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CoaX Helicopters' response to CASA UAV Airworthiness Framework

CASA must develop an Airworthiness Framework that will enable Remotely Piloted Aircraft Systems (RPAS) to operate effectively and safely in the National Airspace (NAS). Policy, rules and procedures derived, even partially, from manned regulation that are not appropriate, not applicable or used as a non-comparable reference should be discarded. It is vital that the Airworthiness Framework is crafted in the context of Unmanned Systems and how to optimise RPAS capability within that context. Establishing a world leading standard for UAS Airworthiness will provide a valuable stimulus for aviation in Australia.

CoaX Helicopters would prefer to see as much industry self-regulation as possible but believe it is important to have strong oversight guidance to ensure safe operation is assured. A well designed Specific Category system utilising an effective Concept of Operations (ConOps) matrix should satisfy most stakeholders. Use of the Certified category may be necessary in some cases such as Large UAS having specific flight characteristics or capable of performing particular tasks. If the need requiring certification (for example kinetic energy) could subsequently be transposed into the Specific Category ConOps matrix the system could be designed for growth without the need for new legislation.

By and large the draft Airworthiness Framework provides a sound basis for UAS regulation however CoaX Helicopters believes that they could be further improved by incorporating the following concepts.

3.4.3 Scaled risk-based categorisation

The following scaled categorisation is proposed for Australian UAS:

- ***open category, comprising of: − very small RPAS − small RPAS***
- ***specific category***
- ***certified category, comprising of:***
  - ***restricted category UAS***
  - ***fully type certificated UAS.***

These categories are structured in such a way that the airworthiness requirements are scaled according to the risk associated with the aircraft and the permitted operations. As the risk of the operation and the aircraft increases, the requirements would become more rigorous. At the highest end of the scale, a large UAS carrying out a high risk operation would be required to comply with airworthiness standards that provide an equivalent level of safety as that of a similar kind of CPA carrying out the same kind of operation (i.e. be type certificated and use certificated equipment).

In consideration of the Specific Category, CoaX Helicopters has long argued that RPAS ConOps should be derived in broad terms on Task versus Capability. This should in fact be a multi-dimensional table. Different dimensions could

- Categorise the flight envelope of the UAV
- Describe the types of mission that can be flown by the UAV
- Describe the applicability of a particular payload or package that may be integrated or optionally added to the UAV
- Add provision for multiple airframes operating concurrently to increase task effectiveness
- Where appropriate, risk should be associated with elements in the matrix
- Dimensions could also be defined for maintenance procedures ie by the UOC or by the manufacturer and the licence, if any, required to undertake the procedure.

More dimensions may become evident over time and some others are described below.

Defining rules for risk would further strengthen the confidence and resultant output from the matrix.

By developing a comprehensive ConOps matrix it will be far easier to categorise UAV's, especially Large UAV's, if they are only undertaking a subset of the full suite of capabilities possible with the RPAS. This methodology will assist in development of adequate minimum equipment list (MEL) standards. It will also assist in approval licencing for the Remotely Piloted Aircraft Operator's Certificate (ReOC) against the ConOps matrix.

A simple example would be a daytime LIDAR task requiring nothing more than VLOS conditions. The same aircraft however could undertake the same task at night but may require collision avoidance systems, BVLOS flight and ADS-B. By default a CoaX Helicopters rotorcraft will fall into the Certified category but good drafting of the ConOps should allow operations within the Specific category. In certain cases, modification of software code or hardware switching may allow movement within the ConOps matrix to offer differing outcomes.

Depending on the nature of the task, different considerations will arise for the UAV provider from the perspective of the ReOC holder. If the ConOps document is detailed enough it should cover the levels of training and certification required by the ReOC holder to satisfactorily undertake the mission. From the UAV provider's perspective he/she could provide an airframe which has been assembled to only meet or has, through unservicablities, degraded to meet only the day VLOS standard.

By developing this matrix in a generic fashion, using descriptors that may not necessarily be applicable to a specific company, characteristics would describe boundary limitations such as maximum and minimum airspeed, altitude and MTOW. For example, looking at the Task dimension for example and locating the ability to drop payload may produce an outcome that requires either additional training by the remote pilot or removal of the aircraft capability or depending on the payload, possibly requiring fitment of dispersal monitoring equipment.

