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Agenda Item 30: Other issues to be considered by the Technical Commission

CURRENT STATUS AND FURTHER DEVELOPMENT OF THE GLONASS ORBITAL CONSTELLATION

(Presented by the Russian Federation)

EXECUTIVE SUMMARY

This paper provides information on the current status of the Russian GLObal NAvigation Satellite System (GLONASS) orbital constellation and addresses some aspects of its further development and use as part of the global navigation satellite system (GNSS). In the long term, it is expected that avionics standards will be available for all GNSS elements and signals.

Strategic Objectives:	This working paper relates to the strategic objectives *Safety* and *Air Navigation Capacity and Efficiency.*
Financial implications:	Without financial implications.
References:	Annex 10, *Aeronautical Telecommunications,* Volume I — *Radio Navigation Aids* Doc 10115, *Report of the Thirteenth Air Navigation Conference (AN-Conf/13),* Corrigenda Nos. 1 and 2, and Supplement No. 1 Doc 9849, *Global Navigation Satellite System (GNSS) Manual*

1. INTRODUCTION

1.1 GNSS is a global shared resource that can be used to implement many useful applications, therefore basic GNSS services should be provided without charging direct user fees. The use of signals transmitted by multiple satellite constellations (MC) in many frequency bands (MF) offers now the possibility to further improve navigation performance and obtain significant operational benefits.

1.2 The Russian Federation assumes a position on the integrated use of several (or all) basic constellations transmitting signals in many frequency bands (MFMC) protected for aviation purposes. In the long term, it is expected that the avionics standards will ensure the use of all MFMC-based GNSS elements and signals. As GNSS evolves, ICAO Standards and Recommended Practices (SARPs) and industry standards should be updated to apply to all GNSS elements.

2. CURRENT STATUS OF THE GLONASS ORBITAL CONSTELLATION

2.1 Number of satellites of the orbital constellation of the system

2.1.1 Over the last few years, the GLONASS orbital constellation has been maintained at a nominal level with 24 satellites and has been significantly upgraded. As of 23 June 2019, 24 satellites are used in the GLONASS system for their intended purpose, of which 23 are 2nd generation spacecraft (SC) (GLONASS M) and one is of 3rd generation (GLONASS-K).

2.1.2 On 27 May 2019, a GLONASS-M satellite was launched from the Plesetsk launch site. The satellite was placed into orbit and adopted for management. The GLONASS-M satellite placed into orbit is located at the 12th point.

2.2 Current GLONASS performance

2.2.1 The current GLONASS system performance is evaluated and presented to the ICAO on a regular basis; the results confirm compliance with the ICAO SARPs. At the moment, the performance of ranging accuracy averaged over the orbital constellation is at the level of 1.4 m. Given that, the probability of a major service failure the requirements for which are planned to be included into the SARPs, is 6·10-5 according to the data as of the end of 2017.

3. SHORT-TERM PLANS FOR THE DEVELOPMENT OF THE GLONASS ORBITAL CONSTELLATION

3.1 Further launches of GLONASS spacecraft will be performed when necessary to replace depleted or out-of-service satellites. 3 upgraded GLONASS-M spacecraft (the upgraded GLONASS-M satellite, along with the emission of frequency division signals in the L1 band also emits a code division signal in the L3 band) were manufactured and stored as spare satellites for further launches. The launch of the upgraded GLONASS-M spacecraft will make it possible to switch to the code division of signals (CDMA) in the L3 band in shorter time. After these 3 satellites are launched, the constellation will be further updated through the launch of the GLONASS-K SC and the upgraded GLONASS-K2 which, starting from a certain sequence number will emit a code division signal at the L1 frequency along with the emission of signals at the L3 CDMA frequency. At the moment, 3 upgraded GLONASS-M spacecraft emitting L3 CDMA signals are already in orbit (in mid-2014, the first modernized GLONASS-M spacecraft with a CDMA signal transmitter at the GLONASS L3 frequency was launched and put into operation). Despite the introduction of CDMA signals, backward compatibility of the new satellites is provided since along with the emission of CDMA signals in the L1 and L3 bands the emission of FDMA signals in the L1 and L2 frequency bands is preserved.

