A proposal for ionospheric scintillations (area of "Space-based navigation services and users")

- Noticed:
  - a strong influence of the ionospheric scintillations on radio-propagation signals (very large range of human activities)
  - Along the geomagnetic equator after the sunset (but not only)
  - a few knowledge of the effects

- The GPS/GLONASS permanent network is an opportunity for a global near real-time observation system
**Industrial GPS applications : Offshore survey**

- Fugro Dutch holding company

**Oil exploration disturbances report:**

/ Several hours of complete drop-outs of the GPS L2/L1 phase signals (Angola, Brazil…)

/ INMARSAT disturbances for the differential correction distribution directly to the GPS antenna

**Requirement:**

/ Real time information of the scintillations for operation management, prediction model

---

**Industrial GPS applications : Airplane navigation**

**Point in for airports final approach:**

/ in French Overseas Territories and Africa

**Requirement:**

/ Rate of navigation errors and outages

/ Alert message (Notice to Airman)

---

**GPS applications : Space-based mission analysis**

**Requirement:**

/ Link budget and power attenuation at L-band

(up to 20 db for space to Earth GPS link, a few db at LEO orbit)

/ ESA-ATV - Automated Transfer Vehicle on ISS – Final docking to ISS is with GPS automatic guidance. ISS is at the altitude of maximum ionisation

**Condition : C/No ratio available**

---

**“Eroding GPS Worries Pentagon”**

(Aviation Week & Space Technology Nov 4, 2002)

+ “The health of the Global Positioning System satellite constellation is rapidly eroding… More than half the GPS satellites in orbit are no longer fully operational”

+ Any GPS positioning/navigation application with operational or geodetic performance constraints may also be concerned
Other industrial GPS applications

/ GPS equipment: technology development, qualification

/ H.F. Telecommunication:
Defense, aircraft passengers communication by email and telephone...

Science: observations, monitoring, studies

- A worldwide and continuous scintillations data base
- Monitoring (geographical distribution, dynamics...)
- Main events investigation: solar flares, earthquakes
- [TEC calculations]

Science: calibration

- Ionospheric scintillation monitors
  (high repetition rate receivers at least 1 sec)
- External comparisons:
  - SuperDARN radars
  - DORIS (400 MHz, worldwide network of 50 permanent stations)
  - Global Ionospheric Maps from the CODE/AIUB (Center for Orbit Determination in Europe)

Scintillation Space Weather Service (1/6)

Some ESA AO requirements: quasi-real time, operational context, user criteria and evaluation, public part and web interface, final cost-benefit elements

Data (2)        Processing (5)

Public service (4)  Dedicated services (4)

Calibration (5)            Prototype, evaluation and market development (6)

Potential developments (6)
ESA Workshop: Space Weather Applications Pilot Project 16-18/12/2002 ESTEC, Noordwijk, The Netherlands

**Scintillation Space Weather Service (2/6) : Data**

- **IGS permanent network**
- **1 hour stations**
- **3 sec rate**

Continuous GPS/GLONASS signals provided by:
- the IGS International GPS Service Data centers
- the Brazilian Network (RBMC/IBGE)
- Space Agencies

Data from campaigns provided by partners of the proposal

**Scintillation Space Weather Service (3/6) : Processing**

To be specified according to the user need, but basically:
- L2-L1 signal tracking drop-outs
- Rms phase fluctuations to determine a scintillation level parameter
- Incident signal power attenuation
- Data base and outputs

As secondary products:
- TEC and GDOP

**Scintillation Space Weather Service (4/6) : Public & commercial**

- **Public service**
  - Scintillations global maps:
    - 1 hour refreshment
    - Day/night activity
  - Web interface including general and technical presentation
  - A prototype available Jan. 2004

- **Dedicated services**
  - Specific graphs (maps, histograms...) and statistics parameters: period, site, satellite, receiver type
  - Specific analysis:
    - Data from a receiver in orbit
    - Regional monitoring, alarms
    - Occurrence characterization (versus local time, geomagnetic location, solar and geomagnetic activities)

**Scintillation Space Weather Service (5/6): scintillation index calibration**

High repetition rate receivers (at least 1 Hz) processing:
- to derive the scintillation indexes (S4 and Sf)
- to validate the scintillation level parameter

**Kourou**
- a strategic site
- along the geomagnetic equator
- a GPS Ashtech-ZXII3 as part of the GSTB Galileo System Test Bed (ESA/ESOC)
- an EGNOS Ranging and Integrity Monitoring Station
Scintillation Space Weather Service (6/6) : prototype and perspectives

Prototype, evaluation and market development

Potential developments

2005-2007

/ Pre-operational service in real conditions (ex: solar cycle max)
/ Evaluation of products, cost/benefits study
/ Promotion
/ Implementation of commercial applications
/ Processing of old data
/ Tests of prediction models
/ Application to other data (altimeters...)

