UNMANNED AERIAL VEHICLES IN NATIONAL AIR SPACE

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INTRODUCTION

The safety of humans and aviation assets is paramount in flying, with all else being secondary; if there is ever a conflict or ambiguity in the interpretation of a rule, the rule of thumb is, 'flight safety is of paramount importance', and all actions are to be tailored accordingly. Thus, the guiding principle in manned flight has been one of 'see and avoid,' other than when a flight plan has been filed under Instrument Flying Rules (IFR), during which the onus of supervisory control is with an air traffic agency. Unmanned Aircraft Systems (UAS) have brought in a new dimension for the implementation of the 'see and avoid' dictum, as they go against the most basic 'given' in air traffic management, of a pilot being in the cockpit to follow the maxim. All prevalent flying structures, rules, regulations, advisories, procedures, visual signals *et al* have been framed accordingly.

As has been the case with most cutting edge technology, the UAS was born as a pure military machine that was flown and used in restricted air space reserved only for the military. However, its use in the civil market was soon realised and roles for it proliferated, from photography to courier delivery and from crop spraying to inspection of electric transmission lines, requiring sharing of air space with the military. A need was felt,

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A need was felt, more than two decades ago, to regulate air space usage by UAVs through legislative and regulatory processes. Major work is being done in the United States where UAVs should have been transiting civil air space by end of 2015, as per a direction given to FAA under the FAA Modernisation and Reform Act of 2012 (P.L. 112-95).

more than two decades ago, to regulate air space usage by Unmanned Aerial Vehicles (UAVs) through legislative and regulatory processes. Major work is being done in the United States where UAVs should have been transiting civil air space by the end of 2015, as per a direction given to the Federal Aviation Administration (FAA) under the FAA Modernisation and Reform Act of 2012 (P.L. 112-95).[1] By an Act of Congress in 2003, FAA had been directed to include in its next generation air transportation system , "…a wide range of aircraft operations, including airlines, air taxis, helicopters, general aviation, and unmanned aerial vehicles."[2] This gave an impetus to the administrators to continue working towards accepting UAVs in the US national air space. Clearance for using international air routes would be the next logical step and the International Civil Aviation Organisation (ICAO) is already at work for framing rules and Standard Operating Procedures (SOPs) to ensure the regulation of unmanned aerial traffic internationally. An ICAO meeting in January 2007 concluded that "… ICAO should serve as a focal point for global interoperability and harmonization, to develop a regulatory concept, to coordinate the development of UAS Standards and Recommended Practices (SARPs), to contribute to the development of technical specifications by other bodies, and to identify communication requirements for UAS activity."[3]

The introduction of armed UAVs and the rapid advancement of artificial intelligence has added a more intricate complexity to the requirement. In hot

1. Bart Elias, *Pilotless Drones: Background and Considerations for Congress regarding Unmanned Aircraft Operations in the National Airspace*, US Congressional Research Paper 2012, available at http://fas.org/sgp/crs/natsec/R42718.pdf. Accessed on February 22, 2017.
2. Ibid.
3. ICAO Cir 328, "Unmanned Aircraft Systems (UAS)", Order Number: CIR328, 2011, p. 1.

spots of the world, where conflict is taking place, both UAVs and armed UAVs are flying in the national air space in many countries, as well as crossing international boundaries on operational missions. However, this is happening within air space that is uncontested and where one side has total air control; it would not be wrong to say that the side using UAVs in such an environment is regulating the air traffic routing and procedures in such areas. Civil traffic is conspicuous by its absence in such places, and military aviation rules the roost, as it were. The Afghanistan-Pakistan border, Yemen, Somalia and the air space around Israel are examples where aerial military unmanned air operations are underway but air space conflict issues have not acquired any urgency to demand the creation of legislation and implementation of special rules. In the Western countries, however, civil drone flights have become worrisome and some initial rule-making has already taken place. For example, drones in Germany must not weigh more than 25 kg[4], while in the UK, stringent rules and regulations have been laid down in a UK Civil Aviation Authority Manual CAP 722.[5]

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This essay will, in two sections, deal with the issue of air space management and interoperability/joint operations matters. In the first section, air space management issues would be examined in three parts. Firstly, the existing air traffic services structure would be studied, especially the principles in force to ensure safe flow of traffic. Secondly, its adaptation to the introduction of UAVs would be derived; this would include the

4. US Library of Congress, “Regulation for Drones: Germany”, Available at https://www.loc.gov/law/help/regulation-of-drones/germany.php. Accessed on February 19, 2017. .
5. UK Civil Aviation Authority, “Unmanned Aircraft Systems Operations in UK Airspace : Guidance”, available at http://publicapps.caa.co.uk/docs/33/CAP%20722%20Sixth%20Edition%20March%202015.pdf. Accessed on February 19, 2017.