The confluence of the intersecting points of Task V Capability V RePL skills V MEL could result in a list of Risk evaluations that must be satisfied prior to flight. The degree of risk should dictate the level of approval required ranging from direct supervision by CASA to UOC holder (and possibly UAV manufacturer) to the ReOC holder.

Use of approved equipment as outlined in 3.4.2 Outcome-based framework would help significantly in the above discussion.

These comments are also reflected in section 4.6 Required instruments and equipment.

4.2.2 Certified category

> ***UAS carrying out high risk operations (such as low-level operations of a large UAS over populated areas) would be type certified in order to ensure an appropriate level of safety.***
>
> ***Under Part 21 of CASR, a UAS could be issued with a TC in the same manner as a CPA. However, the current Part 101 regulations effectively limits type certification of UAS to the restricted category. This was appropriate when those regulations were made because there were no dedicated airworthiness standards for UAS, but there are now an increasing number of dedicated type certification standards for UAS. CASA therefore proposes to expand the type certification options for UAS to increase the flexibility of the regulations for the UAS industry.***
>
> ***Type certification of a UAS would be under an approved airworthiness standard, such as Certification Specification Light Unmanned Rotorcraft Systems (CS-LURS) or Light Unmanned Aeroplane Systems (CS-LUAS). These arrangements would require a CofA in a similar manner to CPA to demonstrate that the UAS complies with its type design. Due to the distributed nature of UAS subsystems, a UAS TC would include the remote piloting station and the command and control link.***
>
> ***Type certification of a UAS would provide for operations covered by the TC and ensuing CofA to be included in an operator's UOC without further airworthiness assessment of the UAS by CASA.***

> ***In a similar manner to CPA, certified UAS may need to be supplemented with certificated equipment required under the operational regulations in order to carry out operations that are not covered by the TC, e.g. if the TC did not include operations under Instrument Flight Rules (IFR).***

CoaX Helicopters strongly opposes direct adoption of airworthiness standards such as the *Certification Specification Light Unmanned Rotorcraft Systems (CS-LURS).*

As stated in that document:

> ***CS-LURS.1 Applicability (See AMC CS-LURS.1) This airworthiness code is applicable to Light Unmanned Rotorcraft Systems with Light Unmanned Rotorcraft maximum certified take-off weights not exceeding 750 kg.***
>
> ***For the purposes of CS-LURS the Light Unmanned Rotorcraft is a conventional helicopter. In operational terms, applicability of this airworthiness code is limited to all DAY/NIGHT VFR Visual Line Of Sight Operations and excludes all human transport, flight into known icing conditions, and aerobatics*.**

Numerous arbitrary restrictions exist in the CS-LURS document, some of which were originally based on manned recreational aircraft. CoaX Helicopters understands that in the original draft proposal these preconditions were based on those of Very Light Aeroplanes (EASA Certification for Very Light Aeroplanes. CS-VLA Book 1 Airworthiness Code). The overhead and complexity of the rotor system and gearboxes substantially differentiates a Very Light Helicopter from a Very Light Aeroplane and are not at all applicable to certification and airworthiness of unmanned rotorcraft as the CS-LURS has done.

CoaX helicopters is developing a range of rotorcraft that will have a range of MTOW from 150kg to in excess of 1500kg. Essentially, the same engineering is applied for all of these rotorcraft, merely a different power plant and rotor disk size. There is no intrinsic difference between our lower MTOW helicopter and our higher one and as such, no arbitrary weight limitation should be applied as has been stipulated in the CS-LURS.

In order to be competitive in a commercial sense however, the class definition of Small Unmanned Rotorcraft should be identical to that of Small Manned Rotorcraft. The EASA specification for Small Rotorcraft includes maximum weights up to 3175 kg. (EASA Certification for Small Rotorcraft. CS-27 Book 1 Airworthiness Code, Amendment 2, 17 Nov 2008. CS 27.1 Applicability) (Search:- CS-27 Amdt 2 final.pdf)

Also, our CoaX Helicopters rotorcraft is non-conventional, it has no tail rotor since it uses a coaxial rotor head. Many multi rotor and tilt rotor systems may fall into this class.

