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UAV[1] OPERATION IN AERODROME SAFETY AND ACS[2] PROCEDURES

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Abstract:

Nowadays, the use of unmanned aircraft in the vicinity of airports, morover in controlled zone, can be realized, whether civil or military missions. Concerning the process of a flights, lasting from taking-off to landing, the most critical sector of the airspace are the final approach- and initial climbing area. The aerodrome controller is responsible for spacing in the above mentioned area, meanwhile prevent collisions, expedite and maintain the ordely flow of air traffic. The article describes the goals of UAV operation in controlled zone, moreover analyzes the aeronautical information services and air traffic control procedures and work factors affecting the flexible use of airspace, flight planning and airspace management when traditional aerial vehicle and UAV are flying at the same time. Finally, the authors propose a possible safety risks and solutions. The subject ,which is evaluated in the followings, is closely concerning to the „Új Széchenyi Terv (New Plan Szechenyi) **„TÁMOP-4.2.1.B-11/2/KMR-2011-Critical infrastructure defending research"** tender, and its subordinated plan, called „Data integration", which highlighted project is the „Operations of Unmanned Aerial Vehicle and its aspects for Air Safety" analyzing the UAV operations in vicinity of airfields.

1. Introduction

The controlled aerodrome and its controlled zone, concerning the ICAO[3] class of airspace (could be "C" or "D") copes with IFR[4] and VFR[5] traffic, moreover under VMC[6] conditions, when the visibility makes it possible a VFR flight could operate as SVFR[7] if the aerodrome controller cleares it. The air traffic control service is available for those, who departing, arrival or crossing the controlled zone. But the separation is depending on flight rules of traffic in different class of airspace. In order that an aerodrome controller makes each traffic to comply with rules, and prevents mid air collisions meanwhile

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1 UAV: Unmanned aerial vehicle, aerial vehicle, which is capable for unmanned flight
[2] ACS: Aerodrome control service: air traffic control service for aerodrome traffic
[3] ICAO: International Civil Aviation Organization
[4] IFR: Instrument fligh Rules
[5] VFR: Visual Flight Rules
6 VMC:Visual meteorological Conditions
[7] SVFR: Special Visual flight Rules

provides orderly and expeditious flow of traffic, it is necessary to own each information about details of traffic. The quality and integrity of datas are contributing to aerodrome controller's decision making procedures. In addition we should not forget about ground movements of aerodrome, where a controller also responsible for the separation of aircraft and obstacle, aircraft and other vehicles and it is necessary for a vehicle to obtain ATC[8] clearance to operate in maneuvering area. Under low visibility in a busy international aerodrome movement of aerial and other vehicles is trailed with SMGCS[9] system. Local operations of a controlled aerodrome goes along with strickt rules and procedures which also contains coordination with neighbouring air traffic services, aeronautical information services, aerodrome reporting office and last but not least with emergency services. Simply stated, that accustomed operation of controlled aerodromes is a well-established process, which is varied in case of significant weather or an emergency situation. Obviously in those cases an aerodrome control service launch their proper procedure to avoid further disease and care safety. An aerodrome controller task also extends the providing of economical and safety air transport with flexible utilization of airspace. In this meaning they have to exploit the aerodrome control zone with maximum capacity. This is involved the application of proper SID[10], implementation of delayed start up procedures, properly selection of taxing routes or the continuous information of VFR traffic. In this well organized "chaos" shortly a new element may appear, the unmanned aerial systems, whose on board system developments are going to reach that safety level, which will makes them able for common flight with their conventional "partners" in the civilian airsapace. The integration to the civilian airspace is the common issue of air traffic services, manufacturers, pilots and further applicants as well. According to a study of EUROCONTROL[11], which was published several years ago, air traffic services can also handle the unmanned systems in those cases if they are able to operate in each class of airspace like the manned ones. It contains also the same flight rules, flight planning mission tasking procedures and capability of "sense and avoid". More accurately in order to enter in the aerodrome control zone they have to get the controller's clearance, to have valid flight plan, to operate by IFR or VFR, to maintain two way radiocommunication with control tower and to have on board transponder. Unmanned systems should be capable for obeying order of controller without delaying and for make out targeted and "for-all" information. It is also very important to implement proper procedures in case of emergency or radiocommunication failure as it does a manned aircraft. It is worth to note, that the malfunction or interruption of contact in communication between aerodrome controller and "pilot" of unmanned vehicle or between "pilot" and the vehicle also means radicommunication failure. The next point is to emphasise the operational frequency, which must work safe and protect against unauthorized users- intruders-otherwise the unmanned vehicle get unlawfull interference namely hijacked. Obviously it entails consequence and penalty as well. In an air traffic controller this time occurs, that an aircraft which is under unlawfull interference is expected to be in emergency. In this case the alarming system starts its process, including Search and Rescue Coordination Centre. However there is nobody on board, but we should not forget about the possible vicitims and missing person on the ground, who may took an aviation accident. If an aerial vehicle

