COST 296 Action: **M**itigation of **I**onospheric **E**ffects on **R**adio **S**ystems (MIERS)

Approved Minutes of the 7th Management Committee Meeting
10-14 July 2007
Hotel Globus, Prague, Czech Republic

1. Welcome

AB (COST 296 Chairperson) welcomed all participants (Annex II – List of attendees) and thanked JL for hosting this meeting, everyone for coming and wished us all a good meeting and an enjoyable joint IRI Workshop.

2. Approval of the Agenda

The Draft Agenda for the meeting was approved see ANNEX I

3. Adoption of the Minutes of the sixth MC meeting

The minutes of the sixth MC meeting held at INGV, Rome, Italy were approved.

4. Official status of the COST 296 Action by 10 July 2007

AB reported that there are 18 signed countries with Croatia intending to sign and 7 signatories from non-COST countries. The Department of the Air Force, AFRL, USA is considering joining COST 296 but there is a question about the military use of the results to be resolved.

5. Report on the ARM Budapest meeting

AB gave a 15 minute presentation, and was congratulated by our reporter, Pr Luis Manuel Correia for the presentation and for the largely improved progress report. Was questioned about the participation of non-COST institutions as in some cases the added value for COST is not so obvious.

Pr Correia also mentioned that the COST296 web site needed some improvement. A task force led by Prof Radicella has been set up to look into how the COST296 web site can be improved (see point 18).

An important recommendation we mentioned that in collaborative papers COST296 must be acknowledged otherwise the paper is not considered as resulting as part of the COST collaboration.

6. **COST296 Budget 1 July 2007 to 30 June 2008**

AB reported that unfortunately there is no COST Budget (Annex III Proposed budget) yet arranged for this period as the contract has not been signed between the European Commission and the ESF. The best case scenario is that there will be news by the end of September regarding the budget, the probability of the contract being signed is high but not 100%. As a consequence the reimbursement for this meeting will be much delayed.

7. **Collaboration with COST724**

BZ reported that a list of the ionospheric models developed during the last COST Actions as been established and transmitted to COST724.

8. **COST activities related to IHY**

LC reported that the calendar initiative has reached a conclusion with drawings from 3 children from each participating country being chosen as part of the 2007/2008 IHY Calendar, each child and an accompanying adult will be invited to attend a grand launch on 20 September 2007 at INGV, Rome. Travel funding for this event will be covered by each participating countries own administration, INGV will provide accommodation and local transportation.

9. **Workshop on Scintillations**

VR outlined a proposed Ionospheric Scintillation Workshop that could be held either at INGV Italy or the University of Nottingham, UK in February 2008. More details will be circulated by the local organiser(s) in due course. This Workshop is also dependent on the ESF budget being granted to COST296

10. **Short Term Scientific Missions (STSMs) on the budget (July 06-June 07)**

Six STSM took place during the COST296 2006/07 financial year: Ioanna Tsagouri from NOA, Greece visited IAP, Prague in February 2007; Zeynep Kocabas from METU, Turkey and David Gunashekar from Liecester University both visited University of Rennes, France during April 2007; Zbysek Nuchutny from IAP, Prague visited Sodankyla Geophysical Observatory, Finland in March 2007; Mainul Hoque from DLR, Germany visited Leeds University in March 2007; and Dimitis Fotiadis from Thessaloniki University, Greece visited IAP, Prague in April 2007. Reports from all STSM were presented during the MC meeting.

11. **Receipt and adoption of the progress reports of Working Group Leaders**

WG 1: Ionospheric monitoring and modelling (ANNEX IV)
WG 2: Advanced terrestrial systems (ANNEX V)
WG 3: Space based systems (ANNEX VI)

12. **Collaboration with Action IC0603 on Antennas**

AC gave a presentation on his activities with Action IC0603 on Antennas and asked permission to attend, with COST296 financial support, the next MC of this action. This request was granted with a fixed financial reimbursement of 1000€.

13. **Short Term Scientific Missions (STSM) Proposals from WG Leaders for next budget period**

All Working Groups proposed STSM and presented written proposals all STSM are dependent on how much ESF grant is for the next financial period. Working Groups 2 and 3 had no written proposals but plan to discuss and present something at the next MC meeting.

14. **Next meetings of the COST296 Action**

LE and HH – our Cyprus colleagues offered to host the next COST296 meeting in March 2008.
Turkish MCM members asked that the following letter be included in these minutes:

ORTA DOĞU TEKNİK ÜNİVERSİTESİ (ODTÜ)
MIDDLE EAST TECHNICAL UNIVERSITY (METU)
06531 Ankara, TURKEY

ELEKTRİK VE ELEKTRONİK MÜHENDİSLİĞİ BÖLÜMÜ
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

Prof. Dr. Alain Bourdillon
IETR - Université de Rennes1
Bât 11D, Campus de Beaulieu
35042 Rennes Cedex
France
e-mail: alain.bourdillon@univ-rennes1.fr
tel (33) 2 23 23 56 21
fax (33) 2 23 23 56 47

Dear Alain,

As I promised in Prague, I am sending the statements I made concerning the place of the next MCM in written form:

COST 296 7th MCM, Prague, 14 July 2007

Ersin Tulunay's comments orally expressed during the 7th MCM to be put into the minutes:

1.We do not have any negative feeling against the people of Southern Cyprus.
2.As you see, we are in very good collaboration with Harris and Lefteris.
3.Cyprus is an area under dispute as we stated during 6th MCM in Rome as well.
4.COST 296 Administration consulted the issue by Brussels.
5.Therefore, we have had to consult Turkish Ministry of Foreign Affairs and an official reply was received.
6.Southern Cyprus claims sovereignty over Northern Cyprus. It does not have right to do this.
7.As a result, Southern Cyprus puts unusual and unacceptable restrictions on the Turkish subjects.
8.It must be realized that this is not a problem of Yurdanur Tulunay and Ersin Tulunay. National representatives of a "COST country" are not being allowed to enter Southern Cyprus.
9.This fact must be considered seriously by the COST 296 MCM.

Please consider the above statements exactly made orally by Ersin Tulunay during 7th MCM to be put into the Minutes of the 7th MCM.

Thank you. Best regards,

Prof. Dr. Ersin Tulunay

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Middle East Technical University,
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BZ also proposed that in 2008 COST296 should organise a special meeting to celebrate 20 years of participation in a COST Action. Further discussions at the next MC meeting.

15. International meetings relevant for the COST296 Action

There are several international meetings relating to COST296 activities:

CAWES Campaign, Canada, August 2007
Series of Schools in L'Aquila Italy, March 2006-Fall 2008
EUCAP 2007, Edinburgh, UK, 11-16 November 2007
IUGG Perugia – Poster session in Cattacombs.
URSI GA 2008, Chicago, USA
EGU 2008, Vienna
IES: Ionospheric Effects Symposium: 13-15 May 2008, Washington DC.

16. ITU-R

Question asked by Peter Bradley: What should the IRI and COST296 now be doing in foF2 mapping?

Establish a Joint Steering Group? …………..Yes

17. Discussion on FP7

ESF Research Networking Programmes - 2007 Call for Proposals
The ESF is pleased to announce a Call for Proposals for new Research Networking Programmes. OPEN Deadline: 30 October 2007; 16.00hrs CET
Introduction
An ESF Research Networking Programme is a networking activity bringing together nationally funded research activities for four to five years, to address a major scientific issue or a science-driven topic of research infrastructure, at the European level with the aim of advancing the frontiers of science.
Key objectives include:
creating interdisciplinary fora;
sharing knowledge and expertise;
developing new techniques;
training young scientists.
A successful Programme proposal must show high scientific quality and also demonstrate added value by being carried out at a European level rather than by individual research groups at the national level.
Proposals may be submitted in any or across several of the following broad scientific fields:
Earth and Environmental
Physical and Engineering Sciences
Science driven issues of Research Infrastructures in any of the above fields

18. COST296 web site

A task force to improve the COST296 web site was formed lead by SR.

19. **Any other business……….**There was no other business.

ANNEX I

Seventh Management Committee meeting of the COST 296 Action

Mitigation of Ionospheric Effects on Radio Systems (MIERS)

Hotel Globus, Prague, Czech Republic
10 - 14 July, 2007

Approved Agenda

1. Welcome
2. Approval of the Agenda
3. Adoption of the Minutes of the sixth MC meeting
4. Official status of the COST296 Action
5. Report on the Budapest meeting
6. Status of COST296 Budget from 1 July 2007 to 30 June 2008.
7. Collaboration between COST296 and COST724
8. COST296 Activities related to the IHY
9. Workshop on ionospheric scintillations, measurements and modelling
10. Short Term Scientific Missions (STSMs). Report on those already done
11. Receipt and adoption of the progress reports of Working Group Leaders
    - Report on WG1
    - Report on WG2
    - Report on WG3
    - General Discussion
12. Collaboration with Action IC 0603 on antennas
13. Short Term Scientific Missions (STSM). Proposals of WG leaders for the new budget period
14. Next meetings of the COST296 Action
15. International meetings relevant for the COST296 Action
16. ITU-R Activities
17. Anything new in FP7?
18. Task force for our Web site
19. Any other business

Alain Bourdillon

ANNEX II

COST 296 Action MC meeting 10-14 July 2007
List of Attendees

J Azevedo	(JA) University of Madeira, Madeira, Partugal **(NR)**
P Benzce	(PB) Hungarian Academy of Sciences, Sopron, Hungary **(NR)**
Y Beniguel	(YB) IEEA, France **(NR)**
B Bidiane	(BB) Royal Meteorological Institute of Belgium, Belgium
I Blanco	(IB) INTA, El Arenosillo, Spain **(NR)**
A Bourdillon	(AB) University Rennes 1, France **(Chairman, NR)**
J Boška	(JBO) Academy of Sciences of Czech Republic, Prague, Czech Republic **(NR)**
P Bradley	(PAB) Invited expert, Slough, UK
D Buresova	(DB) Academy of Sciences of Czech Republic, Prague, Czech Republic
Lj R Cander	(LC) Rutherford Appleton Laboratory, Chilton, Didcot, UK
A Casimiro	(AC) University of Algarve, Faro, Portugal **(NR)**
H Haralambous	(HH) Fredrick Institute of Technology, Nicosia, Cyprus **(NR)**
N Jakowski	(NJ) DLR/DFD, Neustrelitz, Germany **(Co-Leader WG-3, NR)**
S S Kouris	(SK) Aristotelian University of Thessaloniki, Thessaloniki, Greece **(NR)**
I Kutiev	(IK) Bulgarian Academy of Sciences, Sofia, Bulgaria **(NR)**
J Laštovička	(JL) Academy of Sciences of Czech Republic, Prague, Czech Republic **(Co-Leader WG-1, NR)**
J-P Luntama	(J-PL) Finnish Meteorological Institute, Helsinki, Finland **(NR)**
C Mayer	(CM) DLR/DFD, Neustrelitz, Germany
A Mikhailov	(AM)
B A de la Morena	(BM) INTA, El Arenosillo, Spain **(NR)**
B Nava	(BN) Abdus Salam ICTP, Trieste, Italy
L Perrone	(LP) INGV, Rome, Italy
S Radicella	(SR) Abdus Salam ICTP, Trieste, Italy
B Reinisch	(BR) ULM, Lowell, Massachussetts, USA
V Romano	(VR) Istituto Nazionale di Geofisica e Vulcanologia, Rome, Italy **(NR)**
H Rothkaehl	(HR) Space Research Centre, Warsaw, Poland **(NR)**
P Sauli	(PS) Academy of Sciences of Czech Republic, Prague, Czech Republic
H Strangeways	(HS) University of Leeds, Leeds, UK **(NR)**
I Stanislawska	(IS) Space Research Centre, Warsaw, Poland **(Co-Leader WG-1, NR)**
E Tulunay	(ET) The Middle East Technical University, Ankara, Turkey **(Co-Leader WG-2, NR)**
A Vernon	(AV) Rutherford Appleton Laboratory, Chilton, Didcot, UK **(COST296 Secretary)**
R Warnant	(RW) Royal Meteorological Institute of Belgium, Belgium **(Co-Leader WG-3, NR)**
EM Warrington	(MW) University of Leicester, Leicester, UK **(Co-Leader WG-2, NR)**
N Zernov	(NZ) St Petersburg University, St Petersburg, Russia
B Zolesi	(BZ) Istituto Nazionale di Geofisica e Vulcanologia, Rome, Italy **(Vice-Chairman, NR)**