With an autonomous UAV, or the UCAV, there would be no pilot in the loop but possibly, a man *on* the loop – the difference between the two being that while in the former, a human is controlling operations, in the latter, the machine is carrying out pre-programmed as well as autonomous actions, and the human role is just supervisory in nature.

study for any modifications that may be required in the case of Unmanned Combat Aerial Vehicles (UCAVs). Lastly, organisational changes to implement the modifications that may be needed would be brought out. The discussions would then flow into the second section where additional important issues, other than those concerning air space, are debated. Though there are major differences between a UAV and an armed UAV (the armed UAV is an intermediate machine and could be likened to a benign transport aircraft platform that has been retrofitted with armament), these terms would be used interchangeably to mean an unmanned aerial vehicle. In addition, the added complexities of UCAVs that affect their operations in the non-segregated air space would also be covered. This study takes as a truism that, in the foreseeable future, the Indian national air space would be predominantly a joint user air space, where military and civil, manned and unmanned, air operations would take place simultaneously**;** it would not be an either/or situation. Before moving to Section I, a few explanations would be in order.

If air space had been a total military asset all over the world, then the integration of UAS would not have been a problem, as a centralised military command post would have ensured separation. But in yesteryears, when a UAS was talked about, it carried the tag of 'unmanned' as there was no pilot in the cockpit; it was a remotely piloted aircraft, with a human being in control of the flight – the so-called Man in the Loop (MIL), and, hence, came the more technically correct term, Remotely Piloted Aircraft (RPA). With an autonomous UAV, or the UCAV, there would be no pilot in the loop but possibly, a man *on* the loop – the difference between the two being that while in the former, a human is controlling operations, in the latter, the machine is carrying out pre-programmed as well as autonomous actions, and the human role is just supervisory in nature.

A little earlier, it was said that the challenge of safety regulators and operators is to 'see and avoid.' This is not wholly correct as the 'eyes' of the pilot only observe an event but it is the sensory impulse that is generated that enables him gain situational awareness of the environment around him to plan further action. Thus, if technology permits the operator of an aerial machine to have a 'sense' of the environment around him, then it is not necessary to replicate human vision in order to have accurate situational awareness. So the correct terminology to use is 'detect/sense and avoid' and this becomes an imperative Qualitative Requirement (QR) for UAS, so as to de-conflict with other aerial traffic.

SECTION I – AIR SPACE MANAGEMENT ISSUES

EXISTING AIR TRAFFIC MANAGEMENT STRUCTURE

The present Air Traffic Management (ATM) structure to manage and de-conflict air traffic is based on two types of control:

- **Procedural Control:** In procedural control, a defined volume of air space is delineated for a specified time to de-conflict air space users. If properly implemented, procedural control is simple to follow, as it is based on the go/no-go criteria, based on rules dependent on air defence identification procedures, types of available voice and digital communications between aircraft and air space control elements, control measures such as height bands dependent on aircraft types and restricted zones such as firing ranges and/or areas. An American Joint Services publication qualifies procedural control as a process which relies "..on common procedures, designated air space, and promulgated instructions by an air space control element to de-conflict and activate Air Traffic Control Measures (ATCMs), Air Space Control Measures (ACMs), Fire Support Coordination

"No aircraft capable of being flown without a pilot shall be flown without a pilot over the territory of a contracting State without special authorization by that State and in accordance with the terms of such authorization…."

Measures (FSCMs), and Air Defence Measures (ADMs)."[6]

- **Positive Control:** As the name suggests, this is a 'hands-on' control and relies on surveillance, accurate identification, and effective communications between air space control elements and air space users; in positive control, an air space user is told by an air traffic controlling authority exactly what to do and when. A lot of identification and surveillance equipment goes into effecting positive control to include radars, Identification, Friend or Foe (IFF) interrogators and receivers, beacons, tracking computers, data links and communications equipment. There are two essential requisites for positive control, viz., capability to locate and identify air space users and ability to maintain continuous communication with them for dissemination of instructions. In a contingency of communication failure, positive control procedures have the capability to move to procedural control for continuation of safe flight.

