

**Annex 3
to Doc.WGCEM/1/00**



COST

COST Action 296

Mitigation of Ionospheric Effects on Radio Systems (MIERS)

PROGRESS REPORT

Period: from February 2005 to May 2006

This Report is prepared by the Management Committee of the Action and presented to the relevant Technical Committee or directly to the Committee of Senior Officials.

The report is a "cumulative" report, i.e. it is updated annually and covers the period beginning from the start date of the Action.

CONTENTS**1. OVERVIEW: Action Identification Data****COST Action 296 Title: Mitigation of Ionospheric Effects on Radio Systems (MIERS)**

TC Recommendation: 13 October 2004
CSO Approval: 1 December 2004

First MC meeting: 4 February 2005
Last MC meeting: 27-29 April 2006

Start date: 20 January 2005
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Final Report:
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Number of signatories: 17

Signatories and date of signature:

Austria 27 April 2005	Greece 22 January 2005	Poland 20 January 2005
Belgium 20 January 2005	Hungary 20 January 2005	Portugal 21 January 2005
Bulgaria 20 January 2005	Iceland	Romania 22 January 2005
Croatia	Ireland	Slovakia
Cyprus 20 May 2005	Italy 22 January 2005	Slovenia
Czech Rep. 10 February 2005	Latvia	Spain 20 January 2005
Denmak	Lithuania	Sweden
Estonia	Luxembourg	Switzerland
Finland 03 March 2005	Malta	Turkey 28 September 2005
France 03 March 2005	Netherlands	United Kingdom 20 January 2005
Germany 20 January 2005	Norway	

Institutes of non-COST countries:

- 1) *Russian Academy of Sciences (IZMIRAN) (RUSSIA) - in process*
- 2) *University of St Petersburg (RUSSIA) - in process*
- 3) *University of Massachusetts Lowell (USA) - in process*
- 4) *Polar Research Institute of China (CHINA) - in process*

Area: TIST, telecommunication

Action Web site: <http://www.cost296.rl.ac.uk/>

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2. OBJECTIVES

The main objective of the COST 296 Action is to:

- Develop an increased knowledge of the effects imposed by the ionosphere on practical radio systems, and for the development and implementation of techniques to mitigate the deleterious effects of the ionosphere on such systems.

Further objectives of the Action are to:

- Support and enhance the existing European facilities for historical and real-time ionospheric data collection accessible to all.
- Exchange information on methods and algorithms to mitigate the effects of ionospheric perturbations and variations on advanced terrestrial and space-based communication services by creating an effective computing infrastructure.
- Develop an integrated approach to ionospheric modelling.
- Create the mechanism needed to ingest measured parameters into models, extend and develop suitable mitigation models and define the protocols needed to link models together.
- Make applicable results available to the ITU-R and to promote the research aspects to funding agencies such as ESA, ESF, eContent and FP 6/7.
- Many aspects of this Action are relevant to the future European Space Programme (ESP), and a specific aim is to elaborate inputs for the preparation of this programme.
- Strengthen the existing areas of expertise by stimulating closer cooperation between scientists and users.
- Focus the scope of all the previous COST ionospheric related studies to the mitigation of ionospheric effects on specific radio systems that are in operational use or in the development stage.

3. TECHNICAL DESCRIPTION AND IMPLEMENTATION

The research programme is defined under three topic headings, as follows:

Ionospheric monitoring and modelling

- Near-Earth space plasma monitoring by vertical incidence and oblique sounding networks and GNSS techniques (retrospective and real-time).
- Data ingestion and assimilation into ionospheric models, including data collection and processing, and the adaptation of models to enable data ingestion and assimilation.
- Near Earth space plasma modelling and forecasting including mitigation of ionospheric perturbations, tomographic imaging for model validation and channel modelling techniques.
- Climate of the upper atmosphere including long-term ionospheric trends, gravity and planetary wave effects on propagation and ionospheric space weather.

Advanced terrestrial systems

- Radar and radiolocation, including ionospheric effects on surface-wave radar and radiolocation systems, frequency management of ground-wave and sky-wave radars and angle of arrival measurements for sky-wave signals.
- HF/MF communications including digital radio systems, wideband propagation modelling and development of a hardware simulator, increased capacity of HF links through MIMO techniques (experimental measurements and simulation) and extension of existing wideband HF simulators to the MF band.
- Spectrum management, including the use of GPS to improve HF communications management, adaptive waveform management and the effects of infrasound on radio propagation.

Space-based systems

- Ionospheric effects on space-based remote sensing systems, gravity wave effects on GNSS, space plasma media and security implications.
- Special mitigation techniques with emphasis on ionospheric structures, their physical nature and impact on GNSS signals, improved accuracy of GNSS by better ionospheric correction and errors due to ionospheric perturbations.
- Scintillation monitoring and modelling with emphasis on scintillation effects, their physical nature and impact on ionospheric radio systems (GNSS signals in particular), high-latitude and equatorial scintillation effects (experimental work and modelling).