NR: National Representative

ANNEX III

COST ACTION 296

PROPOSED BUDGET FOR THE PERIOD JULY 1ST 2007 TO JUNE 30TH 2008

(1)	TRAVEL COSTS	€ 84.000
(2)	TRAVEL COSTS FOR 2 PARTICIPANTS OF COST NEAR NEIGHBOURS (Russia)	€ 2.000
(3)	WORKSHOP ORGANISATION SUPPORT	€ 7.000
(4)	SHORT-TERM SCIENTIFIC MISSIONS	€ 10.000
(5)	TRAINING SCHOOLS	€ 0
(6)	PUBLICATIONS	€ 1.000
(7)	SECRETARIAT	€ 7.500
(8)	IHY Calendar initiative	€ 5.000
(9)	**TOTAL**	**€ 116.500**

ANNEX IV

Working Group 1 - Ionospheric monitoring and modelling
Report March – June 2007

Jan Laštovička (CZ) and Iwona Stanisławska (PL)

Working Group 1 - Ionospheric monitoring and modelling

WP1.1 Near Earth space plasma monitoring
Leader: D. Altadill (ES)

WP1.2 Data ingestion and assimilation in ionospheric models
Leaders: D. Burešova (CZ) and B. Nava (I)

WP1.3 Near Earth space plasma modelling and forecasting *Leaders: I. Kutiev (BG) and H. Strangeways (UK)*

WP1.4 Climate of the upper atmosphere
Leaders: J. Bremer (D) and E. Turunen (FIN)

WP1.1 Near Earth space plasma monitoring

Terms of reference:

1. **developing monitoring techniques and parameters describing the state of the ionospheric plasma, to include ground-based and space based techniques,**
2. **maintaining and extending the flow of real-time and retrospective ionospheric monitoring data to databases,**
3. **validating the quality and consistency of monitoring data, particularly those collected in real time,**
4. **supporting and developing INTERNET sites and protocols for disseminating data products.**

Specification of work and results (Related to ToR 1)

The UMLCAR has provided the program settings for Digisondes for a Specific campaign of precise measurements of virtual height of the E-layer (h'(f)). The campaign is actually running under the COST296/IHY initiatives. The software to obtain the h'(f) from the High Doppler resolution mode measurements performed by the Digisondes have been prepared by researchers from the UMLCAR and URL.

Specification of work and results (Related to ToR 2)
Ionosondes of the COST296 network continue contributing with real-time VI data to WDC for STP, Chilton (RAL), DIDBase (UMLCAR), and DIAS (NOA) databases.

The UMLCAR continued to archive in DIDBase all digisonde data available in real time via Internet, these include the European COST296 stations.

Specification of work and results (Related to ToR 3)

The revised VI ionograms of Ebro (URL) and El Arenosillo (INTA) stations and its deduced profiles and ionospheric characteristics are available in graphical form at their respective Web sites (http://www.obsebre.es/php/ionosfera.php, revised data; and http://www.inta.es/iono/) and in digital form on request. Their revised data, as well as the automatic data, are sent to the several Ionospheric Databades. El Arenosillo (INTA) maintains its TEC and profiles databases.

The UMLCAR archives all edited ionogram data together with the autoscaled values in DIDBase. The edited data files include the name of the scaler, and the DIDBase user can select the files with the "most trusted" editor. UMLCAR encourages all other digisonde users that perform hand-scaling routinely or for special campaigns to archive the edited data in DIDBase (DIDBase manager: Grigori_khmyrov@uml.edu).

Specification of work and results (Related to ToR 4)

The COST Prompt Ionospheric Database at RAL (http://www.ukssdc.ac.uk/prompt_ database.html) continues to receive, catalogue and archive auto-scaled data on a real time basis from ionospheric sounders across Europe. The full set of contributing instruments now numbers 10 in Europe, at Athens, Chilton, Dourbes, El Arenosillo, Juliusruh, Lycksele, Pruhonice, Rome, Tortosa, and Tromso.

The Ionospheric Weather page at IZMIRAN website (http://www.izmiran.ru/ionosphere /weather) is maintained as described in the Electronic Bulletin for News on the Solar-Terrestrial Physics (http://www.izmiran.rssi.ru/magnetism/ELNEWS/index.htm; in Russian). A technique is proposed for reducing the foF2 critical frequency by the function of the solar zenith angle (Altadil et al., 2006) which improves correlation between the data of different stations and the inter-seasonal correlations at a given location. This technique allows increasing the number of stations data at the Ionospheric Weather web page of IZMIRAN to 26 locations, including some stations at low and high latitudes in both North and South Hemispheres (Blanch et al., 2006).

The Web services of the Ionospheric Dispatch Centre in Europe (SRC) provide on line access to data base of the critical frequency of F2 ionospheric layer and M(3000)F2 forecast for all available sites (RWC-Warsaw/IDCE http://www.cbk.waw.pl/rwc/idce, and ftp://www.cbk. waw.pl/idce). Ionosonde data are available from 1983 up to last measurements from all over the world in IIWG format. Daily plots for 30 stations from all over the world are presented along with their digital version. 24-hours ahead forecast for every station in digital and graphical form is supplied also. The GPS measurements from Warsaw station are available. Continuous now-casting of regional ionospheric conditions over Europe, East Asia and Australia area and catalogues of the quiet and disturbed days and of ionospheric disturbed periods with duration of three hours or longer are compiled and presented for European stations (these catalogues are available at the IZMIRAN Web site also). Finally, the Web sites of Cost296 related topics are available on the web navigator (http://rwc.cbk.waw. pl/cost296/).

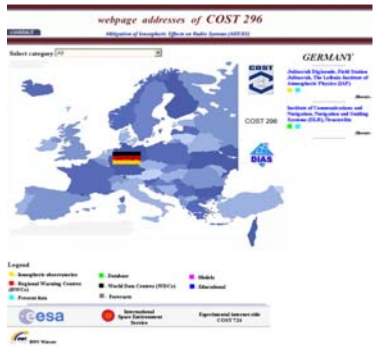


Fig.1. European ionospheric weather related web pages Navigator. Joint action with COST 724
http://www.cbk.waw.pl/cost296/

The INGV continued to carry out the eSWua project which is based on measurements performed by all the instruments installed by upper atmosphere group of INGV. A hardware-software system for a data base (DB) is being standardized for historical and real time observations from different instruments [AP1]. An interactive web site supports a well organized DB aiming to be a powerful tool for scientific and technological community in the field of telecommunications and Space Weather (Altadil et al, 2006). The first two DBs related to the Rome DPS digisonde and the 4 GISTM (GPS Ionospheric Scintillation and TEC Monitor) measurements has been completed concerning population, tests and output procedures. A dynamic web site (www.eswua.ingv.it) has been opened to the community for a real time access to raw and processed data. The COST296 Action (http://www.cost296.rl.ac.uk) offers the possibility to share the expertise of excellence in Europe in order to test the potentialities of the system, which can be, in turn, extended to host other data and scientific tools provided and suggested by the partners of the same Action. The eSWua is contributing to the projects in the frame of international collaborations where the interoperability of the system and effective data access are necessary requirements (Virtual Observatories, www.egy.org, and Interhemispheric Conjugacy Effects in Solar-Terrestrial and Aeronomy Research, ICESTAR, http://www.scar-icestar.org). The eSWua is the outcome of a big effort of manpower, time and funds motivated by the awareness that geoscience has to rely on structured digital data and on appropriate scientific procedures developed ad hoc by experts open and shared among the international community.

The COST296 community is performing a coordinated E Layer Precision Group Heigh Measurement (PGHM) campaign to contribute to the objectives of the Third CAWSES Global Tidal campaign scheduled from 1 June to 14 August 2007. The campaign is based on the advantage of High Doppler resolution mode technique imbedded in the Digisondes which makes able to measure the virtual heights h'(f) of the E-layer with an accuracy of 0.5 km. The European Ionospheric Observatories participating to this initiative are described in Table 1. The PGHM campaign is supported by the University of Massachusetts Lowell (USA) that has provided the PGHM program settings. The PGHM data is being centrally archived in Drift Database at the University of Massachusetts Lowell (USA).

Table 1. Participating European Ionospheric Observatories.

Institution	Station Details	PGHm Status	Sounding times (minutes)	Notes
INGV (Italy)	Roma, DPS-4 (41.8N; 12.5E) RO041. Enrico Zuccheretti (zuccheretti@ingv.it)	Running	10, 25, 40, 55	"Weak" E-trace
IAP (Germany)	Juliusruh, DPS-4 (54.6N; 13.4E) JR055. Jens Mielich (mielich@iap-kborn.de)	Running	0, 15, 30, 45 (4-22UT)	Data delayed
NOA (Greece)	Athens, DPS-4 (38.00N; 023.60E) AT138. Anna Belehaki (belehaki@space.noa.gr)	Running	12, 27, 42, 57	"Weak" E-trace
UFA (Czech Rep.)	Pruhonice, DPS-4 (50.00N; 014.60E) PQ052. Josef Boska (boska@ufa.cas.cz)	Running	12, 27, 42, 57	
RAL (UK)	Chilton, DPS-1 (51.60N; 358.70E) RL052. John Bradford (J.Bradford@rl.ac.uk)	Running	7, 17, 27, 37, 47, 57	Data download
Qinetiq (Norway)	Trosmo, DPS-4 (69.6N; 19.2E) TR169. Paul Cannon (pcannon@qinetiq.com)	Running	12, 27, 42, 57	
URL (Spain)	Ebro, DGS256 (40.8N; 0.5E) EB040.David Altadill (daltadill@obsebre.es)	Stopped, June 27	2, 17, 32, 47*	Noisy E-trace, bad records.
INTA (Spain)	El Arenosilo, DGS256 (37.10 N; 353.27 E) EA036. Iñigo Blanco (blancoai@inta.es)	Running	2, 17, 32, 47*	Noisy E-trace

WP1.2 - Data ingestion and assimilation in ionospheric models

Terms of reference:

1. **Determine additional data products for inclusion in the COST271 Action Space Weather Database to improve support for ionospheric modelling; promote the generation of such products, to include manually corrected ionospheric parameters and N(h) profiles covering the entire European region,**
2. **Promote and coordinate the creation of a suitable set of very high quality experimental data (like TEC and ionospheric parameters) for model validation and data ingestion studies,**
3. **Promote and coordinate the creation of a set of "synthetic" data (produced with a model) for assessment of retrieval techniques,**
4. **Select and validate appropriate models and data ingestion and assimilation techniques,**
5. **Improve/develop real-time or near-real-time electron density reconstruction techniques,**
6. **Identify criteria to be used to validate the data ingestion and assimilation techniques,**
7. **To carry out specific studies on the use of the selected data ingestion techniques in order to improve the models formulation (structure) and applicability under different degrees of disturbance of the ionosphere.**

Specification of work and results (Related to ToR 1)

1. Manually corrected ionograms are sent daily to three different locations via ftp: UMLCAR, INTA web page and WDC 1.
2. Ionograms are manually edited daily. Also, El Arenosillo has started to send the manually edited ionograms into the DIDBase in a monthly base.