ADAPTATIONS FOR UAS TO OPERATE IN NON-SEGREGATED AIR SPACE

The operations of UAS would have to adhere to the above two types of controls, as per existing laws and regulations. The in-force policy document for UAS operations is ICAO circular CIR 328 which states that as per Article 8 of the Convention on International Civil Aviation, signed at Chicago on December 7, 1944, and amended by the ICAO Assembly (Doc 7300), "No aircraft capable of being flown without a pilot shall be flown without a pilot over the territory of a contracting State without special authorization

6. US Joint Chiefs of Staff, Joint Airspace Control, Joint Publication 3-52, November 13, 2014, p I-5, http://www.dtic.mil/doctrine/new_pubs/jp3_52.pdf. Accessed July 20, 2015.

by that State and in accordance with the terms of such authorization….” Further, the circular quotes the Global Air Traffic Management Operational Concept (Doc 9854) which states, “An unmanned aerial vehicle is a pilotless aircraft, in the sense of Article 8 of the Convention on International Civil Aviation, which is flown without a pilot-in-command on-board and is either remotely and fully controlled from another place (ground, another aircraft, space) or programmed and fully autonomous.” This understanding of UAVs was endorsed by the 35th Session of the ICAO Assembly held in September-October 2004, and has not been amended since.

Only RPAs will be able to integrate into the international civil aviation system in the foreseeable future. The functions and responsibilities of the remote pilot, as also his own safety, are essential to the safe and predictable operation of the RPA while it (the RPA) interacts with other aircraft and the Air Traffic Management (ATM) system.

Since there had been a great demand, especially from commercial operators, to open up the air space to UAVs, ICAO clarified in unambiguous terms, “UAS will operate in accordance with ICAO standards *that exist for manned aircraft* (emphasis added) as well as any special and specific standards that address the operational, legal and safety differences between manned and unmanned aircraft operations. In order for UAS to integrate into non-segregated air space and at non-segregated aerodromes, *there shall be a pilot responsible for the UAS operation* (emphasis added). Pilots may utilize equipment such as an autopilot to assist in the performance of their duties.”[7] Thus, it is abundantly clear that, as of the present, humankind is not willing to have an autonomous machine in the same air space as a manned one due to flight safety reasons. Only RPAs will be able to integrate into the international civil aviation system in the foreseeable future. The functions and responsibilities of the remote pilot, as also his own safety, are essential to the safe and predictable operation of the RPA while it (the RPA) interacts with other aircraft and the Air Traffic Management

7. n.3, p.7.

(ATM) system—this aspect is an important point in the decision-making loop (for authorising UAV operations in the non-segregated air space) and will be covered subsequently.[8]

To fly in a common user air space, a UAV / UCAV would need to have the following prerequisites:[9]

- Certification for the RPA, its operator and remote pilot. This necessitates laying down of internationally accepted rules, since in international transit, every country over which the unmanned aircraft is flying, would insist on adherence to its standards. It needs to be appreciated that this is a very stringent requirement since it is not just the certification of the machine that is being talked about, but the complete system of ground-based equipment (at origin, in transit and at destination), communication relays as also the competence of personnel who would service the system and fly the unmanned aircraft remotely.
- Approvals from competent national authorities to operate the RPAs as a complete system. Since the sourcing of the various systems and sub-systems would be different from one country to another, the system as a whole would need to be approved. Any changes of sub-systems having an impact on flight safety would require a re-verification.
- Equipment for interaction with Air Traffic Control (ATC) and other aircraft ('other' aircraft include UAVs and UCAVs). This implies that there would have to be a certain amount of standardisation so as to enable airborne equipment (of manned and unmanned objects) to communicate with each other and with ground-based equipment. This requirement would have to transcend operating personnel of different nationalities and equipment of different origins. The requirement thus takes the form of a global communication protocol agreed to by all concerned. With developments taking place at a fast pace in swarming techniques, additional and unique requirements would arise as foolproof communication would be necessary between the following.

8. Ibid., p. 3.
9. Ibid., p. 6.

  - Ground control at place of launch (whether the pilot in the loop or the air traffic control) and the UAV and/or UAVs being controlled.
  - Other ground controls that would be involved in the transit of the UAV, including at the destination.
  - Airborne controller of the UAVs (whether the pilot of another aircraft as in a hybrid manned/unmanned formation, or a controller in an Airborne Warning and Control System (AWACS) or Airborne Early Warning (AEW) aircraft) with the UAVs or the swarm being controlled.
  - Integral swarm communications.
  - Communication between various airborne controllers whose UAVs/swarms may land up in a conflict situation.

