European Satellite Navigation Systems

EGNOS
European Geostationary Navigation Overlay System
• ESA, EC and Eurocontrol
• accuracy: ca. 1-3m horizontal (2-4m vertical)
• operational since: Oct 1, 2009
• GPS based

GALILEO
European Satellite Navigation System
• EC and ESA
• accuracy: ca. 1m
• developed to become independent of US GPS
• operational since 21.10.2011 (launch)
Space weather effects can strike anywhere

**Infrastructures**
- Satellite sensors
- Power grids

**GNSS Users for positioning**
- Aviation
- Offshore drilling
- Maritime Transport

**GNSS users for precision timing**
- Telecommunications
- Financial Services (?)

Secondary effects need to be considered!
Scintillation effects by Space Weather

- Geostationary Satellite, altitude ca. 30,000 km
- Ionosphere, altitude ca. 80 – 1000 km

Areas of increased electron density due to solar flares

Normal ionospheric signal delay

GPS receiver antennas

Joint Research Centre

Signal-to-noise ratio (dB)

Loss of tracking

Time (sec)
The binding link: GNSS receivers

- Solar Activity
- Satellite
- Maritime
- Air Traffic
- Grid
- Telecommunications
- Others

European Commission
Research Approach

Set up continuous ionospheric scintillation measurements

- JRO – Jicamarca Radio Observatory, Peru

Replay the recorded scintillation effects under laboratory conditions to different GPS receivers

- JRC – European Microwave Signature Laboratory EMSL, Italy
Observation: after-sunset effects

Signal/noise ratio ok
Satellite “visible” on this elevation
Signal collapses / too weak
Satellite behind the horizon

On low satellite position, the signal could be lost in scintillation
Conclusions

Question: “Can we survive a day without Satellite Navigation?”

Answer: “Yes, but it might not be very pleasant!”

What should we work on?

- **Scientific Reports** – the impact of space weather on our technological infrastructures
- Technical **standards** for resilient GNSS receivers
- A better **public understanding** of science
That’s where we will continue ...