3. El Arenosillo is taking part in the E Layer Precision Group Height Measurement (PGHM) campaign to contribute to the objectives of the Third CAWSES Global Tidal campaign scheduled from 1 June to 14 August 2007.
4. El Arenosillo maintains TEC and Profiles databases.
5. El Arenosillo maintains an Ursigram database and daily sends ursigrams to RWC Warsaw (ISES).

   Grupo Ionosfera de la Estación de Sondeos Atmosféricos "El Arenosillo"

Specification of work and results (Related to ToR 4 and 6)

The development of the Electron Density Assimilative Model (EDAM) has been continued. EDAM provides a means to assimilate measurements into a background ionospheric model. The assimilation is based on a weighted, damped least mean squares estimation. This is a form of minimum variance optimal estimation (also referred to as Best Linear Unbiased Estimation, BLUE) that provides an expression for an updated estimation of the state (known as the analysis) that is dependent upon an initial estimate of the state (the background model), and the differences between the background model and the observations. The error covariance matrices of the background model and the observations are also included to control the relative contributions of the background and the observations to the analysis.

The following improvements have been made to EDAM:

1. The primary background model variable has been changed from electron density (e-m-3) to the log of the electron density (log10[e-m-3]). This reduces the dynamic range of the background model and increases the stability of the assimilation.
2. EDAM maintains a rolling six hour store of data from each input GPS station. This is used to reduce noise in the phase levelling process that is used to calculate slant TEC.
3. The noise in on the pseudorange measurements is estimated and used to set the measurement variance.
4. User generated receiver differential code biases can now be included.
5. The code used to generate the background error covariance matrix has been made more efficient.

Centre for RF Propagation and Atmospheric Research, QinetiQ, Malvern, UK.

EDAM testing has been conducted with a global distributed set of vertical ionosonde profiles provided by the US Air Force Research Laboratory. All the ionosonde data has been hand scaled/checked. Example results for September 2006 are shown in Figures 2 and 3 for the ionosonde at Wallops Island. Figure 2 gives the results for foF2, whilst Figure 3 gives the results for M(3000)F2. The overall results for all ionosondes are given in Figures 4 and 5 as a function of magnetic latitude.

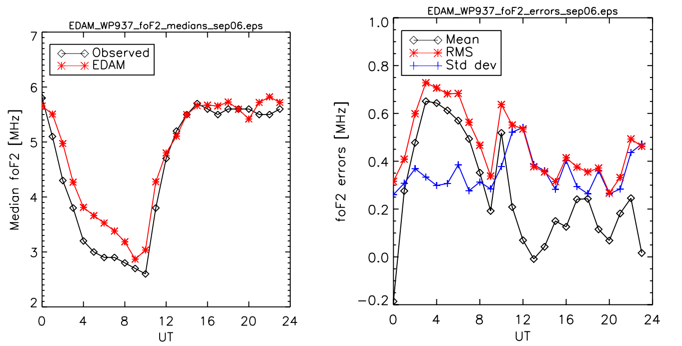


Figure 2. Median values of foF2 and EDAM errors for Wallops WP937.

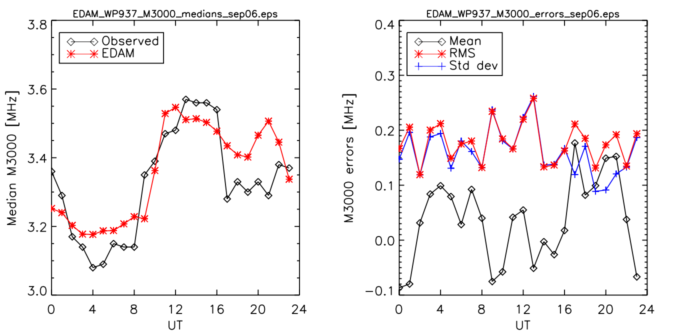


Figure 3. Median values of M(3000)F2 and EDAM errors for Wallops WP937.

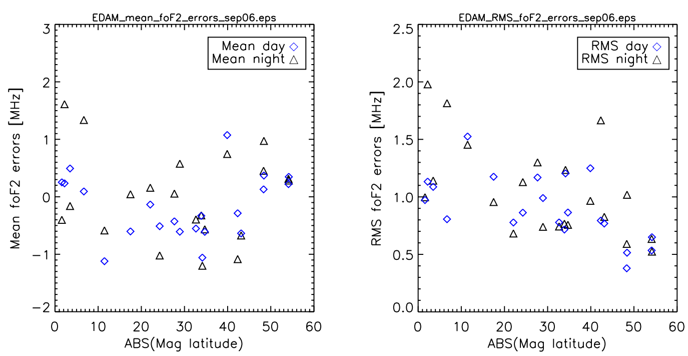


Figure 4. Mean and RMS foF2 errors vs. magnetic latitude.

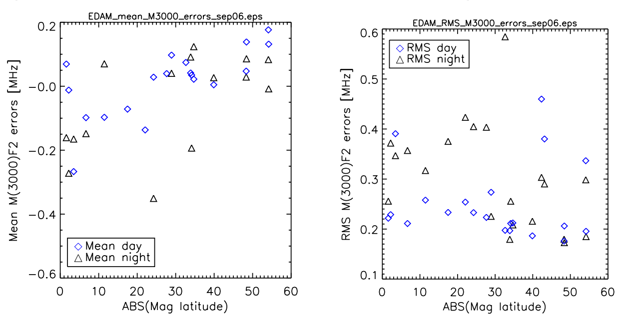
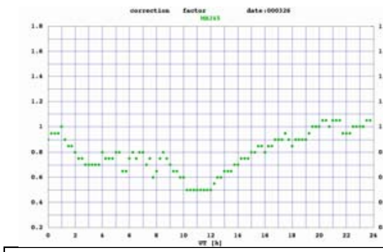
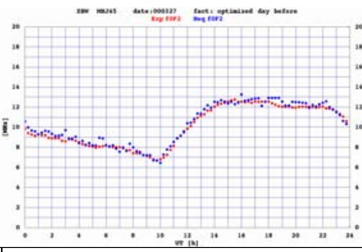


Figure 5. Mean and RMS M(3000)F2 errors vs. magnetic latitude.

Specification of work and results (Related to ToR 4, 5, 6 and 7)

Using NeQuick, a model assisted ionosphere electron density retrieval technique has already been developed. The technique relies on the calculation of the model driving parameter Az (ionization level) for the locations and epochs of interest. The suitable Az values are computed through the model adaptation to GPS derived TEC data. Recently, in order to improve the NeQuick electron density profile formulation, the NeQuick based retrieval technique has been applied using a further adaptation of the model to experimental foF2 data. In particular, data obtained from ionosondes located in the vicinity of the GPS receivers have been used to constrain the model slab thickness and the corresponding profile shape parameters. Some preliminary results concerning the modification of the bottomside F2 layer thickness parameter for a specific location at a given time are shown.





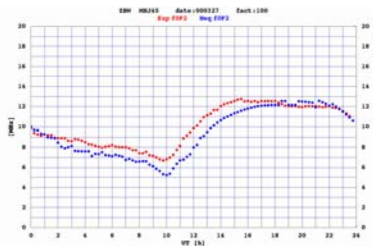


Fig. 6. Best values for the correction factor of the NeQuick bottomside F2 layer thickness parameter at Millstone Hill as a function of UT for the day 26 March 2000.	Fig. 7. Retrieved and experimental foF2 values at Millstone Hill as a function of UT for the day 27 March 2000. The retrieved foF2 values have been obtained using for each epoch the best correction factors of the daythe day before.	Fig. 8. Retrieved and experimental foF2 values at Millstone Hill as a function of UT for the day 27 March 2000. The retrieved foF2 values have been obtained adapting NeQuick to slant TEC only.

Figure 6 shows the values for the correction factor of the NeQuick bottomside F2 layer thickness parameter at Millstone Hill as a function of UT for the day 26 March 2000. These values are computed adapting the model to slant TEC and foF2 values in the area of interest.
Figure 7 indicates the performance of the model when it is adapted to slant TEC only, provided the correction factor of the NeQuick bottomside F2 layer thickness parameter is computed using data of the day before.
Figure 8 indicates the performance of the model when it is adapted to slant TEC only, without any improvement of the model thickness parameter.
Aeronomy and Radiopropagation Laboratory, ICTP, Trieste, Italy

Specification of work and results (Related to ToR 3 and 4, 5 and 7)

- The NeQuick ionosphere electron density model, version 2.0, has been finalized and presented. Major changes have been introduced in the model topside formulation and important modifications have also been introduced in the bottomside description. In addition, specific revisions have been applied to the computer package associated to NeQuick in order to improve its computational efficiency. In addition, specific studies about the thickness of the NeQuick F2 layer bottomside have been performed. The attention has been focused on the model behaviour at low latitudes comparing modeled profiles parameter with the ones extracted from experimental data, mostly related to the African and the Indian sector. Different levels of solar activity, seasons and local times have been considered

- The comparison of calculated *Pc(t)* and experimental *Pe(t)* phase paths for 21 selected days of 2004 allows us to estimate the magnitude of the difference between the values of the phase path obtained by the Digisonde Portable Sounder DPS-4 and the new Doppler type system during the common volume measurements at European midlatitude station Pruhonice. To avoid additional inaccuracy, scaling of all ionograms obtained from DPS-4 was manually corrected. It is also important to note that days of 2004 involved in the analysis were geomagnetically quiet days, except for days 42, 69 and 96, when moderate-to-intense storm conditions took place. The overall average difference between *Pc(t)* and *Pe(t)* is *m*=11.1±1.2 km, standard deviation is 5.0 km. In the best case the average daily difference was about 3 km, which is comparable with the height resolution of the digisonde measurements. The substantial disagreement between *Pc(t)* and *Pe(t)* is obtained in three cases: (1) presence of Es layer, (2) when the sounding frequency is close to the critical frequency of ionospheric layer, and (3) during geomagnetic storms.

Specification of work and results (Related to ToR 5 and 7)

- STORM model implemented into IRI 2001 version has been verified for European region under strong-to-severe geomagnetic storm conditions, which occurred during summer (May –August) and winter (November - February) months. The ionospheric F region response to geomagnetic storms was analyzed to define changes in the state of ionization at the peak of electron density (NmF2). As for the seasonal preference, during storm main phase over European middle latitude only negative phases dominate in summer, while during winter occurrence of both negative and positive phases is more probable. To evaluate the quality of the STORM model output we compared it with observed ionospheric response above at least 4 European middle latitude stations during strong-to-severe winter and summer geomagnetic storms. To perform a detailed comparison between observed and model-generated NmF2 values the correlation coefficient, normalized mean root-square error (RMS error), skewness and a confidence interval are evaluated. The STORM model more effectively captures the negative phases of the summer ionospheric storms, while electron density ehancement during winter storms is reproduced with lower accuracy. Results for 14 selected storms will be presented during IRI/COST 296 meeting in Prague (10-14 July, 2007).