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- Predictable actions, so that human operators know what to expect of an unmanned aircraft under a given set of inputs. In the case of a manned aircraft, acceptance of an order by a human recipient would result in a predictable action. A similar response would be expected of an RPA, and it would normally be so too since there is a man in the loop, albeit at a remote location from the unmanned vehicle. This requirement would seem to disqualify a UCAV totally, since it would be acting autonomously; this aspect is discussed subsequently.
- Contingency procedures. As a general rule, contingency procedures demand predictable actions that are understandable and anticipated

To identify and avoid bad weather is very important from the point of safety. Here, the RPA faces a limitation, as it would not be able to 'visually' report weather conditions around it, the way a pilot can, by observing, analysing and passing on his deductions to the air traffic control and other aircraft.

by all. In RPAs, the presence of a man in the loop would normally meet this requirement. Such may not be the case with UCAVs due their autonomous nature. Software solutions in the embedded artificial intelligence would need to be exhaustive to replicate the actions of the remote pilot (of a UAV if he was in the UCAV loop) in order to measure up to this requirement. "Air navigation service providers will need to review emergency and contingency procedures to take account of unique RPA failure modes such as C2 link failure, parachute emergency descents and flight termination."[10]

- Collision and hazard avoidance equipment and capability. Though all the points mentioned above are important, this one would be the final test for acceptance or rejection of a UAS. Since the whole aim of the evaluation process is to determine the ability of a UAS to safely transit an air space along with manned aircraft, the capability to sense/detect likely situations that may cause a collision with another airborne or ground-based object, in other words, to avoid getting into a hazardous situation, would be a capability that would be critically evaluated. This would involve, not only the equipment (both airborne and ground-based) but also the electronic reasoning and logic fed into the system.

Unless unique types of air spaces, with varying minimum requirements are promulgated, the above requirements, met in full, would be necessary to impart the following capabilities to an RPA.

- Recognise and understand aerodrome signs, markings and lighting, which would be mandatorily required for ground handling, pre and post a mission.

10. Ibid.

- Recognise visual signals, on the ground (e.g., for parking or other marshalling actions while manoeuvring on the ground) and in the air (e.g. during an interception);
- Identify and avoid terrain, when operating close to the ground, e.g., during take-off/landing operations in a hilly area [like Leh or the Advanced Landing Grounds (ALGs) in northeast India] or during pre-planned low flying.
- Identify and avoid bad weather, which is very important from the point of safety. Here, the RPA faces a limitation, as it would not be able to 'visually' report weather conditions around it, the way a pilot can, by observing, analysing and passing on his deductions to air traffic control and other aircraft. Similarly, reporting of weather to a remote pilot by the ATC would not be assimilated in a manner that a pilot in the cockpit would be able to do. In the majority of cases, the remote pilot would err heavily on the side of caution, resulting in probable sub-optimal execution of missions in less than ideal weather.
- Provide "visual" separation from other aircraft or vehicles. The detection would come about by using electronic sensors; and though the distance and positioning of the object in space would be available, the "sense" of the situation that a human brain would form would be difficult, if not downright impossible, to replicate electronically.
- Avoid collisions by taking required actions in a manner consistent with flight safety.

The above requirements place a heavy demand on engineers and industry to devise solutions for the critical requirement of 'detect and avoid'. It may well transpire that the solution could be to have transitional phases and have the air space opened up for UAS operations in a gradual manner over time, with relaxations of restrictions in tranches as technology progresses and matures

ICAO has accepted that integration of RPA into aerodrome operations will prove to be among the greatest challenges. As it states,

Since the present rules demand manoeuvring of the RPA through a remote pilot, a time latency factor in execution of orders and tasks comes into the equation; safety considerations will demand, at the very minimum, low latency so that safety is not compromised.

At issue are provisions for the remote pilot to identify, in real-time, the physical layout of the aerodrome and associated equipment such as aerodrome lighting and markings so as to manoeuvre the aircraft safely and correctly. RPA must be able to work within existing aerodrome parameters. Aerodrome standards should not be significantly changed, and the equipment developed for RPA must be able to comply with existing provisions to the greatest extent practicable. Moreover, where RPA are operated alongside manned aircraft, there needs to be harmonization in the provision of ATS. Consideration may be given to the creation of airports that would support RPA operations only. Current provisions regarding aerodrome design, construction and operations would continue to apply, however ,some amendments or additions may be necessary to accommodate unique RPA issues.[11]

Technology will play a vital role in the ease of acceptance, or otherwise, of UAVs in the common user air space. Since the present rules demand manoeuvring of the RPA through a remote pilot, a time latency factor in execution of orders and tasks comes into the equation; safety considerations will demand, at the very minimum, low latency so that safety is not compromised. While normal operations would generally meet the criteria, it is the emergency manoeuvring to avoid collisions, or other flight safety situations, or to follow orders of air traffic control, that would constitute the deciding factor. The UAV would need to be an effective communication relay for the remote pilot, since the ATC would be observing the UAV and issuing orders to it (the UAV) for implementation, as it would to any other manned aircraft; the actions would have to be relayed to the remote pilot whose control inputs would then govern the RPA's behaviour—as brought out earlier, a very low latency time would be an imperative requirement.

