from nation state to nation state. Consideration for categorization of UAS operations therefore does not consider environmental issues.

2.3 UAS Operational Category Development

In developing the categories for the involvement of regulators in the UAS sector it is important that a proportionate approach be taken, focusing on the unmitigated⁵ risk of the intended operation. Utilizing the Concept of Operations (ConOps) methodology and understanding the full implications of the UAS operations determine the level of regulatory involvement to achieve an acceptable level of safety. There will be low complexity systems operating in relatively benign operating environments that will require little, or no, oversight. There will be those operations that do not fit neatly into little oversight or full regulatory burden. With this in mind a three-category approach for UAS has been developed. Appropriate assessment of the risk must be undertaken to establish an aircraft operation in the correct category. Once the appropriate level of regulator involvement is applied to the operations, the residual risk of all UAS operations should be at an acceptably low risk level.



*Other Certificate: Based on the outcome of the operational risk assessment.

Figure 2: UAS Operational Categorization

2.3.1 Rationale for Categorization

Categorization places a level of pragmatism into the risk based approach. In an ideal situation, each UAS operation could be assessed on its own merits and the level of regulator involvement could be assigned commensurate with the unmitigated risk. However, for unmitigated low risk operations, this approach would overburden operators and aviation regulators with a process to develop and accept, respectively, operational risk assessments. For unmitigated high risk operations, scaling regulator involvement beyond that of manned commercial air transport would undermine these existing accepted practices and is not seen as an efficient mechanism in controlling risk. A three category scheme corrects for these

⁵ Unmitigated Risk: Risk levels prior to the application of mitigations.

issues on the low and high risk end while keeping to risk based principles for all operations.

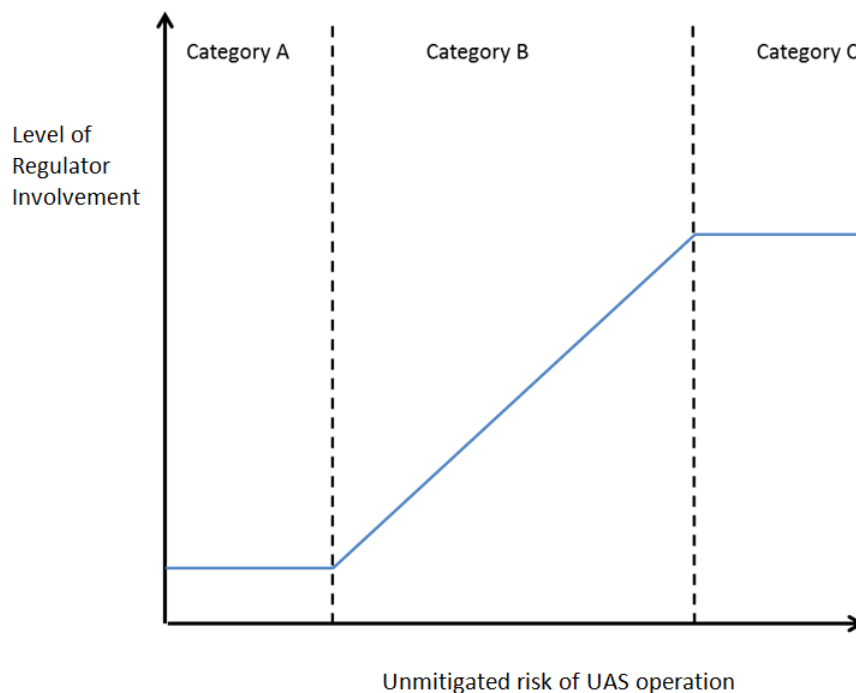


Figure 3: Regulator Involvement Based on Operational Risk

There are inherent difficulties in defining and implementing specific thresholds that determine the involvement of any regulator. Operations that reside near the boundary of two categories due to the unmitigated perceived risk will constantly challenge the assumptions that were used to derive those categories. This challenge, and any resulting re-evaluation of category boundaries, should be accepted as UAS operations evolve and mature.

2.3.2 Risk Management

Only UAS operations which pose an acceptable level of risk to people on the ground, other airspace users, and critical infrastructure should be allowed by regulation. This acceptable risk should not be misunderstood to be no risk. The effects of the regulator involvement, as determined by the UAS operational category, in combination with other mitigations discussed in the section 2.4, should ensure that the unmitigated safety risk of the operation is brought down to an acceptable level of risk.

The acceptable level of risk can be expressed as a safety objective for all categories of operation.

2.3.3 Enforceability of UAS regulation

Enforcement of UAS regulation must be considered during regulation development. Traditional participants in aviation regulation enforcement, like aviation safety inspectors, will continue their roles as appropriate. Their training and expertise will enable them to properly administer and use discretion in their safety oversight responsibility. Their traditional work environments will allow them to provide a strong oversight capability where UAS might pose the most risk to manned aviation.

Meanwhile, as the volume of UAS increases for reasons such as their ease of use and low

cost, proper administration of new UAS regulations will require new enforcement participants⁶ and techniques. Authorities may leverage local law enforcement that may not have historically enforced aviation regulation or may not have aviation experience in general. While providing for a much more comprehensive coverage capability than traditional aviation safety inspectors, the primary drawback of using local law enforcement is their relative inexperience in aviation. There is also the risk of inconsistent interpretation of the rules and regulations. Therefore, in using this type of enforcement mechanisms, the Authorities must place emphasis on suitable regulations which are clearly interpreted and where violations can be easily, quickly, and accurately determined.

2.4 Risk Mitigation Strategies

There are many ways to mitigate risks associated with UAS operations. Traditional approval mechanisms from manned aviation are appropriate and should be applied to the highest unmitigated risk UAS operations. Conversely, a less burdensome means of mitigating risk could be applied to lower unmitigated risk operations. This section describes some of the primary means of mitigating UAS operational risks.

2.4.1 Airworthiness

Less risk bearing UAS operations could be deemed fit to fly solely by the operator without interaction with an aviation authority or any type of airworthiness approval. More risk bearing UAS operations would demand more traditional approval means. The issuance of a Certificate of Airworthiness (CoA) is one means of mitigating risks associated with UAS operations. By terms of ICAO Annex 8, a CoA shall be issued by a contracting Authority based on satisfactory evidence that the aircraft complies with the design aspects of the appropriate airworthiness requirements. This implies a fundamental level of regulator involvement in the oversight of the design aspects and a set of appropriate airworthiness requirements for the UAS. Each of these provides an additional layer of safety, backed by the experience of manned aviation, to ensure the UAS has an appropriately airworthy design. Additionally, it will help ensure that the quality of the production of the UAS is able to catch defects and non-conformities to the design.

2.4.2 Operational Limitations

Operational limitations are another way to manage the risks of UAS operations. There are many operational limitations that could be applicable including altitude limitations, airspeed limitations, geographical limitations, temporal limitations, line of sight limitations, etc. For example, altitude limitations can prevent a small UAS from being lethal in the event of crash or they could control exposure to airspace where manned aviation is frequently found.

2.4.3 Operational Approvals

Operational approvals could include such documents as UAS operator certificates, specific approvals, flexibility provisions (e.g. exemptions) or permissions. These should be considered based on a risk- and performance-based approach as well as proportionality. For lower risk operations requirement of operator or pilot certificates might be too burdensome for operators as well as for authorities. For highest risk operations operator and pilot certificates should be required; the requirements should be comparable to requirements concerning manned aviation. Between the highest risk and lowest risk operations there is a great variety of operations. In most cases the need of operational approvals should be considered thoroughly, and a pilot certificate should be required. Local circumstances (e.g.

⁶ New enforcement participants could include delegated responsibilities.

population density) should be taken into account when considering whether the certificate or approval is required or not, for a certain type of operations. Equipment capability (e.g. number of rotors, fail-safe functions, and redundancy systems) should be a factor when determining appropriate level of requirements. Self-declaration (e.g. registration) could also be considered in some cases.

2.4.4 Operator Competence

The operator competence will mitigate risks associated with UAS operations. A competent operator will reduce incidents with regard to the operational limitations set forth by the Authority and ensure proper coordination, as needed, with other airspace users. Basic navigation skills remain important in many UAS operations to ensure the aircraft is flown safely. System specific training will also mitigate operational risk by ensuring proper normal and emergency procedures are followed for each aircraft type.

2.4.5 Identification

Proper means of identification of the UA (e.g. in flight) and its operator will mitigate some risk from irresponsible or uninformed use. It would provide a compliance and enforcement tracking mechanism which would instill a level of responsibility to the operator for safe operations. Electronic identification of UAS may be in most cases more practical than visual identification. The standard registration marks for international operation in place for manned aviation could be applicable to UAS, but may not be appropriate for certain types and uses which would require the development of new identification means.

2.4.6 Design Approvals and Features

Historically, regulator design approval of all aircraft has been used as an additional layer of safety in protecting the lives of the pilots, passengers, and people on the ground. This paradigm, the risk profile, shifts with the introduction of unmanned aircraft where the crash of the vehicle no longer implies fatalities on-board the aircraft. Fatalities to other airspace users and people on ground are still a possibility. However, aircraft design approval, at a vehicle and component level, can mitigate the safety risks associated with UAS operations.

Design approval can be of the rigor used for manned aviation where regulators or designees extensively review and approve all engineering aspects of the aircraft and its components to ensure it will operate its intended mission with the highest level of confidence. Design approval could also potentially be scaled down to a less onerous process. Component level approval, rather than that of the entire aircraft, could be used to mitigate specific risks. For example, an appropriately designed and installed parachute could mitigate the risk of life and property on the ground. Many Authorities already have regulatory means to approve aircraft component design, e.g. Technical Standard Orders, which could be used in this new capacity.

