Communications To and From Unmanned Aerial Vehicles

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Introduction

Radio Controlled aircraft models which were first made in 1930 in USA are the forerunners of UAVs (Unmanned Aerial Vehicles). UAVs/drones/RPVs (Remotely Piloted Vehicles) are becoming an extremely important part of modern warfare. These are mostly being used for ISR (Intelligence, Surveillance and Reconnaissance) and ELINT (Electronic Intelligence) tasks. RPVs enable troops on the ground to see across a street/beyond the hill, in close vicinity or wider areas of interest comprising hundreds of km. RPVs can be also gainfully used in anti terrorist operations and help in ensuring port and border security as also for policing and internal security applications.

Some UAVs are also armed and have proved to be a very effective weapon platform to track and attack pinpoint stationery and moving targets in Iraq and Afghanistan. In fact larger UAVs can carry out most of the tasks that a small aircraft can, without danger of losing or capture of air crew and at the same time stay aloft for weeks. As a result of the loss of U2 spy plane over USSR in 1960 and capture of Gary Powers the Pilot, research on UAVs was speeded up in USA. Accordingly, the downing of US drone in Iran in early Dec 2011 created much less international row than downing of U2 and capture of Gary Powers!!

With the advent of solid state electronics and super miniaturisation technology the designers could pack much more electronic based payloads in UAVs. This opened many vistas for designing and exploiting use of these birds. During the past few years of combat in Iraq and Afghanistan, UAVs have become integral and critical part of military operations. Ground stations, each supporting a number of UAVs, increased from 16 in 2002 to 1000 in 2008, with nearly 6,000 birds in use.1

Categories of UAVs

UAVs can be categorised under three types-

(a) **Type I or Micro UAV**s are portable and hand launched. They are used to find out what is happening in the close vicinity. The payload is about three to four pounds and endurance is nearly an hour. They normally carry a single camera.

(b) **Type II UAVs** can be carried by two men and have payload of five to 30 pounds. Different types of sensors including EO (Electro Optical), IR (Infrared) or SAR (Synthetic Aperture Radar) can be fitted in them. Such UAVs support formations; brigades, divisions and corps and can have endurance of about 12 hrs. They are capable of operating to the line-of-sight horizon; distance being limited by ground to air communication link.

(c) **Type III UAVs** have size and payload close to nearly a ‘two passenger’ capacity aircraft. They can carry a wide range of sensors, including if required, sophisticated on-board image and sensor data processing systems. Such UAVs like Predator can also be armed with weapons so that they can be used in a hunter/killer role.2

Competing Considerations for Payloads in UAVs

UAVs, particularly Types I and II, have serious limitations of size, engine power, duration of flight and resultant weight carrying capacity. There are competing requirements e.g. fuel, range, communications equipment, cameras, radar and take off power, demanding a share. Which requirement will get how much space and weight in a UAV depends on the role for which the UAV is designed. In order to reduce peak take off power, various kinds of assisted take off methods are made use of.

Communication Links for Operation of UAVs

The planners for induction and operations of UAV systems in our Defence Forces need to realise and appreciate that sophisticated, secure and reliable communications are required to control the flight of a UAV and downloading information being collected by the on board instruments. This information may be in the form of data, imagery and or video. Band width required for down load links is therefore much more than needed **for** up link communications.

Type I and II UAVs invariably do not use satellite links because they cannot carry high-gain tracking antennas. Also they change attitude too rapidly for a tracking antenna to stay locked on any satellite. Therefore, line-of-sight, air to ground communications are used for such UAVs. In case a UAV has to fly low or range of its communication link is affected due to distance or intervening terrain, another UAV can be used as a relay station or a relay station can be located on higher ground.

Satellite links are normally used for Type III UAVs, which are much larger. These links can handle long distance high band width data/videos containing information gathered by various sensors fitted on the UAV. In addition line-of-sight communication equipment can also be installed for command and control, and dissemination of data. Iranians have claimed that the American drone that landed in their territory in Dec 2011, was as a result of their capturing the control link of the drone!! Technical features to minimize susceptibility to jamming and interception are most essential. Initially, communication links with UAVs were mainly analog FM. However, these are being changed to digital links to meet the requirement of security, improved range and efficient use of spectrum. Some peculiarities concerning fitting communication systems in UAVs are mentioned below : –

(a) Placement of antennae on UAVs poses some technical problems due to limited space. In case a UAV has to circle, the antenna can experience a shadow effect from the fuselage, affecting the commerciability of the link.

