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INFORMATION PAPER

REMOTELY PILOTED AIRCRAFT SYSTEMS PANEL (RPASP)

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Joint demo flights of manned and unmanned aircraft in Russian Federation in non-segregated controlled airspace under RLOS and under existing ICAO, EUROCAE and ETSI standards

(Presented by Edward Falkov)

SUMMARY

The set of joint demo flights of manned and unmanned aircraft for different customers in Russian Federation within 2011-2015 is described. The two-component architecture of airspace with RPAS module allows to localize the problems induced by appearance of RPAS in civil airspace with manned aircraft inside the RPAS module without no affecting to manned aircraft. All flights under RLOS were executed in accordance with existing ICAO, EUROCAE and ETSI standards.

1. INTRODUCTION

1.1 The lack of regulation for RPAS to fly safely in non-segregated airspace is being considered as the main obstacle to integrate RPAS into civil airspace. The efforts are directed to minimize any new developments in ATM and reconsider existing standards from the point of view to provide for international seamless flights of RPAS in global scale and to determine what is necessary to add/change in existing standards.

1.2 Before new developments it looks appropriate to make review and analysis to what extent existing standards might be used for RPAS integration into civil airspace.

In Russian Federation the set of technologies based on Very High Frequency Data Link Mode 4 (VDL-4) was researched for different CNS/ATM applications for commercial, state and experimental aircraft. One of the important applications is Automatic Dependant Surveillance – Broadca1st (ADS-B) which in future are being considered to replace Secondary Surveillance Radars (SSR). Together with ADS-B Out and ADS-B In, there are also demonstrated a lot of efficient applications like TIS-B, situational awareness, A-SMGCS, S&R, DGNSS, FIS-B, CPDLC, AOC and others. The technologies based on VDL-4 showed high effectiveness in the issue of integrating of RPAS into civil airspace what was proven by series of demo flights carried out for different customers.

2. DISCUSSION

2.1 [1] describes joint flights of three piloted and two unmanned aircraft in common airspace that were held in the presence of UASSG members during the 7th UASSG meeting in St.-Petersburg in 2011. Take-off mass of participating aircraft was in the range of 5 - 12000 kg.
Used in the flights datalink based on VDL-4 and answering ICAO, EUROCAE, ETSI standards provides in broadcast mode for functioning of ADS-B Out, ADS-B In, TIS-B, FIS-B, A-SMGCS functions and situational awareness both for unmanned and piloted aircraft as well as point-to-point communications, which may serve as a back-up link for RPAS control.
Casual loss of surveillance conducted by RPAS pilot with the help of his own means was insignificant, since the pilot could acquire information of his RPA via ATC center, thus we saw elements of communications “robustness” (elements of “internet in the sky”). Separation of all aircraft and collision avoidance with each other and with ground mobile objects was provided by the situational awareness of all pilots and was managed by an ATC controller.

[2] studies the interaction of piloted general aviation Jabiru-450 aircraft and Ptero RPAS equipped with a small-size (300 g) transceiver. There was demonstrated complete “air-to-ground” and “air-to-air” information interaction for both pilots and for ground control stations.

[3] studies the possibility of RPAS use in search-and-rescue (S&R) operations. Fixed-wing and rotorcraft RPASs were used. In the works there took part Pallada company – an official body operating in the Russian CAA search-and-rescue system. Results of the studies confirmed the efficiency of applied engineering solutions for the management of S&R operations with the help of RPAS.

[4] continues the S&R line of RPAS use but under the aegis of Russian CAA (RosAviatsia). In flights there participated piloted (An-2) aircraft with airborne troops and various unmanned aircraft. Search for simulated crash scenes, delivery of medical means to the simulated crash scene with RPAS help, management of interaction of all the participants of demo flights at all stages of the operations were studied. The flights resulted in RosAviatsia’s decision about the official attraction of RPAS to S&R activity with needed management of piloted and unmanned aircraft interaction based on demonstrated technologies.

[5] studies the interaction of fixed-wing and rotorcraft RPAS and ground stationary and mobile objects in Gasprom favor to look for presence of non-legal activity in territory around gas-pipelines. It demonstrates the interaction of RPAS with various ground mobile objects in the protected zone of Gasprom infrastructure.

