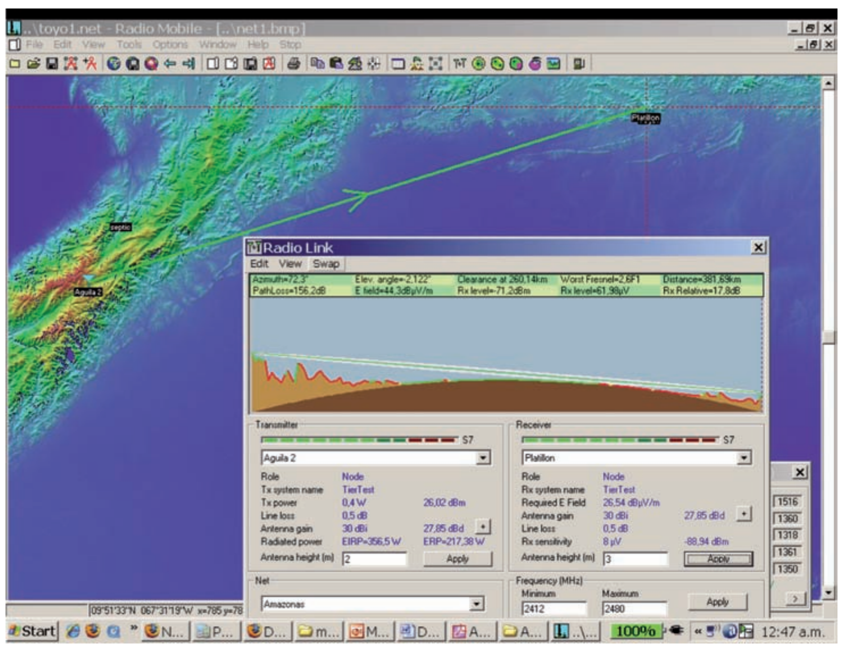
Radio Science Bulletin

ISSN 1024-4530

INTERNATIONAL
UNION OF
RADIO SCIENCE

UNION
RADIO-SCIENTIFIQUE
INTERNATIONALE



No 339
December 2011

URSI, c/o Ghent University (INTEC)
St.-Pietersnieuwstraat 41, B-9000 Gent (Belgium)

Contents

Front cover: ““The layout and profile of a 382 km path in a wireless sensor network using low-cost Wi-Fi technology. See the paper by Ermanno Pietrosemoli. on pp. 23-31.

For information, please contact :
The URSI Secretariat
c/o Ghent University (INTEC)
Sint-Pietersnieuwstraat 41, B-9000 Gent, Belgium
Tel.: (32) 9-264 33 20, Fax: (32) 9-264 42 88
E-mail: info@ursi.org
http://www.ursi.org

The International Union of Radio Science (URSI) is a foundation Union (1919) of the International Council of Scientific Unions as direct and immediate successor of the Commission Internationale de Télégraphie Sans Fil which dates from 1913.

Editorial

Our Papers

In this issue, we have a very interesting special section on "Wireless Sensor Networks." The papers in this special section describe three case studies from a joint workshop on "Wireless Sensor Networks for Environmental Monitoring in Developing Countries." This was a joint workshop of the International Telecommunications Union (ITU) and the International Centre for Theoretical Physics (ICTP). A report on this workshop that includes an introduction to these papers in the special section appears separately in this issue, so I won't repeat the information contained there. The very substantial efforts of Ryszard Struzak in bringing us this special section are gratefully acknowledged.

Our fourth paper in this issue is also special: it is an invited paper based on one of the General Lectures given at the URSI XXXth General Assembly and Scientific Symposium in Istanbul, Turkey, last August. The author, Asta Pellinen-Wannberg, provides a very interesting introduction to the impact high-power large-aperture radars have had on the study of meteors. The paper begins with a short history of the development of the science of meteors. It then presents an introduction to the basic concepts associated with meteors and meteor research, with figures illustrating several of these concepts. The development of meteor radars and high-power large-aperture radars is then reviewed. Part of this review is an explanation of the capabilities of each of the various radars in terms of the science for which they enable exploration. The meteoroid environment is explained. The concept of the head echo of a meteor is introduced, and the information that can be obtained from studies of such echoes is presented. The fundamental parameters related to meteors that can be observed with high-power large-aperture instruments are reviewed, along with explanations of how these parameters can be observed using such instruments. The observing strengths of the various instruments now available are reviewed, and case studies are given illustrating how the strengths of the tri-static EISCAT UHF high-power large-aperture system can be used. This is an excellent introduction to and review of the impact this class of observing instrument has had on the study of meteor science.

Our Other Contributions

This issue also contains reports on several important symposia. One of these is the 2011 ICEAA/APWC conference. This is the joint meeting that will be held again September 2-7, 2012, in Cape Town, South Africa, in conjunction with the new URSI Commission E Electromagnetic Environment and Interference Symposium. Announcements for the Commission E and ICEAA symposia appear in this issue. Information on all three meetings can be found at http://www.iceaa-offshore.org/.

Kristian Schlegel has brought us another book review. We also have URSI Commission business reports, news from URSI Member committees, and the announcement of the XXXth URSI GASS Student Paper Competition winners. Because this is the last issue of the year, the annual listing of the addresses of all URSI officials appears.

Best Wishes!

By the time you read this, the new year should have just started. My very best wishes to all Radioscientists for a most happy, healthy, safe, and prosperous New Year.

Ross

In Memoriam

David H. Staelin
1938 - 2011

David H. Staelin, a professor in the MIT Department of Electrical Engineering and Computer Science and the Research Laboratory of Electronics, died November 10, 2011, of cancer. He was 73.

Staelin joined the MIT faculty in 1965, conducting research in radio astronomy. Among his first accomplishments, in 1968 he developed a computationally efficient algorithm that enabled him to co-discover the Crab Nebula Pulsar, helping confirm the existence of neutron stars predicted by theoretical physics. Over time, Staelin's interests expanded to include remote sensing for climate monitoring, a field to which he brought a strong command of electromagnetics, signal-processing methodology, and computational trends. Among many examples of his leadership in this field, he was principal investigator in the development of the first two Earth-orbiting microwave-imaging spectrometers, launched in 1975 for mapping global temperature and humidity through clouds. He was also a co-investigator on the 1977 NASA Voyager 1 and 2 spacecraft missions, studying non-thermal radio emission from the outer planets. Staelin received the IEEE Geoscience and Remote Sensing Society (GRSS) Distinguished Achievement Award in 1996. Starting in 1998, he co-developed techniques using operational millimeter-wave sounding satellites for more-frequent and complete mapping of global precipitation.

In recent years, Staelin turned his attention to diverse emerging problems requiring sophisticated signal-processing and estimation theory. These included the development of practical image- and video-compression technology, advanced methodologies for data-rich manufacturing problems, heterogeneous and wireless communication architectures, and, most recently, neuronal computation models. Highly entrepreneurial, Staelin helped start and direct several companies with colleagues and students.

StaelinFest, an event held at MIT this past July to celebrate Staelin's career, was attended by faculty, colleagues, and former students from around the country (see http://www.rle.mit.edu/staelinfest/ for highlights and guestbook). At the event, he also received the distinguished 2011 John Howard Dellinger Medal, awarded to him by the International Union of Radio Science for profound contributions to remote sensing over his career. Staelin was also a Fellow of the IEEE and the American Association for the Advancement of Science. He served as Assistant Director of MIT's Lincoln Laboratory from 1990 to 2001, and as a member of the US President's Information Technology Advisory Committee from 2003 to 2005.

A. J. Gasiewski
University of Colorado, Boulder
E-mail: Al.Gasiewski@colorado.edu

Letter to the Editor

Regarding a Column by Dr. J. C. Lin

We would like to respond to a column by Dr. J. C. Lin, published in the *IEEE Antennas and Propagation Magazine*, and – in virtually identical form – in the *Radio Science Bulletin* [1, 2]. In these columns, Dr. Lin discusses the composition of the *IARC Monographs* Working Group that convened in May of this year to assess the carcinogenic hazards from exposure to radiofrequency electromagnetic fields. After Dr. Anders Ahlbom's withdrawal from the Working Group, Dr. Lin concludes that also Dr. Ronald Melnick should have been excluded from participating, on the basis of an alleged conflict of interests. In view of this, Dr. Lin questions the IARC's consistency and degree of seriousness in dealing with the declaration of interests, and its ambiguous manner in addressing conflicts of interest. We would like to respond to these allegations as follows:

The *IARC Monographs* identify environmental factors that can increase the risk for human cancer. Interdisciplinary working groups of expert scientists review the published studies and evaluate the weight of the evidence that an agent could alter the age-specific incidence of cancer in humans. The principles, procedures, and scientific criteria that guide the evaluations are described in the "*Preamble* to the *IARC Monographs*" (see http://monographs.iarc.fr/ENG/Preamble/ index.php). All experts must complete the "WHO Declaration of Interests" form before an invitation can be extended. Answering "yes" to a question on this form does not automatically disqualify or limit participation in an *IARC Monographs* meeting. After Dr. Ahlbom had submitted his initial "Declaration of Interests," he was invited as a working-group member. In the week before the meeting, Dr.

