International Civil Aviation Organization

WORKING PAPER

ASSEMBLY — 39TH SESSION

TECHNICAL COMMISSION

Agenda Item 36: Aviation safety and air navigation implementation support

THE CURRENT STATUS AND FURTHER DEVELOPMENT OF THE GLONASS ORBITAL GROUPING IN SUPPORT OF MULTI-CONSTELLATION GNSS IMPLEMENTATION

(Presented by the Russian Federation)

EXECUTIVE SUMMARY

This paper presents information on the current status of the Russian GLONASS orbital grouping and considers several aspects of its further development and use as part of a multi-constellation dual-frequency (MC/DF) Global Navigation Satellite System (GNSS) to ensure the safety and efficiency of international civil aviation flights.

Action: The Assembly is invited to:

a) note the content of this paper; and
b) instruct the ICAO Council to review the issues surrounding international regulatory control of the use of elements of multi-constellation GNSS with the purpose of increasing the safety and efficiency of international air navigation.

Strategic Objectives:	This working paper relates to the Safety and Air Navigation Capacity and Efficiency Strategic Objectives.
Financial implications:	Financing as part of the ICAO Regular Programme budget
References:	Annex 10, Volume I. *Aeronautical Telecommunications – Radio Navigation Aids* Doc 9849 – *Global Navigation Satellite System (GNSS) Manual* Doc 10007, AN-Conf/12 – *Twelfth Air Navigation Conference*

[1] Russian version provided by the Russian Federation.

1. INTRODUCTION

1.1 In June 1996, the Government of the Russian Federation proposed to the President of the Council of ICAO the possibility of using the GLONASS system to meet the needs of international civil aviation in conjunction with the obligation to provide a GLONASS global navigation satellite system orbital grouping standard-precision signal to the global aviation community on a non-discriminatory basis, free of direct user charges, for a period of at least 15 years. The Russian Federation has also committed to notifying ICAO of the planned discontinuation of GLONASS maintenance at least six years before any such discontinuation occurs. In the very same year, 1996, the ICAO Council approved the Russian Federation’s proposal.

1.2 The subsequent deployment and development of GLONASS in the 1990’s occurred under substantially different economic conditions, and as a result, the number of orbital groupings fluctuated from time to time. Thereafter, the optimal number was gradually restored. Since 2011, the system has been maintained at its optimal level of 24 satellites in three orbital planes.

1.3 When reviewing issues relating to GNSS development and, specifically, the status of the GPS and GLONASS systems, the Twelfth Air Navigation Conference held in Montreal from 19-30 November 2012 noted the fact that GPS and GLONASS had been proposed to the international community for use without payment of direct user charges, and it recognized that GNSS is a global resource for collective use with many useful applications, and that basic GNSS service should therefore be provided free of direct user charges.

2. CURRENT STATUS OF THE GLONASS ORBITAL GROUPING

2.1 Composition of the GLONASS orbital grouping

2.1.1 In recent years, GLONASS has been maintained at the optimal level of 24 satellites, and it has been significantly modernized. As of July 2016, the GLONASS system, in line with its intended use, included 24 satellites, 23 of which were second generation (GLONASS-M) space vehicles (SVs), and one third-generation (GLONASS-K). However, one GLONASS-M space vehicle (successful launch conducted on 29 May 2016), was put into service on 27 June 2016, two SVs are being held in orbital reserve, and another GLONASS-K space vehicle is undergoing flight tests.

2.1.2 Further GLONASS space vehicles will be launched as operationally required in order to replace outdated equipment or satellites no longer in service. Two standard GLONASS-M SVs and six upgraded GLONASS-M[2] SVs have been manufactured and stored as a reserve for launches in 2016-2017. The launch of the upgraded GLONASS-M SVs will make it possible to transition to code division in the L3 band within a very short period of time.

2.2 Current GLONASS performance

2.2.1 Assessments of the current operational performance of the GLONASS system were conducted from January 2012 to April 2016. The results demonstrated that currently, on the whole, the overall average reliability of each navigational space vehicle and the precision and reliability of the system meet the requirements of the ICAO SARPs. Specifically, the daily standard deviation of the

[2] The upgraded GLONASS-M satellite transmits code division signals in the L3 band in addition to frequency division signals in the L1 band.

GLONASS distance does not exceed 6 m throughout the entire orbital grouping, as specified by SARPs, and it is, on average, equal to 1.7 m in all assessed intervals. Currently, the reliability of each SV as compared to the previous year's indicator is between 0.9987 and 1.0, which meets the requirements of the SARPs. Furthermore, the probability of a major service failure (for which requirements will be included in the SARPs by late 2016 or early 2017 after the publication of the GLONASS Open Service Performance Specification – OS PS) is gradually decreasing and, according to data from mid-2016, is less than 10^{-5}.