Design 'features' implies the requirement for specific functionality or capability on an aircraft without regulatory involvement in the design or installation⁷ of the functionality. In instances where the risk is relatively low, this 'soft' requirement could provide a level of safety assurance to an UAS operation. Standards for consumer products could be one means of scaling down regulator involvement as a 'softer' requirement than full design approval.

2.5 UAS Operational Categories

Based on the unmitigated risk associated with UAS operations, every UAS operation should

⁷ Installation may be approved by the Authority as necessary.

be characterized by one of three categories. It should be noted that the same UAS can be operated in principle in different categories because of possible different operational scenarios considered.

2.5.1 Category A (Open)

This category identifies those UAS operations that present low unmitigated risk. The concept that there will be minimal regulatory involvement applies in this category. Self-certification or adoption of industry standards may apply but there are no mandatory airworthiness requirements. Risk mitigation is applied through the adoption of operational limitations (e.g. limited to specific geographical locations and in VLOS) and hence there will be no mitigation applied through approvals issued by an aviation regulator. The operator is responsible for safe operations.

2.5.2 Category B (Specific)

Where an UAS operation goes beyond the operational limitations of Category A and safety is not (at least fully) assured by relying on a certificated design as foreseen in Category C, the operation will need to be independently assessed by the Authority under this category. An acceptable level of risk is ensured by a risk assessment of the operation that identifies the applicable mitigations, which can contain requirements addressing the design, operational limitations, and qualifications of the operator or of the pilot. Varying levels of oversight will be needed in this category. The aviation regulator will need to decide what level of oversight is required and issue an operational approval.

Several operators may want to conduct similar types of operation in category B. In such cases, compliance with the assumptions and conditions of a generic risk assessment endorsed by the Authority may be acceptable in lieu of requiring an individual risk assessment for all operators concerned.

2.5.3 Category C (Certified)

Full regulatory oversight will apply in this category similar to that of traditional manned aviation. The UAS in this category will carry high levels of unmitigated risks, which cannot be solely mitigated through operational limitations. A level of risk mitigation will be applied through regulatory oversight. A UAS in this category would likely require a Type Design approval (e.g. Type Certification), a Certificate of Airworthiness, Flight Manuals, Instructions for Continued Airworthiness, production approvals and other associated certificates of traditional civil aviation.

	UAS Operational Categorization		
	A	B	C
Operational Approval	No	Yes	No
Type Design (TC/STC)	No	Maybe*	Yes
Certificate of Airworthiness	No	Maybe*	Yes
Conformity to Design Standard	Maybe	Maybe*	Yes
Pilot License	No	Maybe*	Yes
Operator Approval	No	Maybe*	Yes
Maintenance Approval	No	Maybe*	Yes
Production Approval	No	Maybe*	Yes

*- implies that some approvals may not be mandatory depending on the outcome of the risks assessment

Figure 4: Minimum set of requirements for the specific UAS Operational Categories

Note: Figure 4 states a minimum set of requirements for the specific UAS operational categories. Authorities may desire, or be required by their legal structure; to have a higher burden on the lower risk operations than what is documented in the chart.

3 Category A – Open Operations

Category A addresses UAS operations for which an acceptable level of risk can be achieved through a performance-based approach such as by operational limitations, compliance with industry standards, and with no or minimal involvement of the regulator.

3.1 Category A Development Approach

This section clarifies the rationale and assumptions behind Category A UAS operations, aims at identifying possible types of operations falling in this category and discusses the suitability⁸ of risk mitigation measures that can be used to delineate Category A from other categories of the JARUS UAS Operational Categorization. The analysis focuses particularly on the interrelations of the risk mitigation measures, their effect on safety, as well as their enforceability.

3.1.1 Rationale for Category A

The risks of an UAS operation can be summarized as follows: mid-air collision with manned aircraft, harm to people on the ground, and damage to critical infrastructure. The regulation applicable to UAS operation should contribute to limit the frequency of occurrence of these events to an acceptable level for society. The operational categorization scheme described in section 2 stipulates that in Category A, this goal should be achieved only by operational limitations, enforcement and with no or minimal involvement of the aviation regulator given the low unmitigated risk presented by the considered operations.

Several reasons justify the existence of such a category: Firstly, experience in various countries has shown that such a regulatory concept can ensure safety in an effective and efficient manner. Secondly, the classic approach to aviation regulation, even if adapted in a very light manner, would most probably be too burdensome, due to the fact that it is inherently not fit for task, as protecting the person on the aircraft is its prime task. Thirdly, burdensome and disproportional regulation would most probably lead to the development of illegal operations, due to difficulties in enforcement given the very high number of UAS sold and the lack of understanding of the general public of the intention of the rules. It is however challenging for authorities to define proportionate risk mitigation measures that would achieve an acceptable level of safety in the most efficient and effective way possible given the relatively new nature of most UAS operations and the lack of awareness from the general public of the inherent risks of using an UAS.

3.1.2 Examples of Operations falling in Category A

This section only aims at identifying examples of types of operations that would most likely fall within Category A. This list is not intended to be exhaustive nor intended to define particular operational types.

Examples 1: Operation of an UAS designed to be used by novices. These types of unmanned aircraft usually do not exceed a few hundred grams in weight and except in rare cases, their performance is relatively limited.

Example 2: Operation of an UAS sold as a retail consumer product. Most of the time these types of UAS are used for the purpose of leisure or competition. These types of UAs are mainly designed for operations, are usually multirotor equipped with cameras, and do not exceed a few kilograms in weight.

⁸ Suitability is defined as: appropriate, necessary and proportionate

Example 3: Operation of Model aircraft. Model aircraft are UAS that can be amateur built, can exceed a few tens of kilograms in weight and have been around for many years. This activity may require specific operational needs that are usually already managed according to local regulation by aviation authorities, model flying associations, and/or clubs.

Example 4: Professional operation of an UAS that present a low unmitigated risk. For example, low airspace survey of critical infrastructure remote from human habitation.

3.1.3 Risk Mitigation Measures for Category A

This section discusses the risks of UAS operations in Category A and the suitability of mitigating measures to address these risks in order to achieve an acceptable level of safety. Those mitigations measures can be divided in three categories: operational limitations, technical requirements and educational aspects. Each of these categories offer several possibilities that can be overlapping in terms of the risks covered. It highlights the difficult task to find a balance to achieve an acceptable level of risk while not being too burdensome for authorities and users in keeping with the overall concept of Category A.

3.1.3.1 Operational limitations

3.1.3.1.1 Geographical Area exclusions

Prohibiting UAS operations over or near certain areas can be considered as an appropriate mitigation measure to protect people in other aircraft (e.g. defining aerodromes as off limits), third parties on the ground (e.g. defining heavily populated areas as off limits) as well as critical infrastructure (e.g. defining nuclear plants as off limits). This requirement is relatively straightforward to enforce, as it can be translated into static exclusion zones defined by authorities. The proportionality of this requirement depends on the dimensions of the defined exclusion zones and their use by regulators. These dimensions should depend on the nature of the geographical area that is intended to be protected and can thus be specified numerically most suitably at a national or local level. It is the Authority's responsibility to ensure that the information about geographical exclusion areas is easily available and accessible to the general public. The ability for regulators as far as legally possible to define such exclusion zones on a local level also provides more flexibility to tailor the applicability of Category A concept to the Authorities perception of risk and peculiarities.

3.1.3.1.2 Proximity to third parties on the ground

Restricting the use of UAS from over or near people limits the likelihood of these people being injured in case of an accident. The appropriateness and necessity of the limitation depends on the safety distance to people to be respected, the maximum number of persons (group of people⁹ or population density) above which an UAS can be used, as well as limiting the characteristics of the considered UAS (such as weight, speed, energy, explosiveness, etc.). Due to limited amount of occurrence data, the proportionality of such requirements is difficult to assess. A proportional approach, accepting a low level of risk, could be to limit operations where the risk is clearly high (e.g. over groups of people standing closely together) or rely on compliance to industry standards for UA operations in proximity to persons.

3.1.3.1.3 Protection of other users of the airspace¹⁰

i) *Airspace exclusions*: The UAS operator and/or pilot in Category A has to be aware and act in accordance with the specific rules and requirements in the various airspace classes and the UAS itself will not be equipped with features allowing its full and safe integration into the airspace. Operations of UAS in Category A should therefore be limited to parts

⁹ Authorities can determine how they define group of people.

¹⁰ This section also discusses limitations regarding altitude.

of the airspace where only a low density of manned operations can be assumed. Limiting the operation of UAS in Category A in specific airspaces only (e.g. not in controlled airspace or only in coordination with the air traffic service provider, away from aerodromes) and limiting the maximum flight altitude below the locally applicable minimal flight altitude for manned aviation are appropriate measures for the separation of UA from other airspace users. This mitigation measure can be overlapping with geographical area exclusions mentioned above in case of aerodromes or controlled airspace exclusions.

- ii) *Visual contact*: Even with airspace exclusions, the event of encounter with a manned aircraft cannot be ignored within Category A. Requiring the pilot to ensure direct unaided visual contact with the UA ensures that the he/she can manage its flight and meet separation and collision avoidance responsibilities while operating conditions (e.g. weather) are implicitly addressed.

3.1.3.1.4 Other considerations

Other operational limitations can be set in order to mitigate the risks in Category A. For instance, the complexity of considered operations can be limited by excluding certain particular types of operations (e.g. autonomous flights, control of multiple UAS by a single pilot, night operations, etc.). Those complementary operational limitations would cover general risks associated with the use of UAS.