11. Ibid.

Peculiarities: The unmanned aircraft presents a large number of peculiarities that need to be addressed by aviation administrators and operators. While many have been discussed earlier some more special issues that need to be factored in are now covered.

- Wake turbulence is an important flight safety issue and considering the varying sizes and weight categories of unmanned aircraft, special studies may need to be undertaken to address this point. Separation standards may have to be re-defined and, may be, the procedures too.
- Transportation of restricted cargo, i.e., carriage of armament on board an unmanned aircraft is a special case for both UAVs and UCAVs. Military unmanned aircraft would have ordnance in certain flights. Even manned aircraft sometimes carry such load when transiting through civil air routes—the difference is that there is a pilot on board to take decisions in case a situation that warrants their jettisoning arises. So, when an unmanned aircraft with armament traverses through the unsegregated air space, safe routes and/or corridors may have to be laid out, so that it can be jettisoned in an emergency to a safe area. Alternatively, other than in the case of war, carriage in normal transit may have to be forbidden and the armament transported by other means, putting a limitation on emergent operations. Presently, this has not created any problems as such flights have taken place in the segregated air space, ensured by the military air space control. However, ICAO CIR 328 clearly states, "Payload on RPA is not a factor considered within this document except as it pertains to dangerous goods. Likewise, any communications/data link requirements for the payload are not addressed herein." This implies that a UAV/UCAV with armament would have to be considered as a special case and rules framed accordingly. Similarly, Command and Control (C2) links for the payload being carried would form a special case for consideration.

  Diversions to non-military airfields not equipped to handle UAVs may be required due to a host of reasons like bad weather, aircraft emergency, etc. What happens then? Are all civil/military airfields expected to be equipped to cater to such diversions? If not, flight plans of unmanned aircraft would have to be tailored accordingly, with attendant penalties. Sometimes, the diversion may be ordered by the state over which the unmanned aircraft is flying—this is a right given to all states by ICAO legislation. This brings in an element of compromise of secrecy vis-à-vis the technology of the unmanned aircraft and/or its payload. However, unless the rules are amended, flights of UCAVs in foreign air space are prohibited, as CIR 328 states, "Each contracting State undertakes to ensure that the flight of such aircraft without a pilot in regions open to civil aircraft shall be *so controlled* (emphasis added) as to obviate danger to civil aircraft", [12] implying that an autonomous aerial vehicle of one nation cannot overfly another's air space unless a remote pilot is in the loop.

- Licensing of operating personnel would be complex in the international operations of an unmanned aircraft as the aircraft would land in an airport with its licensed remote pilot or operator (in the case of a UCAV) not available to the airport authorities. There would be issues of licensing of ATC personnel too, as new requirements of handling an unmanned aircraft would have to be added.
- The civil operators, as also the military, would like to have a 'file and fly' approach in unmanned operations. This would have to be handled with care and must follow a sequential approach through risk assessment at periodic milestones, so as to ensure safe and seamless integration of operations in the joint user air space.

ORGANISATION REQUIRED

Every armed force in India that operates an air arm has a specialised branch that deals with aviation issues. Within this branch, there are many specialties that necessitate the existence of sub-branches like those dealing with air defence, offensive operations, transport and helicopter operations, air traffic services *et al.* Unmanned aircraft operations could be part of one

12. Ibid.

such sub-branch or there may be a stand-alone sub-branch dealing with unmanned aircraft operations. Be that as it may, UAV operations in the non-segregated air space would require close coordination with the Ministry of Civil Aviation (MoCA) for the formulation of rules and regulations, as also SOPs. Thus, a joint permanent body of the Ministry of Defence (MoD) and MoCA comprising members from the Services, Directorate General Civil of Aviation (DGCA) and Airports Authority of India would need to be established to act as a nodal point for all issues concerning the use of the national air space by military and civil UAS; these would include, but not be limited to, air space management issues, conflict/dispute resolution, certification of UAVs, training of operators, and creation and maintenance of ground-based operational and administrative infrastructure. The body would be a hands-on entity that would be responsible for drafting rules and regulations, and monitoring their implementation by operators, both civil and military. There would be issues of confidentiality in some military UAS activities and missions; this body would accordingly be charged to ensure de-confliction without compromising the confidentiality of such missions. The responsibility for interaction with the ICAO UAS group and Eurocontrol would rest with this organisation.