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University of Leeds, United Kingdom
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Middle East Technical University, Ankara, Turkey

4.3 Meetings of the Management Committee

4 February 2005, Brussels, Belgium
30 and 31 May – 1 June 2005, Trieste, Italy
13 and 16 November 2005, Noordwijk, Netherlands
27-29 April 2006, Neustrelitz, Germany

4.4 Meetings of the Working Groups

27 April 2005, Vienna, Austria, Meeting of the WG Leaders
4 – 5 July 2005, Seminar on ITU-R issues, Graz, Austria
3 April 2006, Vienna, Austria, Meeting of the WG Leaders

4.5 Short-term scientific missions

Murat Ozgur from METU (Turkey) to Leicester University (UK)
Andrei Krankowsky from Poland to Spain

Vincenzo Romano from INGV (Italy) to University of Rennes (France)
 Daniel Kouba from IAP (Cz Rep.) to NOA (Greece)

5. RESULTS

During the first few months of COST296 Action two meetings have taken place. The inaugural meeting with 31 participants was held in Brussels on 4 February 2005. Dr. Afonso Ferreira, COST Office, gave a brief orientation on the COST mechanism presenting the general framework created to promote the scientific and technical co-operation in Europe. Relevant information can be found on the COST-website at <http://cost.cordis.lu>. The participants were informed about COST and the current situation in general and the COST Actions in the field of Telecommunication. The Scientific Officer informed the delegates about the principles and procedures related to the COST Actions and about the possibilities of getting activities funded from the COST budget. Dr. Cander gave a brief presentation on the implementation of the COST296 and a lively discussion followed. Workplan for the period 5 February to 30 June 2005 has been approved by MC as follows:

- To define terms of reference for each WP in the Action and associated team members;
- To introduce participants from non-COST countries and organisations in the Action;
- To set up the COST296 website;
- To select the COST296 logo;
- To prepare the joint Workshop with the COST 724 Action before the end of 2005;
- To establish collaboration with other relevant COST Actions.
- To present the different national and international conferences.

The work of the Action started with formulating specific terms of reference that clearly define the goals and distinguish between the Work Package (WP) activities and these will be refined and approved during the second Management Committee meeting to be held at The Abdus Salam International Centre for Theoretical Physics in Trieste from 30 May to 1 June 2005. One day meetings of the Working Group Leaders held in Vienna during the General Assembly of European Geophysical Union (EGU) on 27 April 2005 helped to co-ordinate the work, to focus it and to establish collaborative studies with COST724 Action.

In order to give some publicity early on, a paper was presented at EGU 2005 on the work of the project (Zolesi and Cander, 2005). Subsequently some papers were presented at the European Conference Propagation & Systems (Cander et al., 2005a), the USA Space Weather Week (Cander et al., 2005b), the USA Ionospheric Effects Symposium (Warrington, 2005) and the International reference Ionosphere annual meeting (Zolesi et al., 2005).

At the EGU 2006 in Vienna, 2 April 2006, a session related to COST296 was organized. The main purpose of the Symposium was to present new information on ionospheric measurements and advanced measuring techniques, on measurement

evaluation, interpretation, dissemination and archiving, on development of methods of ionospheric predictions, forecasting and nowcasting (4 solicited presentations, 9 oral presentations, 15 poster presentations).

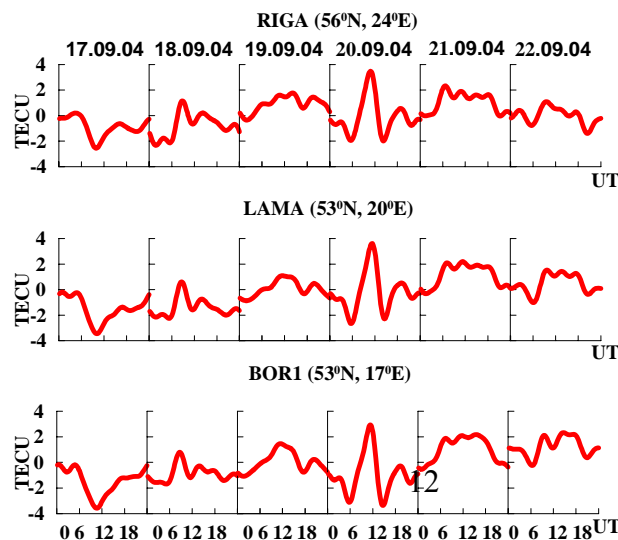
The number of non – COST institutions continues to increase as well as a number of young scientists that have been including as WP Co – Leaders in all WGs.