Operations in icing conditions is being considered for a number of applications of unmanned systems. Rather than eliminating this class as expressed in CS-LURS, rules within the ConOps matrix should provide direction as to how this type of operation must be achieved.

In order to allow unmanned systems to compete effectively and often more safely than manned aircraft CASA should not impose any restrictions that are not purely safety based. Arbitrary weight limitations, configuration limitations, flight envelope limitations etc. should only be implemented on certified aircraft, not on the industry as a whole through policy like the CS-LURS.

We would also caution writing statements as included in the CS-LURS such as

> ***excludes all human transport***

In emergency circumstances where a person will die if they remain in their current location but may survive if they can be rescued by an unmanned aircraft, this type of wording will ultimately cause the loss of life.

4.9.3 Software design assurance

> ***Software would become a dominant design focus for unmanned aircraft systems. Due to the highly automated nature of UAS, this may even become the dominant design consideration. Software design assurance standards similar to those for CPA (e.g. RTCA DO-178) would become increasingly necessary for UAS.***
>
> ***Currently, the American Society for Testing and Materials F38 committee is developing software assurance standards for UAS that will fall into the specific category. Currently, the design assurance level would be between level C and D.***
>
> ***The use of formal software design assurance standards would provide increased confidence in the design of the UAS and therefore provide for a greater scope of operations and faster approvals***

CoaX Helicopters envisages use of "Current off the Shelf" Autopilots. The implementation of software and firmware upgrades will require consideration. In general software and firmware upgrades are done for a number of reasons. These updates may include error correction, improved functionality, improved cyber threat protection and others reasons. It is considered good practice to maintain the latest build for compliance by the autopilot manufacturer however if certification is undertaken at a specific time based on a specific release of firmware and not allowed to upgrade as appropriate, unacceptable consequences may occur.

4.5.1 Type certification

> ***A standard TC may cover, in relation to UAS:***
>
> - ***UAS – no regulation amendments are necessary to provide for the type certification of a UAS. Specific standards would need to be included for UAS, including the unmanned aircraft, RPS and command and control links.***
> - ***RPS – numerous amendments are necessary to provide for the issue of a TC for an RPS as a stand-alone item.***

- ***UAS engine – no regulation amendments are necessary to provide the type certification of an engine for a UAS. Specific standards would need to be included for UAS engines.***

- ***UAS propeller – no regulation amendments are necessary to provide the type certification of a propeller for a UAS. Specific standards would need to be included for UAS propellers.***

A restricted TC may only cover a UAS, i.e. the whole system, not an RPS, engine or propeller separately (similar to the existing regulations, a restricted type certificate can only be issued for an aircraft).

A remotely piloted aircraft (RPA) cannot be type certificated without an RPS, i.e. the TC for an RPAS must mention the RPS (the RPS may be separately type certificated, or be covered by the RPAS TC).

Power plants for unmanned systems are also becoming cost effective. CoaX Helicopters anticipates being able to offer a variety of power plants to the customer and would like to see scope for that in the Airworthiness Framework.

Similarly, the low cost of autopilots compared with manned aircraft may require hardware replacement of the autopilot or indeed other related hardware systems at a much more frequent rate. Any certification process must provide scope for ongoing improvement and upgrade.

4.8.3 Certified category UAS maintenance

UAS in the certified category would require the highest standards of maintenance. UAS in the certified category would therefore have similar maintenance requirements as a CPA. Persons that would be permitted to carry out maintenance on certified category UAS would be:

- ***a Part 66 licence holder***

- ***a CAR 30 approved maintenance organisation***

- ***a Part 145 approved maintenance organisation • the manufacturer of the UAS or associated aeronautical product.***

It would be the operator's responsibility to authorise a person to carry out maintenance on their UAS and to ensure that the person is competent.