A plan should be drawn up to cater to near, middle and long-term implementation of the induction schedule. To do this, studies and assessments would be required to be undertaken with respect to utilisation patterns, operational profiles and associated safety issues.

It is obvious that there would be a step-by-step expansion of the envelope of utilisation of UAS in the joint air space. It would be incumbent on the permanent UAS body to work up the steps and notify them for the information of the operators. A plan should be drawn up to cater to near, middle and long-term implementation of the induction schedule. To do this, studies and assessments would be required to be undertaken with respect to utilisation patterns, operational profiles and associated safety issues. There would be vast variation in each of these aspects. In the civil domain, tasks could vary from delivery of small courier packages to delivery of urgent

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medicines and from crop spraying to traffic management/television coverage; in the military environment, the tasks could be as benign as inter-base transit to transit from a base to an armament range with live, loaded weapons. It should be remembered that an organisation's work culture also impacts the conduct of operations, hence, it is imperative that the rules and regulations that are made and promulgated, take this vital aspect into consideration. In aviation activity in a common area, there has to be only one culture, and implementation of orders and regulations cannot comprise an elastic interpretation by different organisations. Thus, when aerial vehicles, operated by different and vastly varied agencies and of different shapes, sizes, capabilities and limitations transit a common air space, aviation safety demands creation of an aerial cloud where only one set of rules, agreed to, and accepted by, all the operators, is the norm.

It goes without saying that the governing rules and regulations should be drafted as early as possible, since manufacturers and operators have to tailor their processes accordingly. MoCA has made a beginning by issuing *draft* guidelines in April 2016[13] for "Obtaining Unique Identification Number (UIN) and Operation of Civil Unmanned Aircraft System (UAS)." Comments on the draft were asked for from the general public by May 21, 2016. It is presumed that the deliberations are still ongoing, since finalised, approved rules have not yet been issued. There would be a requirement to lay down the capability norms and minima as part of the airworthiness requirements so that equipment necessary to generate the required 'detect/sense and avoid' capability can be designed and manufactured to equip UAVs. These

13. "Guidelines for Obtaining Unique Identification Number (UIN) & Operation of Civil Unmanned Aircraft System (UAS)", available at http://www.dgca.nic.in/misc/draft%20circular/AT_Circular%20-%20Civil_UAS(Draft%20April%202016).pdf. Accessed on February 19, 2017.

are not part of the draft guidelines. Such equipment would be both ground and air-based and a technically qualified organisation to check certification would be needed. Besides the MoD and the civil aviation department, legal and commercial arms of the government would also need to be associated to address issues of liability and commerce. Where would the liability lie in the case of a UAV mishap that causes loss of life and /or property, whether on the ground or to an aerial vehicle, whether manned or unmanned? Would it be the equipment manufacturer or the operator who could be sitting hundreds of miles away, may be in a different country? In the case of a UCAV, it would be more complex as liability determination in the case of a 'wrong' decision by an artificial intelligence enabled machine would have many avenues to be addressed. There are, thus, many other issues like legal requirements, training, security and public relations that need to be looked into.

SECTION II

This section covers issues other than those having a direct bearing on joint utilisation of air space.

LEGISLATIVE REQUIREMENTS

The use of common air space by UAVs may be governed by regulations that are enablers to make full use of their capabilities. For example, a European Aviation Safety Agency (EASA) paper has recommended that regulations should not just be a carry forward of manned aircraft stipulations but be "…proportionate, progressive, risk-based, and the rules must express objectives that will be complemented by industry standards."[14]

Civil aviation in India is governed by the Indian Aircraft Act, 1934, when unmanned flying machines, other than balloons, were very limited and comprised those flown by radio control only; in fact, it is doubtful whether they were even available in India when the Act was formulated. Be that as it may, the Act defines an aircraft as:

14. Beth Stevenson, "EASA Proposes Proportionate Risk Scale for UAV Operation," Flightglobal.com, http://www.flightglobal.com/news/articles/easa-proposes-proportionate-risk-scale-for-uav-operations-410145/?cmpid=NLC|FGFG|FGUAV-2015-0316-GLOBnews&sfid=70120000000taAj. Accessed on February 15, 2017.

It would be appropriate that the implications of UCAVs, which would be a special category of UAVs, transiting the common air space, are dealt with separately. That they would be military machines, and would be flying due to a national requirement, implies that a special dispensation may have to be made with respect to immunity of the operators under certain circumstances.