3.1.3.2 Technical requirements

3.1.3.2.1 Operational UA containment

Technical features such as geo fencing that automatically prevents an UA from leaving permitted airspace either on a static basis (the active exclusion zones are known by the UAS) or a dynamic basis. Mandating geo fencing could be an effective means to prevent excursion from permitted zones and/or intrusions into prohibited zones for Category A (e.g. non-segregated airspace, critical infrastructure, etc.). Geo Fencing could also prevent accidental unauthorized operations over groups of people in the case of large, pre-planned events if it can be monitored on a dynamic basis. However, in keeping with the overall concept of Category A, this technology should be available at a reasonable cost as well as easy to implement. This should be considered when determining if geo fencing should be mandated for all UA or just to a subset depending on size or weight. Furthermore, a geo fencing requirement should not alleviate the operator's overall responsibility to ensure safe operation. To fulfil this objective, information about geographical exclusion areas should be easily available and accessible to the general public.

3.1.3.2.2 Identification means

The ability to identify the UAS and its user would create an incentive for the UAS operator to adhere to applicable rules of Category A by serving as a deterrent to discourage unreasonable operation, and thus lead to a positive impact on overall safety. Mandating such features could give the authorities information on which UAS is used and where on a real-time basis. However, in coherence with the overall concept of Category A this technology should be available at a reasonable cost as well as easy to implement. There can also be other identification means that do not solely rely on new technologies but on existing traditional registration procedures, however such procedures are considered unlikely to limit the involvement of the regulator in Category A.

3.1.3.2.3 Technical specifications

Technical specifications limiting the risk for people on the ground without completely eliminating it could, to a certain extent, be implemented by product safety requirements, which would need to be coordinated with respective requirements in the aviation domain. An approach eliminating almost entirely the risk for third parties on the ground would be to establish stringent technical specifications of any UA (regarding e.g. weight, speed,

frangibility, etc.) used in proximity to public thus limiting the energy of a potential impact with a person on the ground to a non-lethal level or assuring harmless design characteristics. This would probably lead to very low weight, speed and altitude limits for UA that could be operated over people, thus severely limiting the operations covered by Category A in populated areas in general. Such approach could indeed create difficulties for authorities due to the potentially very high number of operations that fall into Category B and would need to be approved, with an uncertainty on the positive impact on safety of this measure.

3.1.3.3 Educational aspects

3.1.3.3.1 Awareness

Key elements in the Category A are responsibility and awareness of the UAS operator and/or pilot. This starts with the need to make UAS buyers aware that they operate an aircraft subject to specific limitations and requirements. The vendor should inform the customers about rules to apply for operating UAS. Users' awareness can also be raised with information campaigns targeting the general public and built around video clips, posters and important messages.

3.1.3.3.2 Basic Aviation Knowledge

Depending on the delimitation of Category A, awareness might not be considered sufficient for the higher end of the covered operations. Basic aviation knowledge could be required from the pilot in that case and this basic aviation knowledge could be obtained on a voluntary basis based on learning objectives and could be sanctioned by the Authority in an appropriate form (for example a certificate or equivalent). The necessity and proportionality of a knowledge test must be assessed and heavily depends on the extent of Category A as defined by the Authority. An e-learning tool could be developed in this regard and is deemed coherent with the overall concept of Category A. Authorities could also rely on the education provided by approved model-flying associations.

3.1.3.3.3 Enforcement

Depending on the legal system of the Authority involved, rules may be enforced by local forces or by other appropriate agencies within the Category A. Immediate sanctions proportionate to the type of infraction similar to those applicable to road users would play a significant role in the education of users. In order to fulfil this objective, rules applicable to Category A must be easily understandable by users and enforceable by local forces, thus the criteria used for delineating Category A from other categories of operations should be as simple as possible. Aviation authorities should coordinate with enforcement authorities to provide the necessary information on limitations and rules applicable to Category A.

3.2 Category A General Parameters

This category is for low risk UAS operations and therefore would require limited or no involvement of Aviation Authorities. Neither airworthiness approval nor licenses for operators and pilots are envisaged.

3.2.1 Risk Assessment

For Category A operations a risk assessment can be conducted by an Authority to derive general parameters that will achieve this safety objective given the safety risks taken into considerations:

- risk towards people on the ground;
- risk towards other airspace users;
- risk towards critical infrastructures.

For Category A operations the assessment of the different risks mentioned above can be

simplified. For instance, concerning the risk towards other airspace users, there are risk mitigations measures already adopted by various Authorities across the world to minimize this risk for operations that corresponds more or less to Category A concept. Those risk mitigation measures are most commonly the following:

- (i) operation in visual line of sight (VLOS),
- (ii) maximum height of operations set below minimum flight height for regular manned aviation operations and
- (iii) safety distance imposed regarding aerodromes.

These risk mitigations have demonstrated their effectiveness by experience and have been largely adopted around the world since no major incident with other airspace users has been recorded when UAS were operated within these conditions. Given the complexity of assessing this risk to other airspace users, there is advantage to using the relative harmony of commonly adopted operational rules in this area by relying on experience and choosing these parameters as a basis for the definition of Category A.

Furthermore, the risk to critical infrastructures applies to large size UAS that, even if they do not crash on third parties on the ground, would cause prejudicial damages to any infrastructure linked to a State's economy, security, health and public safety. Since Category A applies to UAS that will have limited dimensions and mass and for which exclusion zones are likely to be set up around critical sites, the risk to critical infrastructure is limited for this category of operation.

The safety objective for Category A operations therefore depends almost entirely on the risk to people on the ground if the risk mitigation measures (i), (ii), and (iii) from above are implemented. This risk can be assessed by determining the probability of having a crash resulting in a fatality. The conclusions of such an assessment can then help derive general parameters defining the boundaries of Category A operations in order to meet the safety objective.

3.2.2 General and Operational Limitations

There is a general set of operational limitations that would ensure the three operational safety risks identified in section 2.2.1 are managed to an acceptably low level.

3.2.2.1 Proximity

UAS should only be operated from a safe distance¹¹ from critical infrastructures and other airspace users or any group of people¹² who are not part of the operation. This could be accomplished with capability for geographical exclusion areas (Geo-fencing).

3.2.2.2 Dangerous Items

No UAS should carry dangerous items¹³ on board.

3.2.2.3 Multiple UAS

A pilot in command should operate only one UAS at any given time.

3.2.2.4 Dropping and dispensing of items and substances

No object or substance should be released, dispensed, or dropped from an UA except in conditions prescribed by the Authority.

¹¹ Authorities can determine what a safe distance is.

¹² Group of people: As defined by the authorities.

¹³ As defined in national standards.

3.2.2.5 ***Operating conditions***

UAS should be operated in weather and visibility conditions that allow unobstructed visual contact to be maintained with the UA by the pilot to ensure ability to remain well clear of other airspace users and obstacles.

3.2.3 **Use of Airspace and Flight Rules**

There is a general set of airspace and flight rules that would ensure the three operational safety risks identified in section 2 are managed to an acceptably low level.

3.2.3.1 ***Visual-line-of-sight (VLOS)***

Operations should only be operated within VLOS¹⁴ of the pilot.

3.2.3.2 ***Airspace limitations***

Operations in any controlled airspace should require prior coordination with the air traffic service provider in accordance with the Aeronautical Information Publication (AIP).

3.2.3.3 ***Right of way***

Operations should give right of way to all manned aircraft.

3.2.3.4 ***Distance from aerodrome***

Operations should remain a safe distance¹⁵ from aerodromes not excluding the possibility for UAS to be operated below the Obstacle Limitation Surfaces (OLS) established around aerodromes.

3.2.3.5 ***Altitude below manned aviation***

Operations should normally be limited to altitudes below those for regular manned aviation operations.

3.2.4 **Aircraft Design**

There is a general set of aircraft design characteristics that would ensure the three operational safety risks identified in section 2.2.1 are managed to an acceptably low level.

3.2.4.1 ***Maximum Mass***

Maximum mass of the UA should be set to be commensurate with the intended type of operation and its environment.

3.2.4.2 ***Autonomous aircraft***

Autonomous aircraft¹⁶ should not be operated under category A.

3.3 **Sub-Categorization**

Even within Category A the range of operations and the associated risk varies significantly and requires tailored operational limitations. While it is commonly accepted that UAS of a few grams and limited performance are operated by untrained "pilots" like children/families

¹⁴ An operation in which the remote pilot maintains direct and unaided visual contact, other than corrective lenses, with the UA. The capability will allow the remote crew to maintain direct visual contact with the aircraft to manage its flight and meet separation and collision avoidance responsibilities.

¹⁵ Authorities can determine what a safe distance is.

¹⁶ Autonomous Aircraft is defined as an unmanned aircraft that does not allow pilot intervention in the management of the flight.

even in densely populated areas, the operation of an aircraft of a few kg would pose an unacceptable risk to third parties when operated in the same environment and requires more robust mitigations.

Reasonable operational limitations for vehicles where an impact is expected to result in casualties on the ground or in other aircraft require the full scope of mitigations as foreseen for Category A. The application of the same set of mitigations as applied to the smallest vehicles would not seem to be compatible with the current and general safe practice e.g. operation of toys in parks and backyards.