WG 1 - Ionospheric monitoring and modelling

- The COST Prompt Ionospheric Database at RAL, UK (<http://www.ukssdc.ac.uk/promptdatabase.html>) continues to receive, catalogue and archive auto-scaled data on a real time basis from 10 European ionospheric sounders, namely Athens, Chilton, Dourbes, El Arenosillo, Juliusruh, Lycksele, Pruhonice, Rome, Tortosa, and Tromsø. The ionospheric radio occultation measurements onboard satellite CHAMP provided automatically retrieved electron density profiles, which can be downloaded via new DLR service SWACI (<http://www.kn.nz.dlr.de/swaci/>). Within SWACI, several nowcast and forecast products were developed: Total Electron Content (TEC) maps, spatial and temporal TEC gradient maps, etc., and recently the 3-D reconstruction of the electron density distribution in the ionosphere and plasmasphere (CHAMP data).
- RAL has continued to run and improve the Space Weather Web Facilities for Radio Communications Users at <http://ionosphere.rcru.rl.ac.uk/> based on the contributions of COST296 institutions. This 24/7 on-line service includes interactive forecast maps of foF2, MUF(3000)F2 and ITU-R NeQuick modelled TEC over Europe based on ionosonde measurements, near real-time dynamic system for monitoring ionospheric propagation conditions, near real-time TEC maps and 24 hours single station plots based on TEC, near real-time solar-terrestrial and ionospheric indices and warning messages, and archive. RWC Warsaw provides at <http://cbk.waw.pl/rwc> and also at <ftp://www.cbk.waw.pl/idce/> ionospheric characteristics actual and from the previous 2 months, and 24 hours ahead forecast for European, Asian and Japanese regions at maps and some ionospheric stations, and solar and geomagnetic activity information; other ionospheric/telecommunication information at <http://www.cbk.waw.pl/cost296>.
- Results of joint measurements of the digisonde DPS-4 and Doppler system at Pruhonice were compared. Under stormy conditions or presence of a well-developed sporadic E layer, a significant disagreement between both measurements exists. During geomagnetically quiet days, absence of sporadic E, and for high quality ionograms and correct scaling, the automatically calculated ionosonde electron density profiles are reliable. A comparison of electron density profiles derived from ionograms using methods POLAN and NHPC (algorithm applied routinely by digisondes) shows that the reflection heights computed by NHPC are higher for nighttime profiles, however, with larger standard mean deviations. That computed by POLAN are higher at daytime, and the standard mean deviations are smaller.

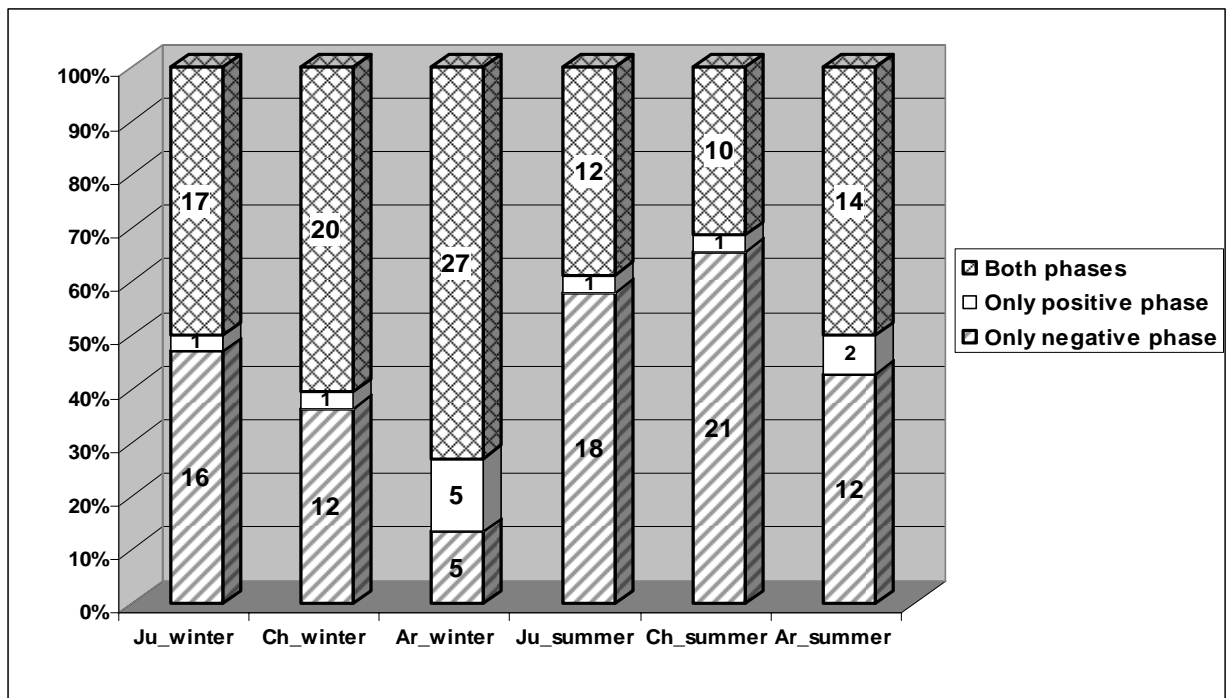
- The comparison of the IRI 2001 model reconstruction of the ionospheric ionization under quiet and disturbed conditions and an analysis of the effectiveness of the IRI 2001-predicted N(h)-profile updating with real-time measurements show that the IRI model calculations agree worst with observations during daytime hours at heights 200-400 km under disturbed conditions. This has been confirmed by comparing radio propagation parameters generated by a 2D ray tracing software abcray03 with those predicted by IRI 2001 and NeQuick models. The Ebro team (Spain) with Czech team developed a Local Climatological Model for ionospheric bottomside parameters. The model improves IRI 2001 prediction by a factor of two.
- The operational version of the Polish instantaneous ionospheric 3D mapping model of electron concentration has successfully been tested.
- The neurofuzzy techniques have been applied to model and predict foF2. The method has been tested under quiet and moderate geomagnetic conditions providing foF2 forecasts (1-24 hours in advance) with relative mean deviation between 5-11%.
- 3D gradient effects on transionospheric paths (such as from GPS) have been determined by ray-tracing through a realistic 3D IRI ionosphere with altitude dependent latitudinal and longitudinal gradients. Determination of the correlation distance in the presence of ionospheric irregularities was made for spaced antennas on multipath HF links with implications for design of SIMO and MIMO systems.
- Model assisted ionosphere electron density reconstruction methods, based on Vertical or Slant TEC data ingestion into NeQuick model have been developed and tested. The results clearly indicate the effectiveness of the ingestion techniques to improve model performances. A new topside formulation has been proposed for the NeQuick model.
- The evolution of diurnal variations of TEC four days before and one day after a Baltic region earthquake is presented on Figure 1. The anomalous behavior of diurnal TEC variations is clearly seen on 20 September 2004 over all observed stations. Such behavior of TEC was not observed 10 days before and 10 days after the earthquake.