> 'Aircraft' means any machine which can derive support in the atmosphere from reactions of the air (other than reactions of the air against the earth's surface) and includes balloons, whether fixed or free, airships, kites, gliders and flying machines.[15]

So effectively, the present UAVs would be covered under the definition of 'aircraft' as given in the Act; however, considering the multifarious usages that the UAVs would be put to, it would be prudent that legal opinion on the sufficiency of the Act, as it exists today, is obtained. It would be appropriate that the implications of UCAVs, which would be a special category of UAVs, transiting the common air space are dealt with separately. That they would be military machines, and would be flying due to a national requirement, implies that a special dispensation may have to be made with respect to immunity of the operators under certain circumstances. The criticality of UCAVs to the Indian military, as determined by the Parliament, should form the basis of the review of the Indian Aircraft Act.

SECURITY REQUIREMENTS

The security of aircraft and personnel takes on a different meaning when considering operations of unmanned aircraft in the unsegregated air space. With manned aircraft, anti-hijack security checks are carried out on passengers as well as aircrew; these checks are also done on all technicians, personnel (be they caterers, sanitation workers *et al*) and vehicles entering the sanitised area of an airport. Thus, an aircraft takes off from a sanitised area and with

15. The Aircraft Act 1934, available at http://dgca.nic.in/rules/act-ind.htm accessed on February 22, 2017.

security cleared people (passengers and crew) on board, thus, ensuring the aircraft's security from a hijack. In the case of UAVs, there are two ways by which security can be compromised. Firstly, by taking over of the machine by interfering with its data link mechanism (hacking, spoofing and other types of attacks), as is reported to have been done with a sophisticated RQ 170 American UAV by the Iranians on December 4, 2011 (the UAV was shown absolutely intact on Iranian television)[16]. This can be avoided by laying down stringent technical certification requirements which have adequate layers of hardware and software enabled security. The second way of hijacking a UAV is by holding a hostage or subverting the UAV operator. Thus, the physical security of a remote work station (including from a heavy weapons attack) and sanitisation of the remote workplace and personnel in it becomes a vital imperative. It would have to be ensured that a rogue operator (of his own volition or under duress) does not wreak havoc in air space having both manned and unmanned aerial vehicles. This would also have to be guaranteed when UAVs on Beyond Line of Sight (BLOS) flights are handed over from one control station to another; the complexity in this would arise from the fact that the operators could be from two different organisations – in fact, they could be from different nations too for long range UAVs which would transit international routes. Thus, Indian rules would have to be in conformity with international operations to ensure standardisation. The empowered DGCA/MoD body would have to lay down rules and a mechanism to ensure this in a fool-proof manner.

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16. Frank Gardner, "Why Iran's Capture of US Drone will Shake CIA," available at bbc.com, http://www.bbc.com/news/world-us-canada-16095823. Accessed on February 22, 2017.

The public relations campaign can take the path of seminars, symposiums, public broadcast media like radio, television and print, as well as taking opinion makers through a detailed explanation of the safety factors built-in through simulation exercises.

TRAINING

Since there are varied types of unmanned aircraft (gradation depending on all-up weight, size and capability), it is a given that the training requirement of all the operators cannot be of the same rigour; however, certain baseline parameters have to be the same. In order to ensure standardisation, it may be necessary to establish a training institution. In the US, the FAA has selected the Mississippi State University to set up and operate a National Centre of Excellence under a public-private partnership programme. The centre's research areas will initially include, among other things, search and avoid technology, control and communications and training and certification of the human resource.[17] Considering the odds involved, a similar research set-up may be required to advise the MoCA/MoD team so that their deliberations and decisions remain contemporary and are based on the latest developments in the UAV field. For sure, there are major differences between military unmanned aircraft and those of the civil operators, but certain 'rules of the air' for unmanned operations in the non-segregated air space would have to be mandated. This may result in the loss of some operational 'bite' or flexibility but it is a loss that may have to be accepted for the sake of perception management of the public at large.

PUBLIC RELATIONS

The introduction of UAVs in the civil air space would raise many observations and fears amongst the public. Some are already being voiced and are genuine, for example, privacy concerns, but many may be exaggerated, especially those concerning security. It is essential that sensitisation of the public with salient aspects of joint usage of air

17. Juliet van Wagenen, "MSU to Lead Public Private UAS Airspace Integration Team," *Avionics Today*, http://www.aviationtoday.com/av/topstories/MSU-to-Lead-Public-Private-UAS-Airspace-Integration-Team_84992.html#.VVF8jI6qqkp. Accessed on February 25, 2017.

space be commenced sufficiently before the start of these operations; this would ensure generation of a healthy debate on contentious issues and those that have a psychological effect on the public. This is an imperative that can be forgotten at the expense of credibility of the joint usage plan, and the target audience should not only include the lay public but also government officials and law makers. It needs to be remembered that an unmanned vehicle traversing the same air traffic service route as a passenger-carrying aircraft, would require a leap of faith on the part of the lay public; a pilot has been seen as the conduit of safe transit in aviation and, suddenly, his absence from the cockpit would require human emotions to be genuinely assuaged. The campaign can take the path of seminars, symposiums, public broadcast media like radio, television and print, as well as taking opinion makers through a detailed explanation of the safety factors built-in through simulation exercises.

