GNSS vulnerability

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Egypt

Presentation Outline

- GNSS in Aviation
- Operational benefits
- Four pillars of GNSS services
- Chicago convention & GNSS
- GNSS Vulnerabilities
- Spectrum regulations
- GNSS Vulnerabilities mitigation
- ICAO/ANC 12 & GNSS vulnerabilities mitigation
- challenges
- Conclusion

GNSS in Aviation

- Direct, obvious uses of GNSS:

1) Aircraft Navigation:

- Supports Area Navigation, User Preferred Route
- Universal coverage worldwide - Terrestrial, Oceanic
- Accuracy adequate for all ops except Precision Approach
- Proven very high Availability, Continuity, Accuracy & Integrity

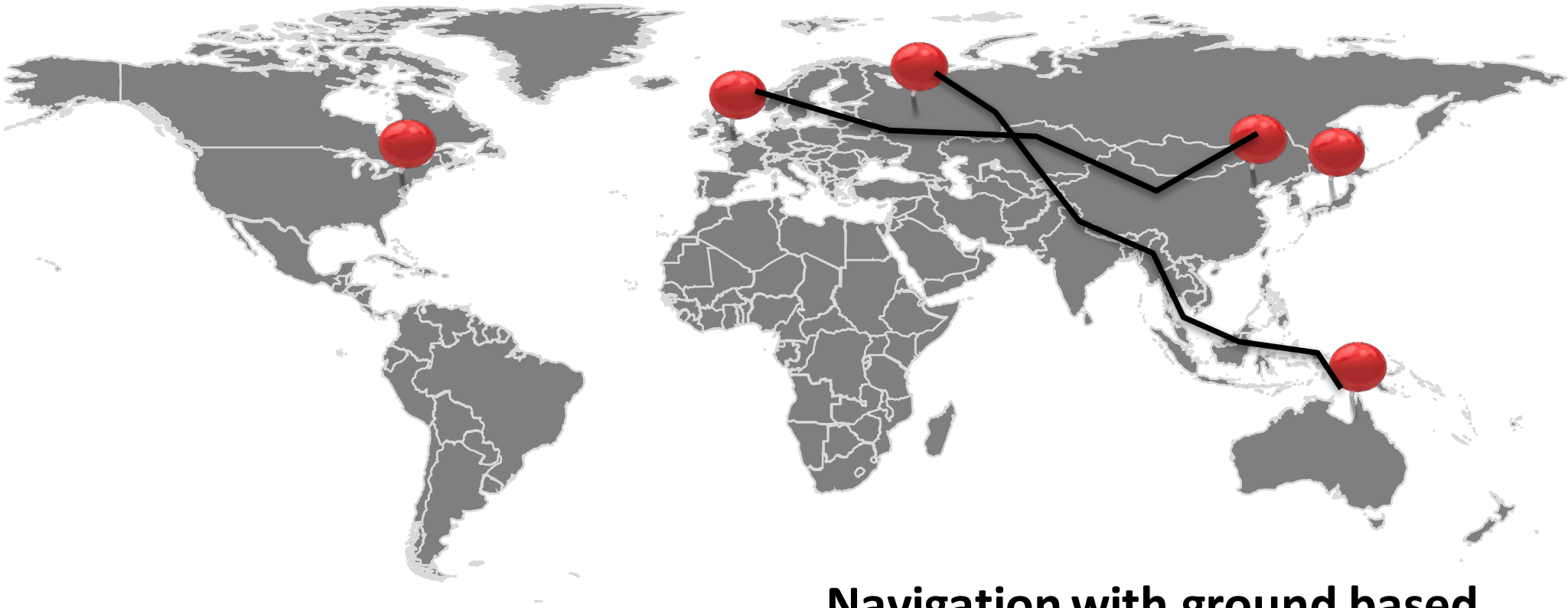
2) Aircraft Automatic Position Reporting:

- ADS-B – broadcast – used by other aircraft and ATC
- ADS-C – contract – used by ATC