Along with the organization of joint flights of piloted and unmanned aircraft much attention was paid to managing of flights of piloted aircraft and creation of ATC ground infrastructure on VDL-4 use basis [6-10]; it showed significant benefits concerning implementations based on ADS-B with situational awareness and adjacent applications of FIS-B, DGNSS, AOC, etc. Specifically, [8] describes joint flights in favor of the State Customs Service; along with aircraft to the surveillance there were attracted vessels and ground vehicles. It was demonstrated that the applied communication system provides full mutual surveillance of all vehicles as well as needed interaction of airborne, naval and ground vehicles both with each other and with ground surveillance stations.

[10] describes the use of a small-size (mass 300 g) handheld transceiver in airborne troops guy landing allowing to follow all the way of leading paratroopers up to their landing, thus estimating the wind conditions that allowed to adjust the subsequent full assault landing. The similar transceiver looks very appropriate to be used within RPA.

2.2 Some clarification are given below how in flights mentioned interaction of all airspace users RPASs including with each other and with ATC was managed.

ICAO RPAS Manual [11] considers a few schemes providing for communications between RPS, RPA and ATC. One of them in the part of voice communications is given in Fig. 1.

Fig. 1. Direct voice communications between RPS and ATC.

This option does not require a VHF radio on RPA and uses direct communications pathway between ATC and the RPS. The approach is transparent to ATCO, his procedures and actions do not differ from similar ones as for manned aircraft, and there is no need in new equipment for ATC. The party-line effect through VHF voice is provided and "all communications between the remote pilot and ATC are broadcast on the sector frequency for other airspace users to hear, and all voice communications on the sector frequency should be available to the remote pilot. This assists the remote pilot in building and maintaining situational awareness in the airspace" [11].

When we consider interaction not only one RPS with ATC but a few ones the requirement to provide for party-line effect leads to consider broadcast application on the sector frequency as it is shown in Fig. 2. It does not procedurally affect any other airspace users manned aircraft including.

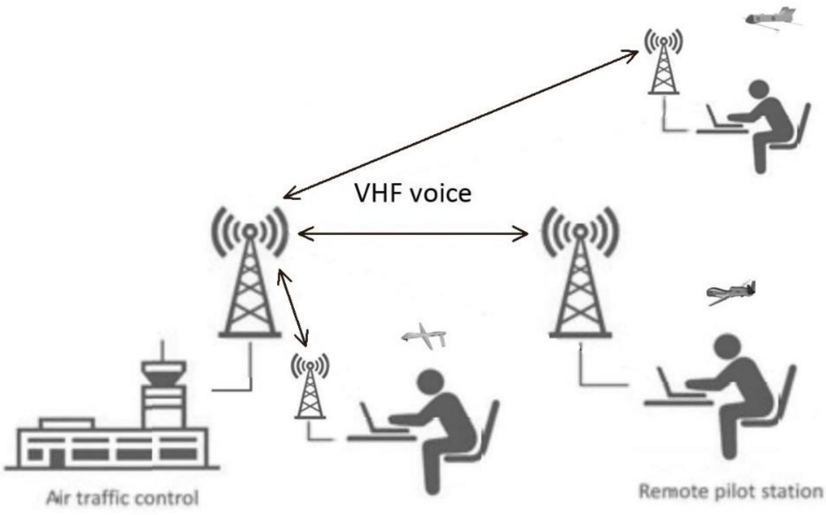

Fig. 2. Direct voice communications between a few RPSs and ATC on the sector frequency providing for party-line effect.

Besides voice communications data exchange between RPS, RPA and ATC must be realized.

Among others ICAO RPAS Manual considers the following option for providing data communications shown in Fig. 3 "between ATC units and the remote pilot via the RPA, which is transparent to ATC and requires no additional infrastructure or equipment in the ATC unit. This approach also has the advantage that it is compatible with existing ATC operations across the globe".