Figure 1: Δ TEC over RIGA, LAMA and BOR1 stations, 17-22 September 2004.



- The daily, seasonal and long-term patterns of the standard deviation $\sigma(h)$ of the electron density profiles $N(h)$ recorded above Ebro station shows that the larger variability occurs during night-time and is stronger at the base of the F -region. Typical values of variability at altitudes of the electron density maximum are 10–20%, whereas they reach 50% during nighttime at the base of the F -region.
- The Matlab codes for fast detection of the acoustic-gravity wave pulses have been developed and successfully tested on the 1-minute sounding campaigns and applied on the data of the solar eclipse 3 October 2005.
- F2-layer disturbances not related to geomagnetic activity (Q-disturbances) are both positive and negative. Their amplitudes are comparable to moderate ionospheric storm effects. Positive disturbances are more numerous than negative ones at all latitudes and at any level of solar activity. Both types are more numerous (twice) during solar minimum. Both types of disturbances are most frequent in the evening and night-early-morning LT sectors and they are rare during daytime.
- In Europe the presence of both phases of ionospheric response to geomagnetic storm is common, more frequent in winter and at lower latitudes. Only negative phase is more frequent in summer. Only positive storm phase appears rarely, more at lower latitudes.

Figure 2 - occurrence of negative and positive phases during geomagnetic storm main phase above three European stations Juliusruh, Chilton (high mid-latitudes) and El Arenosillo (low mid-latitudes) for winter and summer half of the year for the period 1995-2005, 65 strong-to-severe geomagnetic storms.



WG 2 - Advanced terrestrial systems

WP2.1 - Radar and radiolocation

1. Angle of arrival measurements for sky-wave signals

Measurements campaigns have been carried out. While the use of a heterogeneous antenna array is tied to the antennas responses, we are investigating some solutions to verify or to correct these responses. Since an electromagnetic calibration is difficult to achieve, a passive method to estimate some discrepancies between models and measurements is applied to our different arrays. Estimated angles of arrival, in the particular case of an incoming carrier of an AM broadcast transmitter, allow comparison of the amplitudes and phases of received signals to those expected by the theoretical responses.

2. Propagation effects that influence radar and radiolocation systems

The northerly ionosphere is a dynamic propagation medium that causes HF signals reflected from this region to exhibit delay and Doppler shifts and spreads which significantly exceed those observed over mid-latitude paths. Since the ionosphere is not perfectly horizontally stratified, the signals associated with each propagation mode may arrive at the receiver over a range of angles in both azimuth and elevation. Such large directional spreads may have severe impact on radio systems employing multi-element antenna arrays and associated signal processing techniques. In order to better understand the directional characteristics of HF signals reflected from the northerly ionosphere, prolonged measurements have recently been made over two paths: (a) from Svalbard to Kiruna, Sweden, and (b) from Kirkenes, Norway to Kiruna. Consideration has been given to modelling the propagation effects in the form of a channel simulator suitable for the testing of new equipment and processing algorithms. This work has now been reported in *Radio Science* [Warrington *et al*, 2006].

3. Real time HF raytracing through a tilted ionosphere

High frequency (HF) direction finding (DF) systems measure the angles of arrival of signals at selected frequencies. With this information, raytracing can accurately determine the location of the HF transmitters if the 3-D electron density (N_e) distribution between the DF site and the transmitters is known. A collocated digisonde at the DF site measures the vertical electron density profile and the local ionospheric tilt providing, in real time, the inputs for the construction of the 3-D N_e distribution. The vertical profile is automatically obtained from the ARTIST-scaled ionogram, and the local tilt from the skymaps recorded after each ionogram. Raytracing through simulated tilts shows that the differences in ground distances for one hop high frequency (HF) propagation vary from about 1 km to 100 km depending on the assumed tilts and distances. Operational tests for distances up to approximately 100 km have demonstrated good results in determining the transmitter location in real time.

4. Inversion of HF radar backscatter ionograms

A backscatter elevation ionogram is the result of one elevation-scan backscatter sounding. Figure 1 presents a backscatter ionogram recorded by the NOSTRADAMUS radar.