A first subcategory could be defined for harmless UAS. UA in this subcategory would feature appropriately limited technical specifications (e.g. mass, size, speed) that would justify their operation without taking into account some of the general parameters for the open category (see 3.2.1). For the operation of UAs with technical specifications that go beyond those for the first subcategory, additional subcategories could be established, requiring further mitigations (e.g. operational, technical, and educational) identified in 3.1.3. The subcategories should be established in a way that leads to a harmonized safety level as described in 2.3.2.

3.4 Category A Authority Involvement

3.4.1 Registration

Registration of UA is a prerequisite for operator identification, as described in sections 2.4.5 and 3.1.3.2.2. The use of traditional aircraft registries and their underlying international legal framework (i.e. ICAO Annex 7) is considered to be inappropriate in particular for smaller systems, which are primarily used domestically. Furthermore, the expected high volume of UA would create an excessive administrative workload for authorities if existing registration systems and processes for manned aviation would be used for all UA. Therefore, for Category A operations, Authorities should establish technical and administrative solutions that maximise the use of the registry for the purposes of identification (e.g. by ensuring accessibility for law enforcement) and minimize unnecessary administrative burden (e.g. by enabling the use of electronic or network based solutions). Different criteria could be used for different UAS subcategories. When deciding which UAS should be registered for Category A operations, Authorities should consider the positive benefit of inferred operator accountability while weighing the added safety benefit of identification. Authorities may also wish to consider privacy and security aspects in their ability to positively identify operators.

3.4.2 Safety Data Collection

The current proposal for classification is based on assessing the unmitigated risk of the operation of the UAS. This assessment of the risk is done based on all available current knowledge of the risk of operations, which is mainly based on the limited operational experience available at some of the Authorities. From the perspective of risk based methodologies, this means that the risk assessment is primarily based on expert judgement, and quantitative or qualitative methods based on data as much as possible. Therefore, we currently speak more of 'perceived' risk.

It would be preferable to base the risk assessment on objective, quantitative data. This means that operational data from UAS operations should be collected and analysed to provide a quantitative substantiation of the expert judgement that is currently being used. With this data the JARUS risk assessment methodology that is currently being developed can be used to validate the operations that will fall under the Category A operations. The data can also be used to assess other operations in order to properly define Category A to include all unmitigated low risk UAS operations.

In order to assess the proportionality of such risk mitigation measures, the gathering of occurrence data is crucial, allowing a constant monitoring of the accepted level of risk by the regulator who can amend the risk mitigation measures if such action is needed. Alternatively, or in combination with this collection, regulators could review the safety benefits of a third-party liability insurance requirement. Additionally, the efficient occurrence data reporting would allow a regulator to assess the impact of such an amendment on safety.

3.4.3 Informing Enforcement Personnel

Authorities who rely on local forces to enforce the regulation applicable to Category A operations should provide training of these enforcement personnel to complete their tasks. This training should introduce UAS types and applications, the risks associated to their use and the applicable regulation. Guidance could also be given on how to characterize an illegal UAS operation and what appropriate action should be taken in such a situation. Enforcement personnel can be trained via a web-based application and should be equipped with tools to help them determine if a UAS operation is operating illegally.

3.4.4 Education and Safety Promotion

Category A envisages no or low involvement from the Authority with no formal approval process. However, the Authority involvement should not be limited to defining the operational limitations and technical specifications of mandatory features for this category of operation. The Authority should play an important role in promoting the applicable safety rules to the general public by using different available means such as consumer leaflets and safety promotion campaigns. A given user should not be expected to understand the subtleties of the regulation but should be made aware of the principal limitations and he/she should understand the risks inherent to the use of an UAS outside of those prescribed limitations. Authorities should also, to the extent possible, inform users of non-air transport regulations which could be applicable to Category A operations (e.g. privacy or data protection, radio frequency communication, security).

4 Category B – Specific Operations

Category B addresses UAS operations that go beyond the conditions defined in Category A. The extent of regulatory involvement will depend on the risk of the operations as addressed in Section 2. Examples of operations that would most likely fall within Category B are listed below. This list is not intended to be exhaustive nor intended to define particular operational types.

Example 1: Operation of an UAS operating beyond visual line of sight of the pilot in command of the UA. The essence of this operation is that the pilot and or operator no longer maintain visual contact with the UA being operated. The use of visual observers or technological means could be ways of achieving BVLOS flight operations.

Example 2: Operation whereby a pilot or operator can control and monitor multiple UAS simultaneously.

Example 3: Operation of UAS with high level of automation.

Example 4: Operations over people outside the boundaries defined by the Authorities for Category A.

Example 5: Operations that permit objects being dropped from a UAS.

4.1 Category B Development Approach and Rationale

The extent of regulatory involvement for Category B is dependent on the operational risk assessment using a methodology such as the Specific Operations Risk Assessment (SORA)¹⁷.

The traditional approach used in manned aviation may not be appropriate for UAS Categories A and B. Therefore, the concept of the SORA was developed for Category B UAS. The purpose of the SORA is to propose a methodology for the risk assessment primarily required to support the application for an authorization to operate an Unmanned Aircraft System (UAS) within the specific category.

The SORA serves as a means of evaluating risks for the purpose of determining the acceptable UAS operations. The operational risk assessment performed by the operator is subject to review and approval by the Authority. Category B operations are only permitted upon receipt of authorization from the Authority based on an acceptable operational risk assessment. The SORA identifies several threats that may cause harm to people on the ground, harm to other airspace users and damage to critical infrastructure, these threats relate to one primary hazard which is “UAS operation out of control”¹⁸.

The method of achieving Category B operational approval is depicted in Figure 5 whereby, the SORA assesses the safety risks (associated with people on the ground, other airspace users and damage to critical infrastructure risks), analyses the applicant’s proposed operations and establishes an adequate level of confidence that the UAS operations can be conducted with an acceptable level of risk mitigation.

The operational approval is issued to the operator by the Authority¹⁹ based on an acceptable

¹⁷ “Specific Operations Risk Assessment” developed by JARUS.

¹⁸ “UAS Operation out of control” is defined by the SORA.

¹⁹ The Authority reserves the right to delegate UAS operational approval to other approved organizations or qualified entities.

risk assessment. For harmonization of UAS Category B operational approvals, the use of the SORA to conduct risk assessments is recommended.

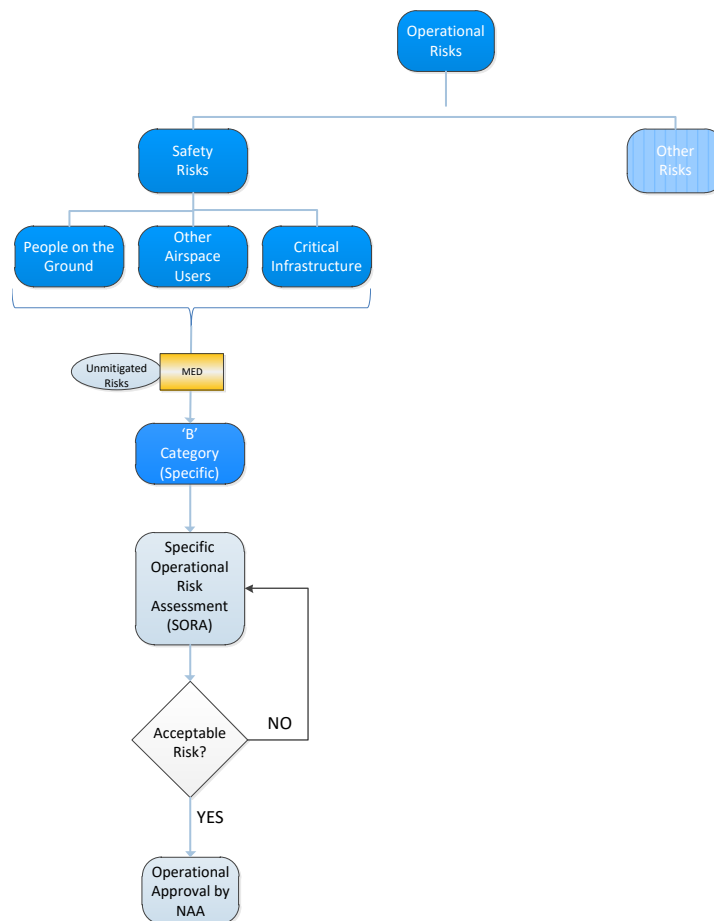


Figure 5: Category B – Specific Category Risk Assessment

As part of the risk assessment submittal, the applicant is required to provide detailed information on the pilot/operator responsible for maintaining safe operations of the UAS. Operational limitations may be put in place by the Authority based on the outcome of the SORA.

In situations whereby more operators plan to conduct similar types of operation, it would be impractical to require an individual risk assessment for all operators concerned. In order to avoid such repetitive individual approvals, the Authority may approve similar operations based on standard scenarios²⁰ with known safety risks and acceptable risk mitigations. Self-declaration based upon standard scenarios could be a basis for Category B approval. The standard scenarios will be approved and published by the regulators²¹.

Industry standards (for example, RTCA, EUROCAE) could be used to demonstrate robustness of risk mitigation measures identified in the SORA if acceptable to Authority. The

²⁰ Standard Scenarios: Description of a type of operation for which a specific operations risk assessment (SORA) has been conducted and accepted by the Authority.

²¹ Some Authorities may elect to conduct operational risk assessments to establish standard scenarios for use by the applicant.

industry standards will require an acceptance or recognition by the approving Authority.

The SORA identifies mitigation means adequate to carry out operations in Category B which is feasible up to a certain level of operational risk, and above this level of risk, the operations is to be carried out in the certified category.

Although a Category B operation does not require certification of the aircraft, the operator may choose to operate in Category B with a certified aircraft based on economic reasons, rather than based on the risk level of the operation. For example, the applicant may decide that certification (and a type certificate) will facilitate sales internationally or they may want to undertake series production.

