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IP01- Update on Dual Frequency Multi-constellation(DFMC)

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Update on Dual Frequency Multi-constellation(DFMC)

ICAO Council adopts ICAO SARPs for dual-frequency multi-constellation (DFMC) GNSS in March 2023

The DFMC GNSS SARPs will introduce the next generation of GNSS for aviation:

- two entirely new GNSS constellations, Galileo (Europe) and BeiDou (China), are being standardized by ICAO for the first time.
- the existing SARPs for the GPS (USA) and GLONASS (Russia) constellations are being enhanced to introduce a second frequency and modernized technology.
- the existing satellite-based augmentation system (SBAS) SARPs are being enhanced to introduce a second frequency and the ability to augment the new constellations.

Update on Dual Frequency Multi-constellation(DFMC)

Application of DFMC

DFMC standards apply to:

- Four core constellations: BeiDou (China), Galileo (Europe), GPS (USA), GLONASS (Russia)

  Note: Japan proposed QZSS as a 5th core constellation, which is being studied

- Three ICAO GNSS augmentations:

➢ SBAS

➢ ABAS– ARAIM

➢ GBAS

Update on Dual Frequency Multi-constellation(DFMC)

Benefit of DFMC SARPs

DFMC will give aviation access to over 50 additional new GNSS satellites and modernized satellites for existing constellations, which will:

- mitigate vulnerabilities in respect of ionospheric disturbance and radio frequency interference due to availability of a new frequency.
- contribute to mitigate ionospheric scintillation and mitigate the risk of having insufficient satellites within a single constellation due to the availability of multiple constellations.
- enhance GNSS robustness due to the increased system redundancy both in terms of frequencies of operations and of satellites in use.
- improve overall safety, capacity and efficiency by providing better navigation performance and availability
- expand the range of PBN operations supported in a given area
- enable the introduction of precision approach procedures at aerodromes where they cannot be supported today
- potential for further rationalization of conventional navigation aids.

Update on Dual Frequency Multi-constellation(DFMC)

Benefit of DFMC SARPs

Due to ICAO recognition and standardization, this global infrastructure provided by individual States or group of States can be confidently embraced by other States because:

- the validation process conducted by the ICAO Navigation Systems Panel is an independent verification that a constellation can meet civil aviation requirements
- the involvement of GNSS-provider States in the ICAO standardization process provides an additional measure of trust
- GNSS-provider States will comply with the new GNSS SARPs and will provide formal letters of commitments to ICAO to that effect.

Update on Dual Frequency Multi-constellation(DFMC)

GPS

- The main intent of the SARPs changes was to extend the current provisions to include the modernized GPS L5 signal.
- The GPS legacy Standard Positioning Service (SPS) Full Operational Capability (FOC) was declared in July 1995:
  - the legacy SPS comprises only the C/A-code signal transmitted at the L1 frequency
  - SARPs for GPS were first included in Annex 10 in 2001
- The SPS modernization includes the addition of a pair of signals (I5-code and Q5-code) transmitted at the L5 frequency along with several other improvements:
  - currently 15 GPS satellites capable of L5
  - FOC for the modernized SPS now expected in the late 2020s
- The GPS SARPs are applicable for the system in its current state, an update to the SARPs will be prepared when IOC and/or FOC for L5 is reached.
- The updated commitments to ICAO for the modernized SPS will be confirmed through an official letter of the U.S. Government to ICAO.

Update on Dual Frequency Multi-constellation(DFMC)

GLONASS

The main intent of the SARPs changes was to extend the current provisions to include the new L3 signal (with CDMA) and CDMA modulation on L1 (L3 OC, L1OC).

The GLONASS Channel Standard Accuracy (CSA) legacy service is based upon 24 satellites and is fully operational for aviation use in the L1 frequency band using frequency division multiple access (FDMA – L1OF):

- SARPs for GLONASS were first included in Annex 10 in 2001

The modernization of the CSA implements code division multiple access signals (CDMA) in the L3 band on the majority of satellites by 2021.

The further implementation of L1 CDMA signals is planned to be completed by 2028 and will retain backward compatibility with the FDMA signals:

- at the moment, 6 upgraded GLONASS-M satellites transmitting L3OC CDMA signals and one GLONASS-K satellite are already in orbit.

