NON-MILITARY UAV APPLICATIONS

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ABSTRACT

At present time there exists on-going need and demand for air vehicles and services for the real-time remote sensing both at national and international level. Unmanned aerial vehicle (UAV) is very useful to solve a number of non-military tasks as an effective means of search, detection and identifying of the objects and subjects of interest as well as the precise determination of their coordinates. Disaster management and oil and gas pipelines monitoring may be the first large scale practical applications of non-military UAVs.

Almost all technical problems of UAV technology development have been already solved except one. It is the «sense and avoid» problem. This problem could be successfully overcome with a help of the GNSS (Global Navigation Satellite System) Transponder Concept.

The main obstacles for UAV applications are not technical. They are in the arias of legislation, regulations, certification and air traffic management. Small size UAVs and optionally piloted air vehicles (OPAV) are the most likely to be ready for legal limited practical applications in the nearest future.

International cooperation could speed up the process of civil and commercial UAV applications.

INTRODUCTION

The military has a long and continuous history of involvement with UAVs in many countries as well as in Russia (1). The advantages offered by UAVs to the military are numerous, most notably in mission areas categorized as the dull, the dirty and the dangerous.

Some Nations have very ambitious and extensive military UAV development and investment programs. The US Department of Defense prepared and presented the Department of Defense’s (DoD) Roadmap for developing and employing Unmanned Aerial Vehicles (UAVs) and Unmanned Combat Air Vehicles (UCAVs) over the next 25 years (2002 to 2027) (2). The UAV Roadmap provides a Defense-wide vision for UAVs and related technologies as a new era of capabilities and options. UAVs have been labeled as transformational technologies that could change how wars are fought and won (3).

Consideration of UAVs for reconnaissance, surveillance and target acquisition roles in military missions is likely to be dominant in the near future.

UAVs have the potential to revolutionize contemporary concepts on air power. Removal of aircrew and their support systems means UAVs are capable to fly longer, higher and faster without endangering lives. Furthermore, they promise better cost-effectiveness and greater utility than manned aircraft (4).

All these UAV advantages may be very useful for civil and commercial applications.

Some applications from military uses, such as observation and reconnaissance, could be modified for civil market. At present there exists on-going need and demand
for air vehicles and services for the real-time remote sensing both at national and international level. Effective means for search, detection and identifying the objects and subjects of interest as well as for precise determination of their coordinates are necessary to solve a number of non-military tasks:

- Fire-fighting;
- Disaster assessment and management;
- Life search and rescue;
- Border surveillance;
- Police surveillance;
- Counter terrorism operations;
- Large scale public outdoor events surveillance;
- Important objects and VIP guard;
- Ground and sea traffic surveillance;
- Environmental control and monitoring (including air and sea pollution);
- Telecommunications;
- Crop monitoring;
- Animal surveillance;
- Fisheries protection;
- Mineral exploration;
- Ground mapping and photography;
- Meteorological observation;
- Pipeline and power line monitoring;
- Freight carrying.

The often promised widespread use of UAVs in the global civilian market has generally not yet been realized. There are some examples of successes in specific niche market survey, but generally, the civilian UAV market remain elusive (5).

In spite of military dominance of the UAV sector to date, there is large potential for civil applications by private and public entities. There are some key challenges facing the civil UAV community: civil safety and environment certification, standards for manufacturing and operating of UAVs, radio frequency spectrum, export controls and insurance. The main challenge is UAVs fully integration into civil airspace (6).

**UAV INTEGRATION INTO NON-SEGREGATED AIRSPACE**

As far as the access into non-segregated air space is concerned, military and civil UAVs have very much in common. The places where even military UAVs can regularly operate right now are closed off from civil airspace. The most UAV operations are in tightly controlled, restricted airspace. There is very limited access to civil airspace for specific times, locations and operations. The reason is the absence of legislation and regulations governing UAV flights management in unrestricted airspace and UAVs integration into the existing air traffic management system.