With the capacity now even for Large UAV's to be constructed or updated with printed components and the capability to produce comprehensive animated graphic instruction ware there will be less need for maintenance on a Certified UAS to only be undertaken by licenced aircraft maintenance engineers.

Again, through good definition of a comprehensive ConOps matrix that could perhaps be based on data from integrated HUMS to develop predictive maintenance schedules more effective procedures could be introduced for licenced versus non licenced but adequately trained maintenance personnel.

A suitable standard for use of components created by 3D printing should also be incorporated.

4.9.1 Separation and collision avoidance

One of the biggest issues for UAS flying BVLOS operations involves the ability to see and avoid aircraft. It is possible under VLOS operations for the remote pilot to see and avoid other aircraft and to separate the unmanned vehicle, however, when under BVLOS conditions this is not possible. To allow proper separation of the aircraft in lieu of the ability of the remote pilot to physically see and avoid the aircraft, sensors on board the aircraft can be used. Sensors designed to perform these functions are part of what is known as the detect and avoid (DAA) system.

The minimum operational performance specifications (MOPS) for DAA for a range of operations are currently being developed by the Radio Technical Commission for Aeronautics (RTCA) and the Joint Authorities for Rulemaking on Unmanned Systems (JARUS). These safety performance levels, once solidified, would form the basis for the international aviation communities' regulations for DAA.

The proposed framework would provide for these standards to be formally adopted into the Australian legislation. Manufacturers and operators could then determine means of meeting the MOPS for the operation or system under consideration, and once demonstrated satisfactorily to CASA that the system meets the MOPS, the system would be approved for that purpose. It is expected that an ATSO (or a recognised foreign equivalent) to meet the MOPS would be developed, which would further facilitate production and expand the availability of approved systems for the UAS community. These approved systems can then be used to expand the range of operations carried out by a UAS.

The short term goals for DAA would be to have in place MOPS for aircraft transitioning through other airspace to fly in class A airspace, because in this class of airspace, IFR aircraft would have the required electrical visibility for the prototype DAA system sensors to determine other aircraft positions.

After this operational goal is verified and validated suitably, the next stage would be work on MOPS for aircraft that operate VFR (such as would be encountered in class G airspace). This would be necessary for the UAS to maintain safe separation and avoidance of aircraft flying under VFR.

In lieu of these MOPS, the determination of risk mitigation via DAA or other means (such as segregation of airspace) for UAS to fly above 400 ft would be determined by a case-by-case risk assessment. In some of these cases, further mitigation

techniques would be required to allow the UAS to operate safely with other aircraft in Australian airspace

There is a case to subdivide BVLOS operations into Radio LOS without or without visual acquisition. Large UAS can easily operate at distances that are further than the distance required to manually control a UAS, ie I can see the UAV but I cannot confidently control the UAV manually. At these intermediate ranges it is still possible to provide collision risk mitigation purely visually or with a combination of sensors and visual acquisition. This may allow Large UAV operations at ranges greater than VLOS but not require a full suite of BVLOS sensors and command and control systems to carry out the mission.

Other Comment - Cyber Threat

Resilience to cyber threat against UAS should also be incorporated into the Airworthiness Framework particularly for Large UAS operating BVLOS. Malicious and accidental threats to data links and navigation systems such as GPS are becoming more prevalent. Although illegal to implement, research into Spoofing and Jamming is producing more effective results. UAS operators cannot simply expect that because it is illegal to jam or spoof or possibly capture a UAS that it will not happen. Cyber threat should hold similar weight to a collision avoidance threat. Big sky theory in the ether will not hold water.

OLAP Process

The ConOps matrix is in fact an Online Analytical Process (OLAP). A simple description is given at

https://en.wikipedia.org/wiki/Online_analytical_processing

Using OLAP, CASA could actually move away from any hard definition for UAS categorisation. Differentiating for example between < 2kg and 2kg – 25 kg could all be described within the OPLAP in such a fashion that asking the appropriate question could simply result in an ‘Approved’ or ‘Acceptable’ result set that is not reliant on a weight definition. It would open the door to flexible criteria that currently cannot be effectively described in the current lexicon.

For your consideration

Regards

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