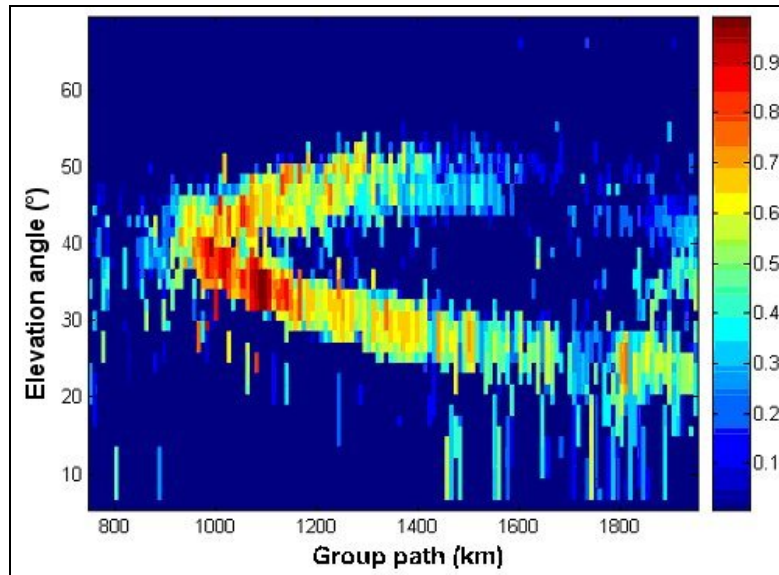


Figure 1 : Elevation-scan backscatter ionogram.

The objective of the work is to recover the parameters of the model parameters using several points of the measured elevation ionogram (ONERA, France).

WP 2.2 - HF/MF communications

1. Wideband propagation modelling and development of a hardware simulator

An IDL GUI (XIPPT) has been developed to demonstrate the use of EDAM predictions. XIPPT provides an interface to QinetiQ's Integrated Propagation Prediction Tool (IPPT) and allows a user to access IPPT's propagation models (Figure 1). Furthermore XIPPT embodies a scheduler that will download EDAM output from an FTP server at set times and call IPPT to perform propagation predictions. IPPT itself has been modified to detect and use the EDAM output if it is present in the IPPT working directory. The aim of this software is to be sufficiently flexible that it can provide a realistic test of the EDAM output, and to be reasonably close to how an operational tool may look, whilst remaining simple enough to demonstrate and place with potential users without extensive training.

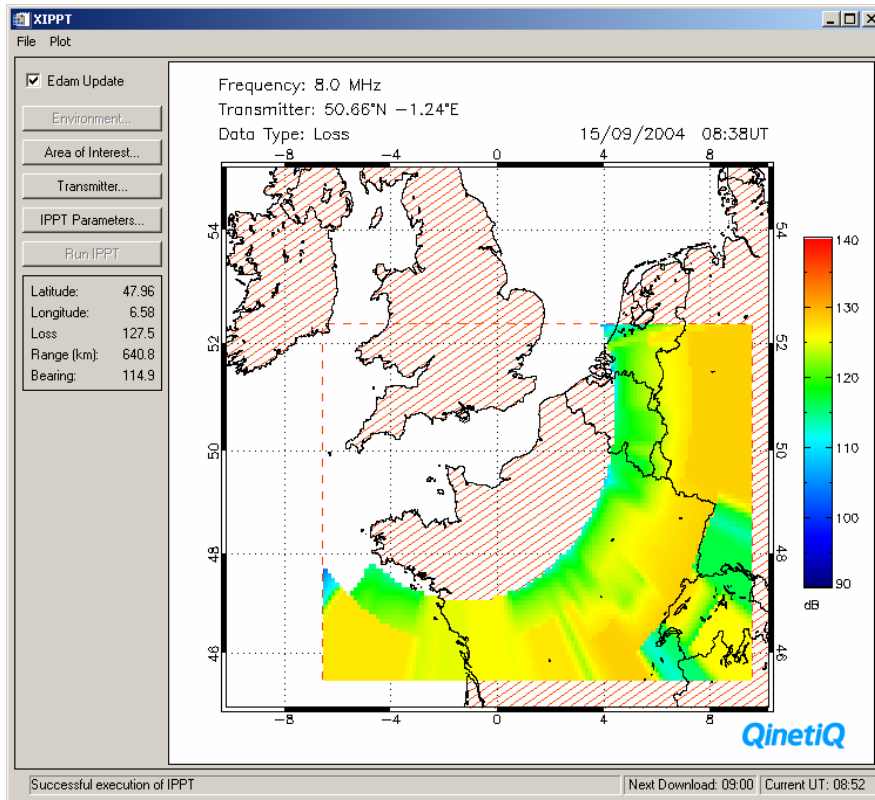


Figure 1: Screenshot of XIPPT showing an HF loss prediction using EDAM output.

The Tactical Enhanced Muf Prediction for the Local Area (TEMPLAR) has also been developed. The tool is based on EDAM and exploits a single GPS receiver to provide a local area (up to 700 km) now-cast of the maximum usable frequency for HF communications operators. Results indicate that the TEMPLAR MUF estimates are susceptible to bias caused by variations in the ionospheric slab thickness (UK).

2. High data transfer rate system of radio communications through the ionospheric channel

A digital transmission has been established through the ionospheric channel, operating between Rennes (France) and El Arenosillo (south of Spain). The waveform was a QAM16 modulation with a symbol rate of 7500 bauds (30 kbits/s data rate) and a maximum power of 700 W.

The heterogeneous array used at the reception used the space and antenna diversity.