In April 2006 European Organization for the Safety of Air Navigation (EUROCONTROL) has sent their recommendations to many of the European countries in the form of a document titled “EUROCONTROL Specifications for the use of military unmanned aerial vehicles as operational air traffic outside segregated airspace” (7). It is proposed that on the basis of this document European countries would pass their law relative to military UAVs flights in non-segregated national airspace.

The EUROCONTROL high-level, generic specifications have been drafted by the UAV Operational Air Traffic (OAT) Task Force (TF). The TF recognized that there was
an interest in operating military UAVs as General Air Traffic (GAT) and in the operation of civil UAVs. The EUROCONTROL Specifications for the Use of Military Unmanned Aerial Vehicles as Operational Air Traffic Outside Segregated Airspace is intended for general public.

The consequent draft specifications follow three basic principles. Firstly, UAV operations should not increase the risk to other airspace users. Secondly, air traffic management (ATM) procedures should mirror those applicable to manned aircraft. Thirdly, the provision of air traffic services to UAVs should be transparent to air traffic control (ATC) controllers.

The specifications are also innovative insofar as they are not constrained by limitations in current UAV capability such as sense-and-avoid. The specifications will therefore only be practicable once Industry develops this and other necessary technology. The number of specifications is 33. These cover the whole set of UAV operations.

**UAV SEPARATION PROVISION AND COLLISION AVOIDANCE**

There is a requirement for manned aircraft that they shall not be operated in such proximity to other aircraft as to create a collision hazard. The same requirement should apply to UAVs. Effective separation provision and collision avoidance represent the greatest technical challenge confronting the routine operation of UAVs outside segregated airspace.

The hierarchy for the application of separation provision and collision avoidance for a UAV (recommended by EUROCONTROL) should be:

a. ATC - separation provision.
b. Pilot-in-command - separation provision and collision avoidance.
c. Autonomous operation – collision avoidance.

The UAV pilot-in-command may have surveillance information available to him to assist him with separation provision and collision avoidance, and such sources should be utilized wherever practicable. However, in addition, he will require technical assistance to detect and avoid conflicting traffic with the same degree of assurance as a manned aircraft flying according to visual flight rules (VFR). Thus provided for, he could then be responsible for the safe conduct of a flight, unless loss of control data-link made it impracticable, at which point an automatic system would take over to ensure collision avoidance. The technical assistance – embracing the concept of Sense and Avoid – should therefore:

a. Enable the UAV pilot-in-command to maintain visual meteorological conditions (VMC) when operating VFR.
b. Detect conflicting traffic.
c. Enable the UAV pilot-in-command to interact with conflicting traffic in accordance with the right-of-way rules.
d. Ensure automatic collision avoidance in the event of loss of control data-link (7).

The military and civil UAV OAT operations in non-segregated airspace will not be acceptably safe without an effective collision avoidance system and UAVs sense-and-avoid technical capability.

The above mentioned three basic principles of the consequent draft specifications (UAV operations should not increase the risk to other airspace users, ATM procedures should mirror those applicable to manned aircraft, the provision of air traffic services to UAVs should be transparent to ATC controllers) could be realized only together with an appropriate communication, navigation and surveillance system for
UAVs air traffic management. The system has been already created and used in civil aviation. It is based on the GNSS (Global Navigation Satellite System) Transponder Concept.

The only existing and effective sense and avoid technology for separation provision and collision avoidance of military and civil UAVs flying outside segregated airspace is a communication, navigation and surveillance (CNS) system based on the GNSS transponder concept (8).

This technology is in use for civil aviation in Russia, Sweden and some other countries. There are no good reasons to deny it for military and civil UAVs as OAT in non-segregated airspace. We consider it logical and well-founded to put in the EUROCONTROL Specifications two additional sections:

3.4.5.2 The GNSS transponder concept should be implemented in order to provide effective sense and avoid capabilities for military UAVs. The GNSS transponder is a communication, navigation and surveillance (CNS) system capable of calculating its position (GPS) and forwarding this information to all other units within range. The received information from other units can be used for collision avoidance purpose.