[8] *ATC: Air Traffic Controller*
[9] *SMGCS: Suface Control Guidanance and Control System*
[10] *SID: Standard Instrumental Departure*
[11] *EUROCONTROL:Specifications for the Use of Military UAVs as Operational Air Traffic Outside Segregated Airspace Edition 1.0,2007*

is under unlawful interference, it raises suspicion of terrorism and entails alarming of National Security Services. Shortly summarizing the above written statements, beyond the well- functioning and many times tested procedures of an aerodreome controller, it is possible to install new ones, which serve not only for air traffic safety, but aviation security as well.

2.Chapter

2.1 The application of UAV in controlled zone of controlled aerodromes

The controlled zone of a controlled aerodrome usually covers horizontally 5-10 NMradius area from the ARP[12] and in vertically up to 4000'altitude. It means, that this area from the ground is controlled, so even if for the agricultural work, which usually does not happen higher than 50 m AGL[13], it is compulsory to have ATC clearance and all equipment which nevessary for operation in controlled airspace.Approximetly this height range is going to be preferable or unmanned aerial vehicles in "light" (zero) category, for their aerial work. There is range of potential application also in civilian area, which makes them suitable for the implementation of many tasks.

These applications could be the followings:

- traffic monitor, mainly in busy road conections;
- pipeline check;
- borderline control, which is a highlighted task at the border of Schengen Area;
- survelliance of plow land;
- search and rescue- or emergency management;
- or cartographic flights.

The above mentioned flights are normally affecting the aerodrome controlled zone, but till now have done by manned aircraft. In order to provide the safe and orderly flow of traffic in the controlled zone, an aerodrome controller has to look throw all risks and determine the proper and safest arrival and departure path, even though tail wind could make it inconvenient. Here should be notifying that in selection of "runway–in-use" first of all the wind direction is preferable, secondly the applicable noise abatement procedure, the traffic intensity and also the runway configuration. So that, the controller may offer an opposite direction for departure in order to expedite the traffic flow and it is the pilot's decision to accept it or not.

12 ARP: Aerodrome Reference Point
13 AGL: Above Ground Level

2.2 **Cooperation between UAV and aerodrome controller in function of categories and capabilities.**

The traffic of controlled zone is not only featured by low altitude flights, but also departure arrival traffic and crossing traffic higher level. In the further parts of the paper the writers examine the cooperation of ATC and UAV controller through the several situations.
There are different points of view for categorizing UAV-s, like Maximum Take Off Weight, endurance, maximum altitude or distance. Concerning these features it possible to distinguish the followings:

UAV class	MTOW kg	Distance	Radius NM	Alt feet
Class 0	< 25	close	< 10	1000
Class 1	25-500	short	10-100	15000
Class 2	501-2000	medium	101-500	30000
Class 3	2000<	long	500<	30000<

1.Table

According to the viewpoint of an ATC there are many complementaries necessary to know about the traffic. Namely the followings:

- does it have transponder on board;
- the communicitaion and navigation systems makes it able to keep in contact with ATC;
- its turbulence category;
- its approaching speed on final;
- whether able for maintaining the given level;
- how fast able to replan their route in case of avoiding manouvere;
- does it have ACAS or TCAS equipment on board, which makes it able to sense the conflicting traffic and avoid it;
- does it have CPDLC contact for reducing verbal communication between ATC and "pilot in command.

Furtherly exemining the UAVs in general, independent on its type, which kind of information and orders they get from ATC in different situation. Inspite of the fact a UAV was developed for military purposes, many civilian applications would prefer its capabilities. But it is also imaginable, that after a tranining, in a temporary reserved or segregated area, it is flying back to home base or alternate aerodrome, crossing civilian airspaces controlled and uncontrolles ones as well. It is worth to know, that in many countries in Europe between "danger", "temporary reserved" or "segregated" areas and the home base aerodrome usually civilian airspace located. They do not have direct contact line or corridor to the home base, because in this area all traffic handled as GAT[14], the only excuse could be the MAC[15], but it is designated for high speed fights of military aircraft. Returning to the aerdrome controlled zone, writers examine the UAV, which is supposed

