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MEASUREMENT OF GNSS INTERFERENCE AT AIRPORT ZILINA

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Abstract

The paper described the problems of GNSS interference measurement at airport Zilina. The Global navigation satellite systems (GNSS) are widely used both for civilian and military operations to determine the location, speed, acceleration, and trajectory of the user on the ground. GNSS refers to a constellation of satellites that provide signals from space transmitting positioning and timing on data receivers. The intentional errors include jamming and spoofing which are caused by systems sharing the same frequency illegally. The method for measuring signal interference is defined by the parameters that affect the calculation of the position of interest. Monitoring the extent of the interference and its impact is a necessary procedure for the successful management of aircraft operations at the airport.

Keywords

GNSS, GPS, GLONASS, interference measuring, EGNOS

1. Introduction

The problems of measuring GNSS interference is very complex, because are necessary know of the type of source interference and potential hazard impact on CNS equipment infrastructures.

Global navigation satellite systems (GNSS) are widely used both for civilian and military operations to determine the location, speed, acceleration, and trajectory of the user on the ground (Rostáš & Škultéty, 2017). GNSS refers to a constellation of satellites that provide signals from space transmitting positioning and timing on data receivers (Curran et al. 2016). The US Global Positional satellite (GPS) provides a global position and time determination to both civilian and military operations. It relies on the world geodetic system (WGS) to offer geographical coordinates. The Russian GLONASS and the European Galileo are used in civil aircraft operations (ICAO 2012). The ability of the signals to create their solutions is subject to several sources of disturbance which cause errors in the measurements processed by the receiver. These errors damage positioning accuracy (Gao, Sgammini, Lu and Kubo 2016). Earth receivers may sense signals and build navigation solutions from more than one satellite at any particular time.

As the GNSS signals approach the ground, their power and chip rate diminishes and assumes a short period of Pseudorandom Noise (PN) codes making it susceptible to interference by electromagnetic signals. These interferences are either intentional or unintentional. The intentional errors include jamming and spoofing which are caused by systems sharing the same frequency illegally. Other causes are attributed to signal components such as intermodulation, dispersion and harmony emerging from radio broadcasting and communication emitters. The other source is the leakages of electromagnetic radiation in the navigation frequency band resulting from electronic equipment (Novák, Havel and Bugaj 2018). Often, harmonic challenges the stability of GPS band signals. The unintentional sources of interference emerge from suppressing jammers which makes the receiver unable to yield PNT results. The spoofer which makes the receiver give false results, and hence necessitates the use of GLObal Navigation Satellite System (GLONASS) to identify and measure the errors. Since human activities cause intentional interference, the determination of the location, transmission power and boot time are variable which makes it hard to examine.

2. GNSS interference measurement methodology

The method for measuring signal interference is defined by the parameters that affect the calculation of the position of interest. As a result, identifying the interfering signal and the associated effects on the GNSS is vital. The GNSS signal strength is different for each of the constellation systems, whether it is GLONASS, GPS, or Galileo. Also, critical locations of the broadcast signal are different for different systems (Novák, Havel and Bugaj 2018). The GNSS references use the difference in the time of travel of radio waves from at least four satellites to fix the position of the receiver and get an accurate value for time. By principle, the timing synchronization identifies areas that are vulnerable to jamming of the GNSS references. Necessarily, the preamble timing synchronization and the parity check are vulnerable to jamming interference (Yang, Kang, Kim and Park 2012). According to Curran et al. (2016), measuring the extent of jamming interference depends on the output of the sensitive areas and the transmission time during navigation as summarized below figure 1.

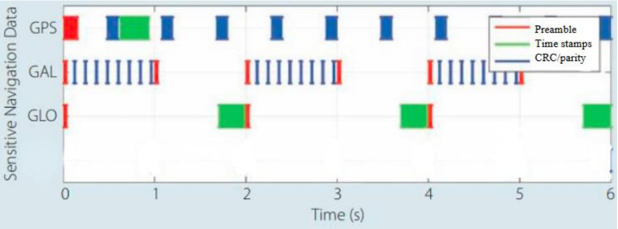

Figure 1: The sensitive navigation data during the time. Source: Adapted from Curran et al. 2016.

