Chapter 16

Augmentation Systems: The Use of Global Positioning System (GPS) in Aviation

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ABSTRACT

The global positioning satellite system (GPS) has been utilized for commercial use after the year 2000. Since then, GPS receivers have been integrated for accurate positioning of ground as well as space vehicles. Almost all aircrafts nowadays rely on GPS based system for their take off, landing, and en-route navigation. Relying on GPS alone does not provide the meter level accuracy needed to guarantee safe operation of aircrafts. Thus several augmentation systems have been deployed worldwide to enhance the accuracy of the GPS system. Several augmentation systems that serve local as well as wide coverage areas are discussed in this chapter, specifically the LAAS system, the WAAS system as well as the EGNOS system. The architecture as well the performance metrics for each of these augmentation systems are presented and discussed.

INTRODUCTION

In the year 2000, selective availability (SA) was removed from the global positioning system (GPS) signals, and thus the position estimates on earth improved from several hundred meters to tens of meters. This significant improvement opened the door for a wide variety of civilian and commercial applications that can utilize GPS for navigation, location determination and tracking.

GPS relies on signals transmitted from visible satellites (at least 4) to estimate the location and time of user equipment on earth (or close to earth). It uses a carrier frequency of 1575.42 MHZ with a bandwidth of 2 MHz. The navigation data from each satellite (also called ephemeris) is spread with a unique code for each satellite to allow the receiver to identify the satellite being used. In the receiver, the spread GPS signal is de-spread with the same spreading code used by the satellite, and the signal is reconstructed again. The difference between the starting of the spreading code in the
receiver and the one received gives an estimate of the time traveled, and thus the distance from the satellite. This ranging estimate is called the pseudorange (PR). The PR is not precise and needs refinement to provide more accurate location estimates. In addition, the GPS signal goes through the atmosphere, and thus suffers from Ionospheric and Tropospheric delays which add to the position estimate errors.

Also, the GPS signal at the receiver might get degraded because of its multipath component that represents an attenuated and delayed version of the original signal due to its reflection from the ground close to the receiver terminal. This multipath can degrade the location estimate significantly if not taken into account, especially in applications that involve human lives, such as avionics. Most of the delays and errors in the GPS estimate due to atmospheric, receiver or multipath can be compensated for and corrected for to achieve meter level accuracies. Some of the corrections can be performed using more complicated receiver models, while others rely on augmentation systems that correct for atmospheric errors utilizing what is called differential GPS (DGPS).

In DGPS, reference stations in known locations are used to calculate the differences between the true location and the one given by a GPS receiver. The difference is a common estimation error that can be used in the vicinity of the reference station to correct for common errors. The geographical area can be up to several kilometers. Thus, if these corrections can be broadcasted to users in the vicinity, the common errors seen by the users can be eliminated, and their position estimates will improve.

Augmentation systems for GPS utilize DGPS for correction creation, and then broadcasting the correction information for location and time back to users, aircrafts or vehicles. Several GPS augmentation systems have been proposed and implemented in the USA and Europe. In the USA, the Federal Aviation Administration (FAA) have implemented the local area augmentation system (LAAS) for airports to aid in precision approach and landing, and the wide area augmentation system (WAAS) to aid in aircraft navigation as well as precision approach of aircrafts to airports all over the continental USA. While in Europe the European geostationary navigation overlay service (EGNOS) is deployed to aid aircrafts in their navigation and precision approach and landing in Europe.

In this chapter, we will go over the architecture of the three augmentation systems; LAAS, WAAS and EGNOS, as well as discuss their features and accuracies.

THE LOCAL AREA AUGMENTATION SYSTEM (LAAS)

The Local Area Augmentation System (LAAS) is an augmentation between the satellite based Global Positioning System (GPS) service with ground based stations to provide accurate correcting information for aircraft landing and approach in airports. The initiative was proposed by the Federal Aviation Administration (FAA) in late 1990’s. LAAS has to meet stringent requirements that will provide accuracy, integrity, continuity and availability of service for aircrafts during their final approaches to airports which require the greatest safety and reliability. It relies on local area differential GPS (DGPS) for horizontal and vertical position fixing that is broadcasted to aircrafts in the airport vicinity to enhance position accuracy.

LAAS has been deployed in several airports around the continental USA, and is currently under heavy investigation to meet the stringent requirements of the three categories of precision approach and landing in airports.

Architecture

The current LAAS architecture consists of three major segments: The ground station segment,
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