Ahlbom submitted a more-comprehensive "Declaration of Interests," adding that he served on the Board of Directors of his brother's consulting firm, Gunnar Ahlbom AB, a consulting firm in the domains of European Union (EU) affairs, especially working with commercial entities in telecommunications. One of the declared projects included major telecommunication companies as partners. Based on a perceived conflict of interest in his updated "Declaration of Interest" form, the IARC invited Dr. Ahlbom to remain in the working group, but as an invited specialist. This decision was discussed with Dr. Ahlbom in several long phone calls. Nevertheless, he decided to withdraw himself from the working group. We understand that he has since resigned from the Board of Directors of the consulting firm, i.e., the activity that had led us to make our decision over a perceived conflict of interest.

Dr. Melnick had declared serving as a scientific advisor in a research project funded by the EU on the assessment of exposure and risk from wireless network devices. Being aware of this, we invited Dr. Melnick as a working-group member. During the *IARC Monographs* meeting, Dr. Lin alerted us per e-mail that "Ron Melnick Consulting is a for-profit, commercial entity with special interest in RF bio-effects and biological responses to mobile phones." The IARC immediately contacted Dr. Lin, asking for additional information. "My interest in sending the e-mail was to alert you to the obvious" was his sole response. Nevertheless, we discussed with Dr. Melnick his "Declaration of Interests," but have not considered any further action necessary in relation to his participation in the working group.

The IARC recognizes and values its public responsibility and accountability. We greatly appreciate the interest and support of the scientific community in fulfilling the important role we have to play in providing the evidence-base for cancer prevention and control.

Dr. Melnick sent us the following response to Dr. Lin's publication:

> In his letter about the IARC working group on RF EMFs and cell phones, Dr. Lin assumes that because the IARC determined that Anders Ahlbom had a potential conflict of interest due to his role as director of his brother's consulting firm then, for consistency, anyone else who is a consultant is also conflicted and should have been removed as well from the expert working group. Since I do not know the details of the IARC decision or of Ahlbom's choice to not participate on the working group as a nonvoting member, I can only address inferences made in Dr. Lin's letter. As Dr. Lin noted, after my retirement from the US National Institute of Environmental Health Sciences (National Institutes of Health), I established a small consulting business of which I am the sole employee. However, in sharp contrast to business conducted by Ahlbom's brother's consulting firm, Ron Melnick Consulting, LLC, has never helped "clients on energy and environmental issues related to telecommunication." In addition, neither I nor any member of my family has ever received payment from any commercial entity with an interest related to the outcome of the meeting on RF EMF. This distinction is the likely basis for IARC's decision to consider my consulting activities as not raising a potential conflict of interest on the working group's evaluation of cancer risks associated with emissions from mobile telephones. Most of my research during nearly 30 years at NIEHS focused on health effects of environmental and occupational chemicals. The project on cell-phone RF radiation that I worked to develop is probably the largest health-effects study ever conducted by the National Toxicology Program (NTP). The reason for this is that unique exposure systems needed to be developed and validated to adequately challenge the hypothesis that non-thermal exposures cannot cause chronic health effects such as cancer under controlled laboratory conditions. The inability of previous studies on RF EMF to adequately challenge that hypothesis, particularly negative studies, adds uncertainty to potential health risks from such exposures. Based on the large number of mobile-phone users worldwide and the recent classification by IARC of RF EMFs as possibly carcinogenic to humans, future results from the on-going NTP studies will provide a major contribution of scientific knowledge on a very important public health issue.

It is of interest to note that Dr Lin's column also appeared in the *IEEE Microwave Magazine*, the Editor of which invited us – before publishing Dr. Lin's column – to respond in the same issue [3]. We also find it remarkable that the reader is not made aware of this triple publication.

Robert A. Baan, PhD
Responsible Officer
IARC Monograph Volume 102 on RF-EMF

Kurt Straif, MD, MPH, PhD
Head of the *IARC Monographs Section*
150 cours Albert Thomas
69372 Lyon cedex 08, France
Section of IARC Monographs
Tel: +33 4 72 73 85 07; Fax: +33 4 72 73 83 19
E-mail: imo@iarc.fr
http://monographs.iarc.fr

References

1. J. C. Lin, "Telecommunications Health and Safety: The Peculiar Circumstances of the IARC Working Group on Radio-Frequency Electromagnetic Fields and Cellular Telephones," *IEEE Antennas and Propagation Magazine*, **53**, 3, June 2011, pp. 202-203

2. J. C. Lin, "Radio-Frequency Radiation Safety and Health: The Unusual Story of the IARC Working Group on Radio Frequency Electromagnetic Fields and Mobile Phones," *Radio Science Bulletin* , No. 338, 2011, pp. 54-55.

3. J. C. Lin, "Health Effects: The Curious Case of the IARC Working Group on Radio-Frequency Electromagnetic Fields and Cell Phones," *IEEE Microwave Magazine*, October 2011, pp. 32-34; IARC's Response, p. 35; Response from Dr. Ronald Melnick, p. 36.

Reply

I appreciate Drs. Robert A. Baan and Kurt Straif's interest in my recent editorial column. However, contrary to what has been alleged in their letter to the editor, the editorial did not make any accusations nor did it draw any conclusions. It simply stated published facts, and expressed the opinion that those were curious and raised questions. It should be noted that the factual statements remain so concerning the events that occurred surrounding the operation of the IARC working group.

With regard to the NTP part of their letter, ascribed to Dr. Melnick,

> ...the (NIEHS/NTP) project on cell phone RF radiation... is probably the largest health effects study ever conducted by the National Toxicology Program (NTP)...to adequately challenge the hypothesis that non-thermal exposures cannot cause chronic health effects such as cancer under controlled laboratory conditions. The inability of previous studies on RF EMF to adequately challenge that hypothesis, particularly negative studies, adds uncertainty to potential health risks from such exposures....Future results from the on-going NTP studies will provide a major contribution of scientific knowledge on a very important public-health issue,

it is interesting to note that Dr. John Bucher, the associate director overseeing the NTP study shared with North Carolina's leading newspapers (the *Charlotte Observer* and the Raleigh *News & Observer* in January 2010) that he "doubts scientific research can demonstrate a link between cell phones and cancer." Bucher was quoted as saying "I anticipate either no correlation or, if anything is seen at all, it won't be a strong signal."

With regard to republication of my *IEEE Antennas and Propagation Magazine* column in other publications, this practice was announced to the readerships of those publications when it first began. The other publications usually carry a note from the editor referencing the original *Magazine* publication. With regard to disclosure of material prior to publication for the purpose of soliciting a response, it is perhaps appropriate to note that the following appears in the IEEE Publication Services and Products Board *Operations Manual*, Section 8.2.1.D, entitled "Editors of IEEE Journals, Transactions, Letters, and Magazines:" "Unpublished manuscripts must be treated as confidential documents by all individuals involved in the editorial process."

James C. Lin

University of Illinois at Chicago
851 South Morgan Street, M/C 154
Chicago, IL 60607-7053 USA
Tel: +1 (312) 413-1052 (direct);
+1 (312) 996-3423 (main office);
Fax: +1 (312) 996-6465
E-mail: lin@ece.uic.edu

[A substantially identical version of this letter and reply appeared in *IEEE Antennas and Propagation Magazine*, **53**, 5, October 2011, pp. 162-163; ©2011 IEEE.]

Wireless Sensor Networks for Environmental Monitoring in Developing Countries : A Report on the 2011 ITU-ICTP Workshop and Conference, and an Introduction to the Special Issue

The "ITU-ICTP Workshop on Applications of Wireless Sensor Networks for Environmental Monitoring in Developing Countries" and "ICTP-ITU International Awareness Conference on Wireless Technologies for Environmental Monitoring" took place at the International Centre for Theoretical Physics (ICTP) headquarters in Trieste, Italy, from February 28 to March 11, 2011. The Secretary General of the International Telecommunication Union (ITU), Dr. Hamadoun Touré, came from Geneva especially to address the participants. The text of his speech is published separately in this *Bulletin*. Sandro Radicella (ICTP), Mario Maniewicz (ITU) and Ryszard Struzak (NIT – National Institute of Telecommunications, Poland) acted as the directors, and Marco Zennaro led the team of local organizers. This short report begins with brief information about the ICTP activities in the field of radio. Some details on the workshop and conference are then given. The report finishes with a few case studies presented at the conference, the papers for which are included the special section in this issue of the *Bulletin*.

