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INTERNATIONAL INSTITUTE FOR THE UNIFICATION OF PRIVATE LAW INSTITUT INTERNATIONAL POUR L'UNIFICATION DU DROIT PRIVE

GNSS: WHAT CAN GO WRONG AND WHAT ARE THE RISKS?

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R Filjar GNSS: What can go wrong and what are the risks?

Content of presentation

- Introducing GNSS
- GNSS vulnerabilities and risks



- Mitigation GNSS vulnerabilities and risks
- Conclusion

- We all are navigators
- Timing, orientation, positioning and navigation are deeply embedded in our lives





GNSS: What can go wrong and what are the risks?

Business environment for GNSS



GNSS: What can go wrong and what are the risks?

• End-user's perspective of GNSS

- End-user does not understand and care for the technology and its vulnerabilities
- End-user assumes absolute GNSS robustness and limitless performance
- Urban legends prevail



- How GNSS works?
- Propagation time measurement-based
- Time synchronisation and common reference framework (WGS84) are essential
- Four non-linear equations of four un-knows yield: 3D position, time



- <u>GNSS architecture</u>
- Space (satellite) segment (GPS: 31, Glonass: 23)
- Ground (control) segment
- User segment
- Propagation media
- Advanced systems: DGNSS, A-GNSS, SBAS (EGNOS) (incl.)



GNSS: What can go wrong and what are the risks?

GNSS vulnerabilities and risks



GNSS: What can go wrong and what are the risks?

- <u>Reduced service availability</u> GNSS vulnerabilities and risks related to utilisation and environment for satellite positioning
- Natural cuases
- Artificial causes

Source: c2h2.ifa.hawaii.edu



Source: Wikimedia



GNSS: What can go wrong and what are the risks?

Space weather and ionospheric disturbances



Source: Lucent Technologies

- Artifical causes of reduced GNSS service availability
- Deliberate or unintentional intereference:
 - Jamming
 - Re-broadcasting (*meaconing*)
 - Spoofing
 - EMC issues

- <u>Mitigation GNSS</u>
 <u>vulnerabilities and</u>
 <u>risks</u>
- Growing reliance on GNSS
- Awareness and impact assessment
- Policy response
- Increasing resiliance



- <u>Conclusions</u>
- Satellite navigation technology matured to the level where numerous technology, economic and safety systems comprise it.
- Satellite navigation becomes a component of national infrastructure.
- Technological, business and legal issues are to be resolved in order to allow for continuous sustainable market growth.

GNSS: What can go wrong and what are the risks?

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THANK YOU FOR YOU ATTENTION!

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- APPENDIX: Vulnerabilities by GNSS segments
- Ground and satellite segment
- User segment
- Propagation media segment

- Ground and satellite segment
- Too few satellites
- Incorrect navigation data
- Jump or drift of satellite clock
- Distorted signal waveform
- Service interuption or satellite loss due to space weather effects
- Attack on ground/space segment
- Augmentation and assisting systems

- <u>User segment</u>
- Leap seconds and roll-overs
- System up-grades
- Receiver software bugs
- Multipath

- Propagation media segment
- Slow variation in ionospheric TEC
- Fast variation in ionospheric TEC
- Ionospheric scintillation
- Local patterns of ionospheric dynamics
- Space weather storms
- Deliberate modification of the ionosphere