GNSS in Aviation

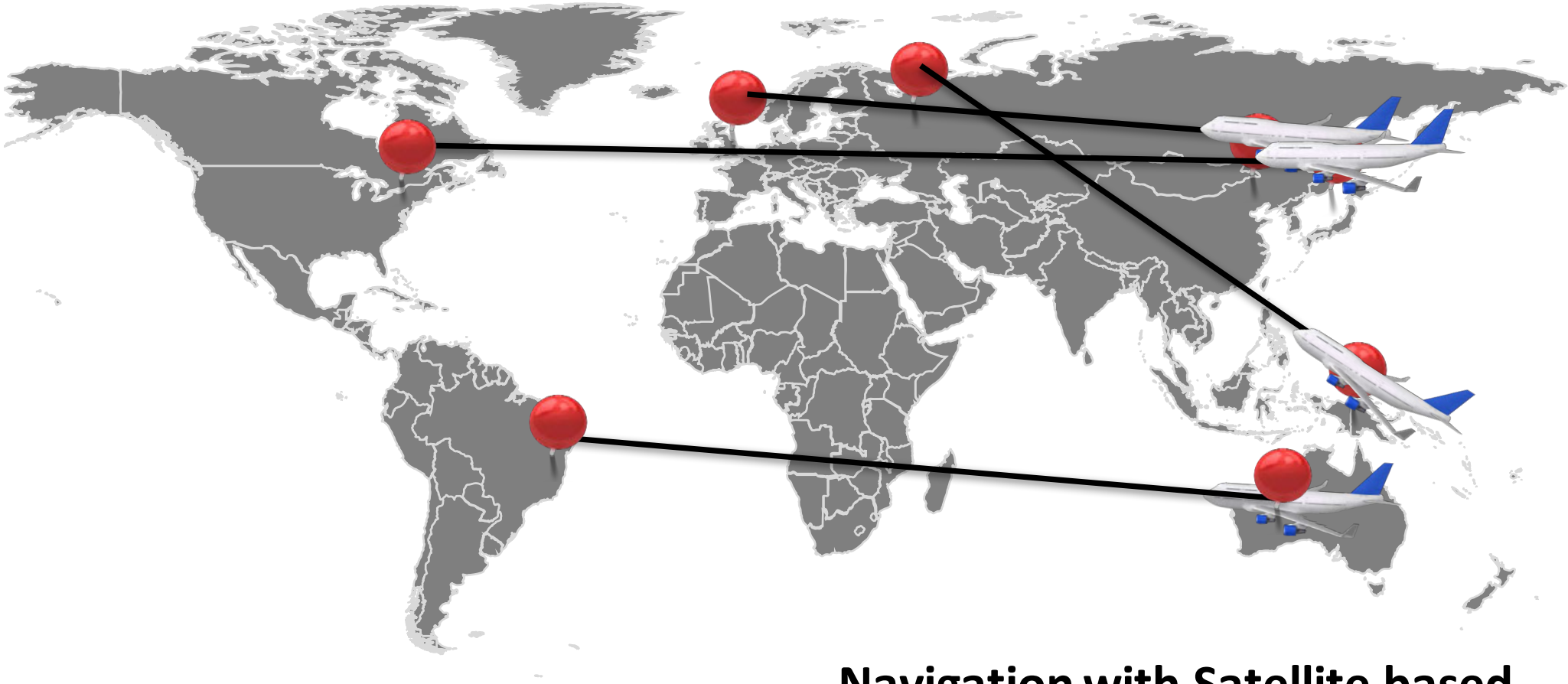
- Not so obvious uses of GNSS – Timing:
  - Clocks – ATC & System monitoring of flight progress
  - Multi-Radar/ADS-B Tracking
  - Communication Bearers
  - Multi-Lateration – Time difference of Arrival