ICTP

The mission of Abdus Salam International Centre for Theoretical Physics (ICTP) is to foster advanced studies and research in developing countries. Founded by Abdus Salam (Nobel Laureate in Physics), ICTP operates under a tripartite agreement among two United Nations Agencies, UNESCO and IAEA, and the Italian government. While the name of the Centre reflects its beginnings, its activities today encompass most areas of theoretical and applied sciences, including information and communications technologies (ICT). ICTP embraces a large community of scientists worldwide. Since its creation, the Centre has received about 120,000 scientists, half of whom have come from the developing world. Visitors have represented some 180 nations and 40 international organizations. In recent years, more than 6,000 scientists visit ICTP annually to participate in its research and training activities, and to conduct their own research.

ICT at ICTP

Sufficient and sustainable human-resource development is essential to fostering the best use of information and communications technologies in the education and research sectors. The ICTP team is convinced that low-cost information and communications technologies, open access, training, and know-how transfer are critical for sustainable development. Appropriate training is fundamental and the most cost-effective long-term investment. ICTP has been playing a leading role in

Figure 1. The participants in the 2011 ITU-ICTP workshop and conference on Wireless Sensor Networks for Environmental Monitoring in Developing Countries (with the ITU Secretary General standing in the center) (photo: M. Zennaro).

Figure 2. One of lectures on how to program wireless sensor nodes/networks (photo: M. Zennaro).

the field of training in information and communications technologies for scientific institutions since 1996. It has established extensive in-situ training programs on wireless communications technologies to facilitate Internet access to unconnected academic and other institutions. Since the initial efforts, ICTP's Telecommunications/ ICT for Development Laboratory (the former Aeronomy and RadioPropagation Laboratory) has held some 40 training activities, attracting more than 1600 participants from Africa, Asia, Oceania, Europe, and the Americas, as well as from international organizations. It has had close collaboration with the International Telecommunications Union (ITU) Telecommunication Development Bureau (BDT). Recently, the ICTP become a Sector Member of the ITU/BDT. In the past, an active relationship with the International Union of Radio Science (URSI) was also established.

Starting from 1998, the ICTP has offered an annual school, focused on wireless networking for developing countries for local-area networks in academic campuses. Topics include theoretical and practical training on low-cost radio techniques, planning, installation, and maintenance of short- and medium-distance point-to-point digital radio links. The schools have used modern technologies and teaching techniques. Emphasis is put on hands-on laboratory sessions and in-the-field practical exercises. In addition to activities held at ICTP headquarters in Italy, training has also been given in developing countries. From 2000 to 2011, the ICTP group has been involved in training activities on the use of wireless for broadband connectivity and computer networking in Benin, Cameroon, Ghana, India, Indonesia, Kenya, Nigeria, Peru, Sudan, Venezuela, and Zimbabwe, to name a few countries.

In 2007, the school's program included the topic of "Wireless Sensor Networking." The potential applications of this technology included water-quality monitoring, intelligent irrigation, and disaster warning, topics extremely relevant to rural and remote areas. This issue is attracting more and more attention as environmental data can enable important advances in science, and improvements of the quality and safety of life. However, at present, environmental monitoring is based on costly macro-infrastructures that use highly accurate and carefully calibrated equipment. Because of high cost, they are deployed at a relatively small number of fixed, sparsely distributed locations, and maintained by organizations with large budgets, rarely available in developing countries. As a result, many databases are incomplete, with wide, blank gaps in large areas of the developing countries. These gaps may be bridged through low-cost micro-infrastructures based on complementary sensing technologies and systems. Wireless sensor networks (WSN) are a low-cost technology. They require low power and are not dependent on any existing network. The vast range of sensors that can be connected to the devices makes them flexible for many different applications, such as air-quality, water-quality and soil-moisture monitoring.

The 2011 Workshop and Conference

The keynote address, "The Role of ITU in a World of Ubiquitous Connectivity," was given by Dr. Touré, the ITU Secretary General. The workshop topics included "WSN Applications," "IPv6 Networking," "Low-Cost Solutions for IPv6," "IPv6 and WSN," "WSN Simulation, Evaluation and Testing," "Basic and Advanced WSN Solutions," and "Spectrum Management and Regulatory

Figure 3. Practical exercises in programming of the nodes/networks, before deployment (photo: M. Zennaro).

Figure 4. Field exercises in deploying a wireless sensor network (photo: M. Zennaro).

Figure 5. An example of an autonomous wireless sensor node placed on a tree (open to show the interior) (photo: M. Zennaro)

Issues." The workshop consisted of lectures (Figure 2), individual programming of wireless sensor nodes (Figure 3), experimenting with wireless sensor networks in the laboratory and in the field (Figures 4 and 5), and collective discussions on specific topics.

An international team of 10 lecturers presented at the workshop and led practical exercises. They came from Denmark, Germany, Italy, Spain, Switzerland, United States, Poland, South Africa, and Venezuela. The workshop targeted not only young scientists, but also telecommunication administrations, regulators, operators and other parties interested in learning more about wireless-communication solutions for environmental monitoring. A total of 30 participants from more than 20 countries participated. The last two days were devoted to a conference entitled "Wireless Sensor Technologies for Environmental Monitoring." At this conference, case studies were presented and discussed, and representatives of administrations and decision makers were introduced to the new technologies for environmental monitoring.

Case Studies: An Introduction to the Special Section on "Wireless Sensor Networks"

This report is complemented by a few case studies presented at the conference and not published elsewhere. These include the following:

"Comparative Analysis of Clustering Algorithms Comprising GESC, UDCA, and *k*-Mean Method for Wireless Sensor Networks," by Fareeha Zafar and Zaigham Mahmood. This paper presents schemes for improving the efficiency of clustering algorithms within wireless sensor networks. Clustering algorithms comprising GESC, UDCA, and the *k*-mean method are analyzed and compared. This is done with the help of certain attributes taken as classification criteria. On the basis of this analysis, a composite technique is proposed. Some suggestions are also presented that if taken into consideration, can help in improving the efficiency of clustering algorithms.

"Peteroa Lightning Monitoring Network" by Fernando Miranda Bonomi, M. A. Cabrera, J. E. Ise, J. Cangemi, and J. Ruzzante. In this paper, the authors describe the efforts of the Laboratorio de Telecomunicaciones of the Universidad Nacional de Tucumán (Argentina) to deploy a prototype low-cost wireless sensor network for continuous real-time monitoring of lightning activity at the Peteroa active volcano. This work is about wireless-sensor-network design and sensor-deployment plans according to topographic characteristics in the vicinity of the volcano.

"Long Distance, Low-Cost Wireless Data Transmission" by Ermanno Pietrosemoli. This paper presents some experiments with inexpensive long-distance radio links (up to ~380 km), as well as two practical wireless networks. One of the networks connects the five islands in the Galapagos national park and marine reserve in the Pacific Ocean, about 1000 km west of continental Ecuador. The second network connects several hospitals to the College of Medicine at the University of Malawi.

Conclusion

The 2011 ITU-ICTP workshop and conference were well received by all. On that basis, the organizers have planed similar activities in February 2012. The full documentation of the 2011 events can be found at:

http://wireless.ictp.it/
http://academy.itu.int/index.php/events/item/462
http://academy.itu.int/moodle/course/view.php?id=314

Information about the 2012 gatherings is at:

http://agenda.ictp.it/smr.php?2329
http://www.ictp.it.

Sandro Radicella, Mario Maniewicz, and
Ryszard Struzak
E-mail: struzak@gmail.com

Speech by ITU Secretary-General Dr. Hamadoun I. Touré

Conference on Wireless Sensors Technologies for Environmental Monitoring

March 10, 2011, Trieste, Italy

The Role of ITU in a World of Ubiquitous Connectivity

Distinguished colleagues, Ladies and gentlemen,

It is a great pleasure to be with you here in Trieste this morning. Today, we truly live in a world of ubiquitous connectivity. I am not referring simply to the fact that there are more than five billion mobile cellular subscriptions worldwide, or that there are now over two billion people online – although these facts are of course very significant. No, I am referring instead to the fact that in the second decade of the twenty-first century, almost everything we encounter in our professional and personal lives is now interconnected in one way or another.