3.5.8. Each military UAV flying as Operational Air Traffic outside segregated airspace should have a GNSS transponder on board (like T2/R2/MXP 3501) which is an effective instrument for separation and collision avoidance in all three modes: ATC, Pilot-in-command and autonomous operation.

UAVS FOR DISASTER MANAGEMENT AND PIPELINES MONITORING

There are the dull, the dirty and the dangerous missions for UAVs not only in war time. The most striking examples are disaster prevention, assessment and management missions.

Irkut Corporation together with the Russia’s Ministry of Emergency Situations (EMERCOM) designs civil unmanned aerial systems (UAS), and also elaborates concept and methods of their applying for disaster management operations - discovery of extraordinary situations and liquidation of their consequences.

According to this concept UAS can be effectively used for a solution of a broad circle of problems, directed on savings of human life, state and private property and environmental protection:

• Potentially disaster areas monitoring;
• Forest fires detection;
• Engineering reconnaissance of the disaster regions suffered from floods, earthquakes, tornadoes, tsunami and other natural disasters;
• Search-and-rescue and disaster relief operations;
• Delivery of the first aid to the sufferers (medicine, food, radios);
• Damage assessment from the natural catastrophes and industrial accidents;
• Real time monitoring of the disaster elimination process;
• Real time support for the effective decision-making process and disaster management operations.

In accordance with Russian Law EMERCOM has a right and competence to use any technology and any tools which are required for disaster management including aerial robots. Thus the use of UAVs as aerial robots in a disaster area is legal. Certainly this UAVs applications are limited in time and in airspace by area of a disaster. But the disaster could happen anywhere and the disaster area could be vast.
Another example of the most likely UAVs commercial application is oil and gas pipeline and power line monitoring. This type of monitoring is much in demand in Russia and in many other counties. Oil and gas pipelines and power lines are fixed located. That is why allocation, concordance and authorization of limited controlled airspace over the pipelines and power lines for UAVs flights, especially at a low altitude, could be realistic in near-term outlook.

These examples illustrate that limited civil and commercial UAVs applications are very realizable and probable in the nearest future.

Step by step approach is the most productive way to go in this area. It is a challenge, because the civil and commercial UAVs flying in non-segregated airspace mean the establishment and evolution of a new industry. In order to be successful and competitive it is necessary to gain experience. It is impossible to predict all technical and operational difficulties beforehand.

EMERCOM and Irkut Corporation together design and introduce new civil unmanned aerial systems taking into consideration this approach. It is a very good example of effective government (EMERCOM as a ministry) to industry (Irkut Corporation) cooperation.

OPTIONALLY PILOTED AIR VEHICLES

The most appropriate candidate for the beginning of UAVs civil and commercial use is an optionally piloted air vehicle (OPAV). It is something in between a traditional piloted aircraft and an UAV. According to the intermediate nature of OPAVs some problems for them probably could be solved easier: certification, standardization, airworthiness, radio frequency spectrum allocation, export control and insurance.

OPAVs are capable to perform a normal piloted flight with a pilot on board. Besides that, OPAV and ground control station’s hardware allows for performing an automated flight (including takeoff, en-route flight, maneuvering and landing) either with or without pilot on board.

Pilot presence on board makes OPAV status fully legal even when the pilot does not participate in control and just works with the payload facilities. At that the flight safety requirements are observed as in case of off-nominal situation or malfunctions occurrence a pilot can cut off the OPAV automatic pilot loop and take over the control.

An important feature of OPAV application is capability of piloted and unmanned flights options. In densely populated regions flights should be performed with a pilot on board. In conditions of emergency or special situation as well as in distant and low populated regions or over the sea OPAV flights may be performed in unmanned mode.

Thus at present OPAV development and application is very urgent. With their aids important tasks may be solved in the interests of state and private sector. In that way money may be raised both for OPAV and UAV technologies further development and gaining commercial interests. Besides that OPAV is an excellent “flying laboratory” to be used for unmanned aviation system newest technologies working out and experimental checking.