Fundamentally, the measurement of the GNSS signal interference requires examination of the effects of errors on all systems, including GPS, Galileo and GLONASS. The process is accompanied by an estimation of the degree of the GNSS to identify the location of the disturbance signal. As a result, measuring GNSS interference requires the definition of the type and intensity of the attack and the position of the source of the disturbing signal (Novák, Havel and Bugaj 2018). The type of attack is defined based on whether it is a simple jamming or a sophisticated attack such as spoofing and meaconing.

Figure 2: GPS jammer from e-shop. Source: Authors.

Through a multidirectional focusing using an antenna with a narrow directional aspect can help identify the location of the source of disturbance, especially for the unitary source of interference. However, for multiple sources, it is necessary to distribute the sources and classify them according to intensity and frequency. To measure the position efficiently, determination of the position of the antenna in the space is the starting point (Yang, Kang, Kim and Park 2012). The most appropriate method to estimate this position is to use the GNSS signal which is less vulnerable to interference. Inevitably, this process will help identify the GPS and Galileo interferences whose configurations depend on the form of initiating GNSS reference. As for the GLONASS, either GPS and Galileo can apply, thus establishing the interdependence that exists between the GNSS constellation systems.

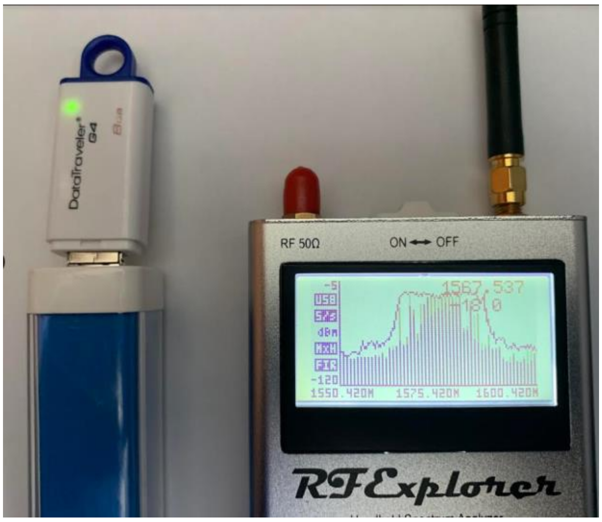

Figure 3: The GPS L1 jammer output power -18dBm. Source: Authors.

Jamming arises when the GNSS receiver receives stronger signals of the same frequency from the other device that overlaps the intensity necessary from the satellite, leading to the unavailability of the system. In order to monitor these errors, the ground system must identify these interferences early enough and design mitigation procedures (Isoz, Akos, Lindgren, Sun and Jan 2011).

Figure 4: The GPS L1 and L2 jammer output power -19.5dBm. Source: Authors.

The other method to measure and mitigate GNSS interference is by receiving and delaying the signal transmission at a set frequency to space by a given time interval. This process confuses the navigation system to provide the inaccurate location of the aircraft. Often, the signal from the delayed line detailing the GPS characteristics that establish hangers, and tunnels with the facility help in crowding out the GNSS interferences and isolating them according to the interface in use.

3. Measuring at Airport Zilina

The development of ground stations that monitor interference is not only hard but also ineffective to singly detect and measure interference of the GNSS reference. Usually, the ground receivers and antenna are unable to cover the entire airport surrounding as well as identify all sources of disturbance due to their short frequency. Subsequently, the installation of a flight laboratory helps in the detection, tracking and measurement of the extent of disturbance over a short period of time to enable the location of the position.