[14] *GAT: General Air Traffic*
[15] *MAC: Military Air Coridor*

to equip with transponder and radio contact with operator, which makes it suitable for civilian airspace Arrival level to the CTR[16] could be 4000', the first IFR level implemented according to ICAO flight rules. In order to enter the controlled zone it is necessary to get ATC clearance, which is possible by air filed flight plan via operator or with an earlier field flight plan. According to the flight plan data the controller gets together the squak and callsign for identification. Afterwards provide arrival information containing meteorological conditions, which originated from METAR[17]. In a case if there has not been installed any instrumental landing system, or the UAV does not have receiver on board, the operator may request cancelling IFR and changing to VFR. It may associated with replaning the flight path.

SPECI ZZZZ 111207Z 32010G17MPS 3000 TSRAGR BKN015CB 14/05 Q1001 RMK YLO
METAR ZZZZ 111215Z 32008G15MPS 0500 +TSRA SCT003 BKN015CB 18/15 Q1003 RMK RED

Receiving the above, on the one hand the operator has to decide if continue approach and avoiding CB[18]- s to reach the aerodrome, or on the other hand diverting to an alternate aerodrome. In the worst case scenario, if the endurance is not enough to reach the alternate, it is possible to land on the field(additionally particular UAVs do not requires developed runway for landing).In this event the main task of ATC to give assistance with information. In order to find the proper place and surface for landing the ATC able to give navigational aids to the pilot. Basicly the ATC has to know the geographical features of the terrain. Secondly the ATC also could provide information according to the data of meteorological radar of the aerodrome, which measures extention of CB, how fast and which direction it is moving, what type of presipitation in and its intensity. In order the successful avoiding action it is worth to refresh rules of avoidance. Flying into CB is strictly prohibitied, and also flying below is not recommended due to severe convection and gust front. Keeping at least 5 NM from the edge and 1000 m above the clouds. Flying between clouds in case of 10 NM distance is allowed. The aerodrome controller radar usually doesn't suitable for measuring these distances accurately, this radar display is authorized only for informing, not vectoring the air traffic. For this instance it is very important to have among UAV payload on board those sensors, that able for distance measuring. The ATC could give navigational aid for finding a proper surface in the event of landing on terrain. In a controlled zone usually abandoned or bailout area is determined for safety landing, jettisoning or forced abandonment cases. The navigational aid this time means to help the crew to localize area, with GPS coordinates, or given heading and distance from a location, or radial and distance from a navigational equipment. It depends on which one suitable for UAV navigation.

As the above example shown us, there is no difference between those procedures which ATC apply in same events for manned aircraft. The only deviation could be that, a pilot of manned one should expect reserves for estimated navigation to alternate aerodrome, which is not practicable and feasible for a short range UAV.

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[16] *CTR: Controled Zone*
[17] *METAR:Meteorological Aviation Report*
[18] *CB: international acronym of thunderstorm*

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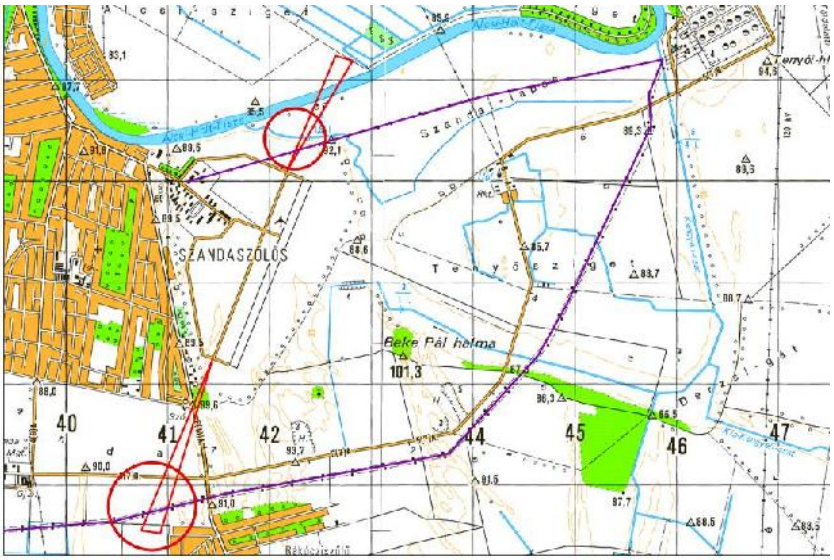
Another situation, the aerodrome controller going to face, is originated from a further civilian application, the pipeline check flight. It is obvious, that these pipelines and electrical wires do not avoid the area of controlled aerodromes, so in order to check them it is necessary to fly across the zone several meters above ground level. The point is to have transponder on board, makes the unmanned aerial vehicle able to be identified by ATC and get monitoring meanwhile flying across the CTR. This flight is going to be a VFR traffic, because of the height in controlled zone (and because the only procedure to do in IFR in CTR could be SID or a STAR[19]). In order to operate as a VFR, need to have VMC conditions, 5km visibility and 1500' cloud base, moreover the ability of " sense and avoid" any confliction. In additional could be important for the ATC if it is a pre programmed autonom flight, which is only monitored by ground station and how accurate the uploaded coordinates for flight planning. Exactly meanwhile the UAV is flying over the pipeline, whether how far deviate its route horizontally. This inaccuracy could be originated from the not precise coordinates, but the blowing wind can drift them as well.