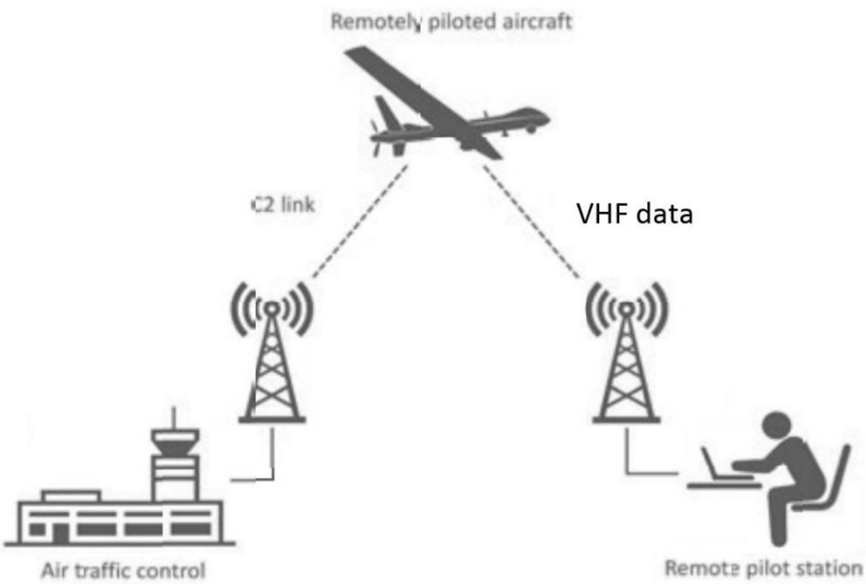

Fig.3. Data exchange between RPA and RPS and between RPA and ATC under RLOS.

Two types of data exchange for a number of RPS if they participate are possible in accordance with Fig. 3: point-to-point and broadcast. There is no indication about it in the Manual.

From one site it is difficult to believe that separate VHF frequencies will be allocated for individual RPS. From other site similarly the use of one sector frequency for voice communications with party-line effect, one or a few allocated frequencies might be used for data exchange, particularly for surveillance via ADS-B. Described approach was used in all RPAS flights in Russian Federation mentioned above. Here we come to the idea of RPAS module (Fig. 4).

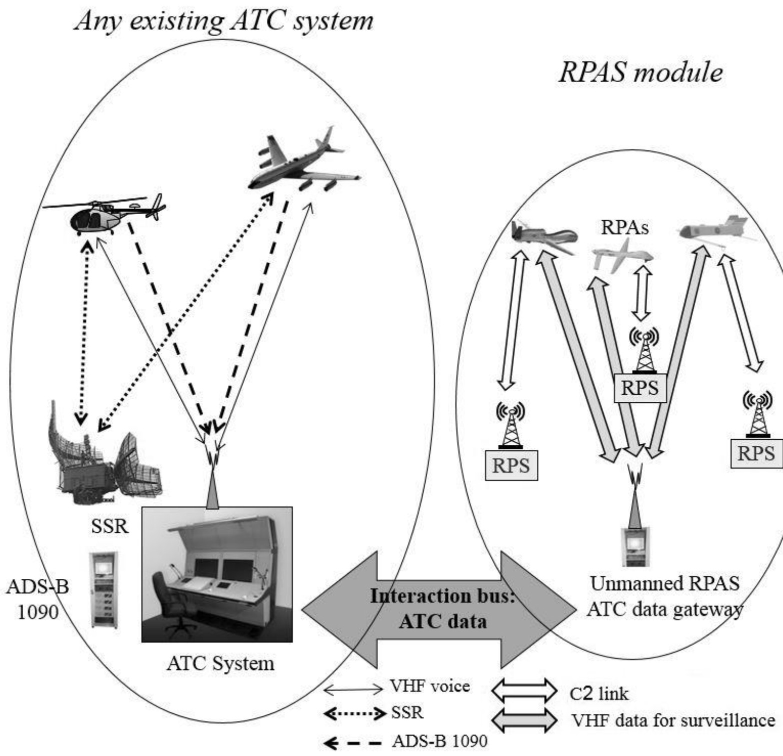

Fig. 4. RPAS module and ATC interaction.

