UNMANNED AERIAL VEHICLES
A DISCUSSION DOCUMENT

By Mike Close

Introduction

It is generally accepted that Unmanned Aerial Vehicles (UAV) are currently the most rapidly expanding area within the international aerospace industry. They are known by other names as well, and although there may be detail differences in interpretation, generically they are all basically similar. Other names included Remote Piloted Vehicles (RPV) and Unmanned Aerial Systems (UAS). The Director of Aviation Safety for Australia (and hence the boss of the Civil Aviation Authority of Australia (CASA)) prefers to call them Remotely Piloted Aircraft (RPA) and remotely piloted aircraft systems (RPAS). The Model Aeronautical Association of Australia (MAAA) calls them Self Guided Model Aircraft (SGMA) in order to provide differentiation between the aircraft it recognises for sport and recreation and those used for commercial applications.

As defined within Australian Regulations model aircraft are limited to sports and recreation use. If you use what would otherwise be a model aircraft for commercial purposes, even if it is only fitted say with a simple camera, then it comes under the UAV Regulations. There are therefore two basic types of UAV. Those that are always under the direct control of the pilot, and those that fly autonomously for at least part of their flight. When used for sport and recreation the former, even if they include sophisticated electronics such as flight stabilisation for on board camera work, are basically just the same in operation as any model aircraft and can be treated as model aircraft by the FAI. The rest of this discussion document has therefore concentrated on the second case whether used for commercial or sport and recreation activities.

The degree to which autonomous control is undertaken in the second class of UAV flying can vary. At the most sophisticated end the flight is fully pre-programmed on the ground. Once ready for flight the entire flight, including landing and takeoff, takes place without any further human interference, commonly using GPS for guidance. It may include terrain following electronics and the distance that it flies is limited by its endurance. Issues such as collision avoidance, with either the ground or airborne obstacles, have to be considered, together with safe abortion of the mission in the event of a malfunction. The level of automatic control can then be reduced progressively down to being mainly under manual visual control and just autonomous once it has been positioned at the point of interest.

Background

The FAI Executive Board Meeting of August 2012 recorded the view that UAVs may be the greatest threat the FA I has faced for a long time. This was on the basis that UAV activity would take priority over sport activity if there were a conflict. Many aspects of normal aviation also take priority over sport if there is a conflict, and so this may or may not prove to be a serious consideration. Of some concern is the

possibility of UAVs being used in a swarm in some applications. UAV do also have to operate safely in the same environment as much non-sporting aviation. Until reliable detect and avoid systems toward other aircraft are developed and particularly become available down to the smaller UAV platforms, this will restrict their deployment into general airspace.

There are other significant considerations for the FAI as it embraces UAVs particularly in a sporting context. Indeed this could well involve a paradigm shift in FAI thinking.

A few years ago an Executive General Manager of CASA held the view that all UAVs should be put under the control of the MAAA. Fortunately that view was overturned when the full potential scope for UAV operations into the future was realised. That said, as someone who spent over six years arguing from the role of MAAA President, that the organisation needed to embrace UAVs or potentially become marginalised in the future, I would be hard pushed to argue against, at least for smaller vehicles, the activity being offered to CIAM. However this is not the question that CASI was asked to consider.

The August EB Meeting recorded the action of:

> c) Tasked the FAI HO to ask CASI to consider UAVs and their sporting potential, and check the definition of UAVs vs. aeromodels.

What follows is a discussion of the issues involved and is from a personal view. I've tried to avoid reaching any firm conclusions as this is clearly a complex debate and one on which there will be many other views and perspectives. Whilst I'm not a UAV operator, I am currently the Chair of the MAAA's SGMA Working Party and have been involved to some extent with the regulatory development by CASA for the operation of UAVs in Australia. CASA are also very much involved with the development of international regulations, with a CASA Senior Manager appointed as Chair of the ICAO unmanned aircraft systems study group. The Director of Aviation Safety chaired the 12th Air Navigation Conference, held in Montréal late last year. This Conference was attended by over one thousand participants from 120 Contracting States. The purpose of the Conference was to define and achieve consensus on the next steps toward realising a collective vision of an interoperable, seamless and global air traffic management system for international civil aviation in the 21st century. A number of recommendations came out of the conference relating to RPAs.

<u>An Aircraft or a UAV?</u>

The January 2013 paper by David Roberts entitled 'European Strategy for Remotely Piloted Aircraft Systems (RPAS) The position of sports and recreational aviation' states four guiding principles should be followed. These are:

1. safety of flight must not be impaired and the low level of mid-air collisions must be maintained
2. there should be no additional equipment requirements for manned aircraft

3. detect and avoid systems used by RPAS must work with uncooperative aircraft
4. RPAS should be marked to improve their visual safety.

