Interference to aircraft GPS receivers

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ENG S WESECHERE

GPS Receiver

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OBJECTIVE

To understand how interference to aircraft GPS receivers is mitigated.

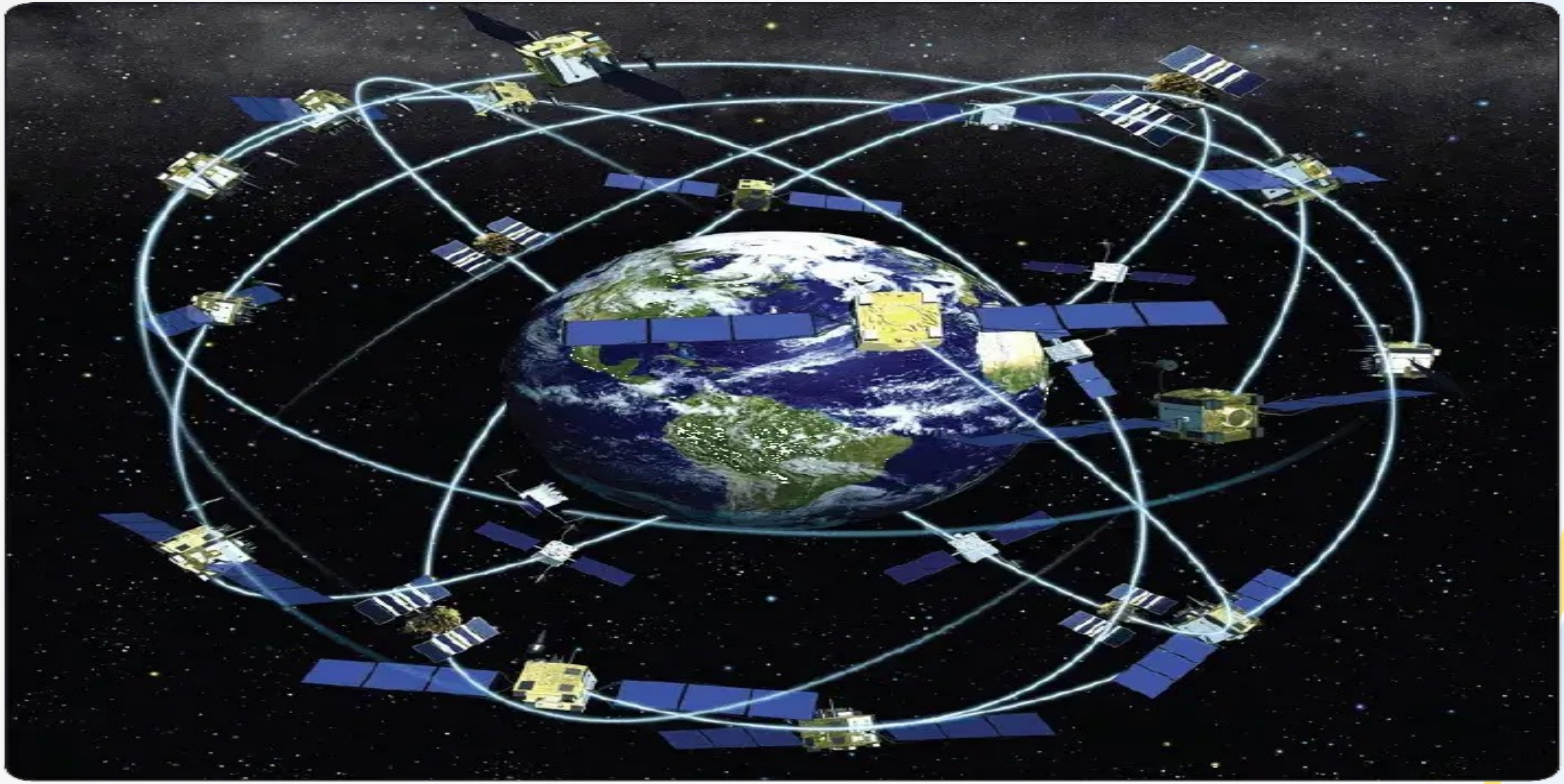
Introduction

- GPS: global positioning system is a satellite-based navigation system that provides location and time information in all weather conditions, anywhere on or near the Earth's surface.
- GPS : the user, satellites, and ground stations. Transponder on board the aircraft connects to multiple satellites which measure the signal to determine latitude, longitude, and altitude.
- Atomic clocks built into the satellites measure the time it takes for the signal to travel from the aircraft to the satellite, this provides a precise determination of where the plane is.
- The satellites send this information to a ground station which further corrects (augmentation) for position error, the information is re-uploaded to a geostationary satellite.
- This corrected information is then sent back to the receiver onboard the aircraft and is displayed on the pilots' screens.

