The research and technology about to change your UAV operations

Jared Haube for Commercial UAVs

UAV technology is an emerging industry, which means both the technological capability and the regulatory environment are progressive in many areas. I caught up with Associate Professor Terrence Martin, at Queensland University of Technology, to discuss the work at the Australian Research Centre for Aerospace Automation (ARCAA), and its relevance to the UAS integration into the National Airspace System.

The pathway for introducing UAVs into the National Airspace System is both operationally and technically challenging. There are a number of outstanding issues including:

- A lack of agreement on performance standards for Sense and Avoid;
- The level of technical airworthiness UAS will need to demonstrate;
- How these platforms will be certified;
- What the equipage expectations will be;
- And what the training expectations for UAS pilots will be.

Ultimately, any UAS operation should be demonstrably safe. And fundamental to this demonstration is the mitigation of two key risks: Mid Air Collisions (MACs) or uncontrolled ground collisions.

Controlled and uncontrolled airspace

A looming decision that will impact on the scale of these separate risks is where to initiate unsegregated UAS operations. This is in addition to the complexity of the risk considerations expanding once operations extend to Beyond Visual Line of Sight (BVLOS) operations.

This decision has often been presented as a binary choice: controlled or uncontrolled airspace. It’s a contentious choice for a number of reasons.

Controlled airspace coincides with significant surveillance assets and ATC services. The NAS is a system designed to improve aircraft separation, traffic flow and minimise the chance of a MAC; even when some of the airborne platforms are electronically (and practically) invisible to UAS.
However, controlled airspace often coincides with areas of dense population. Under these circumstances, a UAS which hasn’t demonstrated appropriate levels of reliability poses a greater risk of ground collision; hence, greater harm to personnel and infrastructure.

This has prompted many to suggest that operations in uncontrolled airspace are the safer alternative. The reliability of the platform, and any subsequent ground collision, will have a lower likelihood of causing damage or injury, because of the lower population levels.

Also motivating this preference is the knowledge that many of the areas where the largest economic benefits can be derived: mining, agriculture, maritime surveillance and power line inspections, for example, coincide with uncontrolled airspace.

However, it has been demonstrated that the risk of a MAC for Conventionally Piloted Aircraft (CPA) is significantly greater in uncontrolled airspace. In fact, it is more than an order of magnitude greater.

Contributing to this is the lack of ATC oversight and traffic management, alongside lower equipage and reporting expectations for aircraft operating in this airspace. UAS which do not have a SAA capability akin to that provided by pilots, would be exposed to even greater risk – particularly the risk posed by non-cooperative, electronically invisible VFR aircraft.

**Technology R&D**

To help navigate these challenges, our team at QUT have been co-operating with Airservices Australia, CASA and industry. The goal is to help better inform these considerations and develop technology to expedite the path for safe BVLOS operations, but at the same time maintain safety levels.

Along with investigating risk based approaches to streamline certification overhead without compromising safety, the ARCAA continues to research and develop Sense and Avoid technologies and other UAS operations (both operationally and technically).

This has come under the auspices of both Smart Skies and Project Resqu. The technologies will ultimately assist Australian industry to strengthen the economic benefits from UAS operations. Several of the individual research topics involve:

- **On-board fault detection & isolation**: Low Size Weight & Power (SWaP) fail safe technologies will be essential for obtaining approvals for operations, certification and procedures.

- **Autonomous emergency landing**: UAV operators will need to demonstrate that they pose no threat to people on the ground or in the air. Forced landings are most commonly attributed to engine sensor failure and adverse weather.
Presently, the main way to reduce the impact of a forced landing is through parachutes and parafoils. However, these are susceptible to wind gusts and other atmospheric conditions. Dr Luis Alvarez and his team are currently examining multiple autonomous landing technologies to cater for the different emergency situations a UAS may encounter, tailored for the UAS class.

- **Sense & Avoid challenges with non-cooperative and cooperative systems:** ARCAA is continuing its development of a passive, non-cooperative DSA (SAA) system which is based on a morphological filtering stage, followed by a *Hidden Markov Model* (HMM) filtering stage.

  The system has been flight tested on board various UAS and a Cessna 172. It’s also been experimentally demonstrated to detect a Cessna aircraft at ranges between 1.1 km and 1.5 km, with a false alarm rate less than 1 false alarm per 6.5 hours. *(Lai, J., Ford, J, and Mejias, L & O’Shea, P (2013), Characterization of Sky-region morphological temporal airborne collision detection, Journal of Field Robotics, 30, pp 171-189).*

  A video feed demonstrating the difficulty of the task can be found at [http://youtu.be/3PapNOG_0EY?list=UUfEARxKebDb3_eFMOVcnra](http://youtu.be/3PapNOG_0EY?list=UUfEARxKebDb3_eFMOVcnra). Static images depicting elements of the system and the challenging environment are shown in Figures 1 through 3.

![Raw Image Frame: 001](image1)

![Region of Interest](image2)

![Point Feature Detection](image3)

![Temporal Filtering](image4)

*Figure 1: Key images from the ARCAA System*
Regulatory environment

As mentioned, introducing UAS into the NAS poses a number of regulatory challenges. CASA must ensure that UAS can operate safely within the NAS. However, it also has to reduce unnecessary governance burdens which stifle industry capacity to operate cost effectively. Getting the safety element wrong will clearly create issues for UAS integration; as will unnecessary governance.

The FAA and EASA in the US and Europe, respectively, have had governmental pressures imposed to progress the development of UAS regulation and subsequent integration. Consequently, key roadmaps and R&D plans have emerged, with some progress made on regulatory development.

These plans have indicated that in the early stages, “accommodation” measures or concession might need to be taken by the regulators and ANSPs. The measures will facilitate early UAS operations, despite uncertainty about their levels of reliability and knowledge about the necessary Sense and Avoid performance standards.

Several reputable agencies have lobbied for a low SWaP, hybrid TCAS/ADS-B system to fulfil the interim role. This would effectively make UAS electronically visible to ATC and other suitably equipped aircraft. However, this approach is not entirely satisfactory – it will only be effective in certain airspace areas for IFR aircraft separation.

The regulatory challenges on the technical front are also challenging. Ultimately, UAS can be built with propulsion, flight control and avionics systems which have similar levels of reliability as manned platforms.

www.commercialuavs.com.au Call + 61 (2) 9229 1000 Email: registration@iqpc.com.au
However, this comes at a cost for the actual systems and subsequent aircraft certification. Moreover, ADSB, TCAS and GNSS systems can also add significant cost – it could severely affect the viability of many smaller UAS platforms.

CASA and the other international regulatory bodies are examining risk based approaches which will still permit UAS operations, with lower certification overheads, but with the trade-off of limitation such as area or altitude restrictions.

It’s a delicate balance for the regulators: ensuring that UAS can be safely seen, avoid other aircraft, and are reliable enough not to increase the risk to the public on the ground – all without burdening industry.

*Terrence Martin will give a detailed breakdown of critical enabling technologies which are being developed, the equipage expectations for RPAS entrants, and future trends for civil utilisation of RPAS.*

*Check out our brochure to see the full program, which features case studies of integration, data management and regulation compliance.*

*If you haven’t had a chance yet, also see our exclusive 2014 report which contains insights of four organisations using UAVs, including:*

- *Melbourne Fire Brigade (Emergency services)*
- *Territory Resources (Mining)*
- *Melbourne Water (Utilities)*
- *Aurecon (Construction)*