With a proviso that point 4 is unlikely to be achieved for RPAS used for covert operations, whether military or civil, I think the most, non RPAS operators anyway, would agree with these points.

The document then goes on to suggest that the fundamental characteristics of an aeromodel (or model aircraft) are:

1. it is operated for sport and recreational purposes and in a non-commercial environment
2. is operated within visual line of sight (VLOS) of the operator
3. the primary purpose of the flight is to fly the aeromodel to increase personal skills whereas in RPAS the primary purpose of the flight is the achievement of the task (aerial work) with the control applied being a secondary or automated function.

Once again I would agree with this but with one caveat, and that is on operating within visual line of sight. Currently in Australia there are a number of people who are operating what they consider model aircraft well beyond visual range and in fact at flight levels causing interaction with RPT. This of course is totally illegal and is causing CASA considerable anxiety. That said CASA do allow small UAVs without any detect and avoid systems to operate beyond visual line of sight. However this is with specific approval and under very controlled conditions where there is no possibility of conflict with any other air traffic. As this is applied in the Outback Challenge, effectively this has been extended to SGMA if required. It is also worth noting that there is a current model aircraft record held by the late Maynard Hill for his flight over the Atlantic. Whilst the aircraft was taken off and landed manually, of course by different people, the aircraft flew the majority of the flight out of sight and autonomously. (No one knows where the ones that did not make it ended up except that it was in the water.)

There are other differences that go beyond operational considerations. It is stating the obvious that a model aircraft is generally just that, a model of an aircraft, scale or otherwise. I agree that, for example, in control line combat aircraft the relationship to a full size aircraft is only to the extent that it has a wing and an elevator. However these models do fly in one of the most physically and mentally demanding model aircraft sports. At the end of one combat round I saw, which a modeller with 50 years experience described as the best he had ever seen, after three minutes both pilots collapsed to the ground with mental and physical exhaustion. Generally model aircraft have an intrinsic maximum size. Whilst there are many half full size model aircraft flying around in the world, these are typically of small prototypes; a Boeing 747 to that scale would be a mammoth undertaking to say the least. Whilst there are a few big models, up to around 8 metre wing span or greater, of larger full size aircraft, in practical terms most model aircraft builders restrict themselves to models that are physically certainly no bigger than a small full size aircraft that carries a human pilot. For FA I competition purposes CIAM does restrict the size and weight of models but

this is driven by practical international transport considerations and larger aircraft than these are common in non-FAI competitions at a national or continental level.

There is no ICAO definition of what a model aircraft is and what a UAV is. Within Australia this is debated within CASA, and whilst individuals have views there is no consensus. I will come back to this topic in the Summary after dealing with a more general discussion of UAVs which will add further to the perspective.

UAV Discussion

UAVs are used for multiple purposes and the only essential difference is the 'mission' payload that they are required to carry. The initial motivation for them was predominantly military, but the current range of applications, both military and civil, are expanding all time. These include agriculture, environmental, law enforcement, fire fighting support, supply line surveillance, photography, TV coverage as well as sport and recreation. The weight and size considerations mentioned above are not true of UAVs. Whilst the public perception of UAV initially was, even if not now, a picture of the Global Hawk, which has a wingspan larger than a Boeing 737, 90% of the UAVs that CASA are asked to certify for commercial purposes are under 7 kg in weight. However the sizes available off the shelf form a continuum from aircraft weighing less than 1 kg to the size of the Global Hawk and there are no natural break points. I understand that there is a specialist UAV available which weights only 16 gm, but costs $1 million for four of them.

In developing new regulations for the certification and operation of UAVs CASA are looking at producing categories based on weight and speed (that is the total energy). These are being developed purely on the basis of safety risk profiles. Within these they will only consider allowing operation without a reliable detect and avoid systems provided that a detail risk assessment shows there is no significant risk of hazard to other aviation users. For example this may be by guaranteed height limitation with no other aircraft of any type being in the area, and then horizontal separation for other hazards, and may include the general public. During a recent chat with the Director of Aviation Safety he told me of an approach on the use of RPVs for hot spot detection during bush fires. His attitude is no way as they would not have detect and avoid. But if they were prepared to operate at night, below 400 feet agl, and other aircraft, such as water bombers, were excluded from the area then they might consider looking at a full risk assessment. It is understood that ICAO may be following this same general approach but are likely to limit their interest to aircraft weighing more than 20 or 25 kg and leave the regulation for smaller vehicles to individual countries.

In principle any commercial UAV of whatever weight can be used for non commercial purposes if the payload is either removed or inhibited. For FA I purposes of course it is possible to create categories based on some criteria but the likelihood is that selection of these, other than fixed and rotary wing, including those with multiple rotors, would be arbitrary rather than scientific. The danger of this is that with the rapid advance of technology the intent of categories could very quickly be overtaken as the intended capability become possible on a smaller and smaller platform.