GNSS in Aviation



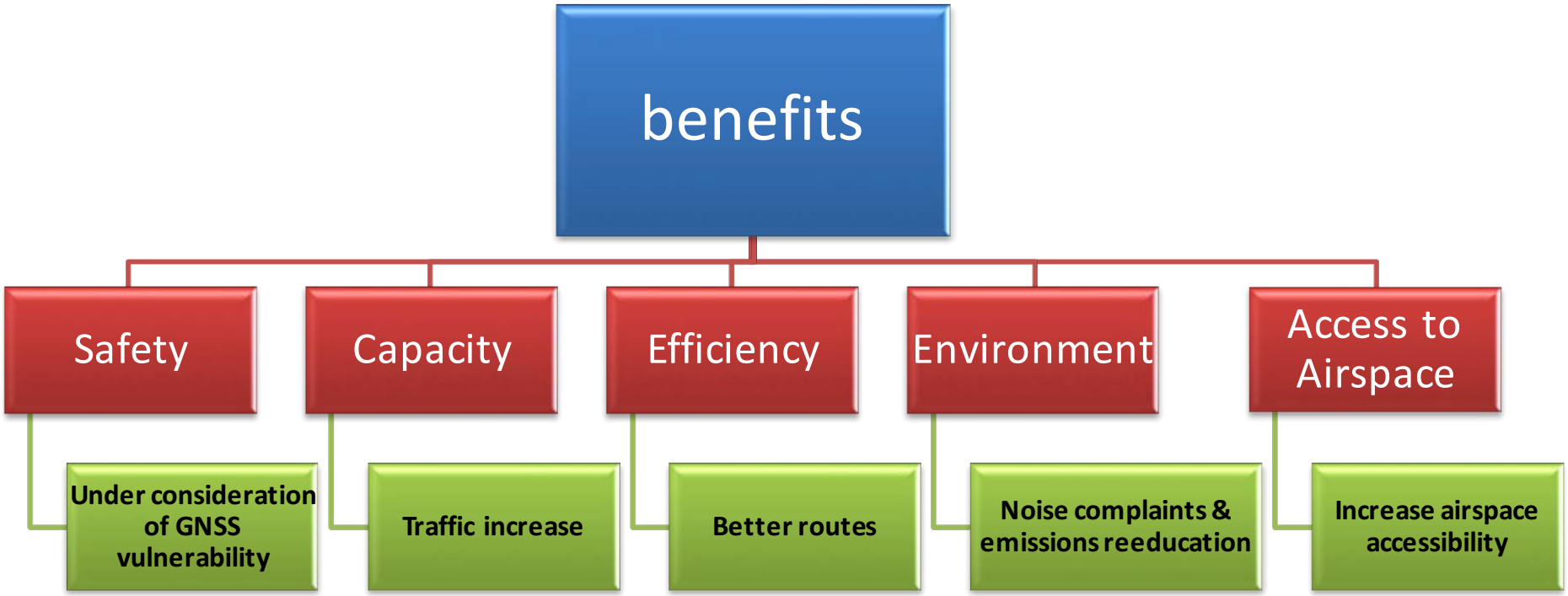
Navigation with ground based

GNSS in Aviation



Navigation with Satellite based

Operational benefits



Four pillars of GNSS services:

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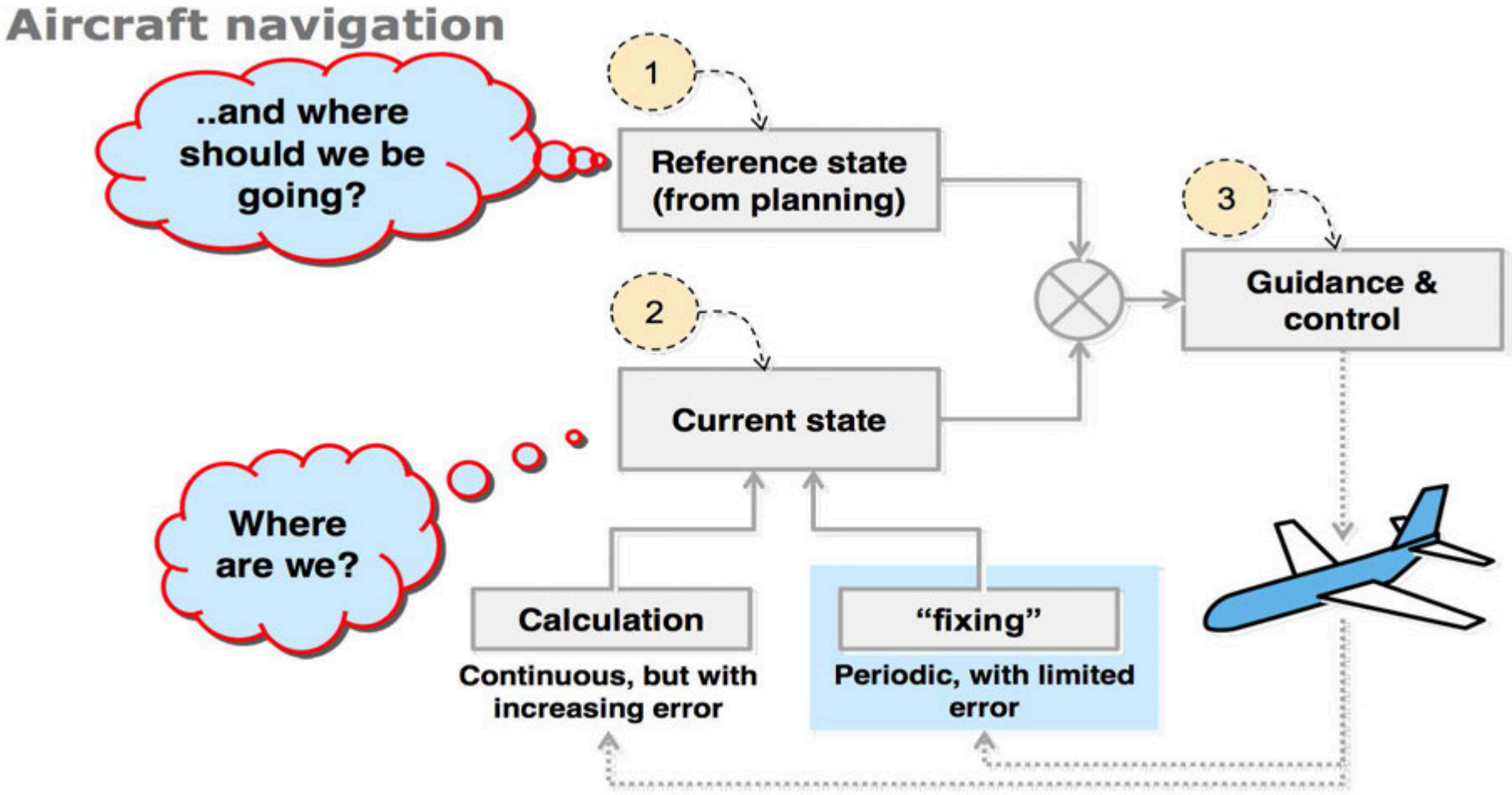
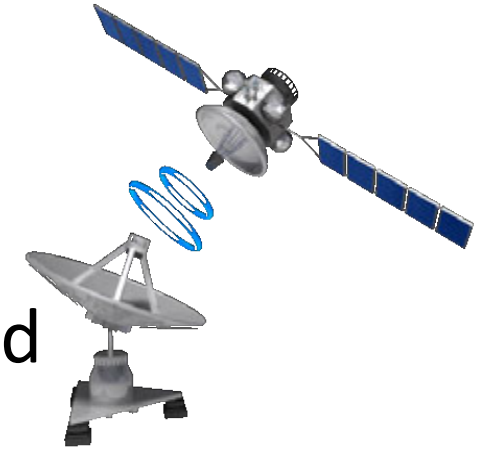
1) Accuracy:



Four pillars of GNSS services:

2) Availability:



planned

available

Proportion of time the System is available to the time it had been planned for the system to be available

Four pillars of GNSS services:

3) continuity:

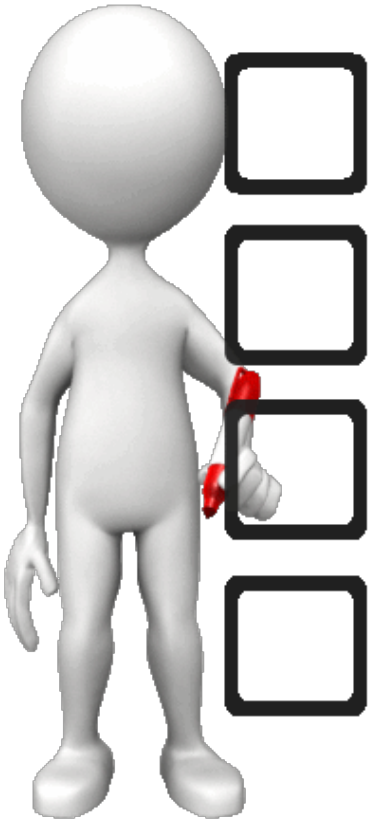
The probability that a system will perform its required function without unscheduled interruption.

Image source from pocket GPS world website

Four pillars of GNSS services:

4) Integrity:

The level of trust that errors will be correctly detected



Chicago convention & GNSS

Article 28 of Chicago convention:

Air navigation facilities and standard systems:

Each contracting State undertakes, so far as it may find practicable, to:

a) Provide, in its territory, airports, radio services, meteorological services and other air navigation facilities to facilitate international air navigation, in accordance with the standards and practices recommended or established from time to time, pursuant to this Convention;

b) Adopt and put into operation the appropriate standard systems of communications procedure, codes, markings, signals, lighting and other operational practices and rules which may be recommended or established from time to time, pursuant to this Convention;

C) Collaborate in international measures to secure the publication of aeronautical maps and charts in accordance with standards which may be recommended or established from time to time, pursuant to this Convention.

Reference : ICAO DOC. 7300/9

Chicago convention & GNSS

Implications of Article 28 of the Chicago Convention:

"A **state** may delegate the provision function to another entity, including a commercial or private operator..." **The State** ”
nevertheless remains responsible for setting and maintaining the standards of the services provided and for the quality of services provided.

Under those circumstances, the relevant States continue to be responsible under Article 28 of the Chicago Convention, “regardless of such delegation.”

Reference : ICAO DOC. 7300/9

Chicago convention & GNSS

Implications of Article 28 of the Chicago Convention:

The implementation of GNSS leaves unaffected the responsibility of States under Article 28, therefore a State using these signals for providing Air Navigation Services remained responsible under this Article **despite the fact that it did not control such signals.**

ICAO, Air Navigation Services Economic Panel, Report on financial and related organisational and Managerial Aspects of Global Navigation Satellite System (GNSS) Provision and Operation, ICAO Doc. 9660

Reference : ICAO DOC. 7300/9

Chicago convention & GNSS

Different point of views:

USA:

- No problem in legal framework or setting the law but the problems due to technical nature or a matter of the lack of resources and political will.

- Work on legal issues must not be permitted to delay technical implementation of CNS/ATM

Reference: AN-Conf/11-WP/160 presented by the United States

Chicago convention & GNSS

Different point of views:

EUROCONTROL:

- most States will not be directly involved in the operation of GNSS systems... Air navigation within their sovereign airspace will consequently rely heavily on facilities beyond their direct control.

- States need to be satisfied.. that the GNSS signals and services offered within their airspace meet the appropriate performance requirements in terms of integrity, reliability, accuracy and continuity and that their liability is clearly defined.

Reference: AN-Conf/11-WP/153 presented by EUROCONTROL

Chicago convention & GNSS

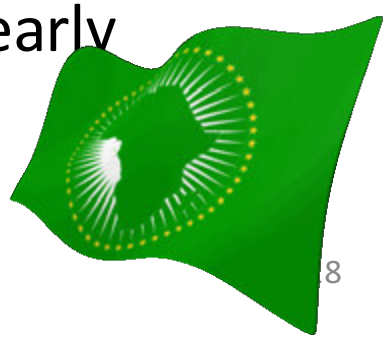
Different point of views:

African States

- states who by themselves cannot provide the GNSS services but yet cannot be relieved of their responsibilities under the Chicago Convention.