WP1.3 - Near-Earth space plasma modelling and forecasting

Terms of reference

1. **List the available forecasting models and classify them by lead-time: warning, nowcasting and forecasting**
2. **Develop common rules for error estimates and testing procedures**
3. **Develop techniques for real-time forecasting (data adjustment)**
4. **Improve the existing and develop new space plasma models**
5. **Forecasting of foF2 and TEC and unifying geomagnetic drivers**
6. **Modelling and predicting different scale ionospheric perturbations**
7. **Tomographic imaging for model validation**
8. **Channel modeling by neurofuzzy and other novel techniques**
9. **Modelling of irregularities for propagation predictions and from inversion of propagation data**

Specification of work and results (Related to ToR 1 and 6)

- A Catalogue of available ionospheric forecasting models developed in the framework of COST-238, -251, -271 and -296 is composed. The Catalogue contains the model name, a brief description of the method used, the lead-time of forecasting and the Web site, if it is operational.

- Development of a new Latitude-Longitude-Time (LLT) model

An empirical 3-D model is developed for studying middle-scale traveling ionospheric disturbances (MSTIDs). The model is developed in the framework of GALOCAD project "Development of a Galileo Local Component for the nowcasting and forecasting of atmospheric disturbances affecting the integrity of high precision Galileo applications", which aims to perform a detailed study on ionospheric small- and medium-scale structures and to assess the influence of these structures on the reliability of Galileo precise positioning applications. GPS-derived TEC is obtained from the Belgium Dense Network (BDN), consisting of 67 permanent GPS stations. The model, named LLT model, describes temporal variations of TEC in latitude/longitude frame (46º, 52º)N and (–1º, 11º)E. The special variations of TEC are modeled by Tchebishev base functions, while the temporal variations are described by a trigonometric basis. To fit the model to the data, the observed area is divided into bins with (1º x 1º) geographic scale and 6 min on time axis. LLT model is made flexible, with varying number of coefficients along each axis. This allows different degree of smoothing, which is the key element of the present approach. Model runs with higher number of coefficients, capturing in details medium-scale TEC structures are subtracted from those, obtained with smaller number of coefficients; the latter represent the background ionosphere. The residual structures are localized and followed as they travel across the observed area. In this way, the size, velocity, and direction of the irregular structures can be obtained.
I. Kutiev

Neural Network Forecasting, Maps, and Process Identification for modelling and forecasting of ionospheric perturbations

Overview of the METU Models (ToR 2); METU FNN and Genetic Programs Forecasting foF2 Maps (ToR 3); and Identification of Processes by Cascade Modeling Technique (ToR 1 and 4)

Y. Tulunay, E. Tulunay, T. Ciloglu, E.T. Senalp, E. Altuntas, Z. Kocabas, T. Yapici
The METU NN model has proven the power of forecasting the parameters of a non-linear process. Overview of the previous and ongoing METU models has been presented at the 2nd European general assembly of the IHY (ToR 2). The development of the large infrastructures of the future for Exploration and Study of the Heliosphere is a process which will link the retrospective information, knowhow, data, laboratory equipments, facilities, scientists and engineers with the ongoing and future bound dimensions. In this context, the data driven models promise the retrospective, nowcast, forecast of the Near Earth Space nonlinear parameters. This modeling instrument is employed in parallel/or individually to theoretical, experimental, operational, system designing activities (ToR 2).

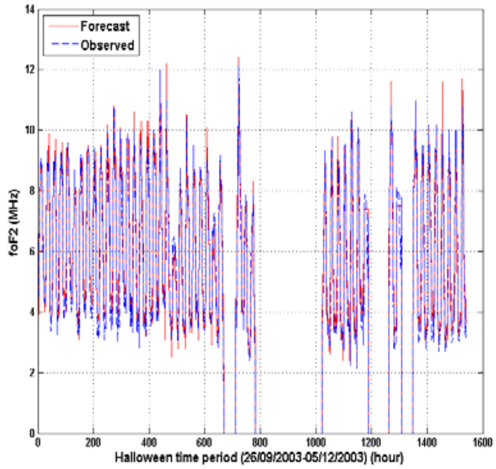


Fig. 9. Superimposed are the observed nd 1-h in advance forecast value of foF2 for Sofia between 26 September and 5 December 2003 (ToR 3).

The forecast foF2 values by METU Fuzzy-Neural Network model (METU-FNN) is presented together with the maps based on such results by Genetic Programming (ToR 3). METU NN and Cascade Modeling (METU-NN-C) technique has been developed for complex nonlinear processes (ToR 1 and 4). METU-FNN approach is employed for forecasting during one of the major storms, Halloween 2003 storm (ToR 3). Since the locations of ionosondes are fixed, there are distinct points for measurement. Several attempts were done for instantaneous mapping foF2. Coupling with Fuzzy NN, a Genetic Programming approach is employed for the generation of a general mapping function for forecast mapping of foF2.

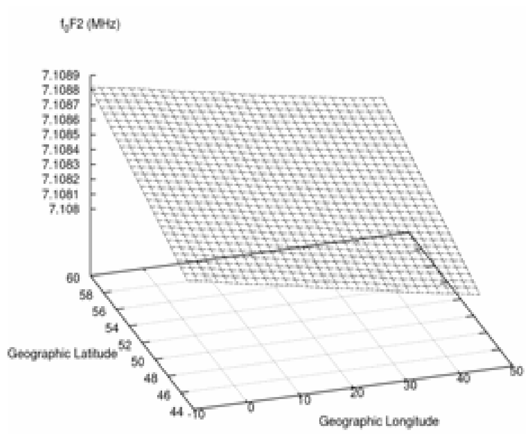
Ionosondes of Sofia, Juliusruh, Chilton, Rostov, Kiruna, and Uppsala are used. Figure 9 gives the observed and 1-h in advance forecast value of foF2 for Sofia between 26 September and 5 December 2003.

An example of the foF2 maps over Europe obtained by Genetic Programming is given in Figure 10.

METU-NN-C technique based on the Hammerstein Model has been employed to estimate nonlinear process parameters (ToR 1). The METU-NN-C Model with Bezier curves in representing nonlinearities are developed and used in forecast operations. In order to compare the one hour in advance TEC forecasts of the METU-NN-C with the TEC outputs of the IRI-2001 Model, a work has been conducted [1]. Figure 11 shows the diurnal variation of the observed Hailsham GPS-TEC values on 18 and 19 April 2002 (ToR 1). Superimposed on this curve are the forecast TEC of the METU-NN-C Model and the TEC output of the IRI-2001 Model. A typical discrepancy between the observed GPS-TEC values and the TEC outputs of the IRI-2001 can be seen in Figure 3 (ToR 1).

In order to further show the generalization capability of the model, identification of a highly nonlinear mechanical processes, a simple forced pendulum and an inverted double pendulum, are chosen as case studies (ToR 4). The nonlinearity is represented by Bezier curves.

METU-NN estimated the upper joint angle at 0.534° average absolute error. However, METU-NN-C estimated the angle at 0.103° average absolute error [4]. In addition, there are some structural advantages in the design and operation of the METU NN-C (ToR 4).



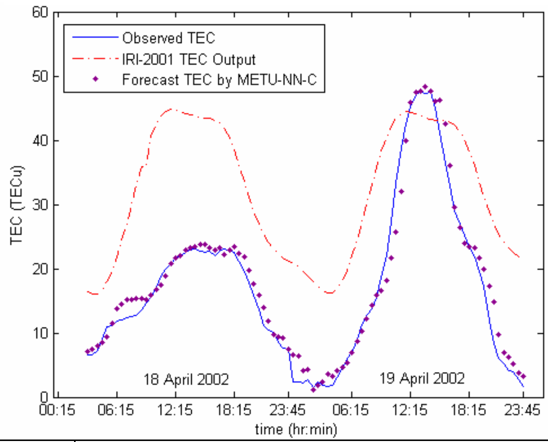


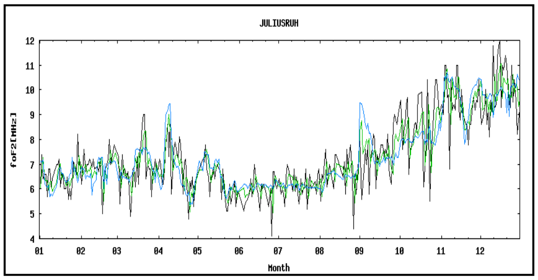
Fig. 10. Map of foF2 values constructed with the outputs of Fuzzy NN model over the geographical coordinates of Europe on 26 September 2003, 10:00 a.m. (ToR 3)	Fig. 11. Observed GPS-TEC values for disturbed solar conditions (solid), IRI-2001 TEC outputs (dash-dotted) and one hour ahead Forecast TEC values by METU-NN-C with Bezier curve nonlinearity representations (large dotted) for the enlarged portion of the time of validation period: 18-19 April 2002 at Hailsham (ToR 1).

Specification of work and results (Related to ToR 6)

A local ionospheric model for forecasting the critical frequency of the F2 layer during disturbed geomagnetic and ionospheric conditions. An ionospheric forecasting empirical local model over Rome (IFELMOR) to predict the state of the critical frequency of the F2 layer (foF2) during strong geomagnetic storms and disturbed ionospheric conditions has been developed as a part of the prediction and retrospective ionospheric modeling over a given area.
Hourly measurements of foF2 obtained at the Rome observatory, hourly quiet-time values of foF2 (foF2QT), and the hourly time-weighted accumulation series derived from the geomagnetic planetary index ap (ap(τ)), were considered during the period January 1976 - December 2003. Under the assumption that the ionospheric disturbance index log(foF2/ foF2QT) is correlated to the integrated geomagnetic index ap(τ), statistically significant regression coefficients are obtained for different months and for different ranges of ap(τ) and used as input to calculate the short-term ionospheric forecasting of foF2. The empirical storm-time ionospheric correction model (STORM) was used to make comparisons with the IFELMOR model. A few comparisons between STORM's performance, IFELMOR's performance, the median measurements and the foF2QT values, were made for significant geomagnetic storm events (ap > 150) occurring from 2000 to 2003. The results provided by IFELMOR are satisfactory, in particular, for periods characterized by high geomagnetic activity and very disturbed ionospheric conditions. These results encourage to a further development of other short - term forecasting empirical local models to a number N of stations to produce a short – term forecasting map of foF2 over the area including the *N* stations under consideration.
Further oblique-incidence ionospheric soundings over Central Europe to test nowcasting and long term prediction models (poster presentation at IRI/COST 296 workshop)
M. Pietrella and L. Perrone

Specification of work and results (Related to ToR 5)

Forecasting of ionospheric characteristics by means of the nearest neighbor and modified neural network algorithms. Algorithms were used for data gaps correction, as well as the characteristics' forecast. They are demonstrating for European area. The accuracy of the obtained maps is enclosed.
M. Tomasik



Forecast of foF2 for Juliusruh/Ruegen and comparison with the measurements.

	El Areno.	Juliusruh	Lopars.	Sofia	Tortosa
El Arenosillo	1,15/0,2	1,20/0,20	x/x	1,18/0,19	0,97/0x18
Juliusruh	1.20/0,21	0,90/0,17	1,40/0,28	1,30/0,20	1,35/0,18
Loparskaya			1,2/x		
Sofia	1.19/0,18	1.29/0,3	1,51/0,7	0,90/0,16	1.21/0,17
Tortosa	0,98/0,18	1,18/0,21	1,75/0,53	1,20/0,20	0.98/0,17

Table 2. RMS error for the NN – 24 hours ahead forecast (forecast from nearby station). (fof2[MHz]/M3000f2).

Name	RMS foF2 [MHz]	RMS M3000f2
El Arenosillo	1,15	0,2
Juliusruh	0,90	0,17
Loparskaya	1,2	x
Sofia	0,90	0,16
Tashkent	1,70	x
Tortosa	0,98	0,17

Table 3. RMS error for the NN – 24 hours ahead forecast.