It is proposed to consider the following. RPS is notionally divided in two parts. The first part provides for the interaction of RPA with the remote pilot; it's just what we call RPS. The second part is to provide for the interaction of RPAS with ATC in the part of data exchange. The analysis shows that in the second part the two-way data transfer may be fully automated, and the second part may function as unmanned unit. In general, the first and the second parts may be split on territory. It looks expedient to unite the second parts of all RPASs in one subsystem. By the definition, this subsystem is connected with every RPS (via RPA) and ATC at the same time. This subsystem serves to all RPASs connecting them to ATC; we propose to call this certain subsystem as a RPAS ATC data gateway. Of course, RPAS ATC data gateway and its connection with ATC have to be certified.

Operation of an unmanned ground RPAS gateway will have no effect on the management of manned aircraft flights, but will deliver information in both directions – from RPASs to ATC in order to build a complete picture of all aircraft in the air and from ATC to RPSs to perform flights under full ATC control. Let's introduce into practice the notion of **RPAS module** which includes:

- RPASs which control RPAs from RPSs with the help of C2 data link;
- Unmanned ground RPAS ATC data gateway providing for interaction of RPASs and ATC.

Establishment of two-component airspace architecture with the pin-pointing of all problems concerning RPAS integration into controlled airspace inside RPAS module provides for the absence of any influence of RPAS on equipment and procedures for manned aircraft.

Within RPAS module each RPS controls relevant RPA with the help of C2 link. To know the RPA position RPAS may use surveillance means developed by RPAS manufacturer; these means need to be certified. For the same goal it is possible to use surveillance means already standardized by ICAO. Information of RPA position enters ATC via surveillance channels adopted for given airspace and via RPAS ATC data gateway. To avoid the certification of RPA-RPS and RPA-ATC surveillance means RPAS developers may apply surveillance means adopted for given airspace.

Thus besides communication interface, on-ground RPAS ATC data gateway solves the task of surveillance interface as well.

If for instance DGNSS approach is used in the given airspace the data concerning integrity and differential corrections from ATC to RPAS might be also sent via RPAS module in broadcast mode.

General requirements to RPAS module allowing RPAS integration into **ANY** controlled civil airspace concerning its interaction with ATC are the following:

- ATC and manned and remotely-piloted aircraft interaction under RPAS integration in any controlled airspace is performed with the help of RPAS module; RPAS module consists of RPASs and an unmanned ground RPAS ATC data gateway connected with ATC; RPAS module should have no effect on the management of manned flights in given airspace as concerns both equipment and executed procedures;
- Within RPAS module each RPA is controlled by relevant RPS using C2 link;
- To be controlled by ATC each RPA must use standardized ICAO surveillance means for given airspace; information of RPA position enters ATC via mentioned gateway.

Taking into account voice communications under RLOS shown in Fig. 2, as a result ATC owns full information about RPAs positions and gives all necessary instructions (voice and/or data) to all RPs; all RPs have got necessary instructions (voice and/or data) from ATC Officer (Fig. 5).