- authorize the use of the system over which they have no control.

- committing both providers and users to accept certain international rights and responsibilities in a form of a binding and enforceable legal instrument which should clearly "spell out the rights and responsibilities".

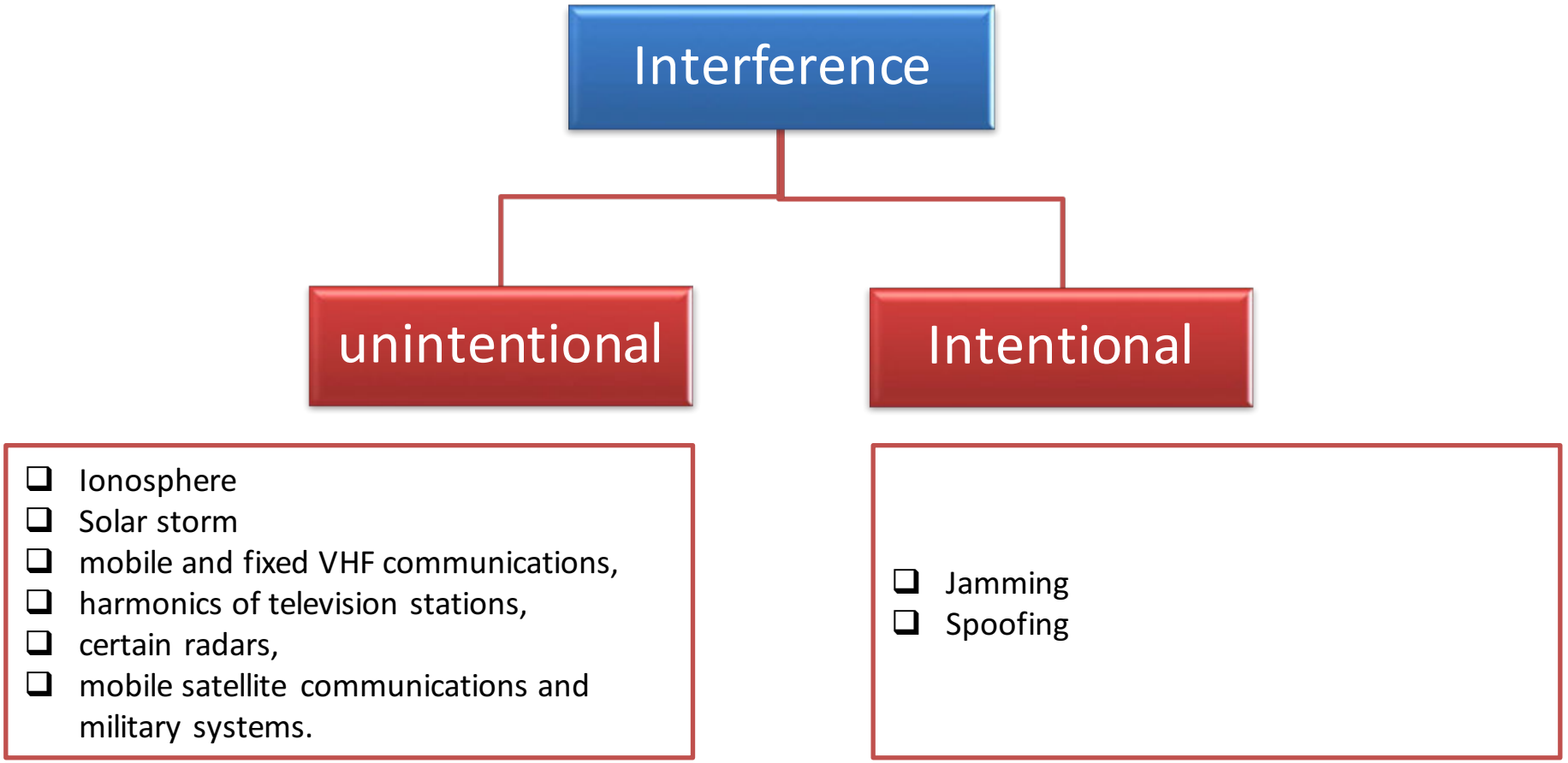


Reference: AN-Conf/11-WP/143 presented by AFI

GNSS vulnerabilities:

Vulnerability:

refers to the inability (of a system or a unit)



GNSS vulnerabilities:

Jamming:

- Late 2009; engineers noticed that satellite-positioning receivers for navigation aiding in airplane landings at Newark airport in US were suffering from brief daily breaks.