The multi channel processing associates the following functions:

- a blind spatio temporal equalization resorting to the combination between the CMA (constant modulus algorithm) and the LMS (Least Mean Square) algorithm
- a carrier recovery, separated from the equalization, containing a second order loop filter
- a symbol timing recovery based on a Gardner detector

Finally, a real time demonstrator has been set up using a DSP board.
(France and Spain)

3. HF MIMO

An application for funding to undertake an experimental investigation into the feasibility of MIMO techniques within the HF band has been successful in UK. Two research assistants will be appointed in the next two or three months and the team will

then be in a position to start work on the technical aspects.

4. Comparison of observations and predictions for HF propagation over northerly paths

Observations of the direction of arrival and signal strength have been compared with VOACAP predictions for four paths, two roughly tangential to the mid-latitude trough, one trans-auroral, and one located within the polar cap. The presence of off great-circle propagation was a common feature of the propagation on all of these paths, although the exact behaviour was different for each path. The principal findings concern paths affected by the mid-latitude Trough, trans auroral path and polar cap path (UK).

5. Gravity and planetary wave and infrasound effects on propagation

Phenomena which could deteriorate HF communications have been pointed out. Specifically, with the Doppler type system, S-shaped phenomena were observed and rapid linear shape changes, both on Doppler shift spectrograms at time scales of tens of seconds (spectral range of infrasound) (Czech Republic).

6. Extension of existing wideband HF simulators to the MF band

Further development of the general techniques to account for the effects of strong fluctuations of the field amplitude in the problem of HF propagation in the fluctuating ionospheric reflection channel have been performed (University of St. Petersburg, Russia).

WP2.3 - Spectrum management

1. Occupancy determination of HF band for the East Mediterranean conducted using calibrated HF spectrum measurements and HF receiver array

Two teams from Cyprus focused their work focused on the occupancy of the HF Spectrum over Northern Europe in cooperation with the Victoria University of Manchester (UMIST). They are also making the development of an online occupancy prediction and plotting software, and made publications of their work.

Teams from ODTU, TUBITAK, ASELSAN and the Univ. of Leicester report that HF propagation measurements have been performed during the 29 March total solar eclipse in Africa (Turkey and UK).

2. Measurements During the 29 March 2006 Total Eclipse Week

The whole HF band ranging from 1 to 30 MHz has been swept using 10 kHz peak and 200 Hz average detectors of a certified EMI receiver (HP-8542E) equipped with a calibrated active monopole antenna (HE-011). Figure 1 shows the atmospheric noise variation almost at the time the total solar eclipse. The results indicate that during the total eclipse the noise level exhibited different pattern. Qualitatively, “the eclipse” values are somehow representing the characteristic behaviour of the night-time.

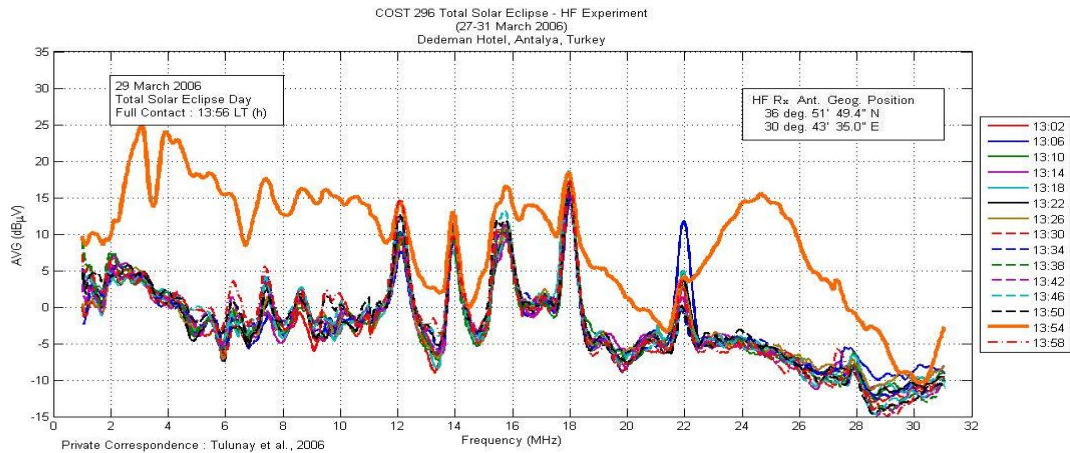


Figure 1. The atmospheric noise level on the time of the total eclipse

3. Supporting research and application in antenna systems to increase their efficiency and mitigate the propagation errors

Research work in the antenna systems was performed. It was also made research work in developing new techniques to analyse the radiation path in propagation channel, and it was made publications (Portugal).

WG 3 Space based systems

WP 3.1 Space plasma effects

Space plasma effects have been investigated according to the terms of reference by several groups in Europe which have reported their activity at the EGU General Assembly 2006 in Vienna.

The German Aerospace Center (DLR) established an operational space-plasma and space-weather monitoring service within the comprehensive project SWACI - Space Weather Applications Center Ionosphere (<http://www.kn.nz.dlr.de/swaci>) (Jakowski et al., 2005). One of the key issues to be addressed in this project is the GNSS reference Network Model Integrity (NMI) under perturbed ionosphere/space weather conditions. The work in this direction was first focused on the assessment of the space weather impact on GNSS-based positioning and NMI in particular (Stankov et al., 2005). The next step will be to properly index the space weather impact (Jakowski et al., 2005) with the aim of eventually predict the network integrity.