2.3 Positive experiences of Russian civil aviation operators using GLONASS/GPS dual receivers

2.3.1 GLONASS is a self-sustaining navigation system that fully meets the requirements of the ICAO SARPs. Moreover, Russian civil aviation actively uses GLONASS jointly with the GPS system through the use of dual GLONASS/GPS receivers developed by Russian industry in accordance with national requirements. Presently, approximately 600 Russian aircraft are fitted with on-board GLONASS/GPS equipment. Practical experience with such navigation receivers has demonstrated a performance improvement in terms of availability, continuity of service, and accuracy of aircraft position location, in particular when subject to interference, for the stable reception of GLONASS and/or GPS navigation signals.

2.3.2 As a result of these performance improvements, there are increasing possibilities to provide VNAV vertical navigation for flights both en route and within the aerodrome area, including for approaches to landing using LNAV/VNAV vertical guidance without ground or satellite-based augmentation. The simultaneous use of two constellations also reduces the impact of individual technical breakdowns on the overall performance capability. Thus, for example, in the well-known cases of the failure of the GLONASS system in April 2014 and GPS in February 2016, the combined GLONASS/GPS on-board equipment maintained the performance capability, and there were no interruptions in aircraft position determination.

3. DEVELOPMENT OF THE GLONASS SYSTEM WITH A VIEW TO ITS USE IN MULTI-CONSTELLATION DUAL-FREQUENCY (MC/DF) GNSS

3.1.1 The concept of multi-constellation dual-frequency (MC/DF) GNSS envisages the use of signals with code division (CDMA) as the basis for efficient interaction and compatibility among the constellations comprising it and the second band signals. In support of the implementation of this concept within the GLONASS system, in mid-2014 the first upgraded GLONASS-M SV was launched and put into operation with a CDMA signal transmitter on the GLONASS L3 band. There are plans to launch six already manufactured, upgraded GLONASS-M space vehicles with this signal in 2016-2017.

3.1.2 GLONASS-K SVs transmit navigation signals with frequency division (FDMA) on GLONASS L1 and L2 bands and new CDMA signals on L3 bands. GLONASS-K SVs have longer active shelf lives, more stable frequency standards, and are equipped with search and rescue devices. Starting in 2018, the development of GLONASS orbital groups will continue through the commissioning of upgraded GLONASS-K space vehicles, which will transmit CDMA signals on the L1 band.

3.1.3 By the year 2021, all GLONASS orbital grouping satellites are expected to transmit the CDMA signal on the L3 band in addition to the FDMA signal on the L1 and L2 bands, and in subsequent years, CDMA on the L1 band. This is expected to be implemented by 2028. Irrespective of the introduction of CDMA signals, backward compatibility with FDMA signals will be supported on all GLONASS-K SVs by transmitting FDMA signals on the L1 and L2 bands.

4. ISSUES SURROUNDING INTERNATIONAL REGULATORY CONTROL OF THE USE OF MULTI-CONSTELLATION GNSS

4.1 Issues involving the joint use of existing and future GNSS constellations were discussed during the Twelfth ICAO Air Navigation Conference (AN Conf/12). The Conference noted the existing potential for significant operational benefits stemming from the implementation of multi-constellation GNSS. Furthermore, the Conference noted several technical and regulatory issues related to the difficulties airspace users will experience if different States or regions issue different mandates for or prohibitions of the use of specific GNSS elements.

4.2 With respect to mandates to fit aircraft with equipment for specific GNSS constellations, the Conference acknowledged that some States might issue such mandates for various reasons. It came to a general consensus, however, that any State that plans to issue such mandates should limit their scope to aircraft operators for which it is the State of Operator. The Russian Federation fully supports this approach.

4.3 With respect to prohibitions, the Conference noted that the authorization of the use of specific GNSS elements could accelerate the process of obtaining benefits contingent upon the use of a specific system or technology, although it acknowledged that in the case of GNSS, a performance-based approach is preferable.

4.4 Nevertheless, difficulties are already arising at this stage with civil aviation authorities issuing authorizations for the use in States of specific GNSS elements. Some States, taking a sovereign approach to ensuring the safety of air navigation services provided in the national airspace, are refusing to issue authorizations for flight operations using GNSS system elements provided by other States.

4.5 Therefore, the joint use of existing and future GNSS constellations clearly requires the settlement of the issues surrounding the legal responsibility at the international level. Furthermore, the Russian Federation does not intend in the near term to introduce any restrictions on the use of GNSS constellations that meet the SARPs requirements in national and delegated airspace, thereby adhering to Recommendation 6/6c of the Report of the AN Conf/2.

4.6 However, it should be noted that several States have already introduced restrictions into their national aviation legislation on the use of GNSS constellations that meet the requirements of the ICAO SARPs. In this context, the Russian Federation considers it appropriate to recommend that the Council of ICAO review the issues surrounding international regulatory control of the use of multi-constellation GNSS with the purpose of increasing the safety and efficiency of international air navigation.

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