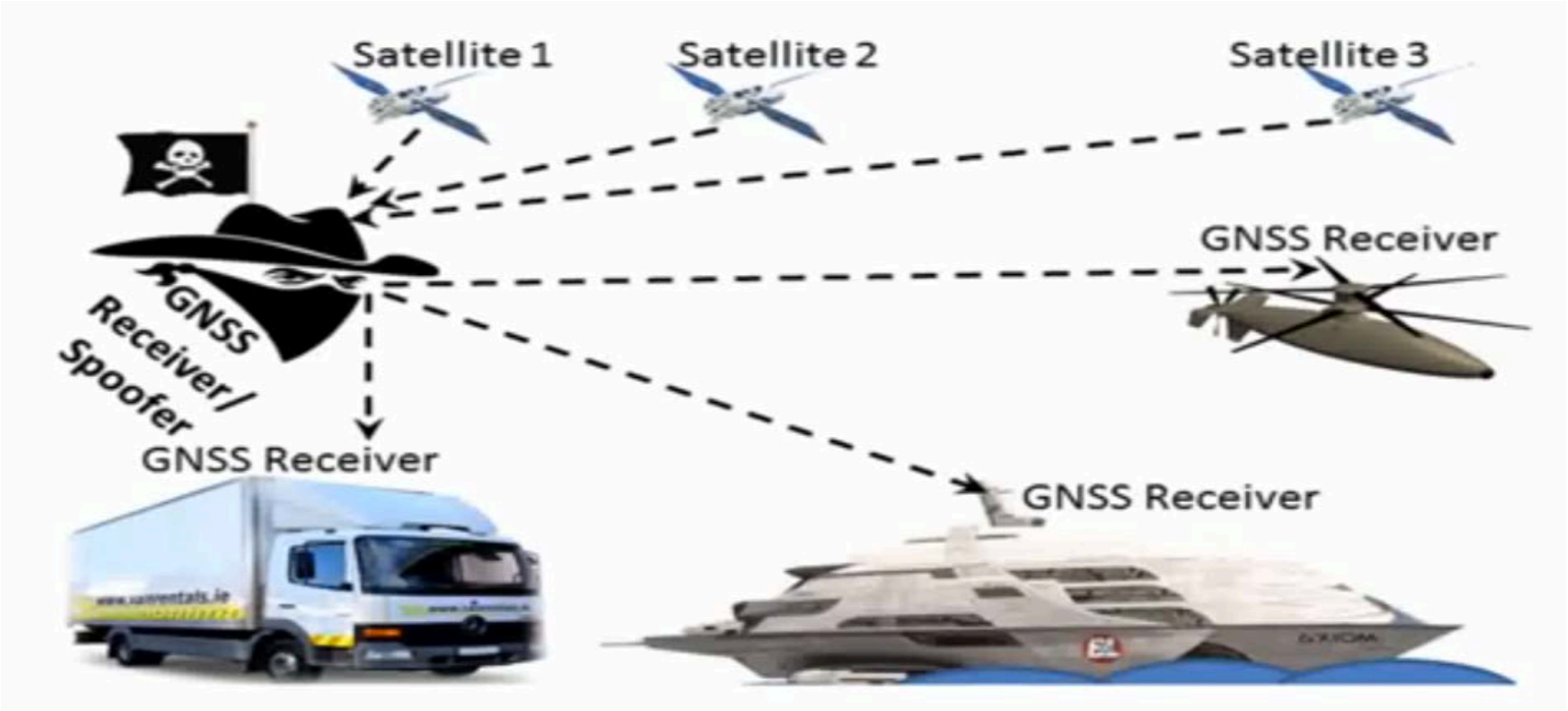
- FAA after 2 moths investigation track down the problem.