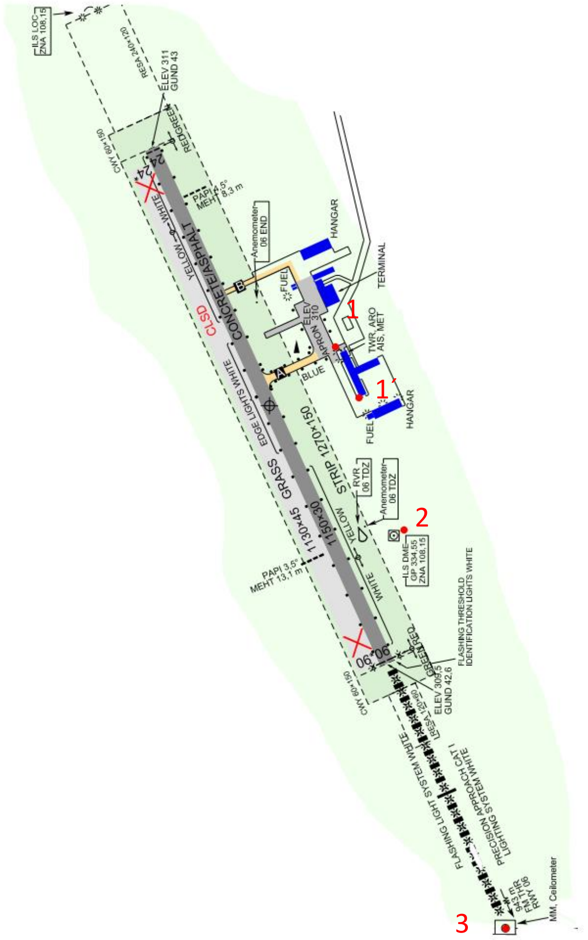

Figure 5: The local maps of the airport Zilina, with potential point for measuring GNSS interference. Source: Authors.

The measurement of GNSS interference at airport Zilina needs two antenna installed at the corner of the airport (Figure 5, position n. 1 and 1´). The other possible installation point is on ILS/GP mast or inner marker (IM) mast (Figure 5., position n. 3).A GNSS antenna that receives signal interferences from the satellite is set outward orienting to receive satellite signals and is installed at a corner in the airport. The other antenna is installed on top of the flight fuselage which helps when the aircraft is approaching the airport. GNSS antennas on aircraft will pick up signals generated from the space and will help during the determination of the position of the user during signal interference. In any case, there is interference; the position of the aircraft is determined based on the conventional ground equipment VHF omnidirectional ranges (VOR) with Distance measuring equipment (DME). During the full spectrum, GPS, GLONASS and Galileo are not consistently disturbed, instead, a single system is used to establish the magnitude of the disturbance (Hoffman 2001). For instance, during GPS interruption, the Galileo system will be used while others will not be considered. It is during the interruption that the direction and nature of the disturbance are measured and recorded. Essentially, the procedure requires monitoring of the signals from the EGNOS L1 satellites in order to determine the integrity of the interference. Subsequently, manual evaluation of the recorded results is undertaken to measure the extent of the interference.

4. Conclusion

Interference poses critical threats to station receivers of GNSS reference. It helps address more professionally safety measures in the airport as well as other processes that rely on GNSS references to determine location and position. Monitoring the extent of the interference and its impact is a necessary procedure for the successful management of aircraft operations at the airport. The antenna used at the ground should actively detect, characterize and communicate the impact on the overall sustainability of the airport operations. The three types of GNSS references, including GPS, GLONASS and Galileo rely on the stability of the receivers to record and read, absence of other instruments with unique electromagnetic effects. The receivers not only collect but may also determine the extent of the disturbance caused by the source. The method of measuring interferences of the GNSS references starts with the identification of the intentional and unintentional sources of disturbances and ends with the determination of the most efficient technical specifications with the ability to detect, record and measure the interference. As a result, to detect, identify, and measure the extent of interference on the GNSS constellations at Zilina Airport, a framework consisting of antenna and receivers is necessary.

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