4.2 Category B Authority Involvement

4.2.1 Risk Assessment Approval

The operational risk assessment is key to granting an authorization for Category B operations. The risk assessment will determine the different levels of evidence needed based on the intended operation. The responsibility of approving the operations in Cat B belongs to the Authority.

4.2.2 Oversight

The oversight of Category B risk assessment and approval process is the responsibility of the Authorities. Oversight of the operational approval should be risk-based.

4.2.3 Safety Data Reporting

Due to the risk associated with Category B operations, all UAS should be included in safety data collection systems. Where applicable, the concept used in ICAO Annex 19 can be used. Such systems should adequately mirror the risk structure unique to unmanned aviation, e.g. by weighing occurrences, incidents or accidents differently, depending on whether they are linked to the risk identified in Section 2.3 (people on ground, other airspace users and critical infrastructure)²².

4.2.4 Identification and Registration

Since Category B operations pose medium risks, identification of the UA and registration of the operator should be required prior to operations in order to enable subsequent identification of the UA operator. The Authority is responsible for defining the registration process and type of information needed; the registration requirement could form part of the operational approval. The ability to identify the UAS operator will enable enforcement of the applicable regulations.

4.2.5 Enforcement

Through the use of registration and identification, an operator can be held accountable for UAS activities, thus promoting public safety. The Authority should decide who is responsible for enforcement while also providing clarity on the enforcement regime. The Authority has the responsibility to provide necessary UA identification, and the conditions and limitations of operations to the enforcement officials, subject to applicable regulations.

²² Refer to 3.4.2 for basic rationale for the need for safety data collection in unmanned aviation.

4.3 International Acceptance of Cat B Authorization

One of the primary objectives of JARUS is to have harmonized regulations. Acceptance of other nations' operational approval is encouraged to avoid undue replication, administrative and technical burden. If not, the involved countries could enter into a bi-lateral/multilateral agreement.

In order for Category B operations to be authorized, an operational risk assessment should be carried out, which ensures that an acceptable level of risk is achieved by the risk mitigations established. This goal must be assured for the involved countries. For this reason, it will be of importance to agree on the acceptable level of safety by all the involved countries.

In order to accomplish an international agreement of Category B authorizations, authorities involved should agree upon a standard for UAS identification and registration for the purpose of safety and enforcement. Also, compliance with requirements of the airspace, equipage and procedures should be enforced.

4.4 Education and Safety Promotion

Education and safety promotion have a crucial role to play in Category B operations. The responsibility for knowing the rules of operations fall under the pilot/operator of the UAS for Category B. Regardless of point of sale, the operator should comply with the specific rules of the State of intended operation.

5 Category C – Certified Operations

Operations that will fall within Category C are those used for commercial air transport of passenger(s), international operations according to ICAO requirements²³, UAS operations for carriage of dangerous goods, which may result in high risk for third parties in case of an accident, and other operations that the authorities mandate.

5.1 Category C Development Approach and Rationale

For Category C, operational activities expected to be performed is mentioned in the operator certificate. The minimum set of requirements for the UAS Category C operations are in accordance with Figure 6.

It is expected that UAS will be used in a much broader variety of operations than current manned aviation. This creates the need for increased flexibility with regards to the process that governs the applicable requirements as well as the interaction between the applicant and the authority to obtain the approvals notwithstanding the need to keep an equivalent level of safety. The applicable requirements will be determined using a risk based approach although a minimum set of requirements will be needed to be eligible to receive the certificates.

5.2 Certified Operations

To operate under Category C, the operator must be certified, have an airworthy aircraft system (Airworthiness Approval of the UAS per Section 5.4), and a licensed pilot/crew as depicted in the figure below.

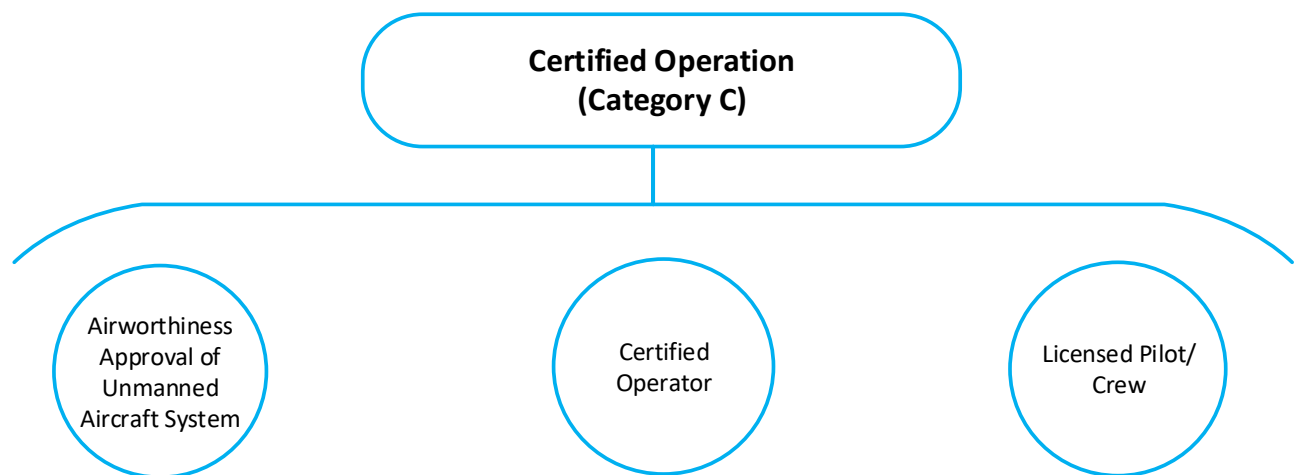


Figure 6: Certified Operation Requirements²⁴

The competent Authority has the responsibility to issue certificates when the applicant is in compliance with the requirements of Category C operations.

An airworthiness approval of the UAS ensures compliance to the airworthiness standards established in the certification basis (initial airworthiness) and the UAS complies with

²³ Unless otherwise permitted by other agreements.

²⁴ Oversight of the C2 service provider are needed to conduct certified operations as a minimum requirement.

requirements to maintain the safe operation (including continued airworthiness and other actions that may be mandated by the Authority²⁵). Refer to Section 5.4 for UAS Airworthiness Approval Requirements.

The operator can operate the UAS only when in the possession of an operator certificate. To obtain an operator certificate, an operator should provide, for the use and guidance of the concerned personnel, an operations manual that describes the organization, including qualification requirements and training for crew, operating procedures and aircraft operating requirements. The manual should be kept up to date. Refer to Section 5.5 for Certified Operator Requirements.

Certified category requires that all personnel who contribute directly or indirectly to safe UAS operations such as pilot, crew or maintenance personnel must be licensed in accordance with the applicable requirements established by the authorities. Refer to Section 5.6 for Licensed Pilot/Crew and other personnel requirements.

The C2 service provider must be under the safety and security oversight of a competent authority of a State, and the C2 CSP must provide the expected performance through the appropriate legal contracting means and should inform in due time the UAS operator of any expected or current communication performance degradation outside of the C2 Link specification. In addition the competent authority shall be informed.

Other organization approvals such as design, production, maintenance, training, may follow specific approval process to obtain the certifications needed to carry out Category C operations²⁶.

5.3 Type Certification Process

The design approval of a UAS including compliance with environmental standards should be handled the same as it is today for manned aviation through type certification.

The UAS²⁷ TC might be comprised of other certificates for components such as the UA, GCS, propellers, engines and equipment (equipment installed onboard the UA and in the control station), which leads to a certificate of airworthiness (CoA).

The UAS TC must take into account all of the equipment required for safe flight of the aircraft to include non-traditional aviation components such as detect and avoid capabilities, C2 links, automation software, etc.

Type Certificate (TC): The approach for achieving a type certificate for the UAS or related products is similar to manned aviation and the intent is to certify that the applicant has shown that the type design complies with the full set of airworthiness and environmental requirements²⁸ identified in the type certification basis. The applicant is entitled to a type certificate if the type design meets the certification basis and it also shows that the type design

²⁵ E.g. Airworthiness Directives

²⁶ E.g. To obtain a TC, a design organization approval may be needed; to obtain a CoA a production organization approval may be needed.

²⁷ Refer to the next section describing the options for TC: Option 1- UAS as a system, Option 2: UAS components.

²⁸ The minimum set of requirements for the Certified Category is defined in the CS-UAS or equivalent certification specifications. The CS-UAS is a performance based code, this means that the CS-UAS requirements are objective requirements to be complied with by means of design related requirements from specific ADS (Airworthiness Design Standard), e.g. the CS-LUAS or CS-LURS, to be listed in the certification basis. For further explanations, refer to the CS-UAS which further explains the concept of the Airworthiness Design Standard.

has no feature or characteristics that make it unsafe for the use which certification is requested.