This ideology is successfully implemented in Irkut Corporation project “Irkut-850”. The system was designed on the basis of the motor glider Stemme S 10 VT (Stemme, Germany) for TV/IR monitoring, air photography and radar imaging. It consists of: optionally piloted air vehicles, ground control station and remote video terminals. Payload: digital photo camera, TV camera, IR camera, TV signal transmitter and side-looking radar (SAR). Control system includes: the ground control station, on board
automatic control system with computer and GPS-receiver. Conventional tack-off and landing

**PERFORMANCE**

- wing span, m 23.0
- length, m 8.42
- height, m 1.80
- max. take-off weight, kg 860
- max. payload, kg 200
- operational ceiling, m:
  - in piloted mode 6,000
  - in unmanned mode 9,000
- operational g-load +5.30 … -2.65
- max. flight endurance, h:
  - in unmanned mode 12
  - in piloted mode limited by abilities of the pilot only
- max. operational radius, km 200
- max. flight speed, km/h 270
- cruise speed, km/h 165
- max. operational range, km 1,720
- aerodynamic performance 50
- max. take-off headwind speed, m/s 10
- runway, m 300

The “Irkut-850” OPAV system has been preliminary tested and approved for disaster management operations.

**SMALL UAVs**

Small, hand-launched, fixed-wing UAVs are the best candidates for various civil and commercial applications. They are not so dangerous in case of accidents because of small kinetic energy. They fly at very low altitude 200 – 300 m. So they do not enter into civil airspace used by aircraft. Moreover they are not expensive.

One of the good examples is the unmanned aerial systems (UAS) «Irkut-2» designed by Irkut Corporation according to the Russia’s Ministry of Emergency Situations (EMERCOM) requirements.

The Unmanned Aerial System «Irkut-2» is designed for TV monitoring and for aerial photography. It is man-packed and hand launch. Miniature unmanned aerial vehicles of classic aircraft design with pulling propeller and flying wing design with pushing propeller are used in this system.

The UAS consists of: miniature UAVs, small-size portable ground control station.

Payload: TV camera with TV signal transmitter or digital photo camera.

Control system includes: ground control station, on board automatic control system with computer and GPS-receiver.

Man-packed, hand or catapult launch, conventional or parachute landing.

**BASIC PARAMETERS OF THE UAS «IRKUT-2»**

- take-off weight, kg ........................................3
- payload weight, kg ...........................................0,4
• maximum flight altitude above the sea level, m …..3 000
• operational altitude, m ................................. 100-1 000
• operational radius, km ..................................10
• maximum flight endurance, min .........................60
• cruise speed, km/h ...........................................80

The unmanned aerial systems «Irkut-2» was tested by EMERCOM in 2006 and prepared for practical application in Russia in 2007.

SUMMARY

Practically there are no unsolved technical problems for the beginning of civil and commercial UAV applications.

An effective air traffic management system for UAVs flights outside segregated airspace as General Air Traffic could be based on the GNSS (Global Navigation Satellite System) Transponder Concept.

It is not reasonable to be waiting for the comprehensive and complete set of laws, rules and regulations concerning UAV civil safety and environment certification, standards for manufacturing and operating of UAVs, radio frequency spectrum, export controls, insurance, air traffic management, and integration into civil airspace. It may take many years in spite of some progress in this area like the EVROCONTROL Specifications for the Use of Military Unmanned Aerial Vehicles as Operational Air Traffic Outside Segregated Airspace.

It is a good idea to start and enlarge limited non-military UAVs applications where it possible, essential, rather safe and cost effective.

International coordination in this area through the International Civil Aviation Organization (ICAO) and the World Radiocommunication Conference (WRC) is critical. International cooperation could speed up the process of non-military UAVs applications.

Disaster prevention, assessment and management is a rather good area to start with international cooperation directed to civil and commercial UAVs applications.

REFERENCES

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