- A cheap GPS jammer on truck passed by on nearby highway.

GNSS vulnerabilities:

Spoofing:

is the broadcast of GNSS-like signals that cause avionics to calculate erroneous positions and provide false guidance.



GNSS vulnerabilities:

What action shall be taking by states????

- identify the vulnerabilities of this system; and
- develop the necessary mitigations

Spectrum regulations

- States should prohibit all actions that lead to disruption of GNSS signals.
- States should to develop and enforce a strong regulatory framework governing the use of intentional in-band radiators including:
  - ❑ GNSS repeaters,
  - ❑ pseudolites,
  - ❑ Spoofers & jammers
- Also in-band radiators including certain television broadcast channels and other industrial applications.
- ICAO Electronic Bulletin EB 2011/56 *Interference*
- states should establish regulations that forbid the use of jamming and spoofing devices and regulate their importation, exportation, manufacture, sale, purchase, ownership and use.

Spectrum regulations

- Some States prohibit all actions that lead to disruption of GNSS signals and prescribe severe penalties for the purchase or use of jammers.
- States should develop the means to detect interference sources in support of enforcement programs.
- States should take more preventive measures to reduce the likelihood of GNSS disruption to aviation by non-aviation users.
- ICAO DOC. 7300 & ITU Regulations protect GNSS frequencies for aviation use especially for electromagnetic spectrum of new application like mobile phones and broadband data service which emit signals stronger than GNSS signals

Spectrum regulations

- future multi-constellation and multi- frequency GNSS equipment for aviation will be designed to maximize interference robustness as much as reasonably possible, it is important that new spectrum services do not neutralize these improvements.

GNSS vulnerabilities mitigation

➢ Installation and operation:

- ❑ On-aircraft interference: can be prevented by proper installation of GNSS equipment, its integration with other aircraft systems (e.g. antenna separation, out-of-band filtering) and restrictions on the use of portable electronic devices on board aircraft.

- ❑ Spectrum management: creation of regulations/laws that control the use of spectrum; enforcement of those regulations/laws; and vigilance in evaluating new RF sources (new systems) to ensure that they do not interfere with GNSS.

GNSS vulnerabilities mitigation

- **New signals and constellations:** Stronger signals, diverse frequencies, additional satellites/constellations, future GEO satellites using satellites which lines of sight are separated by at least 45°

- **Inertial navigation systems (INS) and receiver technologies :**
  - Use of INS RNAV capability after the loss of GNSS or other position updating
  - Use of technologies that add robustness to GNSS receivers to mitigate interference : Anti-jam technologies include advanced antennas and receiver signal processing techniques

GNSS vulnerabilities mitigation

- **Procedural methods:** Aircraft can revert visual navigation, ATC, air-to-air communications within non - ATC or non-radar airspace

- **Terrestrial radio navigation aids:** RNAV DME supporting infrastructure (en route, TMA and approach within area coverage), or ILS/MLS infrastructure for precision approach.

ICAO/ANC12 and GNSS vulnerabilities mitigation:

- Recommendation 6/7–Assistance to States in mitigating GNSS vulnerabilities
- Recommendation 6/8–Planning for mitigation of GNSS vulnerabilities:
- Recommendation 6/9–Ionosphere and space weather information for future GNSS implementation:

Challenges

- GNSS NOTAMs
- Mitigation process
- GNSS Regional Monitor
- ICAO Guidance Materials
- State GNSS regulation
- National spectrum regulation (may be different parties are involved – not limited to CAAs and TRAs)
- Incomplete PBN implementation national plans

CONCLUSION

- GNSS has a lot of operational benefits.
- GNSS is must but how can we implement !!!!
- How to mitigate GNSS Vulnerability.
- Conventional or terrestrial Nav. Aids became not enough to meet aviation requirements with reasonable cost (especially third countries).
- Tomorrow, space also will be more congested than airspace.

Thank you

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