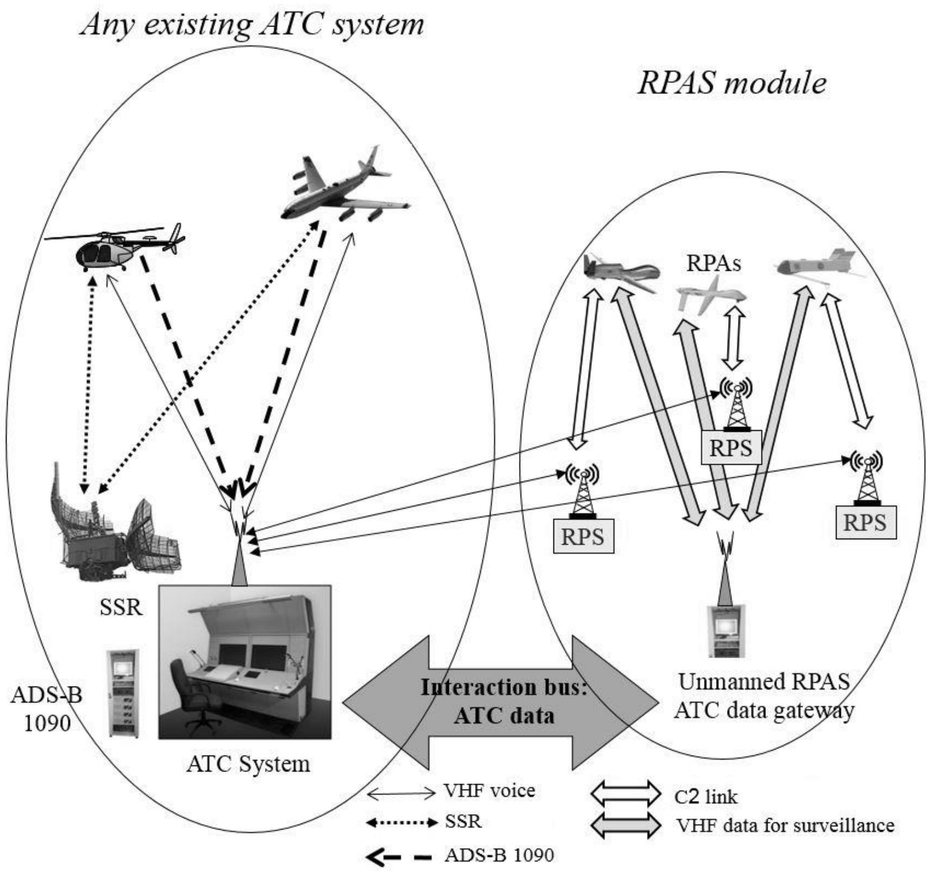

Fig. 5. RPAS module and ATC voice and data interaction.

Significant part in RPAS integration into controlled civil airspace belongs to the situational awareness provision for remote pilots. For that it looks prospective to realize ADS-B In functions at RPASs and TIS-B function at ATC. Inside RPAS module it is possible to provide for the direct mutual surveillance of RPAs with the transmit/receive of ADS-B Out/ADS-B In messages without ATC participation but all information about it will be sent to ATC also.

Additionally, for manned aircraft ATC provides for surveillance with its own surveillance means and transmits this information via ground RPAS ATC data gateway and RPAs to all remote pilots.

As a result, ATC owns complete information of the positions of all manned and unmanned aircraft and gives all necessary instructions (voice and/or data) to all pilots; all remote pilots possess information about RPAs positions either directly via ADS-B or through ATC via TIS-B, and possess information about all manned aircraft positions via TIS-B; all remote pilots have got necessary instructions (voice and/or data) from ATC Officer.

The proposed system with RPAS module owns the ground-based aircraft separation and DAA ability. To improve DAA inside RPAS broadcast data exchange between RPAs should satisfy the following requirements: messages from senders (RPAs and ground gateway) to receivers (RPAs and ground gateway) must be time stamped with error about 10^{-7} sec. that allows to estimate independently the range between the sender and receiver with 30-50 m accuracy.

In the case when in controlled airspace and in RPAS module there is implemented one and the same ADS-B type, the estimation of the range between aircraft made additionally and independently of the content of ADS-B messages may serve as a prerequisite for DAA solution. In the mixed case (manned aircraft are not equipped with ADS-B transceivers at all or in controlled airspace and in RPAS module there are used different data links) ATC system will support ground-based DAA abilities in a whole, and data of surveillance inside RPAS module will serve for the evaluation of GNSS integrity within considered airspace.

The architecture of controlled airspace with the use of RPAS module in the part of data transmittance was applied many times in Russian Federation in 2011-2015 during joint flights of manned and unmanned aircraft of various types and for several functional customers. The similar tests were done with the state aircraft planned to be used in civil airspace under CNS/ATM applications and for experimental aircraft as well.