(b) There are a number of electronic gadgets fitted in a UAV. It is essential that there is electromagnetic compatibility amongst them and any mutual interference is avoided. Particular care has to be taken to ensure that the down link RF power does not jam other electronic instruments (self jamming).

(c) To reduce the weight and space requirements as also self jamming, the RF power of the transmitter in UAVs is reduced and compensated by high gain antenna on the ground. Also, techniques such as downlink antenna space diversity can be used to overcome such problems.

Spectrum and Frequency Management is Essential

The three Defence Services are going in for of UAVs for different applications. The number is going to increase as time passes. In recent years UAVs have been used in asymmetrical wars in Iraq and Afghanistan. But in case of a full fledged or limited war that India might get involved in, the adversary will also be using UAVs in considerable numbers**.** Large frequency bandwidths are required for high definition video, laser designators, SAR, ground moving target indicators and multi-spectral imagers, and have to be catered. It is essential that measures are taken for efficient use of spectrum and frequency management, at inter service level.

Analog FM links used on UAVs typically require 20-25 MHz of bandwidth. This puts a constraint on number of UAVs that can be aloft in a given area at any one time; about three is the maximum number. One obvious solution is to have digital links for communications with UAVs and retrofit those using analog links. Also spread spectrum techniques can be of use. It is also essential to examine in depth the frequency bands to be used for UAV communications. Use of Ku band restricts range but has some advantages over commercial bands**.** Different solutions shall have to be found for varied missions and types of UAVs.

Free-space optical communication (FSO) is an optical communication technology that uses light propagation in free space to transmit data for telecommunications or computer networking. Its implementation will reduce burden on the spectrum used for existing radio transmission techniques. However, many technical details such as ability to keep sustained locking would have to be perfected.3

Use of UAVs as Communication Relays and Nodes

Modern communications are using higher and higher frequency bands. Communications in such bands provide much higher band widths and through put. However, such frequencies are highly susceptible to intervening terrain and in cases even objects. Line of sight is, therefore, essential for uninterrupted and high quality communications. Nodes/relays on mountain tops and carried in tethered balloons are some of the means by which line of sight and communication ranges can be increased.

UAVs which have been primarily used for ISR applications as also for hunter killer operations in Iraq and Afghanistan are emerging as new platforms for elevated relays and communication nodes. These can be of particularly use in operations in mountainous/jungle terrain and mobile warfare, to get over line of sight problems, obtain extended ranges and achieve greater reliability. This would enable Signals commander of a Force to have control over such UAV mounted resources and not depend on out side help. Such elevated small nodes/relay stations can be launched and employed for days and weeks depending on operational and technical requirements. A moving node/relay station in a restricted space on a UAV will pose some technical challenges like self jamming and placement of antenna, solutions for which are possible. The US Army is using its Shadow UAV as a relay. The US Air Force has developed a Battlefield Airborne Communications Node for use on high-altitude UAVs such as Global Hawk.4

Conclusion

Operation of UAVs requires secure and reliable ground to air communications for their control and downloading information collected by various ISR systems mounted in them in the form of video and data. While it is possible to mount satellite tracking antennae in larger UAVs, smaller UAVs can only have radio communications due to constraints of space. Also due to limited space, difficulty of fixing various antennae and mutual electronic interference amongst different ISR systems and communication equipment present some technical challenges. Another important aspect is that particularly down links in UAVs require considerable band width as they carry video and large intelligence data.

UAVs are being used primarily for ISR functions and some larger ones which are armed, in hunter/killer role. A new role for using UAVs as aerial relays and communication nodes has also emerged. Difficulties in providing reliable communications in the mountainous terrain in Afghanistan for NATO Forces, has given this a boost. India has even higher mountains and more rugged terrain along its Northern and Eastern borders. Using UAVs for communication relays and as elevated nodes in such areas and for mobile operations elsewhere by the Indian Corps of Signals can be of immense use in ensuring reliable and high quality communications.

There is a need for inter service initiative and staff for coordinating communication requirement for UAVs and using UAVs as relays and communication nodes. In addition, coordination for efficient use of spectrum and frequency management for UAVs in a battle area is also essential at inter service level.

Endnotes

1. Wikipidia History of unmanned aerial vehicles http://en.wikipedia.org/wiki/History_of_unmanned_aerial_vehicles

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4. DEFCOMSYSTEMS-Knowledge, Technologies and Net-enabling Warfare. Communications relay grows with expansion of UAV missions by David F Carr http://defensesystems.com/articles/2009/07/29/c4isr-1-uav-relay.aspx

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