Interesting changes of the ionospheric drifts were observed at Průhonice observatory during several periods of a suddenly enhanced solar and geomagnetic activity (2004 – 2005 year). The analyse of the ionospheric drifts, measured during disturbed conditions, shows, that vertical drift velocity reaches, from typical value 50 m/s for quiet conditions, up to - 60 m/s and -250 m/s during disturbed conditions. The variations in horizontal components are a result of increasing of TID activity during storm. Investigations of ionospheric effects of infrasound continued – a solicited paper was presented at the EGU Assembly, Vienna, April 2006.

WP 3.2 Mitigation techniques

1. Basic mitigation techniques which are based on:

a) separate models

b) operational measurements for real-time corrections

At the end of September 2005 DLR has established the new ionosphere data service SWACI funded by the state government Mecklenburg-Vorpommern which substitutes the ESA co-funded Space weather pilot project SWIPPA. The service provides near-real-time ionospheric information derived from ground and space based GPS measurements: near real time vertical TEC and TEC gradient (temporal and spatial) maps with an update rate of 5 minutes suitable for error mitigation. Research work is focused on improving temporal and spatial resolution of the TEC maps and on developing forecast tools (DLR).

2. Mitigation techniques for specific GNSS applications

a) GNSS radio occultation

Development of special mitigation techniques in the frame of GNSS radio occultation experiments (figure 1) aiming at retrieving neutral atmosphere parameters. In the frame of such applications, it is particularly important to be able to separate ionosphere and neutral atmosphere effects on the signals. In April 2006, six satellites of the Taiwan/US COSMIC constellation have been successfully launched. The ESA satellite MetOp will follow end of June. All these satellites are equipped with high quality radio occultation receivers. These measurements will form a rich basis for error studies with focus on the influence of higher-order ionospheric errors and the development of mitigation techniques (University of Graz).

b) GNSS reference networks

Assessment of the feasibility to use existing ionosphere models or near real time TEC maps in order to mitigate the ionosphere error in mobile GNSS applications. On the one hand, the models used in this study are IRI2001, NeQuick and Klobuchar. On the other hand, up to now, IGS and EUREF data were processed to produce real-time corrections. (Finnish Meteorological Institute)

c) triple frequency methods (Galileo, modernized GPS)

Study aiming at using the third frequency which will be available with Galileo and with modernized GPS for a better mitigation of ionospheric effects on precise positioning, in particular, for a more efficient ambiguity resolution using TCAR method. Different combinations of the 3 frequencies (based on simulated data) are being tested in order to be able to solve ambiguities in real-time using undifferenced observations i.e. only one station is used (Royal Observatory of Belgium).

3. Higher order ionospheric influences in dual frequency systems with emphasis on long-term applications.

Research work is being performed at DLR in order to estimate higher order refraction effects in GNSS systems (DLR)

4. Capabilities and remaining weakness of mitigation techniques for GNSS under quiet and perturbed ionospheric conditions

Studies in order to assess the effects of disturbed ionospheric conditions (geomagnetic and ionospheric storms, scintillations, Travelling Ionospheric Disturbances) on the accuracy of GNSS applications:

- assessment of the effect of TID's on high accuracy real time positioning techniques like the so-called Real Time Kinematic technique : origin of TID's and of their impact in terms of local TEC variability; their effects in the different steps of the data processing algorithms, in particular on ambiguity resolution. It has been demonstrated that strong TIDs can affect ambiguity resolution even on distances as short as 4 km (Royal Observatory of Belgium and the Geophysical Institute of the Bulgarian Academy of Science).
- assessment of the effects of scintillations on high accuracy positioning : data quality (data losses), ambiguity resolution, correlation between scintillation index, data quality and positioning error in order to develop new mitigation techniques. In particular, during the last few months, the impact of scintillations on ambiguity resolution on short baselines has been investigated (IESSG Nottingham, Royal Observatory of Belgium).

WP 3.3 Scintillation Monitoring and Modelling

1. Climatology of irregularities and scintillations under different helio-geophysical conditions from scintillation modelling

After the formulation of a scintillation model based on in situ plasma density data from the DE-2 satellite, some properties of irregularities and scintillation under different helio-geophysical conditions have been investigated. Simulations performed for all the DE-2 passes between 1981 and 1983 that allow covering large area of the globe with scintillation 'measurements' have been used to produce maps of scintillation parameters. Such maps have been sorted in dependence on season, magnetic local time, Kp magnetic index and according to two different latitudinal sectors (invariant latitude between 50° and 70° and invariant latitude greater than 70°). All these information will be crucial for a later use in the prediction of scintillation activity at a given satellite-receiver link. First (preliminary) tests on GPS scintillations data are in progress.

2. GPS scintillation monitoring in the frame of ISACCO (Ionospheric Scintillation Arctic Coordinated Campaign Observations) project

In the frame of the GPS scintillation and TEC monitoring, efforts have been addressed on maintaining the polar station where two GISTM (GPS Ionospheric Scintillation and TEC Monitor) receivers are located at Ny Alesund (79.9N, 11.9E, Svalbard, Norway) under ISACCO (Ionospheric Scintillation Arctic Coordinated Campaign Observations) project managed by INGV. Remote access facility to both data and instruments has been developed and construction of data base is in progress. Last January another GISTM receiver has been installed at the Italian Antarctic Station "Mario Zucchelli" at Terra Nova Bay.