1. An aerodrome contolled area

In the illustration above, it seems where are the "hot spots", which influence decision making process of aerodrome controller. The procedure is the same as manned aircraft, so that the aerodrome controller should apply permission or forbidden to cross the centerline. Before giving the clearance the ATC has to make sure it is possible to clear and the UAV able to comply it. The point is rely on "in time" clearance giving and "real-time" performance. In order that, a UAV can cross the centerline safe, the ATC also has to create the safe distance behind the traffic approaching on final, because a "light" UAV can affected by turbulence. This safety distance has to determine, it is a base of timely given clearance, so we need a single reference point, which is accurate enough for separation. It could be the reference point of runway threshold, which is a critical accurancy data published in AIP[20] , 10^{-8}. Reaching the measured slant range and azimuth from the threshold the UAV could get an acknowledge from ATC to continue via flight plan route. Otherwise it has to start a pre programmed holding procedure.

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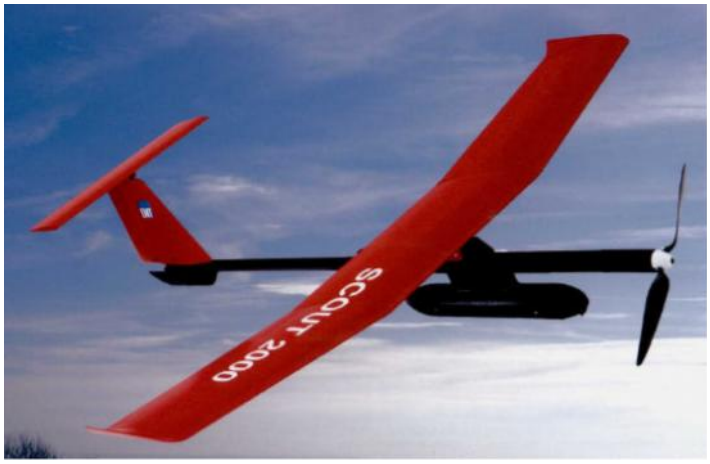
[19] *STAR: Standard Arrival Procedure*

[20] *AIP: Aeronautical Information Publicaton*

This acknowledge may verbally or through a data link, like ADS-B[21], which able for cooperation with automatized ATC systems.



2. Scout 2000, model UAV able for pre programmed flights

In the third situation a model sized UAV could be examined, which does not feasible for integration due to its navigation and communication systems. This kind of UAV operation within a contolled aerodrome only in "occasionally"available airspaces can fly. The basic criterion of this airspace is the decree of National Aviation Authority and contribution of ATSU[22]. From the ATC point of view it is very important for UAV to remain in appointed airspace and hold a safe distance from borders. Namely do not get closer to the borderline than 2,5 NM horizontally and 1000'vertically. Also necessary to announce the start and finish of operation in this airspace, and alarm the ATSU in case of any airspace violation.

It is obvious, that beyond the resolution of the above mentioned situations in controlled areas, the most important task to solve the "sense and avoidance" of contflicting traffic. Those aircraft which equipped with on board transponders, which is compulsory in controlled airspace, are capable to communicate with ACAS II[23]. As it seems in shared videos of Barracuda[24] test flights, happened in Canada, it is proven the UAV able to "sense and avoid" conflicting traffic during its autonom flight. The current results and research points forward the integration to civilian airspace. Concerning the aerdrome controlled zones, the complexity of traffic flow contains not only the traffic follows standard procedures, but others which comply special tasks. These could be VFR or IFR crossing traffic, but had marked to "stay" in flight plan, somewhere on route, or making calibration or test flight, which deviating from GAT rules. Moreover those flight which have priority in traffic flow, like search and rescue mission, medical flight, fireservice flight or disaster management, expected a special handling from ATC. It is also important, that emergency situation of an unmanned aerial vehicle however does not threaten directly human life, but an ATC should handle it with providing priority.

