

“Quickmaps and history of the effects of ionospheric scintillations on GPS/GLONASS signals”

A proposal to ESA Pilot Project for Space Weather Applications

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Space Weather Applications Pilot Project

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Summary

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- + Applications and Users
 - GPS applications and Telecommunication
 - Science
- + Scintillation Space Weather Service
- + Organisation and partnership
- + Work Breakdown Structure
- + Planning
- + CLS and Space Weather

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Introduction

*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

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Applications

- + **Industry** : GPS applications and Telecommunications
 - GPS offshore survey
 - Airplane navigation
 - Space-based mission analysis
 - Other applications
- + **Science**
 - Observation and Monitoring
 - Studies
 - Calibration

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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

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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)

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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

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“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

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Other industrial GPS applications



**Rockwell
Collins**

/ GPS equipment : technology development, qualification

/ H.F. Telecommunication:
Defense, aircraft passengers communication by e-mail and telephone ...

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Science : observations, monitoring, studies

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



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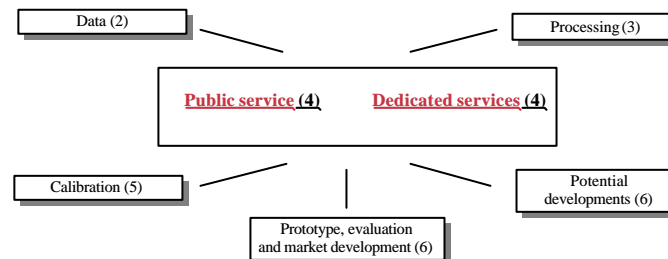
Science : calibration

- + 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)

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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



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Scintillation Space Weather Service (2/6) : Data



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

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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

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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)

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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 σ_f)

/ to validate the scintillation level parameter

/ **Kourou**: a strategic sites 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

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Scintillation Space Weather Service (6/6) : prototype and perspectives

Prototype, evaluation and market development

Potential developments

2005-2007

/ Pre-operational service in real conditions

/ Evaluation of products, cost/benefits study

/ Promotion

/ Implementation of commercial applications

/ Processing of old data (ex: solar cycle max)

/ Tests of prediction models

/ Application to other data (altimeters...)

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Organisation and partnership



CLS 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



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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. Hanuise (LPCE)
200 Technical Specifications	— CLS led
300 Service Development	— CLS led
400 Service Prototype	— CLS led
500 Monitor Experiment	— Led by P. Lassudrie-Duchesne (ENST)
600 User Service Evaluation	— Fugro and LPCE led
700 Future Development	— CLS led

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Planning

N°	Task	2003				2004				2005		
		T3	T4	T1	T2	T3	T4	T1	T2	T3		
1	Kick-off Meeting											
2	WP 000 Management											
3	WP 100 User Needs											
4	WP 200 Tech. Specifications											
5	Deliver of WP 100 and WP200 Reports											
6	Progress Meeting 1											
7	WP 300 Service Development											
8	Progress Meeting 2											
9	Progress Meeting 3											
10	Delivery of Service Prototype											
11	Delivery of WP 300 Report											
12	Progress Meeting 4											
13	WP 400 Service Prototype											
14	Progress Meeting 5											
15	WP 500 Monitor Experiment											
16	Delivery of WP 500 Report											
17	Progress Meeting 6											
18	WP 600 Service User Evaluation											
19	Progress Meeting 7											
20	Delivery of WP 400 and WP 600 Reports											
21	Final Meeting											

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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'Aéronomie/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)

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