Global Navigation Satellite Systems for Civil Air Navigation

Since the mid 1990’s aircraft navigation has slowly migrated from services provided by ground-based navigation aids to satellite-based navigation.

The key enabler of that migration was the declaration in 1993 by the Department of Defense that the Global Positioning System (GPS) had achieved initial operational capability. While GPS provides a means of navigation that typically exceeds the accuracy requirements of aircraft navigation, it does not meet the integrity requirements of aircraft navigation, therefore, various solutions were developed to provide the required integrity performance.

Early on, The MITRE Corporation’s Center for Advanced Aviation System Development (MITRE/CAASD) helped define the concept of Receiver Autonomous Integrity Monitoring (RAIM), an integrity algorithm implemented in GPS avionics. This development allowed the Federal Aviation Administration (FAA) to approve GPS-based navigation for oceanic through non-precision approach phases of flight. It is now expected that RAIM-based solutions will play an increasingly important role in the multi-constellation environment of the future. MITRE/CAASD is working actively in close cooperation with the FAA and the international community to develop advanced RAIM concepts intended to support vertically-guided instrument approach procedures in the future multi-constellation environment.

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MITRE/CAASD has helped define augmentation systems both in terms of high-level system architectures and requirements in order to extend the range of GPS-based flight operations to include vertically-guided instrument approach procedures in the future multi-constellation environment. Two augmentation systems were conceived, developed, and implemented: the Wide Area Augmentation System (WAAS), intended to provide service over the entire National Airspace System (NAS), and the Local Area Augmentation System (LAAS) further discussed below.

WAAS was commissioned by the FAA on July 10, 2003 and has operated continuously since then. The WAAS program was planned by the FAA in four phases extending from initial operational capability to dual-frequency service. The latter service is expected to be achieved around 2018. In support of this activity, MITRE/CAASD has developed simulation tools to evaluate the impact of proposed changes to WAAS on service availability and continuity performance.

In addition, MITRE/CAASD is working with the FAA to develop the LAAS. MITRE/CAASD’s role includes analyses of signal integrity and availability. MITRE/CAASD has also provided technical expertise to FAA/industry partnerships, FAA’s Key Technical Advisors on LAAS, and the LAAS Integrity Panel. This work ensures the integrity and safety of a future LAAS system that will support landings to Category III standards.

MITRE/CAASD is helping to define civil requirements for a new modernized system consisting of GPS III satellites and the Next Generation Operational Control System. In addition to helping to determine the new capabilities offered by this system, MITRE/CAASD is reviewing the system design and working to ensure backward compatibility with legacy avionics.

The inherent low-power of the satellite navigation signals results in a potentially serious vulnerability of Global Navigation Satellite Systems (GNSS) to radio frequency interference. MITRE/CAASD is working with the FAA to supplement Distance...
Measuring Equipment (DME) coverage to provide a second form of Area Navigation (RNAV) to airliners, while carefully constructing a plan to divest about half of the existing Very High Frequency (VHF) Omni Range but still allowing aircraft not equipped with DME RNAV—e.g., General Aviation (GA)—a safe approach in lieu of GNSS navigation. MITRE/CAASD is working with the FAA in an Alternate Position, Navigation, and Timing (APNT) group to study a range of alternative technology for a backup surveillance and navigation system in the 2030 time frame.