2.3 Joint demo flights of manned and unmanned aircraft in non-segregated airspace carried out in Russian Federation in 2011 – 2015 for different functional customers and based on VDL-4 showed the next results:

- Use of ADS-B allows ATC to reliably survey aircraft (unmanned and manned if equipped) with consequent separation and ground-based DAA;
- Situational awareness for remote pilots is provided either directly via ADS-B from aircraft equipped with ADS-B transceivers or via TIS-B from non-equipped aircraft surveyed by means used in given airspace; situational awareness together with ground-based DAA promotes airspace users to fly safely;
- RPASs flights are managed with the help of RPAS ATC data module; inside module each RPA is controlled by relevant RPS; knowing of RPA position by RPS and ATC is being performed with the help of corresponding ADS-B Out and ADS-B In data;
- Regardless of data link used within RPAS module there is no influence to flight management of manned aircraft which is being performed in accordance with existing rules in given airspace;
- Not only surveillance (ADS-B Out, ADS-B In, TIS-B, A-SMGCS, S&R) service but also navigation (DGNSS) one were provided as well as some FIS-B applications (operative delivery of information to all pilots about weather, aeronautical information, digital NOTAMs), CPDLC, AOC and others;
- Only aviation protected VHF spectrum was applied; VDL-4 equipment used in all flights were built in full compliance with standards of ICAO (Annex 10 Vol. 3 and Doc 9816), EUROCAE (ED 108A) and a set of technical specifications and European Norms (EN 301842 and EN 302842) developed by ETSI.

In a whole operable technologies to integrate RPAS into civil airspace based on existing international standards have been demonstrated. The features of used approach under RLOS are use of direct voice communications between RPSs and ATC and use of RPAS module for data exchange between RPA, RPS and ATC. Regardless of use of VDL-4 within RPAS module concerning only RPASs proposed approach is acceptable for any existing controlled airspace.

The range of RPSs – ATC voice interaction might be extended by use of relay ground antennas. Currently Russian industry works in direction of use of RPA as relay for digital voice communications with conversion of voice to analogue form in RPAS module.

2.4 For those (people/companies/countries) who would like to be acquainted with the technologies demonstrated more closely and directly.

Two possible versions of actions to start:

a) Russian team invites (people/companies/countries) to Russian test site. (People/companies/countries) bring their own RPASs. For these RPASs Russian team gives transceivers (a box of nearly of 150 g) for tests. After preliminary preparation (installation on RPAS, EMC, etc.) participation in joint flights of unmanned and manned aircraft;
b) Countries invite and Russian team come with own RPASs, unmanned RPAS ATC data gateway and with some additional transceivers. After preliminary preparation (installation on RPAS, EMC, interfacing of RPAS ATC data gateway with ATC in safe consulting mode, etc.) flight tests are carrying out in countries with demonstrating of capabilities for RPAS to be integrated into civil airspace and with no influence from RPAS to all rest airspace users.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

a) note and review the content of this information paper.

REFERENCE

1. UAS Flights in Siversky, http://www.gosniias.ru/pages/19/01_UAS_Flights_in_Siversky.pdf
2. GA and RPAS flights, http://www.gosniias.ru/pages/19/02_GA_and_RPAS_flights.pdf
3. RPAS for S&R, http://www.gosniias.ru/pages/19/03_RPAS_for_S&R.pdf
4. RPAS under the aegis of Rosaviatsia, http://www.gosniias.ru/pages/19/04_RPAS_under_the_aegis_of_Rosaviatsia.pdf
5. RPAS Flights for Gasprom, http://www.gosniias.ru/pages/19/05_Flights_for_Gasprom.pdf
6. Manned 1 Flights in Yamal, http://www.gosniias.ru/pages/19/06_Manned_1_Flights_in_Yamal.pdf
7. Manned 2 Helicopter Flights in Nadym, http://www.gosniias.ru/pages/19/07_Manned_2_Helicopters_flights_in_Nadym.pdf
8. Manned 3 Flights for Federal Custom Service, http://www.gosniias.ru/pages/19/08_Manned_3_Flights_for_Federal_Custom_Service.pdf
9. Manned 4 Flights for Moscow pilot project, http://www.gosniias.ru/pages/19/09_Manned_4_Flights_for_Moscow_pilot_project.pdf
10. Manned 5 Ilyushin -76 and airborne troops, http://www.gosniias.ru/pages/19/10_Manned_5_Ilushin-76_and_airborne_troops.pdf
11. ICAO Manual on RPAS, Doc. 10019.

— END —