People talk to people. Machines talk to machines. Information is collected, stored, transmitted, and shared in quantities which human minds can barely comprehend. We are already in the process of moving from the "Internet of Things" to the "Internet of Everything." Connectivity, or inter-connectedness, will shape and define the future. I will go further and state that this is not just game-changing, but life-changing. And not just for some of us, but for all of us.

What does this mean for my organization, ITU?

Personally, I think that we are incredibly fortunate at ITU to be very much in the right place at the right time. The rather dry and arcane world of telecommunications has been transformed quite suddenly into a fast-moving and exciting landscape of smart phones, satellite tracking and monitoring, social networking, cloud computing, tablet computing, 3D TV, and so much more.

Distinguished colleagues,

In October last year, we held ITU's 18th Plenipotentiary Conference, PP-10, in Guadalajara, Mexico. As we hoped and expected, PP-10 gave us tremendous opportunities to improve and enhance the work of ITU. Our membership passed many resolutions, which will have a direct effect on connectivity and the way the future of the ICT sector is shaped. Some key examples include resolutions on:

- Accessibility;
- ICTs and climate change;
- Reviewing the International Telecommunication Regulations, one of ITU's four Treaty Instruments;
- Measures to help prevent the illicit use and abuse of telecommunication networks;
- Conformance and interoperability;
- Emergency communications and humanitarian assistance;
- The admission of Sector Members from developing countries;
- The admission of members from Academia;
- Bridging the standardization gap;
- Special measures to assist Small Island Developing States and Landlocked Developing Countries;
- Electronic meetings;
- And a number of key Resolutions on Internet issues.

We will also be continuing to focus on broadband over the coming four years, and you will hear more on this subject tomorrow morning from my good colleague. Mr. Mario Maniewicz, from ITU's Telecommunication Development Sector.

Ladies and gentlemen,

I will not attempt to steal Mario's thunder, but I will just highlight a couple of important points about broadband, particularly in the context of the importance of connectivity and inter-connectedness.

I think in places like Trieste and Geneva, we have a tendency to forget how important the Internet has become in our daily lives – or indeed how difficult it would be for any of us to live and work without it. Yet two-thirds of the global population is still offline, and even when they do have access to the online world, only a tiny fraction of people in developing countries have anything other than a dial-up connection.

Does this matter, when billions of people might arguably be more preoccupied by the daily lack of safe drinking water, rising food prices, and a chronic shortage of healthcare?

It matters very much indeed.

Because broadband is the most extraordinary enabler, especially in the developing world, and especially in countries with large rural and remote populations. It has the potential to massively expand the effective delivery of vital services – such as healthcare and education – to distributed populations which could never be properly served by traditional, centralized models.

It has the power to get people connected – and interconnected – wherever they live. Broadband infrastructure also has the power to massively enable connectivity between objects and machines.

To cite just one example – which is particularly relevant to this meeting – I think we can very soon expect to see sensor and sensor-network applications being used in sectors from energy and transport to industrial applications, precision agriculture and smart buildings. We can also expect increased connectivity to help enable more sustainable production and consumption. This has the potential to deliver both product-specific improvements, such as embedded ICTs for energy-efficient vehicles, and improvements across entire systems, such as smarter transport management. And of course we will also see interconnected ICTs being increasingly widely used to both monitor and improve the environment, through the use of embedded wireless sensor technologies.

The need to highlight the importance of broadband globally, and particularly at the national level, is the main reason why ITU set up the Broadband Commission for Digital Development last year, with UNESCO. We will be holding a Global Broadband Summit in Geneva in October, in conjunction with the ITU Telecom 40th anniversary edition. So, if you haven't already done so, please do mark 24 to 27 October in your diaries – we will look forward very much to seeing you there!

Distinguished colleagues,

I firmly believe that this will be the decade when the Internet becomes truly pervasive and truly ubiquitous – creating a world of ubiquitous connectivity. The Internet will spread everywhere – not just connecting people, but connecting objects, machines, cars, households, factories and governments, in hitherto unimagined ways. This will be very largely brought about by the rapid proliferation of advanced mobile technologies. This is something we can all celebrate.

We are fortunate not just to be working in a sector that is right at the heart of everything that happens in the modern world, but in a sector that has the potential to make real and lasting improvements to the lives of all the world's people.

A few weeks ago, at Mobile World Congress in Barcelona, I challenged government and industry leaders to put all this connectivity – all these amazing mobile devices and incredible mobile technologies – to good use. I asked them not just what they are doing today, but what they will be doing tomorrow to ensure that ubiquitous connectivity plays a real and tangible part in improving global health, global education, and global entrepreneurship. And I asked them what they are going to do in terms of getting the right content onto the right devices in the hands of the right people – wherever they live, and whatever their circumstances.

I am convinced that the right answers will be found, and that we will see not just billions of mobile apps, but perhaps trillions of ways of connecting people, devices, and objects for the benefit of humanity as a whole. And that the world in 2020 will be a better, fairer – and more environmentally friendly – place than the world in 2010.

Thank you.

Comparative Analysis of Clustering Algorithms Comprising GESC, UDCA, and *k*-Mean Methods for Wireless Sensor Networks

Fareeha Zafar
Zaigham Mahmood

Abstract

This paper presents schemes for determining the efficiency of clustering algorithms within wireless sensor networks (WSNs). Wireless sensor networking is a fast-growing technology, and such networks have the capability to distribute tasks within themselves for effective computation. Wireless sensor networks have the capability to sense the environment, process information, and send that information to the end user. These systems are self-organizing, and they manage themselves without any centralized control. Wireless sensor networks are widely used in applications such as disaster management, battlefield investigation, border security, and security surveillance. They are deployed in large numbers, and are even operated in unattended environments, where human monitoring is either difficult or, sometimes, impossible. Therefore, to maintain service quality and a reasonable system lifespan, efficient management strategies are required. Several clustering algorithms have been introduced in this regard. In this paper, clustering algorithms comprising GESC, UDCA, and the *k*-Mean Method are analyzed and compared, with the help of certain attributes that are taken as classification criteria. On the basis of this analysis, a composite technique is proposed. Some suggestions are also presented, which if taken into consideration, can help in improving the efficiency of clustering algorithms.

1. Introduction

A wireless sensor network (WSN) consists of self-managing sensors to monitor environmental conditions, and to pass their data through the network to the main location [1]. The development of such systems was motivated by military applications, such as battlefield surveillance, border security, etc. Today, these networks are widely used in industrial-process monitoring and control, machine-health monitoring, environmental and habitat monitoring, healthcare applications, home automation, and traffic control [1].

Wireless sensor networks consist of network sensors that work together in numbers of hundreds of thousands for signal processing, monitoring, sensing, and control tasks. Wireless sensor networks can manage themselves due to inter-node communications through multi-hop wireless paths. Each node communicates through a radio transceiver, and contains a sensing unit, a processing unit, and an energy-source unit that usually includes a battery or an embedded form of energy harvesting. Each of these units is integrated through ICs with a signal processing and a micro-sensing unit [2].

The sensing integrated circuit measures parameters from the environment around the sensor and transforms the measured parameters into signals. Those signals show the characteristics of the objects and events occurring around the sensors. Each sensor has an onboard radio, which is used to send the collected data to the base station (BS). Sensor nodes can collaborate with their neighbors within communication range to form an ad-hoc network. This technological development encourages professionals to conceive of accumulating the capabilities of sensors in large-scale networks that can be operated unattended [3].

Wireless sensor networks can operate unattended in harsh environments, where human monitoring can be risky and sometimes impossible. Sensors are therefore deployed randomly in the target area by nearly uncontrolled means. In a vast area, large numbers of sensors are deployed in most wireless-sensor-network applications, due to their short battery lifetime and the chances of having damaged nodes during deployment [3]. Appropriate strategies are required for designing and managing this type of network.

Fareeha Zafar is with the Department of Computer Science, GC University Lahore, Pakistan; e-mail: dr.f.zafar@gcu.edu.pk. Zaigham Mahmood is with the Department of Computing, University of Derby, United Kingdom; e-mail: z.mahmood@derby.ac.uk. This is an invited paper for the special section on "Wireless Sensor Networks."

This is een invited paper for the Special Section on 'Wireless Sensor Networks'

Sensors are energy constrained, and their batteries cannot be recharged or replaced. The main challenging factor in the design and function of sensors is thus energy preservation. Designing energy-aware algorithms therefore becomes important for enhancing network lifetime. In the simplest direct-communication routing protocol, each sensor node communicates directly to the base station. As the distance becomes larger, in most cases the sensor more quickly consumes energy [4].