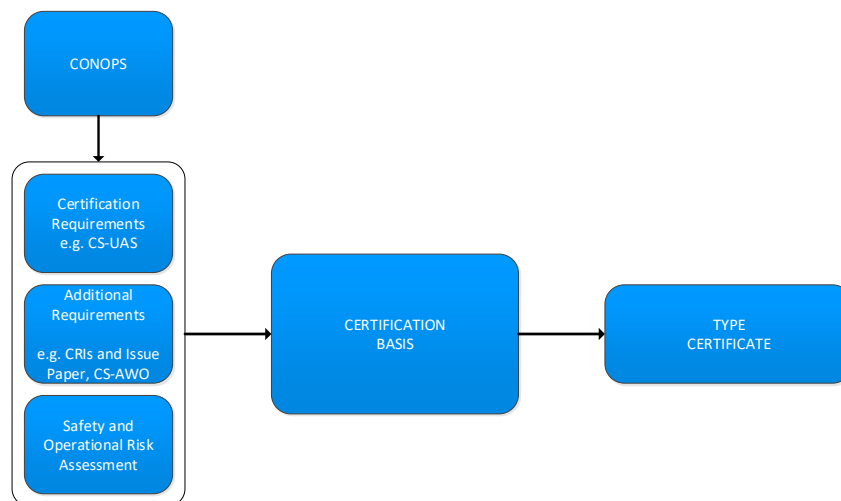


Figure 7: Type Certificate Approach

Certification basis can be based on:

- A Certification Specification for the UAS
- Additional requirements beyond the Certification Specifications used above addressing unique elements of unmanned aircraft such as command and control link, ground control station, emergency recovery, etc. will have to be agreed upon with the competent authority.
- The safety and operational risk assessment

The first two elements above have been combined to form CS-UAS developed by JARUS WG-3. The third element, the safety and operational risk assessment, has been developed by JARUS WG-6.

There are various possibilities to develop or modify certified unmanned aircraft and include:

- unmanned aircraft specifically designed to obtain its own type certificate
- unmanned aircraft derived from an existing manned aircraft design and modified towards remote piloting capability through a Part 21 process.
- The unmanned aircraft could also be operated as a manned aircraft for different flights or even parts of the flight (optionally piloted aircraft).

To account for a larger variety of operations compared to manned aviation, a safety and operational risk assessment could be used to establish the certification basis for the purpose of achieving type certification on the UAS.

Operations outside the initial TC approval would require either a re-certification (extension of scope of the initial TC) or an operational approval from the Authorities.

The following parts are eligible to have a type certificate: UAS, UA, GCS, engines and propellers.

5.3.1 Options for TC

5.3.1.1 UAS as a system

The TC of the UAS includes the unmanned aircraft, C2 link equipment, the control station,

and other components that contribute to the airworthiness of the system during flight.

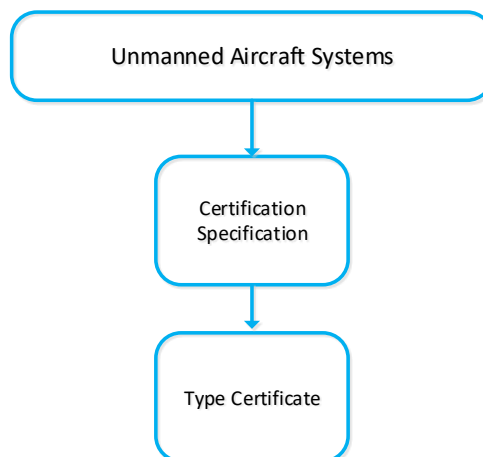


Figure 8: TC Process of the UAS as a system

TYPE CERTIFICATE for Unmanned Aircraft System , Model: TBD	
Type Certificate Holder:	Company XXX Address
UAS Element:	Unmanned Aircraft, Serial # interval (if any) Control Station; Serial # interval (if any), Launch and Recovery Equipment Serial # interval (if any), Etc.
Certification Basis:	Type Certification in accordance with: Certification Specification (CS) XXX, Special Condition, Equivalent Level of Safety, etc.
....	
....	
....	
....	

Figure 9: Sample TC for UAS

5.3.1.2 UAS components

The UAS elements such as control station, C2 data link equipment, and launch and recovery system, may be developed independently of the UA as interchangeable elements, with a range of different performances. In this case, such specific UAS elements will have their own approval.

If the elements of the UAS have separate design approvals or other forms of authorization, the required interfaces and performances should be defined and verified by the TC holder.

The UAS elements should be reflected in the type design. The TCDS will list the elements that are part of the UA type design and necessary to meet certification airworthiness requirements. Refer to Section 5.4.

Service providers could be used to supply services related to C2, communication, ground infrastructure and handling services. Depending on the service providers, various approval processes could be used by the Authorities or operators to ensure safe operations of the UAS.

The process to attain TC/design approval for specific UAS components is outlined in the follow-on sections. For ease of certification, each UAS component requires a certification specification and/or equipment standard.

5.3.1.2.1 Ground Control Station

A GCS design can be approved as a part of a UAS type certificate or can be issued its own type certificate.

It is to be expected that the control station will follow a large variety of design approaches with consideration made on ergonomics and system interfaces with respect to airspace integration.

The level of complexity of the GCS will depend on various factors, such as how much the UAS design relies on pilot input and the level of automation incorporated in the UA.

The large variety of possible designs for GCS requires processes that provide the necessary flexibility as described in section 5.3.1. Furthermore, the certification approach will need to accommodate the fact that the GCS may not be isolated as is the case for a cockpit in a manned aircraft, but part of a wider ground based infrastructure²⁹.

This requires the designer of the UAS (in case of option 1) and/or the GCS (in case of option 2) to stipulate the conditions, under which the GCS shall be operated. This will include a determination of certain core conditions or a core layer³⁰ that will follow processes similar to airworthiness with regard to changes, repair or maintenance.

The TC holders of the UA and GCS are jointly responsible for defining the mechanisms by which the handover process between control stations occur.

5.3.1.2.2 Launch and Recovery

In manned aviation, the design of the manned aircraft system is such that all the elements are part of the aircraft itself. However, for unmanned aircraft system, external components contribute to the control of the UA and are necessary to enable flight and safety of the UAS, such as the Launch and Recovery Equipment (LRE).

Also, traditionally for manned aviation, the LRE is a permanent feature of the aircraft by virtue of the fact that the take-off and landing aspects are conducted by the use of landing gear, brakes and steering control systems. In unmanned aviation, the LRE is not always part of the UA, and could allow for operations with multiple UA at other locations.

The possibility arises also whereby there may be more than one LRE as part of a UAS depending on the type of operation to be conducted.

The LRE could be included in the UAS certification basis and type certification achieved as a system as specified in Section 5.3.1.1 or as a separate component of the UAS with its own approval as specified in Section 5.3.1.2. There exist possibilities to have aspects of the LRE interfacing with the Control Station and UA.

The LRE will be constructed based on a set of design requirements applicable to the UAS using standards.

The standards addressing LRE will account for requirements to include design, interface, safety, operation, performance and maintenance of the LRE for the purpose of ensuring safety for the UA and operators.

²⁹ Ground-based control stations are the normal cases, but control stations may be located elsewhere (e.g. on other aircraft). The term GCS is used for all control stations.

³⁰ According to a tentative approach suggested by the ICAO RPASP, a core layer will be defined by the designer, which will be subject to processes similar to airworthiness. Other layers will be subject to an installation approval that will be issued to the operator by the competent authority.

5.3.1.2.3 Command and Control

From a technical point of view, the C2 Link is the logical connection used for the exchange of information between the control station and the unmanned aircraft to enable the pilot to safely aviate and integrate the UAS into the global aviation, communication, navigation and surveillance operational environment.

Thus, the C2 Link encompasses everything that is in between (and including) the UA/GCS transmitters/ receivers but the C2 Link Service (which may be third party) does not include the UA/GCS transmitters/ receivers as depicted in the figure below.

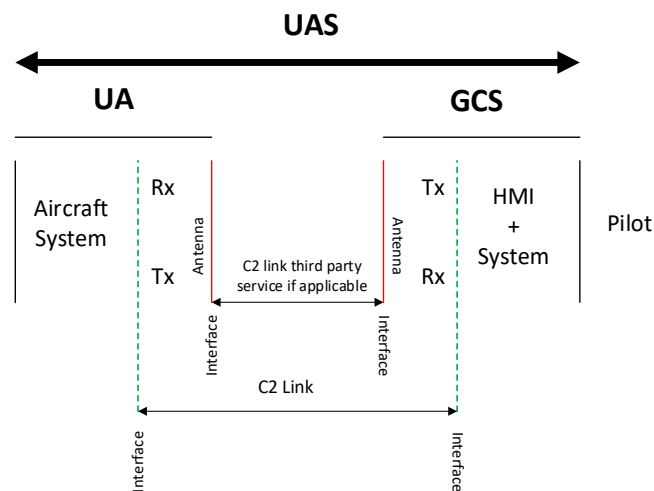


Figure 11: C2 Link

Therefore, the C2 Link includes a physical part of the UA and of the GCS (network or non-networked) which will have to be certified (as depicted in the figures below) and the C2 Link Service will have to be assessed/qualified through other processes.