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[21] *ADS-B: Automatic Dependent Surveillance - Broadcast*
[22] *ATSU: Air Traffic Service Unit*
[23] *ACASII: Automatic Collision Avoidance System*
[24] *Barracuda: European unmanned aerial vehicle (UAV) currently under development by EADS*

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3. Expectation

In order to provide the appropriate air traffic service, it is necessary to keep the two way radiocommunication between ATC and the operator.Also important to realize the suitable radio phraseology with specialities for UAV. It is practicable, at the first contact to add after the callsign that the calling station is “unmanned”.It could be usefull information not only for ATC, but all station on the frequency.

All air traffic services for manned aircraft, should be harmonize with those which related for unmanned ones.It means, that each clearance, order or information is titeled for UAV operator as it normally happens with pilots of manned aircraft.

If it is not possible to complete the given order, or a new one would be preferable, for example the first was technicaly impractical, the UAV operator has to report it clearly “Negative I am not able to comply”.

For idenetification by ATC in controlled airspace it is necessary for a UAV to be equipped with transponder

It is known, that a filed flight plan is necessary in order to fly in controlled airspace. It is for informing the ATSU about flights, so that have to mark all data which detail an UAV flight. It has to contain all information, for example delays on route due to mission task, track, altitude and deviations, or estimated flying time. It is expected that the UAV should carry out the accepted flight plan.Otherwise it have to report changes to ATSU.

Each UAV detailed with its performance.It is very important, mainly for operator, but the ATS personnel as well, to know these details as much as manned aircraft’s. Among parameters the most important are the rate of climb and descend, climbing and descending speed, turning radius, radius of action etc.These data may practicable in response of emergency situation.

UAV flights are limited, as also manned ones, by weather conditions like cloud base, visibility or wind strength and direction. The restrictions of a UAV depends on ATS class of airspace, training level of the operator and flight rules.

Among the list of worries with UAV integration, the most emphasized is the system security in military and civilian applications as well.These are featured by:

- unauthorized and malicious intervention in flows of data
- unlawfull interference of a ground station
- malicious abuse with applying UAV

In order to reduce risks, it is necessary to implement security measures in the operational system, whose guarantee that UAV operation is released for the cleared and supervised task. It is also important to evaluate the possible risks, weekness of system security, authentication, or the hardver and softwere security.

The reliable UAV operation also includes the effective training of personnel, their skills and proficiency. It is basicly expected that a well trained and prepeared personnel complete the flight, which lates from the flight planning and preparation, to the controlling. Only regular training and practices provide maintenance of skills.

Additional expectation of UAV personnel to be acquainted with flight rules, air traffic services, general information about airspace management, use of airspace and basic information about other aircraft. It also could be practicable if the ground would have a display of RAP[25]. It would help for operator to get informed about the UAV position in airspace, other users and the next airspace to enter.

In a UAV operation not only and every time the operator who make final decisions in case of any malfunctions, as it does a pilot of manned aircraft. So that it is also important during the flight, that the system be able automaticly localize and avert the malfunctions.

Finally I would like to emphasise how important for an ATC to be acquainted with UAV, its equipment, special procedures, applications and technical parameters. Only the carefully ruled legal background and application instructions provide the safe and effective opration in the air and on the ground. For further purposes it is recommended to maintain a continuous cooperation between air traffic services and UAV operators.

4. Conclusion

Nowadays the UAV flights in civilian airspace is not infrequent, however these go on far from residental area, where the other flights also do not occur.It seems from the above how many requirements should meet the UAV for further common flights in civilian airspace, after locking out all risks and doubts.

Concerning the appliance prognosis, it imaginable that in the near future also in our airspace, increasing the number of UAV flights. In order to prepare the spread of UAV flights, it is important to draw up criterias and response for all. As an air traffic controller I think it is the near future to keep contact with an operator on the air.

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Our Department of Military Aviation will continue the UAV operator training and also the connected research and analysis of related regulators which was realized through the assistance of the European Union, with the co-financing of the European Social Fund. "Critical Infrastructure Protection Research TÁMOP-4.2.1.B-11/2/KMR-2011-0001" it enjoys the support.

[25] *RAP: Recognized Air Picture*