



ICAO

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Agenda Item 6: Navigation

6.4 Other navigation related issues

**LEO NAVIGATION AUGMENTATION CONCEPT, CONSTELLATION CONSTRUCTION
STATUS AND CIVIL AVIATION APPLICATION RESEARCH IN CHINA**

(Presented by China)

SUMMARY

This paper provides the concept of LEO navigation augmentation, the construction status of LEO navigation augmentation constellations, and preliminary research of LEO navigation augmentation civil aviation applications in China.

1. INTRODUCTION

1.1 Low Earth Orbit (LEO) satellites, with their unique advantages in constellation and signal, have gradually attracted attention in the field of satellite navigation. LEO satellites are expected to become a new increment in the development of a new generation of satellite navigation systems.

1.2 There are two types of LEO navigation augmentation: information augmentation and signal augmentation. Information augmentation improves the accuracy and integrity of Global Navigation Satellite System (GNSS) by broadcasting augmentation information, such as differential corrections, precise ephemeris, precise satellite clock, and integrity augmentation. Signal augmentation provides users with additional radio ranging signal through the integration of communication and navigation systems, and improves navigation service performance through independent positioning or joint positioning with GNSS. Given that the radio ranging signal is also the carrier of augmentation information, GNSS can be augmented by LEO with both information augmentation and signal augmentation at the same time.

1.3 The main advantages of LEO navigation augmentation are high landing signal power and rapid geometry change, which can significantly improve anti-interference ability and geometric structure of existing navigation constellations. Meanwhile, LEO can also be utilized as a space-based monitoring network to supplement the coverage of GNSS ground monitoring stations and realize global monitoring of GNSS. Therefore, LEO navigation augmentation has the potential to improve the

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performance of GNSS civil aviation navigation services such as accuracy and integrity, and ensure the safety and efficiency of civil aviation navigation services in scenarios such as electromagnetic interference and complex terrain.

1.4 This paper presents the concept of LEO navigation augmentation, LEO constellation construction status and research of civil aviation applications in China.

2. DISCUSSION**CONSTRUCTION STATUS OF LEO NAVIGATION AUGMENTATION
CONSTELLATIONS**

2.1 LEO navigation augmentation technology has received extensive attention internationally. Iridium's iGPS service broadcasted navigation messages through high-power signals, assisting users to quickly capture GPS signals, thereby achieving time to first fix in seconds. Iridium NEXT's Satellite Time and Location (STL) service broadcasts encrypted ranging signals and navigation messages, providing navigation enhancement and backup for GNSS and significantly improving anti-spoofing capability. In recent years, the booming development of LEO mega communication constellations represented by Starlink and OneWeb has brought new development opportunities for LEO navigation augmentation technology. The research of Stanford University shows that LEO communication satellites can provide navigation service capabilities comparable to existing GNSS by carrying low-cost navigation equipment. Navigation Innovation and Support Program (NAVISP) proposed by European Space Agency (ESA) is also planning to deploy LEO navigation constellations to complement and back up GNSS.

2.2 LEO navigation augmentation constellation is an important part of comprehensive national positioning, navigation and timing (PNT) system of China in the future. It will provide more ubiquitous, integrated and intelligent PNT services by means of deep integration of communication and navigation. It will focus on improving performance in aspects of positioning accuracy, integrity, space-based monitoring and backup navigation to meet requirements for constructing China's comprehensive PNT system. Several organizations in China have simultaneously performed relevant theoretical research, simulation calculation and proposed corresponding constellation plans. Some constellations have been launched experiment satellites for in-orbit verification, and experimental data of LEO satellite navigation signal and information augmentation have been accumulated.

**PRELIMINARY RESEARCH ON LEO NAVIGATION AUGMENTATION
CIVIL AVIATION APPLICATIONS IN CHINA**

2.3 Combined with construction and development of LEO navigation augmentation constellations, China has performed preliminary research on technologies and methods of LEO navigation augmentation civil aviation applications. Advanced Receiver Autonomous Integrity Monitoring (ARAIM) is an important technological means to ensure integrity of navigation, which employs redundant, dual-frequency measurements from multiple GNSS constellations. Research has been performed on ARAIM fault detection method and ARAIM availability optimization of BeiDou Navigation Satellite System (BDS) assisted by LEO navigation augmentation. Real-time performance of ARAIM algorithm is promoted under circumstance of satellite number dramatically increasing. LEO navigation augmentation constellation is optimized to increase ARAIM availability, which can provide suggestions for the construction of LEO constellations.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

- a) note LEO navigation augmentation concept, constellation construction status and civil aviation application research in China in this paper.