Specification of work and results (Related to ToR 6)

Further oblique-incidence ionospheric soundings over Central Europe to test nowcasting and long term prediction models (poster presentation at IRI/COST 296 workshop)
Pietrella M. (1), L. Perrone (1), G. Fontana (1), V. Romano (1), A. Malagnini (1), G. Tutone (1), B. Zolesi (1), Lj.R. Cander (2), A. Belehaki(5), I.Tsagouri(5), S.S. Kouris (3), F.Vallianatos (4) J.Makris(4) and M.Angling (6)

(1) Istituto Nazionale di Geofisica e Vulcanologia, Italy, (2) Rutheford Appleton Laboratory, U.K, (3) Aristotle University of Thessaloniki, Greece, (4) Technological Educational Institute of Crete,Greece (5) National Observatory of Athens, Greece (6) Centre for RF Propagation and Atmospheric Research, QinetiQ, U.K. (poster presentation at IRI/COST 296 workshop)

After a first oblique-incidence ionospheric sounding campaign over Central Europe performed during the period 2003-2004 over the radio links between Inskip (UK, 53.5° N, 2.5° W) and Rome (Italy, 41.8

N, 12.5E) and between Inskip and Chania (Crete, 35.7° N, 24.0° E), new and more extensive analysis of systematic MUF measurements from January 2005 to December 2006 have been performed. MUF measurements collected during moderately disturbed days ($17 \leq Ap \leq 32$), disturbed days ($32 < Ap \leq 50$) and very disturbed days ($Ap > 50$), have been used to test the long term prediction models (ASAPS, ICEPAC and SIRM&LKW), the now casting models (SIRMUP&LKW and ISWIRM&LKW) and to study the behaviour of these models during different seasons.

Specification of work and results (Related to ToR 6)

From Iñigo Blanco Alegre, Radiopropagation Group, Atmospheric Sounding Station "El Arenosillo" - INTA

- Collaboration with Dr. D. Buresova, from the Institute of Atmospheric Physics, Prague, Czech Republic for the MC meeting in July 2007 taking part in Prague with the study: "Evaluation of the storm model storm-time corrections for European middle latitudes"
- Doctoral Thesis: "Measuring and processing of atmospheric parameters for modelling and forecast in the high ionosphere". Co-directed by Dr. Benito A. de la Morena (INTA) y el Prof. Dr. José Manuel Andujar (Huelva University).

WP1.4 - Climate of the upper atmosphere

Terms of reference

1. **Derivation of long-term trends in different ionospheric/atmospheric parameters and different height regions to get hints about their origin (greenhouse effect, geomagnetic influence, or other sources)**
2. **Detection of signatures of different atmospheric waves (e.g. gravity, planetary and infrasonic), the investigation of their propagation through the atmosphere/ionosphere, and the search for possible predictability of their effects on the ionosphere**
3. **Investigation of ionospheric variability at middle as well as high latitudes (influence of precipitating high energy electrons on the ionised and neutral part of the atmosphere)**
4. **Incoherent radar observations and model calculations for investigations of the coupling between ionized and neutral part of the atmosphere for quiet and disturbed conditions**
5. **Space weather impacts on the midlatitude ionosphere**

Specification of work and results (Related to ToR 1)

The scenario of global pattern of long-term changes and trends in the upper atmosphere-ionosphere system has further been improved. The predominant trends in the observed F2 region peak parameters are of dual origin; trends in hmF2 appear at present to be controlled predominantly by the enhanced greenhouse effect, while trends in foF2 are probably still under dominant control by geomagnetic activity. (Laštovička et al., 2007b, 2007c, 2007d).

The trend investigations in hmF2 have been continued comparing the spatial distribution of the hmF2 trends with the existence of non-migrating waves (Sea-continent transitions) and spatial fields of geomagnetic declination (Bencze, 2007a, 2007b).

Analysis of winds at Collm, also together with other data from the Northern Hemisphere, shows significant non-linear trends during the last 2 decades (Portnyagin et al., 2006).

The analyses of trends in the E- and F1- regions have been continued. An essential part of the foE trends are caused by long-term variations of the ozone content in the Earth's atmosphere (Bremer, 2007).

Using MF radar observations at Juliusruh between 1990 and 2005 the derived mesospheric wind field has been analysed concerning the solar cycle influence and long-term trends. The solar activity effect is most markedly to be seen in the zonal wind field. Here the easterly winds in summer and the westerly winds in winter are amplified by increasing solar activity. The derived trends in the wind field are also most pronounced in the zonal wind component. Here the derived trends during summer are positive above about 83 km and negative below this height. During winter the derived trends are nearly opposite compared with the trends in summer (Keuer et al., 2007).

Specification of work and results (Related to ToR 2)

Response of the ionospheric infrasound to strong meteorological tropospheric events. A case study of analysis of five days of convective storm activity in summer, including one day of severe tropospheric storm, was performed. It showed dominance of Doppler spectra by infrasonic waves of periods of 3-4 min for the severe storm event. For other events, the wave activity in the infrasonic range was not clearly pronounced, even though the tops of cumulonimbus clouds reached high above the tropopause. We found out that the occurrence of 3 – 4 minute waves in Doppler records was influenced by presence of sporadic E-layer. We also analysed three days with winter convective storm activity. In two cases infrasonic waves were not detected. It was expected and corresponds to previous results based on study in North America that a particularly efficient source of infrasound are those storms, during which the heights of cloud tops reach the tropopause or above. Due to the seasonal differences of the stratification/energetic potential of the troposphere, the cumulonimbus does not penetrate the tropopause in winter. In one event (cyclone Kyrill in Europe), infrasonic waves were detected for about one hour, when the cold front of this cyclone was passing over the Doppler system transmitter and receiver sites. (Šindelářová et al., 2007)
Investigations of impact of planetary waves on the ionosphere have been temporarily closed with paper by Laštovička et al. (2007a).

Gravity wave analyses (0.7-3 h period interval) have been performed using LF winds of Collm, no long-term trend was detected, but a possible impact of the solar cycle was found, which is supported by model results (Jacobi et al., 2006).

Long-period (3-20 days) oscillations have been measured at Collm simultaneously by meteor radar temperatures, and scale height estimates using the diurnal cycle of LF refection heights, indicating that neutral atmosphere planetary waves influence the lower E region ionisation (Jacobi and Kürschner, 2006).

GPS satellite measurements are used to analyse waves in the ionosphere (Pavelyev et al., 2006). Planetary wave-type oscillations in ionospheric TEC are analysed using GPS measurements, and compared with stratospheric planetary waves (Jacobi et al., 2006b; Borries et al., 2007).

Specification of work and results (Related to ToR 2, 4 and 5)

- The solar, latitudinal, and seasonal dependence of TEC and slab thickness have been investigated. Analytical expressions depending on cosχ at noon and on latitude were derived. Strong variabilities have been found in relation to magnetic storms. These variabilities have been analysed in detail (Kouris et al., 2007; Kouris, 2007) (ToR 3).

- The investigations of quiet-time disturbances have been continued. A. Mikhailov will present new results at the IRI/COST296 workshop in Prague (ToR 4).
- Investigations of pre-storm enhancements of foF2 continued (Burešová and Laštovička, 2007a, 2007b). The pre-storm enhancements are of limited latitudinal extent in spite of their occurrence both day and night. Several potential sources of pre-storm enhancements are excluded, but their origin remains to be uncovered. (Burešová and Laštovička, 2007a, 2007d) (ToR 5).

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Annex V

COST296 WORKING GROUP 2 "ADVANCED TERRESTRIAL SYSTEMS" ACTIVITIES AND RESULTS

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Abstract.
Main objectives of the COST 296 Action “Mitigation of Ionospheric Effects on Radio Systems (MIERS)” is to increase the knowledge of the effects of ionosphere on practical radio systems and to develop mitigation techniques. The Working Group 2 (WG2) “Advanced Terrestrial Systems” conducts studies towards these objectives concerning the terrestrial systems. In this paper, some information will be presented concerning the activities and results of WG2 briefly.

Terrestrial systems, ionospheric effects, mitigation

1. Introduction

The COST 296 has been launched by the inaugural meeting which was held in Brussels on 4th of March 2005. The action will end on 3rd of February 2005. Main objectives of the COST 296 Action is to increase the knowledge of the effects of ionosphere on practical radio systems and to develop mitigation techniques. Working Group 2 (WG2) “Advanced Terrestrial Systems” conducts studies towards these objectives concerning the terrestrial systems. The WG2 is organized in terms of the following Work Packets (WP) to comply with the Terms of Reference.
WP2.1 Radar and radiolocation
WP2.2 HF/MF communications
WP2.3 Spectrum management
In this paper, brief information is presented concerning the activities and results of WG2.

2. Organization of the Research

The following research and technology development works have been carried out within WG2:
i. 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.
ii. HF/MF communications including digital radio systems, wideband propagation modeling and development of a hardware simulator, increased capacity of HF links through MIMO
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techniques (experimental measurements and simulation) and extension of existing wideband HF simulators to the MF band.
iii. Spectrum management, including the use of GPS to improve HF communications management, adaptive waveform management and the effects of infrasound on radio propagation [COST 296 web site].
These works are conducted under three work packages according to the following terms of reference:
WP2.1 Radar and radiolocation
2.1.1. Hot clutter modeling for surface wave radar. Existing hot clutter models will be evaluated and a new model may be proposed. Models will be validated with measurements from a basic surface wave set-up. An experimental set-up will be designed and implemented
2.1.2. Frequency management of ground-wave and sky-wave radars
2.1.3. Angle of arrival measurements for sky-wave signals
2.1.4. Propagation effects that influence radar and radiolocation systems
2.1.5. The effects of environmental noise on HF radar systems

WP2.2 HF/MF communications
2.2.1. Digital radio systems – predictions, methods of estimating reliability: experimental studies concerning channel reliability by using existing experimental set-up complied with ITU standards will be conducted in cooperation with University of Leicester UK
2.2.2. Wideband propagation modeling and development of a hardware simulator
2.2.3. High data transfer rate system of radio communications through the ionospheric channel
2.2.4. Effects of gravity, planetary and infrasonic wave effects on propagation
2.2.5. Extension of existing wideband HF simulators to the MF band
WP2.3 Spectrum management
2.3.1. Use of GPS to improve HF communications management
2.3.2. Adaptive waveform management;
2.3.3. Effects of infrasound on radio propagation
2.3.4. Occupancy determination of HF band for the East Mediterranean conducted using calibrated HF spectrum measurements and HF receiver array
2.3.5. Supporting research and application in antenna systems to increase their efficiency and mitigate the propagation errors
2.3.6. Developing new techniques to analyze the radiation path in the propagation channel

3. Activities and Results

Some brief information concerning the WG2 activities and results since the beginning of the action lifetime, 4 February 2005, is provided below.

3.1. Radar and Radiolocation

3.1.1. HF Sky-Wave Radar

3.1.1.1. Effects of Space Weather on HF Radar

Effects of space weather conditions on the variation of group range and line-of-sight Doppler velocity of the HF Radar echo signal are to be investigated by using HF Sky-Wave Radar data.
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However, such data are classified and there are no data made open. Therefore, in practice, some semi-synthetic data are generated by using Tasman International Geospace Environment Radar (TIGER) image plots available on internet.

The level of magnetic disturbance due to the geomagnetic storms in the ionosphere is denoted by the ap indices. Table 1 shows the single hop group ranges calculated from the TIGER image plots.