Sensors of different regions of the sensed area can work together to aggregate their data and to provide more precise reporting about their local regions. This data aggregation improves the reliability of the report and reduces the communication overhead in the network, which can lead to energy conservation. To support data aggregation, nodes can be segmented into a number of clusters [3]. Clustering not only allows data aggregation, but also limits the data transmission to mainly within the cluster [5], thereby reducing disputes and traffic on the channel. Each cluster consists of a leader, which is often called the cluster head, and number of member nodes. The member nodes send their data to their adjacent cluster heads, which perform data aggregation and send the data to the base station, either directly or through multi-hop communication using other cluster heads. Cluster heads loose more energy compared to other member nodes, because they often transmit data over long distances. The network must therefore be re-clustered periodically to get a higher-energy node that can serve as the cluster head. Clustering was introduced in wireless sensor networks for network scalability, energy-saving characteristics, and network topological stability [6].

The remaining portion of this paper is organized as follows. Various clustering algorithms in the literature are listed in Section 2. Section 3 address some limitations found in the algorithms. The algorithms are classified, and a composite technique is proposed on the basis of the analysis. Section 4 provides conclusions for the paper, and some suggestions are given in Section 5.

2. Literature Review

Many researchers have exhibited their interest in grouping sensor nodes into clusters for the purpose of achieving network scalability, and have proposed clustering algorithms. Their aim has been to develop stable clusters in environments with mobile nodes. In the literature, clustering techniques roughly fall into two categories: some based on the construction of a dominating set, and others based exclusively on energy considerations.

Several studies [7, 8] have shown that the lifetime of the sensor network can be increased through clustering. The lifetime is the time until the last node of the network exhausts its energy [5]. A major effort depicted in the literature has been the selection of the most appropriate nodes as cluster heads. This was done using the notion of dominating sets (DS), i.e., the subset of the nodes such that any node of the network graph either belongs to a dominating set or is a neighbor of a node of a dominating set [5]. A survey of such methods was given in [9]. The limitation of this approach is that the nodes belonging to the dominating sets are entirely responsible for communication, which causes them to run out of energy very soon. Some algorithms provided a mechanism of addressing the energy-consumption problem due to repetitive communication to the same node (cluster head). The concept of re-clustering was proposed, in which the role of cluster head was rotated among nodes of the cluster [7, 8, 10]. The proposed methods decided whether it would be selected as a cluster-head node or not depending on the residual energy of each node. However, these algorithms ignored the topological features of the nodes [5].

Basagni [11] proposed a distributed clustering algorithm that assumed quasi-stationary nodes with real-valued weights. Chatterjee et al. [12] presented a Weighted Clustering Algorithm (WCA), which combined several properties in one parameter for clustering. Younis et al. [13] presented a protocol (Heed) that periodically selected the cluster head according to a residual energy and the proximity of the node to its neighbors or node degree. Amis et al. [14] proposed a distributed cluster-head election procedure with Max_Min D-cluster, where no node was more than d (a selected heuristic value) hops distant from the cluster head.

Wu et al. [15] proposed an algorithm to find the connected dominated set (CDS) for designing an efficient routing scheme. In this algorithm, each node, v, exchanges its neighbor list with all of its neighbors. A node sets itself as a dominating node if has two unconnected neighbors. Two rules were proposed for reducing the size of the connected dominated set. According to the first rule, a node deletes itself from the connected dominated set if it has a smaller ID than the neighboring dominating node, and the close neighbor set, which includes all of its directed neighbors including it, is completely incorporated in the neighbor set of a neighboring dominating node. According to the second rule, a node deletes itself if has a smaller ID and if its open neighbor set, which includes all its direct neighbors, is completely included in the neighbor sets of two connected neighboring dominating nodes. Zunic et al. [16] proposed an algorithm for the improvement of the protocol proposed in [15]. According to it, the node is called intermediate if it has two neighbors that are not directly connected. An inter-gateway node is that node that is not deleted from the dominating nodes after applying rule 1 from the protocol in [15]. A gateway node is that node that is not deleted after applying rule 2. The node IDs are replaced with a record that includes the node's x and y coordinates, and the node's degree. Only inter-gateway and gateway nodes can retransmit a message. Before a node can rebroadcast a message, it computes the number of one-hop neighbors that have been enclosed from the previous re-broadcasting. Broadcasting proceeds if there are uncovered neighbors.

Qayyum et al. [17] presented a protocol with a high degree of localization. They focused on the reduction of duplicate-message retransmission while forwarding messages to the destination nodes.

A clustering algorithm can efficiently extend the wireless sensor network's lifetime by efficiently using the limited energy resources of sensor nodes. LEACH [7] is an energy-efficient protocol for continuous data delivery for sensor networks without mobility. Sensor nodes are elected as a cluster head using some probability, and they broadcast their decisions. The remaining nodes became a part of a cluster with its cluster head as closest in terms of the communication cost. For balancing energy consumption, the role of cluster head is periodically rotated through re-clustering. Therefore, LEACH counteracts the problem of nonuniform energy drainage through re-clustering.

HEED [8] introduces a cluster radius that defines the transmission power for intra-cluster broadcast usage. The initial probability of becoming a cluster head depends on the residual energy of the node. Final cluster heads are selected according to the intra-cluster communication cost. HEED assumes that cluster heads can communicate with each other and can form a connected graph. Coyle et al. [18] used LEACH-like clustering and multi-hop forwarding for intra-cluster and inter-cluster communication. They also provided a method for computing the ideal values of the algorithm parameters assumed.

Chang et al. [19] proposed a method for maximizing the lifetime of the network through the fair distribution of energy consumption. Nodes selected routes for optimizing performance and adjusted their transmission power levels. Estrin et al. [20] proposed a multilevel hierarchical structure in which cluster heads were selected according to their residual energy. Schaffer et al. [21] proposed an energy-efficient protocol, PANEL (Position-based Aggregator Node Election), which ensures load balancing such that each node is elected accumulator (cluster head) with nearly equal regularity. It uses the geographical information of the nodes to decide which of them should be the aggregators. Since the geographical position of the node is difficult to obtain without of the use of hardware or central coordination, it is therefore a restriction in wireless sensor networks.

Chen et al. [22] proposed an energy-efficient clustering algorithm (EECS) for single-hop wireless sensor networks. It is more suitable for periodic data-gathering applications. It is an extended version of LEACH, with dynamic sizing of the cluster head based on the cluster's distance from the base station. The candidates broadcast their residual energy to neighboring candidates. If a given node is unable to find a node with more residual energy, it becomes a cluster head. EECS uses a weighted function to make sure that clusters that have a larger distance from the base station are of smaller size, so that more energy can be saved for long-distance data transmission. Liu et al. [23] proposed a strategy for saving energy in data collection through exploitation of spatiotemporal correlation. The sink node divides the sensor nodes with similar measured values into clusters. The nodes within the clusters are scheduled to work alternatively to reduce energy dissipation. Agrawala et al. [24] presented the MOCA (Multi-Hop Overlapping Clustering Algorithm), in which sensors are organized into overlapping clusters. The major goal of the clustering is to make sure that every node is either a cluster head or within *k* hops of at least one cluster head, where *k* is a preset cluster radius.

Dimokas et al. [5] proposed an energy-efficient distributed clustering protocol, Geodesic Sensor Clustering (GESC), for wireless sensor networks. This aimed to prolong network lifetime by evenly distributing energy consumption, considering the localized network arrangement and the residual energy of neighboring nodes. The main part of this protocol is the estimation of the importance of sensors corresponding to the network topology. For a more-detailed survey of clustering algorithms, [3, 4, 6, 9, 25-28] can be consulted.

Boregowda et al. [29] presented an approach for maximizing the network lifetime by reducing the number of communications among sensor nodes. It also included a distributed cluster formation technique, an algorithm for maintaining a constant number of clusters by prior selection of the cluster head, and rotating the role of cluster head for even distribution of the energy load on all senor nodes. Hasan et al. [30] introduced a server node (SN), which has the ability to cover a long-distance transmission range. They pinpointed the issue that if the aggregator node becomes nonfunctional, the whole cluster is affected. The aggregator node's role is thus more crucial in the network. Server nodes are responsible for transmitting data from the cluster head to the base station. A server node is deployed in the area where all the nodes in the cluster are easily reachable. Otherwise, it is recommended that another server node be added. The selection of the cluster head is the responsibility of the server node. The *k*-mean clustering method is used for clustering nodes using the nearest centroid. Nallusamy et al. [31] stresses energy-efficient clustering and routing, in which the network optimizes between efficient routing and extending the network lifetime. They used the *k*-mean clustering algorithm for clustering the nodes, and a genetic algorithm (GA) for the calculation of the shortest-path route within the cluster. They clustered the nodes by minimizing the sum of the distances between data and the corresponding centroid of a cluster.