3.2 The main objective of the constellation development is to improve navigation services, particularly at the user level evaluated mainly in terms of the signal accuracy and availability. Improved navigation accuracy is based on the development of space systems including an orbital constellation and a ground control center.

4. DEVELOPMENT PROSPECTS FOR THE GLONASS ORBITAL CONSTELLATION

4.1 In 2019-2020, according to the GLONASS Development Strategy until 2030, 10 satellites of the GLONASS system shall be launched. It is planned to launch five GLONASS satellites in 2019: three GLONASS M spacecraft, one GLONASS K and one GLONASS K2.

4.2 The launch of the GLONASS K2 spacecraft (SC) with subsequent flight test is the most important event in the development of the space segment. This SC will provide navigation not only using existing FDMA signals but simultaneously with a full range of CDMA signals in all GLONASS frequency bands: L1, L2 and L3. Moreover, the GLONASS K2 spacecraft will receive a passive hydrogen frequency standard with an accuracy 10 times greater than the rubidium and cesium “clocks” currently installed on GLONASS satellites.

4.3 A total of nine launches of two satellites in each launch are planned from 2024 to 2034. The first launch of two GLONASS-K2 spacecraft shall take place in the first quarter of 2024. Further, it is planned to perform two launches with two satellites in each launch in the third and fourth quarters of 2025. Since 2030, the nominal GLONASS orbital constellation will consist entirely of 24 new GLONASS K2 spacecraft.

4.4 Another important objective of the constellation improvement is to improve the availability and continuity of signal service. To this end, it is planned to launch GLONASS V spacecraft into high-elliptical orbits in the span of 2023 to 2025. Six GLONASS V satellites will be distributed over 3 orbital planes with an orbital inclination of 64.8°.

5. GNSS AUGMENTATION DEVELOPMENT

5.1 SBAS augmentation deployment

5.1.1 The satellite system for differential correction and monitoring is being deployed in the Russian Federation (the Russian SBAS). By now, the Russian SBAS has not yet reached its design capacity both in terms of the number of range and integrity monitoring stations (RIMS) and the creation of satellite channels for the delivery of wide-area information within the airspace of the Russian Federation. Currently, certification tests of the Russian SBAS are being performed, which will be completed by the end of 2020. The certification of the Russian SBAS will be completed when the Russian SBAS will reach its design capacity.

5.2 Deployment of GBAS systems at Russian airports

5.2.1 At the moment, 112 sets of domestically produced ground-based differential correction and monitoring system (GBAS) stations are deployed at airports of the Russian Federation. The stations comply with the SARPs for the ICAO category I approach.

5.2.2 All GBAS stations installed at Russian airports have passed flight inspection and have been allowed for operation. At the moment, approach procedures for the GBAS-based landing system (GLS) are developed and published in the Russian air navigation information publications (AIP) is being carried on. The implementation of such procedures has been fully completed for 63 per cent of airfields. This work is in progress. For the purposes of the development of GLS approach procedures and their implementation, geodetic surveys are performed in the geocentric coordinate system WGS-84 that is a necessary condition for the introduction of precision approach procedures.

5.2.3 At the moment, all stations providing category I GLS are increasingly used by ATS authorities at Russian airfields as aircraft are increasingly equipped with onboard GBAS receivers.

5.2.4 Three GBAS stations are installed outside the Russian Federation: in Kazakhstan, Azerbaijan and the Republic of Belarus. One mobile station is deployed as maintenance is required to ensure category I approaches at the ice airfield of Novolazarevskaya station in Antarctica.

6. CONCLUSIONS

6.1 Considering the fact that the GPS and GLONASS systems operate in their nominal configurations and are developed in terms of implementation of new signals and that the Galileo and BeiDou systems are expected to be put into operation, the provision of international regulatory support for implementation of the multi-constellation GNSS without restrictions on the use of a particular GNSS element or constellation in the States is a crucial task that requires the development of relevant ICAO provisions. At the same time, the absence of such restrictions shall be implemented at the industrial level avoiding the exclusion of certain GNSS elements from industrial standardization plans.

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