Before looking at the sporting possibilities for UAVs it is worth looking at the Outback Challenge in Australia. This competition has now been running since 2007 and is in fact two separate competitions. The first is held annually and is a competition for high schools, whereas the second is held now held biannually and is aimed at universities and small companies. The stated aim of these competitions is technology, and to encourage young people to develop an interest in this technology within Australia. Specifically for the university level event it is to develop technology that would enable UAVs to detect people lost in the Australian outback and then support them from the air so that they can be brought to safety.

There is a webpage http://www.uavoutbackchallenge.com.au/index.cfm?contentID=3 which covers the high school Airborne Delivery Challenge. The basic outline is that what is essentially a model aircraft is flown manually in a defined racetrack circuit. It has to be fitted with a detection system and a package release system to enable a student who can neither see the aircraft, nor the pilot, to detect, and 'help', 'Outback Joe'. Additional points are available if the package is dropped automatically. Teams cannot use a complete commercial package but can put together a system using proprietary items. The aviation skills needed are really only those needed to fly a very basic model aircraft to solo standard. Cash prizes are awarded with $5000 going to the winning team

The webpage http://www.uavoutbackchallenge.com.au/2011/index.cfm?contentID=5 covers the most recent, 2012, university level Search and Rescue Challenge. This is an altogether more challenging project for which a first prize of $50,000 is awarded. A fixed wing airframe can be up to 150 kg take off weight, or rotary wing up to 100 kg, although most are now significantly smaller. It must not be a commercial complete off-the-shelf system. The aircraft may be taken off manually or automatically, and then has to autonomously overfly an area well beyond visual range and up to 8 km from the takeoff point. 'Outback Joe' is provided with a device producing a heat signature, and the aircraft has to find this and complete the task by dropping a survival package right by it. Despite the competition being well supported, even though many entrants pull out, and the entries include universities and small businesses from within Australia and overseas, in the five years that this event has been held, 'Outback Joe' has only been found once and on that occasion the airborne delivery package had been accidentally dropped earlier in the flight. The challenge therefore still remains to be conquered. Although the organisers require pilots to be MAAA Gold Wing standard, which is still fairly basic, and say that a team is unlikely to win without a good pilot this would not be the MAAA view. Their stated requirement for a 'good pilot' is documented as to be able to trim the aircraft satisfactorily and takeoff and land the aircraft either normally or in an emergency. Whilst the aircraft may be comparatively large, these basic skills are more likely covered by MAAA Bronze Wing's standard and indeed this is the MAAA minimum quoted in the MAAA Procedure for SGMA operation.

As in the case of the Outback Challenge, the essential unmanned and autonomous nature of UAV operations are technology based. This can be the basis for a competition and it is possible to think of a range of events that could be included. These include speed, endurance, combinations of these, and the conduct of tasks such as dropping things, as in the case of the Outback Challenge, or other UAV type activities such as photography. Accuracy of autonomous flying over a course is also

possible but whether the latter would really provide sufficient differential between entrants given that the same accuracy GPS would be the basis of the control of the flight and also the setting of the course.

It is hard to envisage natural UAV tasks that will effectively depend on human skill whilst the activity is being flown, given the basic nature of UAVs. Of course there could be a massive amount of work put into the technology development prior to an event, with the software, the hardware, the integration into the airframe, and evaluation of the results. There might be a limited amount of technology adaptation for local conditions on the day. Despite this unconstructive comment humans are very creative, and it is always possible that over time innovative competitions may quickly emerge.

It is open to question whether these competitions should be considered a sport. CIAM has recently conducted an extensive debate on the Internet on whether model aviation is a sport anyway. Unfortunately this has been undertaken in a forum to which interested members of the public have access. This has the potential to have serious implications for the MAAA in its ongoing pursuit of having model aviation recognised as a sport by the Australian Federal government. This is because, despite the comments being made exclusively by advocates of model aviation being a sport, they have provided sufficient detailed information to make out a strong case that in generally model aviation is not a sport. These arguments are even more relevant to UAVs and they can be significantly extended.

A fundamental question is whether the FAI should consider conducting events either as a sport or otherwise, where the emphasis is on technology rather than flying and other aviation skills. Of course technology is involved in all aviation sports. This not only involves the basic airframes but also in support. For example within the electronic flight bag that glider pilots usually carry with them in competitions these days, they have a suite of electronic support packages including complete competition rules, waypoints, weather forecasts, current conditions with restricted and allowed flying areas. New 'nice to have' packages are being marketed all the time whether or not they have a real benefit. There is no restriction on how these are linked into the aircraft GPS and other navigational aids. UAVs operation can be considered a natural extension of this. Similar technological aids exist in the other air sports but in all these there is a person who is in ultimate control and, whilst technology levels the playing field, the better pilot usually wins.