- after these satellites, the constellation will be further updated through the launch of the LONASS-K and the upgraded GLONASS-K2 which, starting from a certain sequence number, will broadcast L1OC CDMA signals along with L3OC.

Update on Dual Frequency Multi-constellation(DFMC)

BeiDou

- The main intent of the SARPs changes was to include provisions for a sub-set of BeiDou system (BDS) signals (B1I, B1C and B2a) supporting BeiDou Open Service.
- The development of the third phase of BeiDou Navigation Satellite System (BDS-3) was completed and declared commissioned on July 31st, 2020.
- The BDS-3 constellation consists of 24 MEO satellites, 3 IGSO satellites, and 3 GEO satellites:

  - the BDS Open Service (BDS OS) signals B1I, B1C and B2a, transmitted by the BDS-3 MEO and IGSO satellites, are intended for aviation use.

- All requirements specified in the BDS SARPs are based on the BDS-3 constellation configuration of 24 MEO and 3 IGSO satellites

  - the single-frequency BDS OS is based on any one of the B1I, B1C or B2a signals.

  - the dual-frequency BDS OS is based on a combination of the B1C and B2a signals.

- The commitment to ICAO is confirmed through an official letter of the People's Republic of China to ICAO.

Update on Dual Frequency Multi-constellation(DFMC)

Galileo

- The main intent of the SARPs changes was to include provisions for a sub-set of Galileo signals (E1 and E5a) supporting the Galileo Open Service

  - the E5b signal component is described in the SARPs since it is a subset of the overall Galileo signal modulated on the E5 frequency carrier. However, there is currently no intention that the E5b signal be used by aviation receivers.

- Galileo Initial Services were declared in December 2016. Galileo Full Operational Capability is intended by the time Galileo operates under the baseline constellation configuration of 24 slots.
- The current Galileo constellation has a total of 26 satellites in orbit:

  - 22 operational satellites, two satellites in non-nominal orbits and currently under testing,
  - 1 spare satellite, 1 defective satellite operating only one frequency

- Galileo will meet the requirements in the Galileo SARPs by the time of the official FOC service declaration and the corresponding publication of the Galileo OS FOC Service Definition Document.
- The commitment to ICAO is confirmed through an official letter of the European Commission (on behalf of the European Union) to ICAO.

Update on Dual Frequency Multi-constellation(DFMC)

DFMC SBAS

DFMC SBAS supports improved availability, continuity and accuracy by using modernized core constellation ranging sources:

- with two frequencies and from more than one constellation.
- due to dual frequency, DFMC SBAS users directly measure ionosphere delay, instead of calculating it from corrections provided by the ground segment of SBAS:

  - this feature adds robustness against ionosphere effects that impact single-frequency SBAS,

  - extends worldwide areas in which SBAS can support precision approach.

DFMC SBAS capable avionics will have the capability to track the L5/E5a frequency in addition to the L1/E1.

DFMC SBAS service is independent of the legacy L1 SBAS service, and legacy L1 avionics will continue to be supported in a DFMC SBAS environment. Current providers intend to maintain their L1 SBAS service.

Update on Dual Frequency Multi-constellation(DFMC)

DFMC SBAS

- DFMC SBAS avionics will provide robustness against radiofrequency interference on L1 or L5 frequencies:

  - when subject to interference or signal loss on L1, DFMC SBAS avionics will provide horizontal navigation operations using single frequency ABAS on L5 supported.

  - when subject to interference or signal loss on L5, DFMC SBAS avionics will provide precision approach capability with L1 SBAS or horizontal navigation operations only with single frequency ABAS on L1.

- DFMC SBAS design permits augmentation of multiple GNSS with up to a total of 92 satellites concurrently; in comparison, the L1 SBAS design only provides an ability to augment up to 51 satellites concurrently, with SARPs only developed for GPS and GLONASS constellations.
- DFMC SBAS provides a reduction of calculated Vertical Protection Levels (VPLs); the achieved reduction in VPL supports extending SBAS service areas and is expected to enable approval of additional operational capabilities, such as autoland with Category 1 minima.
- The DFMC SBAS concept includes the possibility to use in the future non-Geostationary SBAS satellites as opposed to L1 SBAS equipment which was only designed to operate with geostationary SBAS satellites.

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Action by Meeting

The meeting is invited to:

1. note the information presented; and take action, as appropriate; and
2. provide update on the subject in subsequent meetings.

Thank You!

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