Table 1. Single hop group ranges calculated from image plots

Frequency (MHz)	Group Ranges Calculated From Image Plots (km)	
	ap _ 9	**ap > 9**
11	1090-1950	640-2550
14	1390-2550	700-2250

The results of the analysis are obtained by some signal processing and clustering techniques. The results are summarized below:

It is possible to give some suggestions to the HF radar planners and operators for the radar operating at the frequencies 11MHz and 14 MHz:

i. When ap index is greater than 9, it seems that it is not possible to communicate with the station located within the group range of 640 km at 11MHz and 14 MHz.

ii. When ap index smaller than 9, it seems that it is not possible to communicate with the station located within the group range of 1950 km at 11MHz and 2550 km at 14 MHz.

iii. It seems that the maximum group range of the HF signal for the single hop propagation does not change significantly with respect to the operating frequencies for 11 MHz and 14 MHz. Therefore, there is no constraint about the maximum group ranges for the given frequencies. HF signal can propagate to group ranges of up to 4000 km via second hops [MCM6, 2007 (p.25-27)].

3.1.1.2. A Potential Model for HF Radar

The METU Neural Networks and Cascade Model (METU-NN-C) has been developed which forecasts ionospheric process parameters. In future, the performance of the international reference models such as IRI-2001 can be increased by introducing METU-C modules into the international reference model of interest and by making some adaptations. Therefore, it can also be used for HF radar studies [MCM7, 2007 (submitted)].

3.1.2. Angle of Arrival Measurements

An understanding of the correlation of the HF channel scattering function with geomagnetic activity and particle precipitation is a necessary component in the development of the prediction techniques required for new systems. A number of experiments have recently been undertaken by the University of Leicester in order to develop a better understanding of these effects. In these experiments, the time of flight, Doppler frequency, and azimuth and elevation angles of arrival have been measured over several northerly paths. Measurements from Kirkenes, Norway to Kiruna, Sweden and from Uppsala, Sweden to Leicester, U.K. are reported [MCM5, 2006 (p.27-31)].

It is relevant to determine the correlation between the scattering function parameters and the auroral oval location, in particular the latitude of the southward border of the oval region at the

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midpoint between the receiver and the transmitter (about 20°E for Kirkenes – Kiruna path). The scattering function parameter distributions; distributions of delay, azimuth and elevation angles during the day are obtained. Azimuth deviations of about 40° to the south and up to 50° to the north in day time between 0800 and 1200 UT are observed. These modes are accompanied by delay of about 3-4 ms and elevation angles of 40°-60°. Correlation between these parameters and the auroral oval position are also noted. The southward trace with a maximum azimuth deviation of about 60° occurs at a latitude between 18° and 19° accompanied by a loop-shaped northward trace between 18.5° and 20°. The southward trace can be related to refraction in the southern wall of the mid-latitude trough whilst the northward trace is due to scattering from irregularities in the auroral oval (and also by refraction in the northern wall of the trough) [MCM5, 2006 (p.27-31)].

3.1.3. Propagation Effects on Radar and Radiolocation Systems

3.1.3.1. Directional Characteristics of HF

In recent years, considerable progress has been made in modeling the propagation mechanisms resulting in off-great circle propagation over northerly paths. 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. An analysis of these data has been undertaken and the directional characteristics summarized. Consideration has been given to modeling the propagation effects in the form of a channel simulator suitable for the testing of new equipment and processing algorithms [MCM4, 2006, (p.20-21)].

A collocated digisonde at the Direction Finding (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 Ne distribution. The vertical profile is automatically obtained from the ARTIST-scaled ionogram, and the local tilt from the skymaps recorded after each ionogram. Operational tests for distances up to approximately 100 km have demonstrated good results in determining the transmitter location in real time, and have illustrated the importance of using the actual ionospheric profiles and tilts in the raytracing [MCM4, 2006, (p.21)].

Sensitivity analysis of the heterogeneous array for direction finding applications is under consideration. The structure of a heterogeneous array has been proposed by the I.E.T.R. laboratory for HF direction finding purpose because of its advantages regarding its sensibility to the incident polarization. Sensitivity analysis is based on a perturbation analysis of the direction finding function (Music pseudo-spectrum) [MCM7, 2007 (submitted)].

3.1.3.2. Measurements along the Trough

The nature of azimuthal deviations from the great circle direction that occur over the Uppsala to Leicester path in a period of low solar activity (2006-2007) and high solar activity (2001-2002) differ significantly. It appears that the main factor is the change in the background ionospheric parameters (foF2 and hmF2). In the very weak ionosphere, the rays do not refract sufficiently in the wall of the trough and the radio waves reach the auroral oval zone not at the appropriate angle relative to the magnetic field for scattering on auroral irregularities to occur and consequently do not reach the receiver [MCM7, 2007 (submitted)].

A new type of off-great circle signal, compared with the 2001 measurements, has been observed in 2007. This takes the form of a smooth gradual northward deviation in azimuth, and to a large extent is the main type of the off-great circle propagation observed in the 2006-2007 measurements [MCM7, 2007 (submitted)].

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This type of the signal possibly arises due to scattering on small horizontal scale field aligned irregularities within the trough region. These irregularities are possibly caused by some kind of ionospheric instability. The ray-tracing model previously developed was not able to reproduce this type of signal behavior; therefore some modifications to the ionospheric model are currently being undertaken. Further work is required as the results are not yet well representative of the observations [MCM7, 2007 (submitted)].

3.1.3.3. Inversion of HF Radar Backscatter Ionograms

The purpose of the inversion technique is to recover the initial ionospheric parameters, f_c, h_m, y_m, from three points of the backscatter ionogram. Some elevation-scan backscatter soundings were realized with the HF radar NOSTRADAMUS. After filtering data, n points in the elevation-group path plane were obtained. The inversion technique was modified to remove the outliers in the data [MCM5, 2006 (p.24-27)].

The inversion technique validation on real data is in progress. On the other hand, inversion of ionograms on different frequencies are being considered [MCM6, 2007 (p.24-25)].

3.2. HF/MF Communications

3.2.1. HF Channel Availability under Ionospheric Disturbances

A new approach has been proposed for the assessment of HF Channel Availability under Ionospheric Disturbances. Channel availability is considered as a fundamental component of HF Communication Channel reliability. Modem availability is related to the magnetic indices [MCM5, 2006 (p.33-35)].

HF modems are specified in terms of Effective Multipath Spread, Frequency (Doppler) Spread, Signal to Noise Ratio (SNR), Bit Error Rate (BER), Modulation Type, and Data Conversion (Long-Short Interleaver). Ionospheric disturbances are characterized by Disturbance Storm-Time (DST) index. Throughout the study the HF data obtained in the experiment made between Leicester, UK (52.63_ N, 1.08_ W) and Uppsala, Sweden (59.92_ N, 17.63_ E). The experiment was held in the year 2001, for Effective Multipath Spread, Composite Doppler Spread, and SNR. First joint probability density functions (pdf) of SNR, Doppler, and Multipath Spread versus DST are considered. The availability of the channel is considered by using availability surface of Stanag 4539. It is concluded that the availability of HF Channel is also a function of Dst which is an indication of Space Weather. The proposed method is general and can include other Space Weather parameters which may be thought of being effective on HF communication channel reliability [MCM5, 2006 (p.33-35)].

3.2.2. Simulation Tools for Wideband Propagation Modeling

3.2.2.1. XIPPT Tool

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. 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
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tool may look, whilst remaining simple enough to demonstrate and place with potential users without extensive training [MCM4, 2006, (p.25-26)].

3.2.2.2. TEMPLAR Tool

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 [MCM4, 2006, (p.26-27)].

3.2.2.3. Sporadic E-Layer

Maps of the Sporadic E-Layer parameters showing diurnal and seasonal variations of the spatial distribution have been analyzed. Patches of increased electron density within Es layers develop due to wind shear which produce eddies at mid-latitudes. Thus, Es layers may be considered as thin diffraction screens [MCM5, 2006 (p. 35)].

Later, in the period March-June 2007 the problem of ionospheric sporadic E and HF radio wave propagation has been studied. It has been found that the maximum occurrence frequency of Es layers in summer months is due to maximum wind shear in summer. Further, the transmission loss increases with increasing transmission frequency, but decreases with increasing critical frequency, foEs [MCM7, 2007 (submitted)].

3.2.3. High Rate Data Transfer

3.2.3.1. TRILION Project

A digital transmission have been established through the ionospheric channel, operating between Rennes (France) and El Arenosillo (south of Spain), a radio link with a 1300 km range in the frame of the "TRILION" Project. Most of the results show that the array processing is efficient. The combination of CMA->LMS for equalization is able to converge when fading effect or frequency selectivity occurs. In some cases, the algorithm keeps tracking when jammers disrupt the transmission. Finally, the restored images appear to be good in terms of visual quality. A real time demonstrator with a DSP board has been set up. Preliminary results have been encouraging and the bit rate reached 20 kbits/s within 6 kHz bandwidth, between Rennes and El Arenosillo, for a limited evaluation version [MCM4, 2006, (p. 27-28)].

3.2.3.2. Multi Input Multi Output (MIMO) Systems

Multi Input Multi Output (MIMO) Systems have been shown to be capable of providing significant capacity improvement in a multipath environment (e.g. 20-40 bits/s/Hz for SNRs of 24-34 dB for 8 transmit and 12 receive antennas). Such spectral efficiencies would be very desirable at HF where data rates tend to be significantly limited by a variety of factors including delay and Doppler spread. MIMO systems utilize antenna arrays [MCM5, 2006 (p. 35-37)].

The important issues are: (i) Determination of the correlation distance for spaced antennas on multipath HF links taking account of time-varying electron density irregularities. (ii) Determination of the capacity of ionospheric HF MIMO systems employing linear or planar arrays or co-located antennas [MCM6, 2007 (p. 30)].
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The important questions are: (i) whether the differences between UHF and HF channels are so significant as to preclude the capacity increases found to be possible at UHF; (ii) how large a separation between antennas would be required for sufficient channel decorrelation; (iii) the possibility of the employment of co-located antennas; (iv) which latitude regions would be most ideal for MIMO links. These issues and questions are being addressed in the recent works [MCM6, 2007 (p. 30)].

3.2.3.3. Ionospheric Channels in the Polar Cap and Sub-Auroral Regions

The statistical observations made have quantified the azimuth deviations that might be expected in operating HF systems in the polar cap, auroral, and sub-auroral regions and also indicated the potential increase in signal strength that might be expected over the VOACAP predictions when off great circle propagation occurs [MCM4, 2006 (p. 28-29)].

3.2.4. Gravity and Infrasonic Wave Effects

In the Doppler type systems, S-shaped phenomena and rapid linear shape changes in Doppler shift spectrograms at time scales of tens of seconds which correspond to the range of infrasound are noted [MCM4, 2006 (p. 30)].

3.2.5. Wideband HF Simulators

The works on the effects of strong fluctuations of the field amplitude in the HF propagation through the fluctuating ionospheric reflection channel are carried out [MCM4, 2006 (p. 30)].

3.3. Spectrum Management

3.3.1. Occupancy Determination

3.3.1.1. Measurements during the 29 March 2006 Total Solar Eclipse Week in the Eastern Mediterranean Region

Measurements over the HF band during the 29 March 2006 total solar eclipse in Antalya (36° N, 30° E) Turkey were conducted from the channel occupancy and atmospheric noise points of view. 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) [MCM4, 2006 (p. 31-35)].

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 behavior of the night-time. After the total eclipse the atmospheric noise level returned back to its pre-eclipse pattern both in magnitude and configuration [MCM4, 2006 (p. 31-35)].