3. Discussion

The main reason for clustering is not only to improve the network's scalability, but clustering is also an important factor in achieving efficient routing of data within the network. Other benefits of clustering include conserving communication bandwidth within the clusters, avoiding unnecessary message transfers between sensor nodes, and localizing an energy-efficient route setup within the clusters. Clustering also has some disadvantages, due to the overhead caused by cluster formation and maintenance. Clustering imposes an extra burden on energy-constrained or memory-limited nodes. During the cluster-maintenance process, cluster heads occasionally transmit a message to their member nodes to be aware of any network change. This may increase energy consumption, communication traffic, and the hazard of collision when the node density increases. There is therefore a tradeoff between network scalability and energy conservation in clustering schemes.

3.1 Limitations

After a detailed analysis of algorithms [5, 7, 8, 22, 29-31], some limitations are found, as presented below.

LEACH [7] is one of the most popular clustering algorithms for prolonging the lifetime of a network. It was proposed for applications in which sensor nodes are randomly distributed in the sensor field, and are continuously sensing the target's location to send a message to the base station. Clusters in LEACH are formed on the basis of signal strength, and cluster heads are used for relaying messages to the base station. Data fusion and aggregation is local to the cluster. Each non-cluster-head node finds its cluster on the basis of a cluster head that can be reached using the least energy consumption. The authors of LEACH assumed that a cluster head had a long communication range, so that data could be sent directly to the base station. This is not a realistic approach, since the cluster heads are regular nodes and the base station is not directly reachable by all nodes. The authors also assumed single-hop communication for both inter-cluster and intra-cluster communication. LEACH therefore cannot be applied in large-area wireless sensor networks.

HEED [8] extended the basic design of LEACH, using residual energy and node density as metrics for cluster selection for power-balancing purposes. HEED operates in a multi-hop network. The clustering process at each node requires several rounds, and each round is long enough to receive messages from neighbors within the cluster. In HEED, the energy-conservation distribution prolongs the network's lifetime, thus sustaining the stability of the neighbor set. HEED is better than LEACH, which randomly selects cluster heads and which may result in the faster death of some nodes. The selected final cluster heads are well distributed in HEED, and the communication cost is minimized. However, the selection of clusters deals only with a subset of parameters that can enforce constraints on the system. These methods are therefore only suitable for prolonging the lifetime of a network, and ignore the other needs of wireless sensor networks.

In the cluster-creation period, EECS [22] finds a balancing point in energy consumption between member nodes and cluster heads, and cluster heads and the base station. This requires sufficient global knowledge about the cluster heads and the base station's distance, which can add overhead to all sensor nodes.

The purpose of GESC [5] was to extend network lifetime by uniformly distributing energy consumption through considering the localized structure of the network and the remaining energy of the neighboring nodes. According to the experimental results, the authors [5] asserted that GESC clearly improved the lifetime of the network over LEACH and HEED. In LEACH, each cluster node – and especially the cluster head – has to transmit data over a larger distance, which can result in more energy consumption. The cluster head is selected depending on the location of the source, the residual energy, and the significance of the contender, avoiding the effect of hotspots. In addition, the consumption of energy is distributed all over the sensors, because the cluster head is selected at an individual node and differs each time, extending the lifetime of a network. On the other hand, whenever a node failure occurs, all its phases will be performed, which can be the cause of large overhead.

Boregowda et al. [29] claimed that as a probable cluster head is selected in advance for the next round, it avoids fresh negotiation among sensor nodes to form new clusters. However, in each round (except for the first round), only the cluster head is selected in advance, and other sensor nodes have to negotiate to form a new cluster. This can cause an increase in the energy consumption of the sensor nodes. In addition, when the CH_ID [cluster head identification] is broadcast by the base station, each node has to compare its node ID to become the cluster head, which may take excessive time for a large network. Another limitation of this technique is that it involves excessive message exchange, which can be a reason for increased overhead. References [30] and [31] both used the *k*-mean clustering technique for cluster formation. In *k*-mean clustering, the choice of the initial-point selection is very crucial. An inappropriate choice of the initial points may result in a distorted or incorrect partition. The same is the case with clustering sensor nodes. There is thus a possibility that some clusters will get fewer nodes, and some will get a very large number of nodes. Clusters with a larger number of nodes will face inefficient routing within the cluster, and are more prone to energy dissipation.

3.2 Classification

The following is the list of attributes for the classification of clustering algorithms:

1. Existence: Clustering schemes can be grouped depending on whether cluster heads exist within the clusters.

2. Count: In some applications, the set of cluster heads is predetermined, and the number of clusters is preset. Algorithms can therefore be categorized into variable or fixed cluster-head clustering.

Ref.	CH Characteristics				Clustering Characteristics		
	Existence	Count	Selective	Role	Hops	Control Message	Over-Lapping
[7]	Yes	Variable	Random	Aggregation & Relaying	Single-hop	Yes	No
[8]	Yes	Variable	Random	Aggregation & Relaying	Multi-hop	Yes	No
[22]	Yes	Fixed	Random	Aggregation & Relaying	Single-hop	Yes	N/A
[5]	Yes	Variable	Dynamic	Aggregation & Relaying	Multi-hop	Yes	No
[29]	Yes	Fixed	Pre -Assigned	Aggregation & Relaying	Multi-hop	Yes	No
[30]	Yes	Fixed	Dynamic	Aggregation	Multi-hop	No	No
[31]	Yes	Fixed	Dynamic	Aggregation & Relaying	Multi-hop	No	No

Table 1. A comparison of clustering schemes.

3. Selectivity: Depending on whether cluster heads are pre-assigned or chosen from the deployed-node set, a clustering scheme can be grouped as Pre-assigned or Dynamic.

4. Role: In some clustering schemes, cluster heads are not responsible for relaying data to the base station, and only perform data aggregation within the cluster. In most algorithms, both of these tasks are completed by cluster heads.

5. Hops: Clustering schemes can be classified into single-hop or multi-hop, according to the hop distance between node pairs in a cluster.

6. Control message: During the process of cluster formation or maintenance, explicit clustering-related information exchange is possible between node pairs, such as routing information or data packets.

7. Overlapping: In some techniques, when sensors are scattered or not properly placed, there may exist overlapping areas among clusters and nodes.

Table 1 shows a comparison of clustering algorithms, based on attributes selected as classification criteria.

3.3 Proposed Methodology

The clustering algorithm proposed in [30] has proven to be the best technique in terms of clustering. This is because it uses the *k*-mean method, which has proven to be more effective than other clustering techniques, as the convergence in the *k*-mean takes place in a short time, and optimal clusters are obtained. In [30], the server node (SN) was also introduced. This is more powerful in terms of resources. It is responsible for cluster-head selection and for relaying data aggregated from several cluster heads to the base station.

The aim of the server node is to closely monitor the operation of sensor nodes, and to command them. The proposed architecture [30] is shown in Figure 1. With the use of a server node, there is no need for inter-cluster multi-hop communication. This is because cluster heads can directly reach the server node, which then relays data to the base station. However, for intra-cluster communication within the cluster – where data aggregation takes place and the cluster head has to collect data from member nodes – the efficient routing technique (a genetic-algorithm-based address-based shortest-path routing) discussed in [31] can be used. While using the *k*-mean clustering method, there also is no need for any message exchange between nodes for cluster-head selection, which can help in reducing overhead. The combination of these two techniques, given in [30] and [31], can result in a more energy-efficient clustering technique. It also can be scaled well for a larger network.

4. Conclusion

Clustering is the most popular approach adopted by researchers for extending sensor-network lifetime. Clustering not only plays a vital role in improving the scalability of a sensor network, but it also helps in achieving efficient routing of data within the network. By using clustering, all nodes don't have to communicate directly to the base station for data transfer. Only the cluster-head nodes of the clusters are responsible for relaying data to the base station. A server node (SN) is also employed to do this task. In this paper, some recent clustering strategies have been analyzed on the basis of some attributes. All of these techniques have their own limitations, which were addressed in the previous section. After analysis, it can be concluded that *k*-mean clustering has proven to be more efficient than other previously proposed clustering techniques, provided that an optimal value of *k* is selected. This technique also avoids excessive message exchange between nodes, which can cause overhead. There should

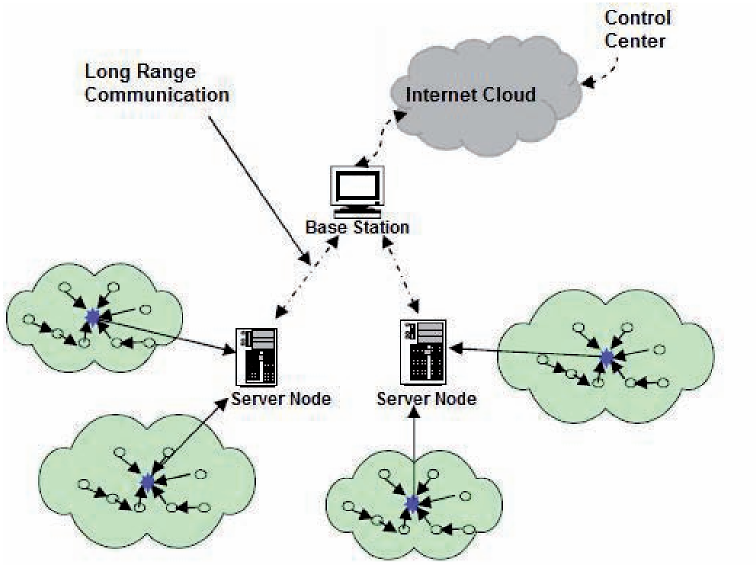


Figure 1. A wireless sensor network architecture with a server node.

be an efficient routing technique for relaying data to the base station. While clustering the topological features of the nodes in a sensor network should be taken into consideration, and small numbers of clusters should also be generated to get efficient routing within the clusters. In this way, energy dissipation can be minimized.