ESL Collecte Localisation Satellites

as the main contractor, in charge of the Service development and operations

PARTNERSHIP

Fugro
AIUB Astronomical Institute of the University of Berne
ENST Ecole Nationale Supérieure des Télécommunications
DGAC Direction Générale de l’Aviation Civile
CNES Centre National d’Etudes Spatiales
LPCE Laboratoire de physique Chimie de l’Environnement
Rockwell Collins

as users and experts

Work Breakdown Structure

000 Project Management

CLS led

100 User needs

2 working groups:

Industrial applications led by F. Boucquaert (Fugro)
Scientific applications led by C. Hamou (LPCE)

200 Technical Specifications

CLS led

300 Service Development

CLS led

400 Service Prototype

CLS led

500 Monitor Experiment

Led by P. Lasnouere-Duchene (ENST)

600 User Service Evaluation

Fugro and LPCE led

700 Future Development

CLS led

Planning

<table>
<thead>
<tr>
<th>Task</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kick-off Meeting</td>
<td>1/1/06</td>
<td>1/1/06</td>
<td>1/1/06</td>
</tr>
<tr>
<td>WP 000 Management</td>
<td>1/1/06</td>
<td>1/1/06</td>
<td>1/1/06</td>
</tr>
<tr>
<td>WP 100 User Needs</td>
<td>1/1/06</td>
<td>1/1/06</td>
<td>1/1/06</td>
</tr>
<tr>
<td>WP 200 Tech. Specifications</td>
<td>1/1/06</td>
<td>1/1/06</td>
<td>1/1/06</td>
</tr>
<tr>
<td>Deliv. of WP 100 and WP200 Reports</td>
<td>1/1/06</td>
<td>1/1/06</td>
<td>1/1/06</td>
</tr>
<tr>
<td>Progress Meeting 1</td>
<td>1/1/06</td>
<td>1/1/06</td>
<td>1/1/06</td>
</tr>
<tr>
<td>Progress Meeting 2</td>
<td>1/1/06</td>
<td>1/1/06</td>
<td>1/1/06</td>
</tr>
<tr>
<td>WP 300 Service Development</td>
<td>1/1/06</td>
<td>1/1/06</td>
<td>1/1/06</td>
</tr>
<tr>
<td>Progress Meeting 3</td>
<td>1/1/06</td>
<td>1/1/06</td>
<td>1/1/06</td>
</tr>
<tr>
<td>Delivery of Service Prototype</td>
<td>1/1/06</td>
<td>1/1/06</td>
<td>1/1/06</td>
</tr>
<tr>
<td>Progress Meeting 4</td>
<td>1/1/06</td>
<td>1/1/06</td>
<td>1/1/06</td>
</tr>
<tr>
<td>WP 400 Service Prototype</td>
<td>1/1/06</td>
<td>1/1/06</td>
<td>1/1/06</td>
</tr>
<tr>
<td>Progress Meeting 5</td>
<td>1/1/06</td>
<td>1/1/06</td>
<td>1/1/06</td>
</tr>
<tr>
<td>WP 500 Monitor Experiment</td>
<td>1/1/06</td>
<td>1/1/06</td>
<td>1/1/06</td>
</tr>
<tr>
<td>Delivery of WP 500 Report</td>
<td>1/1/06</td>
<td>1/1/06</td>
<td>1/1/06</td>
</tr>
<tr>
<td>Progress Meeting 6</td>
<td>1/1/06</td>
<td>1/1/06</td>
<td>1/1/06</td>
</tr>
<tr>
<td>WP 600 Service User Evaluation</td>
<td>1/1/06</td>
<td>1/1/06</td>
<td>1/1/06</td>
</tr>
<tr>
<td>Progress Meeting 7</td>
<td>1/1/06</td>
<td>1/1/06</td>
<td>1/1/06</td>
</tr>
<tr>
<td>Delivery of WP 400 and WP 600 Reports</td>
<td>1/1/06</td>
<td>1/1/06</td>
<td>1/1/06</td>
</tr>
<tr>
<td>Final Meeting</td>
<td>1/1/06</td>
<td>1/1/06</td>
<td>1/1/06</td>
</tr>
</tbody>
</table>
CLS and Space Weather

- CLS is a CNES subsidiary
  Operations of more than 10 satellites for data collection, ground location, altimetry over the oceans (instruments: ARGOS, DORIS, TOPEX/POSEIDON, ...)

- CLS Space Weather activities:
  • Service provider: solar and geomagnetic activity prediction (A. Blusson)
  • R & T: Laboratoire d'Aéroéonome/CNRS, Ecole Polytechnique de Paris
  • Expert supports (LPG Laboratoire de Planétologie de Grenoble, CETP Centre d'Etude des Environnements Terrestres et Planétaires)
  • Member of ISES and ESA/SWWT
  • Associated to the EASE Network of Excellence (EU FP6)