Frequency Bands used

- Two signals loaded with digitally coded information are transmitted from each satellite.
- L1 channel, 1575.42 MHz carrier frequency is used in civil aviation.
- Satellite identification, position, and time are conveyed to the aircraft GPS receiver along with status and other information.
- L2 channel, 1227.60 MHz transmission is used by the military.
- Services in same or adjacent bands should not generate harmful interference to GPS

GPS Constellation



GPS operation

- GPS uses multiple orbiting satellites (up to 24) at around 20 000 km above the Earth's surface.
- A plane must be in view of at least four satellites to determine latitude, longitude, and altitude.
- The fourth satellite measures the time it takes for the signal to be received from the satellite to determine distance.
- The reception of a fifth satellite can isolate a corrupted signal, if one exists, allowing the aircraft to monitor the signal's integrity.

Sources of Interference

- GPS provides weak received signal power at -160dBW. Loss of service can occur at lower receiver power than with terrestrial navigation systems.
- Interference can occur wherever the GPS signal is authorized for use, in-band harmful interference emanates from primary or secondary allocations to the FS.
- Jamming is a kind of radio interference, which overpowers weak GPS signals, causing accuracy degradation and possibly even loss of positioning.
- Unintentional jamming sources include radio amateurs, maritime and aeronautical radiolocation systems as well as electronic devices located close to the GPS receiver which result in GPS receiver not receiving signal meant for it.
- Intentional jamming devices called “jammers” are sometimes found on board of vehicles trying to avoid road tolling by blocking toll system frequency.

Sources of interference

- Spoofing is an intelligent form of interference which misleads the receiver into believing it is at point X when it is actually at Y.
- Point-to-point microwave links operating in the frequency band used by GPS are susceptible.
- Services operating in bands outside the 1 559– 1 610 MHz harmonics.
- Spurious emissions of aeronautical VHF transmitters and out-of-band noise.
- Discrete spurious and intermodulation products (IMP) from radio services operating near the 1 559–1 610 MHz band.
- Existing and future frequency assignments in the 1 559–1 610 MHz band could also cause interference if compatibility is not ensured.

Results of Studies

- Specific VHF transmit antennas located in Television stations do pose a threat to GPS receivers.
- It is feasible for a transmitter operating within specifications to radiate significant power into the GPS L1 band.
- As the spurious emission characteristics of TV transmitters change over time, an ongoing interference mitigation strategy on-board sources in the vicinity of a runway and approach area is required.

Measures to mitigate interference

- Using sensors other than GPS such as an odometry can help flag spoofing by detecting inconsistencies between GPS and the other sensors.
- The GPS antenna location should take into account the possibility of on-board interference from satellite communication equipment.
- Sufficient isolation between transmitting and receiving antenna especially those of the satellite communications and VHF is necessary.
- Transmitter filtering and frequency management controls generation of intermodulation products on the aircraft from one transmitter with multiple carriers or multiple transmitters .
- Weathered joints and connections can generate harmonics leading to on-board interference and should be analysed and controlled.
- Air operators and State regulatory authorities should control such occurrences.

Measures to mitigate interference

- Systems' designers need to maintain the AMS(R)S signal level at the GPS antenna below the agreed protection value.
- International agreement to control the manufacture,import and use of mobile terminals in the vicinity of airports is necessary .
- Avionics must be installed in accordance with industry standards to ensure that the equipment operate as per design.
- Testing for interference with and by other on-board systems is necessary. GPS works pretty well, but inaccuracies do pop up.
- Differential GPS (DGPS) station provides signal correction information by broadcasting a radio signal to all DGPS-equipped receivers in the area.

Measures to mitigate interference

- Appropriately shielded, separated and filtered GPS antenna and cables solves most interference problems on board small aircraft.
- Some personal electronic devices, when used on board an aircraft, are capable of generating sufficient in-band energy to interfere with avionics .
- Receivers which are designed with security and robustness in mind are resilient to GPS vulnerabilities such as jamming and spoofing.
- The best resilience comes from the combination of detection and mitigation mechanisms working together at component level.
- Airframe shielding from ground based interference is necessary.

Measures to mitigate interference

- Safety and efficiency can be maintained by on-board mitigation techniques, procedural methods and back up terrestrial navigation aids.
- States should ensure that regulations are in place to protect the aeronautical radio navigation spectrum allocated to satellite navigation for effective GPS navigation implementation.
- Interference detection, flight inspection and ground monitoring are used to isolate RFI from other interferences in airborne and ground-based systems.
- Identification of airborne GPS RF interference by detecting ADS-B Out signals from co-located aircraft with ADS-B Out transponders.

Conclusion

- Being low power equipment harmful interference needs to be guarded against.
- Enforcement of regulatory measures in manufacture, installation and operation will guard against most sources of interference.
- Regular flight checks, testing and maintenance added to reporting and analysing any occurences will eliminate most sources of interference at an early stage.
- Technical advances have introduced receiver protective measures to enhance its resilience.

References

- ITU Radio Regulations
- ICAO Handbook on Radio Frequency Spectrum requirements for Civil Aviation Doc 9718
- Manual on testing of Radio Navigation aids Doc 8071 Vol 1
- Manual on testing Satellite based aids Doc 8071 Vol 2
- ICAO Annex 10 Aeronautical Telecommunications

THANK YOU