5. Suggestions

There are certain parameters that if taken into consideration can help in minimizing the energy consumption and extension of a network's lifetime. For a larger network, if the total distance from the sensor nodes to the base station is minimized, most of the energy can be saved. However, for a smaller network, the option can be given to the nodes that are near to the base station for them to send data directly to the base station. Moreover, in networks with a larger number of spread nodes, if the distance among the member nodes and cluster head is minimized, energy consumption can be reduced. If we therefore keep the cluster smaller in size, we can reduce the energy dissipation. For this purpose, some threshold can be used such that the number of nodes in the cluster should not exceed that threshold. Alternatively, after clustering, we can check to see if any cluster has a larger number of nodes than the threshold. If so, that specific cluster can be re-clustered to get smaller clusters.

In [29], the algorithm energy level was determined by the base station in the first round. Having cluster heads be regular nodes is unsuitable, because the cluster nodes are responsible for the aggregating and relaying of data, and have more power consumption. A change could therefore be made in this algorithm such that the base station would decide the energy level of the cluster heads after their selection, and these can be given more energy than other nodes. This may increase the lifetime of the network.

6. References

1. http://en.wikipedia.org/wiki/ Wireless_sensor_network.

2. S. Raghuwanshi and A. Mishra, "A Self-Adaptive Clustering Based Algorithm for Increased Energy-Efficiencyand Scalability in Wireless Sensor Networks," Proceedings of the IEEE 58th Conference on Vehicular Technology, **5**, October 2003, pp. 2921-2925.

3. Ameer Ahmad Abbasi and Mohamed Younis, "A Survey on Clustering Algorithms for Wireless Sensor Networks," *Computer Communications*, **30**, 14-15, October 15, 2007, pp. 2826-2841.

4. G. Huang, X. Li, and J. He, "Energy-Efficiency Analysis of Cluster-Based Routing Protocols in Wireless Sensor NetWorks," IEEE Aerospace Conference, March 2006.

5. N. Dimokas, D. Katsaros, and Y. Manolopoulos, "Energy-Efficient Distributed Clustering in Wireless Sensor Networks," *J. Parall. Distrib. Comput.*, **70**, 2010, pp. 371-383.

6. C. Jiang, D. Yuan, and Y. Zhao, "Towards Clustering Algorithms in Wireless Sensor Networks – A Survey," Proceedings of the IEEE Wireless Communications and Networking Conference Budapest, Hungary, April 2009.

7. W. B. Heinzelman, A. P. Chandrakasan, and H. Balakrishnan, "An Application-Specific Protocol Architecture for Wireless Microsensor Networks," *IEEE Transactions on Wireless Communications*, **1**, 4, 2002, pp. 660-670.

8. O. Younis and S. Fahmy, "HEED: A Hybrid, Energy-Efficient, Distributed Clustering Approach for Ad Hoc Sensor Networks," *IEEE Transactions on Mobile Computing*, **3**, 4, 2004, pp. 366-379.

9. S. Basagni, M. Mastrogiovanni, A. Panconesi, and C. Petrioli, "Localized Protocols for Ad Hoc Clustering and Backbone Formation: A Performance Comparison," *IEEE Transactions on Parallel and Distributed Systems*, **17**, 4, 2006, pp. 292-306.

10. B. Chen, K. Jamieson, H. Balakrishnan, and R. Morris, "SPAN: An Energy Efficient Coordination Algorithm for Topology Maintenance in Ad Hoc Networks," *Wireless Networks*, **8**, 5, 2002, pp. 481-494.

11. S. Basagni, "Distributed Clustering for Ad Hoc Networks," Proceedings of the International Symposium on Parallel Architectures, Algorithms and Networks, I-SPAN, 1999, pp. 310-315.

12. M. Chatterjee, S. K. Das, and D. Turgut, "WCA: A Weighted Clustering Algorithm for Mobile Ad Hoc Networks," *Cluster Computing*, **5**, 2, 2002, pp. 193-204.

13. O. Younis and S. Fahmy, "Distributed Clustering in Ad-Hoc Sensor Networks: A Hybrid, Energy-Efficient Approach," Proceedings of IEEE INFOCOM, March 2004; an extended version appeared in *IEEE Transactions on Mobile Computing*, **3**, 4, October-December, 2004.

14. A. D. Amis, R. Prakash, T. H. P. Vuong, and D. T. Huynh, "Max-Min D-Cluster Formation in Wireless ad Hoc Networks," Proceedings of the Annual Joint Conference of the IEEE Computer and Communications Societies, INFOCOM, **1**, 2000, pp. 32-41.

15. J. Wu and H. Li, "A Dominating-Set-Based Routing Scheme in Ad Hoc Wireless Networks," *Telecommunication Systems*, **18**, 1-3, 2001. pp. 13-36.

16. I. Stojmenovic, M. Seddigh, and J. Zunic, "Dominating Sets and Neighbor Elimination-Based Broadcasting Algorithms in Wireless Networks," *IEEE Transactions on Parallel and Distributed Systems*, **13**, 1, 2002, pp. 14-25.

17. A. Qayyum, L. Viennot, and A. Laouiti, "Multipoint Relaying: An Efficient Technique for Flooding in Mobile Wireless Networks," Technical Report 3898, INRIA, March 2000.

18. S. Bandyopadhyay and E. Coyle, "An Energy-Efficient Hierarchical Clustering Algorithm for Wireless Sensor Networks," Proceedings of the Annual Joint Conference of the IEEE Computer and Communications Societies, INFOCOM, **3**, 2003, pp. 1713-1723.

19. J. Chang and L. Tassiulas, "Energy Conserving Routing in Wireless Ad Hoc Networks," Proceedings of the Annual Joint Conference of the IEEE Computer and Communications Societies, INFOCOM, **1**, 2000, pp. 22-31.

20. D. Estrin, R. Govindan, J. Heidemann, and S. Kumar, "Next Century Challenges: Scalable Coordination in Sensor Networks," Proceedings of the ACM/IEEE International Conference on Mobile Computing and Networking, MOBICOM, 1999.

21. L. Buttyan and P. Schaffer, "PANEL: Position-Based Aggregator Node Election in Wireless Sensor Networks," Proceedings of the IEEE International Conference on Mobile Ad hoc and Sensor Systems, MASS, 2007, pp. 1-9.

22. M. Ye, C. Li, G. Chen, and J. Wu, "An Energy Efficient Clustering Scheme in Wireless Sensor Networks," *Ad Hoc and Sensor Wireless Networks*, **3**, 2006, pp. 99-119.

23. C. Liu, K. Wu, and J. Pei, "An Energy-Efficient Data Collection Framework for Wireless Sensor Networks by Exploiting Spatiotemporal Correlation," *IEEE Transactions on Parallel and Distributed Systems*, **18**, 7, 2007, pp. 1010-1023.

24. A. Youssef, M. Younis, M. Youssef, and A. Agrawala, "Distributed Formation of Overlapping Multi-Hop Clusters in Wireless Sensor Networks," Proceedings of the 49th Annual IEEE Global Communication Conference, Globecom, 2006, pp. 1-6.

25. O. Younis, M. Krunz, and S. Ramasubramanian, "Node Clustering in Wireless Sensor Networks: Recent Developments and Deployment Challenges," *IEEE Network*, **20**, 3, 2006, pp. 20-25.

26. M. Younis and K. Akkaya, "Strategies and Techniques for Node Placement in Wireless Sensor Networks," *Ad Hoc Networks*, no. doi:10.1016/j.adhoc.2007.05.003, 2007.