Whatever the merits of competition events, records will always be claimed for UAVs, in the same way as they are for manned aviation, whether under the control of the FAI or not. As well as being claimed by enthusiasts, these can be set by commercial equipment using professional crews and in same cases have to be, such as the longest flight with a commercial airliner when in an A380 was flown to Australia non-stop on a delivery flight. This is already happening with UAVs and I noted that one manufacturer in his publicity for a relatively small 3.3 meter wingspan UAV, is claiming a world endurance record of a non-refuelled flight exceeding 45 hours. This time is short compared to some larger UAVs.

<u>FPV discussion</u>

The above discussion has been around UAVs. Before closing it is probably worth reviewing an intermediate step between conventional model aircraft and UAVs. This is First Person View (FPV). These are flown for recreation as well as for commercial uses. The technology employed enables the pilot to control the aircraft using a radio down link from the aircraft which provides him with a visual picture or pictures as though he were actually sitting in the aircraft. These screens can even be built into his headset. With these to guide him he flies the aircraft remotely. For safety reasons most recreational pilots, operating under the rules of a national model aviation organisation, are required to have a back up pilot who maintains direct visual contact with the aircraft and is able to take over in the event that the FPV pilot becomes disorientated. Many of the same observations still apply to these as for UAV but it is easier to envisage competitions where flying skills are more significant in the final result. This could be regarded as a natural extension for CIAM.

Summary

Given that a UAV has an almost limitless set of characteristic it is hard to come up with a simple and readily agreed definition as to what is a UAV and what is a model aircraft, particularly if you look to future technology developments. Clearly there is no weight differential as there is a complete overlap in weights of UAVs to those of model aircraft. If you take the suggested characteristics of model aircraft put forward in David Roberts' paper, if used in an FAI non-record context both UAV and model aircraft would be used for sport and recreational purposes and in a non-commercial environment. Equally many UAVs operate only within Visual Line of sight. It is also possible to have a UAV where much of the flight is controlled manually just as a model aircraft even if the skill level required is limited.

Coming out of the discussion the best suggestion that I can put forward if a definition is required is that it is a UAV for sport and recreational purposes is if some part of the flight is autonomous; that is the aircraft is flying with no external control input. That would not affect any current model aircraft class and would allow aircraft just using FPV technology to come in as model aircraft. Any classes for aircraft involving autonomous control would then be classified as UAV whether they were to come under the control of CIAM or not. If the FAI were to consider events for them these would almost certainly be a separate style to those currently enjoyed by model aircraft pilots.

Apart from this, as I said in the introduction I have not attempted to come to final conclusions on the questions asked of CASI. What I have done is to try to put together a relatively informed and hopefully unbiased assessment of the current UAV situation to promote a more informed debate.

There are few fundamental questions which have to be either decided or confirmed. The scope of these answers goes well beyond just UAVs into the future. For records there are clear precedents to encompass both sport and commercial operations. As technology develops across all air sports does the FAI hold sports or technology competitions or both? As technology develops what is the minimum level of direct human activity in the performance of an event, if any, that the FAI will not go below for it to be considered an FAI event? To look at this in another area, UAVs are a clear potential implementation of the scenario some envisage that wars will be fought in the

future without human risk and just be ‘my technology fighting your technology’ with no human intervention Maybe it will happen maybe not, but the possibility is there.

Until these decisions are made it is not possible to project what events FAI should consider for UAVs. It probably makes sense to have either a single, or several, weight or size classes for both fixed and rotary wing, which do have different characteristics. These should be limited to allow for international transportation to the event site, assuming that this concept still remains. If more than a single class for each type of aircraft how do you stop technology making the intent of these obsolete as smaller platforms increase in capability or affordability? Maybe these are complications that are best avoided and just have a single class but with an upper size/weight limit for competition purposes. A single size/weight limit could be different for different complexities of the events and could conceivably just be reduced over time as technology develops.

Do you try to limit the technology that can be employed? UAVs are definitely at the forefront of technology development for military applications. This inevitably spills over in the commercial and non commercial areas. A valid question that can be asked is whether all counties, and the citizens of those countries, have the same access to the same technology, which can include miniaturisation. This technology definitely falls into sensitive areas for national security, even at a non classified level. This means that export controls may be applied on a national basis and this would prevent a level playing field.

Despite these questions UAVs are the most rapidly expanding area within the international aerospace industry. Not only is it impossibly to ignore them they also have much more attraction for the youth of today than more traditional aviation activities. If for no other reason than this, the FAI has to encourage and embrace them in some form.