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

3.3.1.2. Occupancy of HF Spectrum over Northern Europe

Mathematical models have been developed which fit the experimental measure of congestion. The aim of the work was to provide experimental data and mathematical models, showing how occupancy varies with frequency, time, threshold level, bandwidth, type of user allocation, antenna, geographical location, and azimuth. Measurement systems are currently installed at Baldock (UK), Linkoping (Sweden), Kiruna (Sweden), and Munich (Germany). These sites provide effective measurement of spectral occupancy over northern Europe. Analysis was undertaken to derive an appropriate model index function for the Laycock Gott model for spectral occupancy [MCM5, 2006 (p. 39)].

Currently, Neural Networks are being used for predicting the likelihood of of Interference to Groundwave Users in the HF Spectrum [MCM7, 2007 (submitted)].

3.3.2. Antenna Systems and Radiation Path Analysis

Works on non-uniform sampling and polynomial interpolation for array synthesis, and array approach for propagation of electromagnetic waves in different media [MCM7, 2007 (submitted)].

4. Conclusions

COST 296 WG2 participants have been working on research and technology development activities on advanced terrestrial systems.

Works on radar and radiolocation have been performed within WP2.1. Works on HF/MF communications have been performed within WP2.2. Works on spectrum management have been performed within WP2.3.

WG2 research and development works conducted since the beginning of the Action on the 4th of February 2005 have been briefly presented in this paper. The Action will end on the 3rd of February 2009. The theoretical and experimental research works of the WG2 participants have produced important products including models and scientific publications in international platforms.

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Acknowledgements

High quality scientific and technical contributions of the participants of WG2 are gratefully acknowledged.

Significant contributions of Prof. Dr. Yurdanur Tulunay in the preparation of the paper; and contributions of Erdem Turker Senalp in the preparation of the text are also acknowledged.

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MCM6 (2007): Minutes of the COST296 6th MCM, 15-17 March 2007, Rome, Italy.

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Warrington E.M., A.J. Stocker and D.R. Siddle. Directional spread characteristics of HF signals received over

paths within the auroral zone. IRST2006
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Sensitivity analysis of the heterogeneous array for direction finding applications (in French). Intermediate report of the “Alibaba” project

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Outreach Activities

The Cyprus Research Promotion Foundation approved a fund for the installation and operation of a Lowell DPS-4D ionospheric monitoring station.

Thesis (MS and PhD)

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Short Term Missions Accomplished

Gunashekar S., University of Leicester visited the University of Rennes, 2 - 6 April 2007
Kocabas Z. (METU) to L. Bertel (Rennes), 2 - 7 April 2007
Sari M.O. (METU) to E.M. Warrington (Univ. of Leicester), 16 - 20 January 2006

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Appendix - A

WG2 Leaders

E. Tulunay and P. Lassudrie Duchesne (A. Bourdillon and E. Tulunay until 5th MCM, October 2006)

WP2.1 Leaders

C. Bianchi and E.M. Warrington

WP2.2 Leaders

J.M. Andujar and Y. Erhel (J.M. Andujar and P. Lassudrie Duchesne until 5th MCM, October 2006)

WP2.3 Leaders

L.W. Barclay and A.M. Casimiro

WG2 Participants

E. Altuntas, J.M. Andujar, M.J. Angling, J.A.R. Azevedo, Y. Bahadirlar, L.W. Barclay, E. Benito, P. Bencze, L. Bertel, C. Bianchi, J. Boska, A. Bourdillon, P. Bradley, D. Buresova, S.O. Buyukpabuscu, R. Caputcu, A.M. Casimiro, T. Ciloglu, L. Economou, Y. Erhel, J.E.N. Field, V. Gherm, S.D. Gunashekar, H. Haralambous, X. Huang, J. Kalmár, W.I. Kassem, Z. Kocabas, D. Kouba, P. Lassudrie Duchesne, J. Lastovicka, G. Le Bouter, D. Lemur, J.P. Luntama, F. Marie, H. Nazli, M. Oger, C. Perrine, B.W. Reinisch, S. Saillant, S. Salous, M.O. Sari, P. Sauli, E.T. Senalp, D.R. Siddle, T. Sinderalova, A.J. Stocker, H. Strangeways, E. Tulunay, Y. Tulunay, A.S. Turk, E.M. Warrington, T. Yapici, N.Y. Zaalov, N. Zernov.

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Appendix - A

WG2 Leaders

E. Tulunay and P. Lassudrie Duchesne (A. Bourdillon and E. Tulunay until 5th MCM, October 2006)

WP2.1 Leaders
C. Bianchi and E.M. Warrington
WP2.2 Leaders
J.M. Andujar and Y. Erhel (J.M. Andujar and P. Lassudrie Duchesne until 5th MCM, October 2006)
WP2.3 Leaders
L.W. Barclay and A.M. Casimiro
WG2 Participants (including the names appeared only in the Minutes of the 2nd MCM)
E. Altuntas, J.M. Andujar, M.J. Angling, J.A.R. Azevedo, Y. Bahadirlar, L.W. Barclay, E. Benito, P. Bencze, L. Bertel, C. Bianchi, J. Boska, A. Bourdillon, P. Bradley, D. Buresova, S.O. Buyukpabuscu, Lj.R. Cander, R. Caputcu, A.M. Casimiro, T. Ciloglu, P. Clency, N. Melida, B.A. de la Morena, L. Economou, Y. Erhel, J.E.N. Field, V. Gherm, S.D. Gunashekar, H. Haralambous, X. Huang, F. Jangal, J. Kalmár, W.I. Kassem, Z. Kocabas, D. Kouba, P. Lassudrie Duchesne, J. Lastovicka, G. Le Bouter, D. Lemur, J.P. Luntama, F. Marie, D. Marin, H. Nazli, M. Oger, C. Perrine, B.W. Reinisch, S. Saillant, S. Salous, M.O. Sari, P. Sauli, E.T. Senalp, D.R. Siddle, T. Sinderalova, A.J. Stocker, H. Strangeways, E. Tulunay, Y. Tulunay, A.S. Turk, E.M. Warrington, T.

YAPICI, N.Y. ZAALOV, N. ZERNOV

New Terms of Reference for Working Group 2 were proposed and accepted as follows:

LIST OF WORK PACKETS AND TERMS OF REFERENCE

(Ref: http://www.ukssdc.ac.uk/twiki/bin/view/COST296/WorkingGroup2)

WG.2 ADVANCED TERRESTRIAL SYSTEMS (Leaders: E. Tulunay (ersintul@METU.EDU.TR) and E.M. Warrington (emw@LEICESTER.AC.UK))

WP2.1 Radar and radiolocation (Leader: E.M. Warrington (emw@LEICESTER.AC.UK))

2.1.1. Frequency management of sky-wave radars

2.1.2. Angle of arrival measurements for sky-wave signals

2.1.3. Propagation effects that influence radar and radiolocation systems

WP2.2 HF/MF communications (Leaders: J.M. Andujar (andujar@UHU.ES) and Y. Erhel (yvonerhel@aol.com)

2.2.1. Digital radio systems – predictions, methods of estimating reliability: experimental studies concerning channel reliability by using existing experimental set-up complied with ITU standards will be conducted in cooperation with University of Leicester UK

2.2.2. Wideband propagation modelling and development of a hardware simulator

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

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

WP2.3 Spectrum management (Leaders: L.W. Barclay (lesbarclay@IEE.ORG) and A. M. Casimiro (acasimi@UALG.PT))

2.3.1. Use of GPS to improve HF communications management

2.3.2. Adaptive waveform management

2.3.3. The effects of environmental noise on HF radar systems and occupancy determination of HF band

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

2.3.5. Developing new techniques to analyse the radiation path in the propagation channel

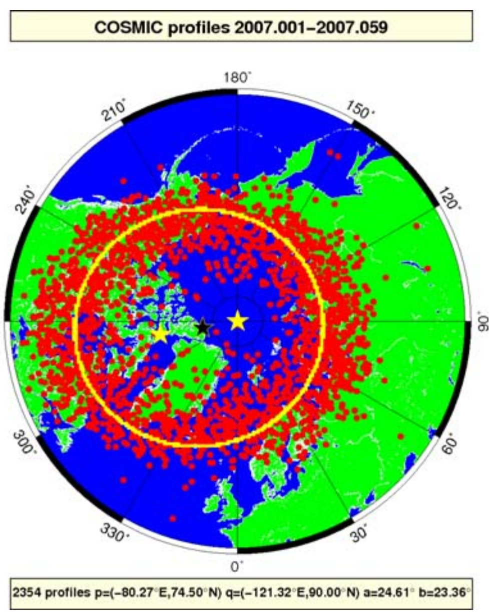
ANNEX VI

WG 3 Report - Space based systems activities within the period March 2007 –July 2007
WG Leaders N Jakowski, R Leitinger and R Warnant

WP 3.1 Space plasma effects (WP Leaders S Radicella and P Sauli)

Large scale effects during severe ionospheric perturbations and their relationships to space weather

To study the geophysical conditions and characteristics of the ionospheric processes in the auroral zone, GPS radio occultation electron density profile retrievals from CHAMP and COSMIC have been used in DLR Neustrelitz to extract those vertical profiles which show the absolute maximum of ionization in the E-layer height range of 90 – 150 km. In order to select these profiles, an algorithm was developed which can recognize the shape of a given profile by fitting an empirical Ansatz to it.
The observations from both data sets clearly show the location of E-layer enhanced events being closely related to the auroral oval around the geomagnetic pole. As expected, the number of such events increases with enhanced geomagnetic activity.
It has to be mentioned that the retrievals from CHAMP and COSMIC provide consistent results.



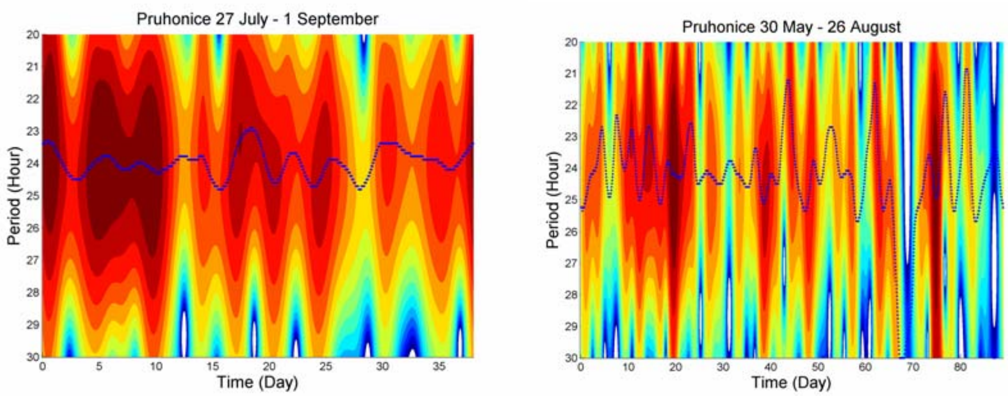
Location of E-layer dominating ionosphere around the North Pole based on radio occultation measurement of COSMIC satellites (red dots). The ellipse, determined by a least squares fit, indicates the auroral zone (DLR, Neustrelitz).

Whereas the ground based measurements show strong horizontal perturbation induced convection of plasma crossing the pole from day- to night-side, the space borne measurements on CHAMP indicate a severe vertical redistribution of the ionospheric plasma during the selected events. Of particular interest is a strong upward lift of ionospheric plasma near plasmapause boundaries.
Average features of ionospheric storms as observed over the European region since more than 10 years confirm seasonal differences in the average storm behavior.