3. Monitoring of scintillations as solar disturbances and magnetic storms signatures on the ionosphere

After a first analysis of the GISTM data acquired at Ny Alesund to investigate the scintillations as signatures of solar disturbances and magnetic storm during the 30th October 2003 event, a deeper study has been performed to follow the ionospheric plasma movement over Europe. In particular, using the observations from a network of GPS receivers deployed by the Bath University (UK) and by IESSG University of Nottingham (UK), similar to the INGV receiver, the investigations has revealed a pattern of irregularity movement coherent with tomographic reconstruction (MIDAS), polar cap ionospheric potential simulation (Weimer model) and SuperDARN

observations.

4. Wavelet analysis of ionospheric scintillation

Since radio scintillation induced by ionospheric irregularities is typically a non-stationary phenomenon, often characterized by sudden impulsive events localized in time, involving several time scales, a study of it based on wavelet analysis has been started. It has been shown that the observation of wavelet energy plots of the scintillating radio signals is a powerful way of localising the most intense events and of resolving their short time structure. A characterisation of the wavelet coefficient statistics of time intervals before, during and after a scintillation event has been initiated, so to draw a relationship between the imminence of burst events and the wavelet statistics of the time interval right before. Last but not least, comparisons are under study between the scalogram of scintillation on a satellite-to-ground radio link and the same plot for the ionization density measured in situ of a region compatible with the radio link.

5. Scintillation monitoring over China

GPS network is running to monitor ionospheric scintillation under the support of NSFC (National natural Science Foundation of China) in low-latitude region of China, which operates at UHF and L bands. A databank has been set up for scintillation data and TEC data management at CRIRP

In the past half year, most of the ionospheric scintillation monitor in the network at Chinese low latitude area has been connected to the internet and ionospheric scintillation data can be transferred to the data center in realtime. Empirical model for nowcast and forecast methods are being tested by the realtime data. Three ISMs has been set in Haikou to receive data of UHF band. Data can also be used to analyze the velocity of ionospheric irregularities.

6. Italy-China scientific and technological co-operation project

Within the framework of the Agreement on Scientific and Technological Co-operation between the People's Republic of China and the Italian Republic, the Ministry of Science and Technology (MOST) of China and the Ministry of Foreign Affairs of Italy in January 2006 approved the project: "**Warning and forecasting methodology in ionospheric scintillation for communication systems**". The activity will take place during three years (2006-2008).

7. DLR activities regarding the investigation of ionospheric scintillations

At present DLR operates two 50Hz JAVAD receiver for the investigation of ionospheric scintillation effects on GNSS in the auroral and equatorial regions. The receivers are located at: Kiruna; Sweden (20.41°E, 67.84°N), Bandung; Indonesia (107.6°E, -6.9°N). DLR has developed and implemented a processor to automatically analyze the 50Hz JAVAD data from these receivers and to retrieve a geo-referenced database of: S4, σ -Phase, dTEC/sec. Since November 2005 the data are processed on a continuous base with a delay of 1 day. The routinely processing of Bandung data are currently at an experimental stage, but data from December 2005 to February 2006 are available at DLR and are currently analyzed. One of the major current aims is, to identify unambiguous scintillation events that can be used i.e. for spectral and amplitude- and phase-scintillation correlation analysis. Software routines for automatic near real-time spectral analysis are currently under development.

Prediction of Ionospheric Scintillations – ESA project (DLR, IETR, ENSTB, GMV, CLS, IEAA) In the frame of an ESA project it is intended to perform studies and measurements campaigns. The aims are: to produce scintillations data base, to derive scintillations parameters and to improve GISM model. This project started in

January 2006 and will last two years.

6. DISSEMINATION OF RESULTS

6.1 Publications and Reports

Proceedings of the second European Space Weather Week is available online at ESA/ESTEC <http://www.esa-spaceweather.net/spweather/workshops/workshops.html>
Preparation of a book is in progress.

Selected papers presented at the EGU 2006 will be published in special issues of Journal of Atmospheric and Solar-Terrestrial Physics, 2007 and Acta Geophysica, 2007.

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6.3 Web site

The Web site of the COST296 action is active on the following address:
<http://www.cost296.rl.ac.uk/>

6.4 Scientific and Technical Cooperation

The research links established as part of previous COST 271 Action have continued into the COST 296 Action. In particular, there is a significant participation of Action members in European Space Weather Program (WG1), URSI Commission G, International Geodynamics Service (IGS) and some of its offspring organisations like the GPS-IONO group and most importantly close collaboration with COST724 Action.

6.5 Transfer of results

None.

7. ECONOMIC DIMENSION

Cost per signatory per year:

4 person/year: Engineer, Researcher	420.000€
- person/year: Technician	-
1.5 person/year: PhD, Student, Secretary	50.000€
Equipment and material costs	-
Travel	10.000€
Total per signatory per year	480.000€

COST Annual Grant Contract to CCLRC Rutherford Appleton Laboratory from 1 July 2004 to 30 June 2005 = 26.000 €.

COST Annual Grant Contract to CCLRC Rutherford Appleton Laboratory from 1 July 2005 to 30 June 2006 = 72.500 €.

8. SELF EVALUATION (only in the last annual progress report)