Threat Model for a Ground-Based Augmentation System

MITRE contributed to the development of a Ground-Based Augmentation System (GBAS) for Singapore Changi Airport by collecting and analyzing anomalies in the ionosphere. MITRE's analysis will give the Civil Aviation Authority of Singapore (CAAS) data to certify the GBAS, thereby enhancing airport operations while demonstrating its leadership in aviation technology in the region.

Background

MITRE analyzed 35 months of ionospheric measurements on behalf of CAAS to support the creation of a GBAS Ionospheric Threat Model (GITM), which will support a safety case for a GBAS at Singapore Changi Airport.

GBASs are highly desirable because they enhance the efficiency of airport operations. Unlike more-common instrument landing systems (ILSs), one GBAS can support multiple runways. GBASs also continue to function during severe weather conditions that may cause service outages for ILSs.

GBASs are precision-landing systems that use differential corrections and integrity data computed at reference stations on the ground to improve the accuracy of measurements obtained by approaching aircraft from Global Positioning System (GPS) satellites (see Figure 1). Antennae in surveyed locations near the airport receive GPS signals, and the GBAS system determines the magnitude of any errors at the airport for each of the GPS satellites.

Need for a Threat Model

Because the antennae are near the airport, any errors sensed by the antennae should be very close to the errors that would affect landing aircraft. However, sometimes phenomena in the Earth's ionosphere cause errors to be different at the GBAS antennae and the landing aircraft. This can cause hazardously misleading information (HMI) during the approach to the runway. Adverse atmospheric phenomena are stronger and more prevalent in areas near the magnetic equator, such as Singapore.

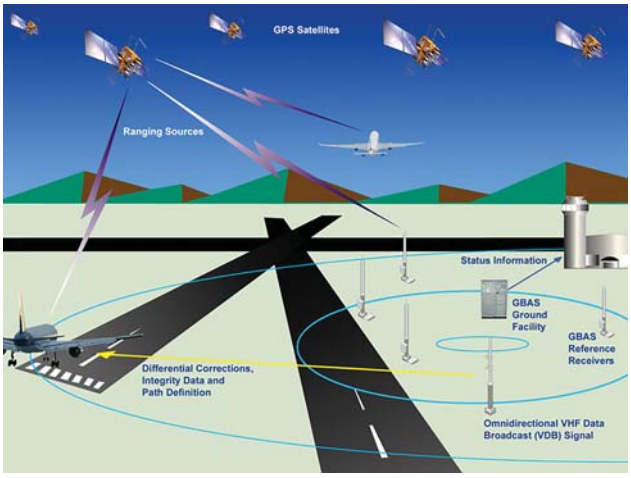

Figure 1. Example of a Ground-based Augmentation System
(Source: United States Federal Aviation Administration)

GITMs are developed to minimize the chances of HMI with GBAS. GPS data are collected, and the behavior of the ionosphere is investigated before the GBAS system is certified. The goal is to capture the full range of ionospheric behavior that could be expected to affect the GBAS at a particular location and then build enough safety margin into the integrity monitors to keep the system safe.

Project Overview

MITRE updated four previously installed ground stations at the airport, known as the Singapore GITM Reference Station (SGRS) network, and recorded GPS measurements from early 2016 to early 2017. CAAS and MITRE also analyzed data collected from 2011 through 2015 from the Singapore

Satellite Positioning Reference Network (SiReNT), which consists of seven stations. Data from the combined SGRS and SiReNT networks (see Figure 2) presented a statistically significant picture of ionospheric variability over Singapore.

The data were analyzed using the Long-term Ionospheric Anomaly Monitor (LTIAM) software, developed by the Korean Advanced Institute of Science and Technology, and additional analysis tools developed by MITRE. MITRE analyzed approximately 180 anomalous ionospheric events and then used the results to create the GITM for Singapore.

The next step is to apply the GITM to offline simulations of GBAS ionospheric integrity monitoring during aircraft approaches. These simulations will be used to evaluate the resulting integrity risk and to determine if additional monitoring, geometry screening, or constraints on the location of reference stations are necessary.

After the GBAS is certified, CAAS will need to continue monitoring and analyzing GPS data and update the GITM to protect aircraft from HMI. This continuous monitoring will allow CAAS to establish its own expertise in GITM analysis and continue being at the forefront of aviation in Southeast Asia.

Figure 2. SGRS and SiReNT Ground Stations