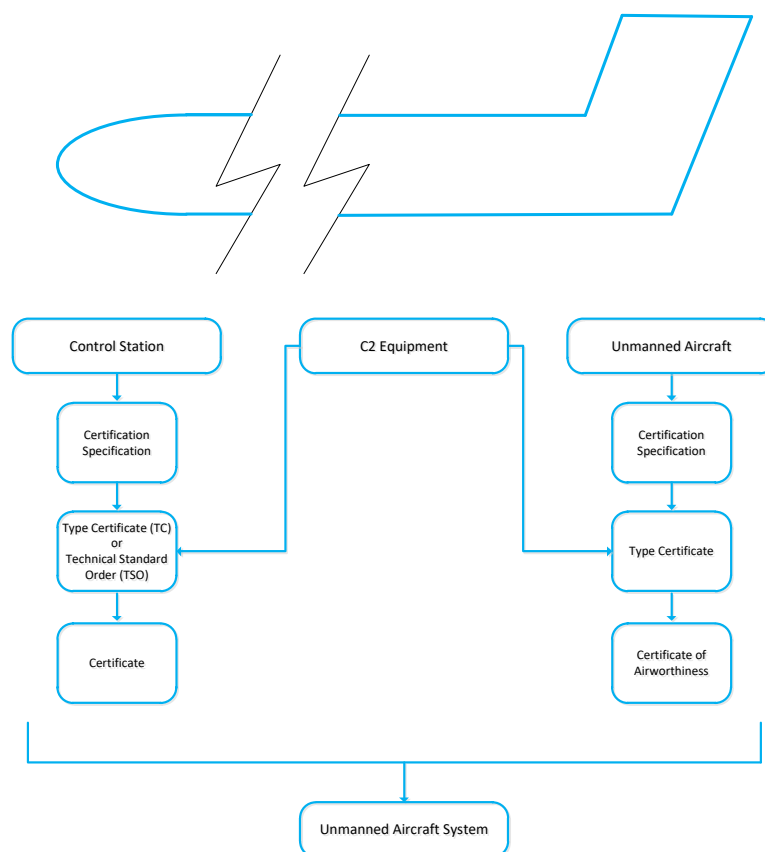


Figure 12: The Design Approval of specific UAS components (C2 is part of the UA and control station certification process)

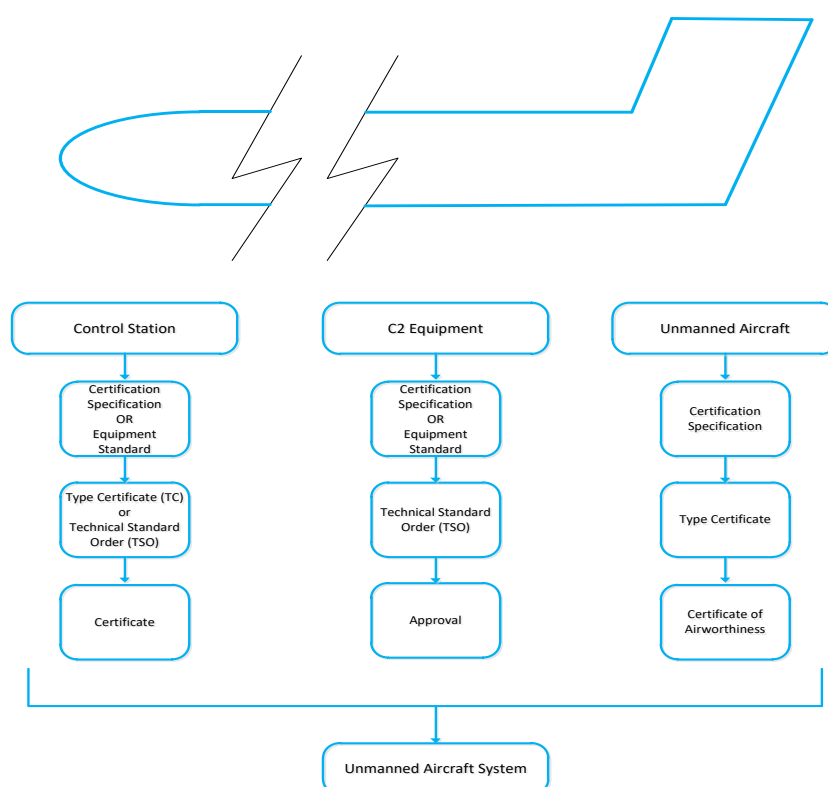


Figure 13: The Design Approval of specific UAS components (C2 has an established equipment standard and TSO)

C2 Link Classification: The C2 Link Provision is of 2 kinds:

- The C2 Link Provision is entirely provided within the UAS.
- The C2 Link Provision is dependent on communication architecture external to the UAS: A Third-Party Communication Service Provider (CSP) is required.

C2 Performance: When a pilot is required to safely operate the UA, the performance of the C2 Link is critical for safe UAS operations. The C2 Link is supporting a wide range of functions and the pilot is remote from the aircraft.

The identified C2 Link performance parameters are:

- Transaction time and transaction expiration time
- Availability
- Continuity
- Integrity

5.3.2 Type Certificate Data Sheet (TCDS)

The TCDS contains substantial information in relation to the certification basis and will contain operational and technical limitations (either directly or by reference to other approved manuals.). The TCDS also defines the configuration of the UAS elements used to conduct various operations.

5.4 Airworthiness Approval of the Unmanned Aircraft System

In Category C, an individual UAS should only be operated if it holds a valid Airworthiness Approval.

A UAS Airworthiness Approval should be issued to an individual UAS if the UA holds a valid CoA and Environmental Certificate(s), and other elements of the UAS (e.g. GCS, LRE) hold valid approvals.

A UA CoA should be issued only if the UA conforms to its type design and is in a condition safe for flight. A CoA is needed for each individual UA.

5.4.1 Certificate of Conformity

Separate certificates of conformity could be used for the elements of the UAS. A TSO or equivalent certification could be issued to parts, systems and equipment to be installed in a UAS, UA, GCS, engines or propellers and for which a specific set of design requirements has been defined and verified. In this case a Declaration of Design and Performances (DDP) should be issued which identifies the part configuration, the design requirements and the level and type of qualification achieved. The part's designer and manufacturer organization should hold appropriate authorizations.

5.4.2 Continued and Continuing Airworthiness

Continued airworthiness addresses all of the processes ensuring that the UAS can be maintained in an airworthy state by ensuring compliance with the airworthiness and environmental requirements set in the applicable type certification basis and maintaining a safe condition to operate throughout its operating life. The TC Holder provides the Instructions for Continued Airworthiness (Section 5.4.2.1) and the Authorities are responsible for the oversight of the compliance to the airworthiness regulations.

The continuing airworthiness processes are intended to ensure that in-service aircraft are managed and maintained correctly, by appropriately licensed persons, in accordance with the instructions developed by the design organisation that are based upon assumptions and considerations made during the design. The continuing airworthiness process will also support any need for modifications (except those handled under the certification process), repair or component replacement after an aircraft has entered service. This will include, for example, the management of configuration records. The operator is responsible for the continuing airworthiness of the UAS.

5.4.2.1 ***Instructions for Continued Airworthiness (ICA)***

ICA provide documentation of recommended methods, inspections, processes, and procedures which form the basis to approve the maintenance program of the UAS operators, as a means to keep the UAS in an airworthy state throughout the operational life of the UAS.

The contents of the ICA are defined by the type certificate holder in compliance with relevant airworthiness requirement and includes aspects such as:

- Airworthiness Limitations
- Maintenance Instructions
- Maintenance Schedule
- Inspection Intervals
- Special inspection techniques
- Servicing Information
- In-Service Experience

Maintenance of some elements of the UAS (e.g. UA software update, GCS maintenance) could be done during flight operations, if safe. The TC holder should describe any limit within the maintenance manual actions that can be conducted during flight operations. The authority has the authority to accept or reject any proposals for in-flight maintenance.

5.5 Certified Operator

Regardless of the nature of the operation (autonomous or non-autonomous), the operator is responsible for the safe operation of the UAS in compliance with the requirements of the airspace in which the operation takes place and the manufacturer instructions as declared in the operations manual. The operator is also responsible for contracting approved services from providers (e.g. communications service providers), as necessary, to carry out its operations.

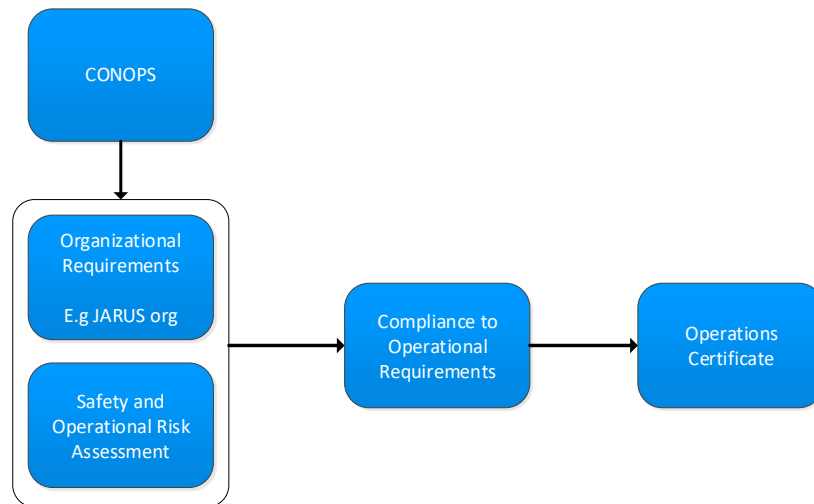


Figure 15: Certified Operator – Approach to obtain an Operations Certificate

For Category C, a Safety Management System (SMS) should consider the risks associated with operating the UAS, similar to manned aviation. Also, additional requirements unique to the UAS such as changes in service providers, need for alternate landing sites, control station hand over at various flight phases should be assessed. The operator is responsible for the safe UAS operation.

This means that the operator is responsible for also using approved elements of the UAS for the intended operation (e.g. a UA with a valid CoA, a GCS with a valid GCS approval) assuring the operating UAS holds a valid airworthiness approval declaring its state of airworthiness.

Also, the operator is responsible for the correct qualification and competency of the pilot and all other personnel involved in the operation. Initial and recurrent training should include the ability of the personnel to demonstrate proficiency with the UAS being operated or maintained.

The operator should consider education and training related to the unique nature and characteristics of the UAS operations (e.g. aircraft type, control station environment, detect and avoid, C2 link), the various types of operation (e.g. VLOS or BVLOS), and contingencies.