As decreed by ICAO, there would be a requirement of ***a pilot in the loop*** **and, hence, for the foreseeable future, true autonomous operations can be ruled out. However, a start needs to be made in India without any loss of time, for setting up a joint MoD-MoCA body to begin addressing the issue.**

SUMMATION

The demand for integration of RPAs into the non-segregated air space has commercial and political overtones that cannot be overlooked or delayed with an elastic timetable. What started as a demand to permit RPAs to transit in the US national air space has now become an international requirement being addressed by ICAO. It is apparent that India cannot remain oblivious to the necessity and, hence, structures need to be put in place to facilitate the induction of RPAs into the Indian air space.

The history of opening up of the national air space in India to joint user requirements (civil and military) has not been encouraging. After many decades of attempts, the burgeoning demand has finally resulted in an initial (and, perhaps, preliminary) document to transit to a process of opening up the military air space to civil traffic through a Manual of Flexible Use of Air Space (FUA) issued on August 28, 2014.[18] Going by that experience, there would be many hurdles to cross when considering RPA operations in the non-segregated and flexible (civil and military) air space; it would be even more difficult when autonomous UCAVs are brought into the picture. As decreed by ICAO, there would be a requirement of *a pilot in the loop* and, hence, for the foreseeable future, true autonomous operations can be ruled out. However, a start needs to be made in India without any loss of time, for setting up a joint MoD-MoCA body to begin addressing the issue. The requirements are many, with the *main ones* summarised as under.

- There needs to be a pilot in the loop at all times when a UAV is flying. Hence, if a machine does not meet the requirements to be called an RPA, it would not be given access to unsegregated air space.
- All rules of the air for manned aircraft would apply to RPAs, in addition to special rules that may be made to co-habit a common air space.
- The RPAs would basically have to conform to the requirements laid down in ICAO CIR 328 and have the following prerequisites:
  (a) Certification, for the RPA, its operator and the remote pilot(s).
  (b) Statutory approvals from competent national authorities to operate the RPA as a complete system.
  (c) Collision and hazard avoidance equipment.
  (d) Equipment for interaction with ATC and other aircraft. This would include the various controllers (airborne or on the ground) that come into the equation when 'swarms' are using the common air space.
  (e) Fool-proof security for the RPA, the remote pilot station(s) and the operators themselves. This is a requirement that would be more stringent and demanding than for current manned operations.
  (f) Contingency procedures that would be unique to RPAs and may

18. Ministry of Civil Aviation, Government of India, August 28, 2014, "Manual of Flexible Use of Airspace in India," http://www.aai.aero/public_notices/FUA_Manual_V1_230315.pdf. Accessed on July 30, 2015.

demand actions from the operating environment that are different than those for a manned aircraft.

(g) Technology that equips the RPA to operate and take actions that are 'predictable,' as would be expected from a manned aircraft.

- Technology would require the following qualities to be embedded in the RPA, with minimum time latency, subsequent to generation of a requirement for action to be taken.
  (a) Recognition and understanding' of aerodrome indicators, lighting, etc.
  (b) 'Recognition and understanding' of visual signals on the ground and in the air.
  (c) 'Identification' and avoidance of terrain in flight close to the ground.
  (d) 'Identification' and avoidance of bad weather, as well as a means of accepting and 'understanding' of weather reports transmited by other agencies/aircraft.
  (e) Ensuring 'visual' separation' from other traffic, as would a manned aircraft.
  (f) Avoiding collision, on the ground and in the air, consistent with flight safety requirements.
- Rules for transportation of restricted cargo would need to be redrafted.
- Wake turbulence criteria and actions necessary would need modification.
- Legal requirements would need to be reworked to cater for peculiarities associated with RPA operations.
- Certain amount of commonality in the basic training for civil and military operators would need codification.

The idea of manned and unmanned vehicles flying together in the same air space is something that the public and government machinery (and that includes human beings), would need to be psychologically prepared for, through a public awareness programme. People need to be assured that the system supports safe 'joint' operations in the non-segregated air space.