To investigate possibilities of describing ionospheric perturbations by such an index, a task force group was established in the COST 296 activity. Preliminary results of a comparative study of ionospheric gradients including vertical sounding and TEC data are presented. Strong enhancements of latitudinal gradients and temporal changes of the ionization are observed over Europe during the 29-30 October storm period. The potential use of spatial and temporal gradients for characterizing the actual perturbation degree of the ionosphere is discussed in the COST 296 Perturbation Index Task Force Group.

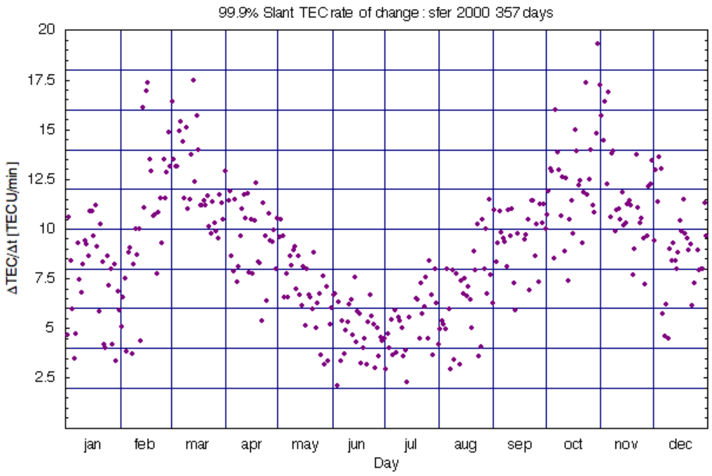
Bottomside Ionosphere

Variability of sporadic E-layer has been investigated at the Institute of Atmospheric Physics (IAP) in Prague (P. Sauli). A detailed analysis of the variability of sporadic E layer (parameters hEs and foes) shows that the central-period of the diurnal tidal component is not exactly 24hours but it varies between 22 and 26 hours at the planetary wave period. The IAP interpretation is based on the perturbation of the height of the Es layer imposed by the 4-day planetary wave. In this mechanism the Es layer is moved up and down by the planetary wave producing a Doppler effect and resulting in a shift of the central-period around 24hours. For a central period varying between 22 and 26hours the perturbation velocities are 0.026m/s and −0.022m/s, respectively.



Wavelike processes at E-layer heights in the mid-latitude ionosphere indicating the action of planetary waves. (IAP, Prague)

Slant TEC rate of change have been investigated at ICTP Trieste (S. Radicella), particularly over the European-African sector. Very large values were found using data from IGS stations located at middle latitudes, during quiet days at high solar activity. Slant TEC, at 30 s sampling interval, data of a series of stations located in southern Europe and the Middle East for all the year 2000 have been used. Slant TEC rate of change values over 10 TECu/min and up to 20 TECu/min have been observed frequently from locations in southern Europe, irrespective of geomagnetic activity. These high values of slant TEC rate of change occur more often during equinoctial months, when the receiver-satellite path looks towards south. These high values of slant TEC rate of change appears to be related to the large gradients of electron density and TEC associated to the presence of the Equatorial Anomaly.



Absolute Slant TEC rate of change for each day of 2000 at San Fernando. Shown are 99.9 percentiles. (ICTP, Trieste)

WG 3.2 Mitigation techniques (WP Leaders: Ulrich Foelsche and Rene Warnant)

3.2.1 Basic mitigation techniques which are based on models and operational measurements for real-time corrections

The University of Liège – Department of Geomatics is performing a study (Ph. D. Thesis) dedicated to the improvement of the NeQuick model for Galileo users. In a first step, the different weaknesses of the model at mid-latitudes are being identified. This study assesses NeQuick predictions using GPS-TEC and Digisonde data from Dourbes Observatory (Belgium). First results are presented at the COST/IRI workshop (University of Liège, B. Bidaine and Royal Meteorological Institute of Belgium, R. Warnant)
DLR has continued operating the ionosphere data service SWACI (http://w3swaci.de) funded by the state government of Mecklenburg-Vorpommern. The service provides near-real-time ionospheric information derived from ground and space based GPS measurements for mitigating first and second order ionospheric propagation errors. (DLR, N. Jakowski).

3.2.2 Mitigation techniques for specific GNSS applications

Ionospheric refraction on GNSS signals received onboard LEO satellites: the bending of the ray path of GNSS signals caused by the ionospheric refractivity has been investigated. Bending effects lead to a deviation of the curved optical path from the straight line of sight (LoS). CHAMP reconstructed vertical electron density profiles are used to investigate bending effects on GNSS signals received onboard Low Earth Orbiting (LEO) satellites. The excess path in addition to the LoS or true range are found to be meter level and the maximum deviations of the curved optical path from the straight LoS are found to be kilometer level for the GPS L2 (1228 MHz) signal. The deviations of tangential heights of the signal paths at the closest point of approach to the Earth surface from that defined by the straight LoS propagation are estimated to be kilometer level. LEO positions may be affected at cm level if the excess path error is not corrected. It has been found that the ionospheric refraction effects are proportional to the rate of change of total electron content (TEC) with the measurement time during an occultation event (DLR, Neustrelitz, M. Hoque and N. Jakowski).

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

Based on a dense network of GNSS stations in Belgium, development of a new TEC mapping technique which allows representing small-scale structures in TEC such as TID's (Geophysical Institute of the Bulgarian Academy of Science, I. Kutiev, P. Marinov, S. Fidanova and Royal Meteorological Institute of Belgium, R. Warnant)
The research group of Astronomy and Geomatics at the Technical University of Barcelona has developed a method for routinely mitigating the ionospheric second order effects on GNSS Geodetic networks. (Technical University of Catalonia, Spain, M. Hernandez-Pajares)
Assessment of the effects of small-scale structures in TEC (mainly TID's and "noise-like" structures) in TEC on high accuracy real time positioning techniques like the so-called Real Time Kinematic (RTK) technique: origin of these structures and their impact in terms of local TEC variability; their effects in the different steps of the data processing algorithms, in particular on ambiguity resolution.
On the one hand, a "climatological" study of TEC variability at Brussels has been performed on the period 2001-2007: frequency of occurrence of small-scale structures, their associated variability (worst case: 10 TECU/min in vertical TEC after an extreme solar flare, similar values are reached during severe geomagnetic storms). On the other hand, the effects of strong TID's and severe geomagnetic storms on RTK has been further investigated (Royal Meteorological Institute of Belgium, G. Wautelet, S. Lejeune, R. Warnant and the Geophysical Institute of the Bulgarian Academy of Science, I. Kutiev).

WP 3.3 Scintillation Monitoring and Modelling (WP Leaders Y Beniguel and V Romano)

The monitoring of ionospheric scintillation activity in the vicinity of Bandung / Indonesia (6.9° N; 107.6°E), Puerto Cruz / Spain (28.9°N; 16.3°E) and Kiruna / Sweden (67.8°N; 20.4°E) has been continued. Within the ESA project 'PRIS' a number of scintillation data were collected in DLR Neustrelitz. The data pool is open for consortium members.
The scintillation index S_4 and σ_φ are derived from 50/25 Hz GPS observations at the three sites on a regular basis. Near real time access to these data is established at the Kiruna and Puerto Cruz station (DLR, N. Jakowski, V. Wilken).

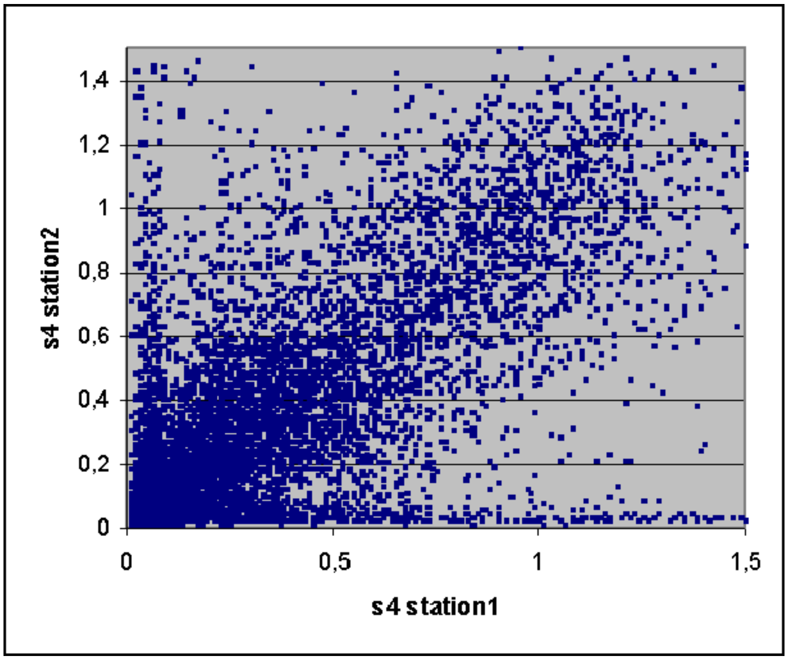
First attempts have been made to generate a scintillation activity map by combining the GISM scintillation model and multistation scintillation data from Brazil (IEEA, Y. Beniguel).

Scintillation Analysis

Correlation distance analysis has been performed:

- For a given satellite, the distance between the IPPs is approximately the same than the distance between the stations.
- The correlation coefficient between the S4 of 2 IPP is assumed to be a gaussian function of the distance : $c = \exp(-ad^2)$
- Since c = 0.8 for d = 100 km, the deduced correlation distance (c = 0.5) is about 175 km.

Case studies have been carried out for the storms during the period 30 October 2003 – 20 November 2003.



S4 data of two collocated stations in Brazil separated by about 100 km distance. The analysis of one week of measurements reveals a correlation coefficient of about 0.8 for all satellites visible at both stations (IEEA, Paris)

Measurements were continued in the frame of the ISACCO (Ionospheric Scintillation Arctic Coordinated Campaign Observations) project of INGV, Rome (V. Romano).
The measurements performed by a chain of similar GISTM receivers located in a latitudinal band between 53° and 78° N, have been analysed to investigate the formation and the dynamics of the Ionospheric irregularities causing scintillations and TEC enhancement over mid and high latitude European area. A multi instrument approach based on the use of an original tomographic technique (MIDAS, Bath University) and on the use of polar cap ionospheric potential simulation (Weimer model), has allowed the study of the ionospheric plasma dynamics under disturbed condition. Signatures of different responses of the perturbed ionosphere due to different external conditions are visible in the regions of enhanced TEC as revealed by the scintillation data.
The IESSG and the ROB/RMI continue to monitor GPS Ionospheric Scintillation and TEC monitor at the RMI observatory in Dourbes by 50 Hz sampling rate.

WG 3 Publications (March 2007 - July 2007)

WP1

Boška, J., Burešová, D., Kouba, D., Šauli, P.: Effects of geomagnetic activity on the E and F region ionospheric drifts during 2004-2007 years, IRI/COST 296 Workshop Ionosphere - Modelling, Forcing and Telecommunications, 2007, Prague.

Coïsson, P., S. M. Radicella, L. Ciraolo and B. Nava; Geographic Variations of Slant TEC Rate of Change During Different Geomagnetical Activity Conditions; paper presented at the IBSS 2007, Boston USA, June 11-15, 2007

P. Coïsson, P., S.M. Radicella, B. Nava and L. Ciraolo Large TEC Rate of Change at Middle Latitudes During Geomagnetic Quiet Conditions at High Solar Activity;; paper presented at the IBSS 2007, Boston USA, June 11-15, 2007

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