The certified operator³¹ demonstrates and is responsible for the UAS Airworthiness, which is based on the CoA of the UA, certificate of conformity of the control stations, C2 link service level agreement and any additional conformity statements.

5.5.1 UAS Operator Certificate

An operator will hold a valid UAS operator certificate in line with the complexity of the UAS operations, which is comparable to the manned aviation Aircraft Operator Certificate (AOC). Organizational requirements for UAS operator certificate are defined in **JARUS WG-2 Document**.

The operator certificate addresses amongst others the:

- operations manual,
- safety management system,

³¹ This is a privilege granted to a certified operator.

- organizational accountability,
- maintenance program,
- record keeping system,
- incidence and accident reporting
- quality assurance
- training

The operator should have adequate capability to address the unique characteristics of the UAS components such as control stations, C2 links, launch and recovery, and detect and avoid.

In the case of certification of UAS components (Option 2 per Section 5.3.1.2) , the operator is responsible for verifying conformity to the required configuration and managing the certificates used in the safe operation of the system in order to assure the UAS actually operated is in an airworthy state. The certificates will be issued by the Authorities of the state of design and manufacturing and must be held by the owner/operator of the State where the UAS is registered to operate.

The operator should establish a reporting system on mishaps, incidences and accidents to the manufacturer and/or Authorities.

5.5.1.1 **GCS Operation**

The operator will be required to ensure the safe functionality of the GCS beyond the conditions stipulated in the GCS design approval, for example with regard to the safety and security of the structure in which the GCS is located or the reliability of the relevant electricity infrastructure.

In case the GCS has a separate design approval (e.g. a GCS TC) independent of the other elements of the UAS (according to option 2), the operator will need to ensure that the specific UAS actually operated is in an airworthy state, which includes a compatibility verification, i.e. that the GCS matches the criteria and specification stipulated in the relevant TCDS of the UA intended to be operated. The operator will need to address the additional aspects unique to the operation of the GCS, such as the adequate qualification of pilots with regard to mission planning, troubleshooting or maintenance.

In the type certificate, multiple configurations should be identified to define the various interoperability of the UA with the control station.

Sample configurations include, but are not limited to the following:

- 1 UA and 1 control station
- 1 UA compatible with various control stations
- 1 control station compatible with various UAs.
- 1 control station for controlling multiple UAs³²

5.5.1.2 **C2 Link Operations**

Appropriate means to monitor the C2 Link performance should be provided.

For this option, the UAs could be also controlled simultaneously (e.g. a swarm), also one UA could be controlled independent of the other UA.

Relationship between RLP, C2 Link Specification and QoS

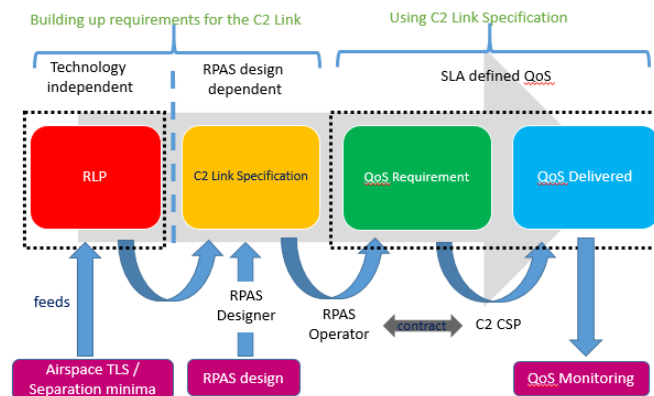


Figure 14: C2 Link Performance Approach

Subsequently, the operator must use a C2 Link that meets the C2 Link Performance Specification. If contracted or self-provided, the specification of the C2 Link provision must be better than or at least equal to the RLP. A service level agreement (SLA) between the UAS operator and the C2 CSP ensures that the provided C2 link operational performance is better or at least equal to the C2 link specification.

Contingency procedures will be needed in the event of a degraded or lost link.

C2 Spectrum: Spectrum has always been a very important resource for aviation for all safety of life applications. The performance of the C2 Link, the spectrum available and the technical and operational specifications of the UAS are interrelated.

The protection of the spectrum is enforced by the individual States and the allocation of spectrum is organized in ITU. In the ITU, WRC resolutions are adopted to provide available spectrum to the users. Some spectrum has already been identified and reserved for UAS operations.

5.6 Licensed Pilot/Crew and Other Personnel

Category C (and in some cases, Category B) operations require licensed pilots with a minimum crew as specified in the TC data sheet and other operational related document defined by the UAS designer.

The pilot responsibilities should be in accordance with the rules of the air, laws, regulations and procedures of those States in which operations are conducted according to the nature of the operations based on manufacturer instructions and the operations manual of the organization. The requirements for the pilots regarding the medical fitness, knowledge and skills should be as defined and assessed by the Authorities.

The competencies of the pilot should reflect the intended operations due to the various UAS designs and operations.

The training for the pilot (as long as the pilot is in the loop) and crew should be competency based and consist of a theoretical and a practical training. For high levels of automation (pilot out of the loop), the system should be designed to ensure safe operation. Pilot and crew requirements to obtain licensing are defined in **JARUS WG-1 Document**.

Category C operations require other personnel who contribute directly or indirectly to safe UAS operations to be licensed to meet the requirements of the documentation associated

with the UAS design.

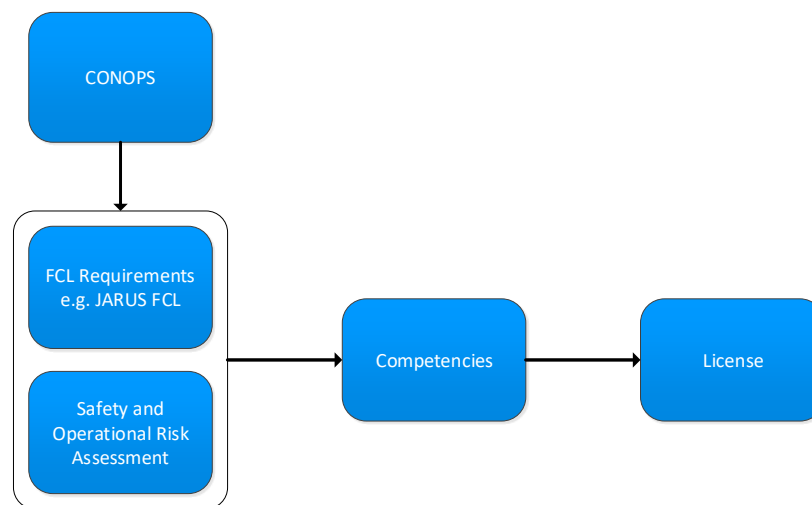


Figure 16: Process to obtain a Pilot/Crew License

5.7 Authority Involvement

5.7.1 Registration

As an aircraft capable of international operations, registration of all UAs under Category C is required consistent with ICAO Annex 7.

5.7.2 Safety Data Collection

Systems for safety data collection should be established for all UAS in this category. Such systems should adequately mirror the risk structure unique to unmanned aviation, i.e. by classifying occurrences, incidents or accidents differently, depending on how they are linked to the risk identified in Section 2.3 (people on ground, other airspace users and critical infrastructure)³³.

5.7.3 Delegation of Authority

The authority is responsible for the approval of the UAS in the initial and continuing airworthiness and could in turn delegate approvals to qualified individuals or organizations. The process for designating qualified individuals or organizations to act as representatives of the Authority³⁴ for the purpose of issuing airman, operating, and unmanned aircraft systems certificates and authorizations should be established by the Authorities. Each Authority is responsible for developing their own UAS designee/delegation program that best suits their needs.

The system of authorization and oversight as known in manned aviation, applied to the unmanned aviation will require more capacity due to the fact that there will be more operators, training organizations, manufacturers and maintenance organizations. Qualified entities

³³ Refer to 3.4.2 for basic rationale for the need for safety data collection in unmanned aviation.

³⁴ The Authority reserves the right to delegate the process of issuing certificates to other approved organizations or qualified entities.

approved by the Authorities could be delegated to perform certain tasks.

As new processes will be defined for the UAS to attain the various certificates, specific training of people involved in the approval should be provided.

5.8 International Category C Operations

To achieve routine global operations, ICAO SARPS that cover UAS operations and airworthiness will be defined and accepted internationally.

With regards to operations outside the scope or before the publication of ICAO SARPS, national regulations established on the basis of JARUS recommendations should maximize the potential for international recognition.

Through the framework of bilateral and multilateral agreements, recognition of certificates will be achieved in the same manner as manned aviation.

ANNEX A – Acronym List

AIP	Aeronautical Information Publication
AIS	Abbreviated Injury Scale
CoA	Certificate of Airworthiness
COS	Continued Operational Safety
ConOps	Concepts of Operation
CSP	Communication Service Provider
CRI	Certification Review Item
ICAO	International Civil Aviation Authority
ICAO RPASP	International Civil Aviation Authority Remote Pilot Aircraft System Panel
ITU	International Telecommunication Union
JARUS	Joint Authorities for Rulemaking on Unmanned Systems
LRE	Launch and Recovery Equipment
OLS	Obstacle Limitation Surfaces
SMS	Safety Management System
SORA	Specific Operations Risk Assessment
TC	Type Certificate
TCDS	Type Certificate Data Sheet
TSO	Technical Standard Order
UA	Unmanned Aircraft
UAS	Unmanned Aircraft Systems
VLOS	Visual Line of Sight
WRC	World Radio Communication Conference