27. B. Baranidharan and B. Shanthi, "A Survey on Energy Efficient Protocols for Wireless Sensor Networks," *International Journal of Computer Applications*, (0975 – 8887), **11**, 10, December 2010.

28. Shilpa Mahajan and Jyoteesh Malhotra, "Energy Efficient Control Strategies in Heterogeneous Wireless Sensor Networks: A Survey," *International Journal of Computer Applications*, (0975 – 8887), **14**, 6, February 2011.

29. S. B. Boregowda, A. R. Hemanth Kumar, N. V. Babu, C. Puttamadappa, and H. S. Mruthyunjaya, "UDCA: An Energy Efficient Clustering Algorithm for Wireless Sensor Network," *World Academy of Science, Engineering and Technology*, **70**, 2010.

30. A. Khan, A. Abdullah, and N. Hasan, "Maximizing Lifetime of Homogeneous Wireless Sensor Network through Energy Efficient Clustering Method," *International Journal of Computer Science and Security*, **3**, 6, 2010.

31. R. Nallusamy, K. Duraiswamy, and D. Ayya Muthukumar, "Energy Efficient Clustering and Shortest Path Routing in Wireless Ad Hoc Sensor Networks (WASN) using Approximation Algorithms," *Journal of Mathematics and Technology*, February, 2010, ISSN: 2078-0257.

The Peteroa Lightning Monitoring Network, Part 1 : Planning

F.M. Bonomi
M.A. Cabrera
J.E. Ise
J. Cangemi
J. Ruzzante

Abstract

There is an increasing interest within the international scientific community in the study of volcanic lightning. Our Laboratorio de Telecomunicaciones, in cooperation with the Argentinean branch of the International Center for Earth Sciences (ICES), is planning to deploy a prototype of a low-cost wireless sensor network for continuous real-time monitoring of lightning activity at the Peteroa active volcano, located close to Malargüe city in Argentina, in the summer of 2012. This work deals with the prototype wireless sensor network design, and sensor deployment plans according to the topographic characteristics in the vicinity of the volcano. The complete description of the final network and the results obtained will be given in the second part of the paper, planned for next year.

1. Introduction

Lightning detection is widespread, with several successful commercial and governmental solutions in existence. In the late 1990s, a team at the New Mexico Institute of Mining Technology developed a lightning mapping array (LMA). It operates in the VHF band, with time-of-arrival-based localization [1]. In the past decade, the University of Munich developed a lightning detection network, operating in the VLF band (LINET). It uses a time-of-arrival-based localization algorithm, capable of discriminating between cloud-ground and inter-cloud discharges [2]. Also in the last decade, a team based at the University of Washington initiated a project to map lightning activity on a global scale, the World Wide Lightning Location Network (WWLLN). Capable of reaching worldwide coverage with a reduced number of sensors, it operates in the VLF band, using a time-of-group-arrival localization algorithm [3, 4]. It currently has over 50 sensors.

However, close-range monitoring of volcanic lightning is still in the experimental stages. Studies are being conducted by a team lead by Dr. Ron Thomas from the New Mexico Institute of Mining Technology. This uses a lightning mapping array deployed prior to eruptions to generate highly detailed maps of lightning activity in the volcanic plume [5, 6].

The Peteroa active volcano (latitude 35° 14’ 24” S, longitude 70° 34’ 12” W) sits on the Argentina-Chilean border at a distance of approximately 90 km from Malargüe, Mendoza, Argentina. The volcano is being monitored by several methods, including seismic sensors, gas sensors, cameras, and satellite-based images. Our intention is to add lightning monitoring to the existing sensor base by deploying a wireless sensor network. To eliminate the need for GPS-based timing, we will use a direction-of-arrival-based location algorithm, with sensors located in close proximity to each other (near 2 km). The ultimate goal is to obtain inexpensive and low-power sensors to be employed in dense networks that can remain unattended for long periods.

The immediate goal is to assess the performance of the proposed approach. A small scale deployment comprising three sensors and a sink node is scheduled for January 2012. With the knowledge gained in this first experiment, a full-scale deployment will be planned.

2. Lightning Detection

Lightning will be detected by sensing the VLF portion of its RF-emission spectrum. Each sensing node will detect the electric and magnetic components of the discharge’s electromagnetic field (by using antennas), and estimate the direction of arrival.

Fernando Miranda Bonomi, M. A. Cabrera, J. E. Ise, and J. Cangemi are with the Laboratorio de Telecomunicaciones, Dpto. de Electricidad, Electrónica y Computación, Facultad de Ciencias Exactas y Tecnología, Universidad Nacional de Tucumán. Argentina; e-mail: fambonomi@gmail.com. J. Ruzzante is with the International Center for Earth Sciences, Malargüe, Argentina.

This is een invited paper for the Special Section on ‘Wireless Sensor Networks’

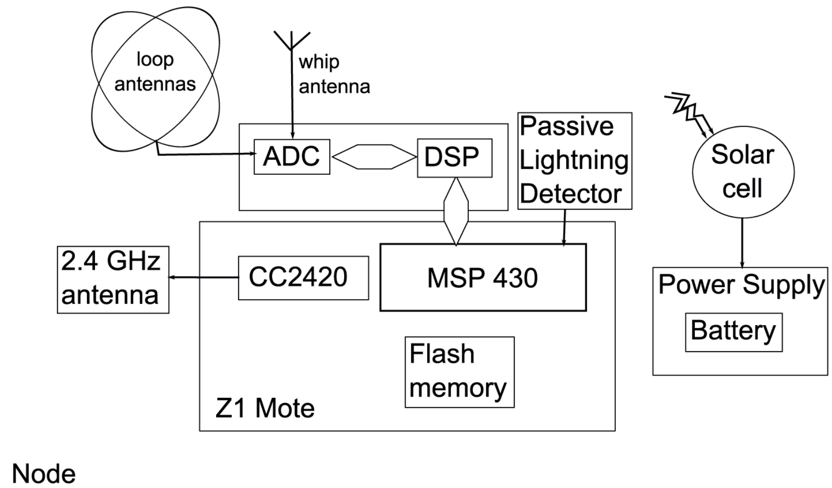


Figure 1. A block diagram for a node of the wireless sensor network.

Loop antennas will be employed for magnetic-component sensing, and whip antennas will be used for electric-component sensing. The signals will be processed within the nodes to identify lightning occurrence, and to estimate the direction of arrival. The discharge can be localized from the estimated directions of arrival at several nodes.

We are currently developing the prototypes for hardware and software for the sensor network. The information conveyed here is preliminary, based on the current status of the development process.

3. Wireless Sensors

Figure 1 depicts the block diagram of a node, based on the Zolertia Z1 mote. It is composed of an IEEE 802.15.4 transceiver; a low-power microcontroller running the *Contiki* operating system; a digital-signal-processor-based VLF-band lightning, detector capable of direction-of-arrival estimation; solar-cell-based energy harvesting; and a passive lightning detector.

Figure 2. The Peteroa volcano (photograph by Cristian Ordenes).

When a node detects lightning, it will transmit the time of detection and the estimated direction of arrival. The transmitted data volume is estimated to be 24 bytes per event. A sink node – consisting of a sensor node attached to an embedded computer with a Wi-Fi network connection – will run the localization algorithm, and locally store and transmit the results.

The main sensing system shuts down in order to save energy when no discharges are detected in a predefined time window. The passive sensor will remain operational to detect new lightning activity. When the passive sensor detects activity, the main sensor is powered up. This allows for low standby power, reducing solar-cell and battery requirements. The estimated average power requirement is 150 mW when lightning monitoring is in progress, and around 1 mW when waiting.

The worst-case average monthly insolation for the area of installation is three sun-hours per day, and the maximum equivalent number of no-sun days is 10 [7]. Valve-regulated lead-acid batteries will be employed, due to their low cost, low maintenance requirements, and ability to charge at temperatures below 0º C. The nodes will use 6 V 10 Ah batteries (allowing for a maximum discharge of 30%, with the sensors being active 50% of the no-sun time). A 3 Wp solar panel will be used for energy harvesting. For the worst monthly average irradiation, it will be able to provide over two times the energy requirements for 24 hours of full-power operation.

The sink node is formed from a single-board computer, a wireless sensor node, and a Wi-Fi/Ethernet bridge. The estimated power consumption is 4.0 to 4.5 W maximum, 1.0 to 1.5 W with the Wi-Fi bridge off, and around 8 mW in standby with the Wi-Fi off. To estimate energy needs, the power consumption was considered to be 4 W for 50% of the time. The sink node will have a 12 V 120 Ah battery, and a 50 Wp solar panel.

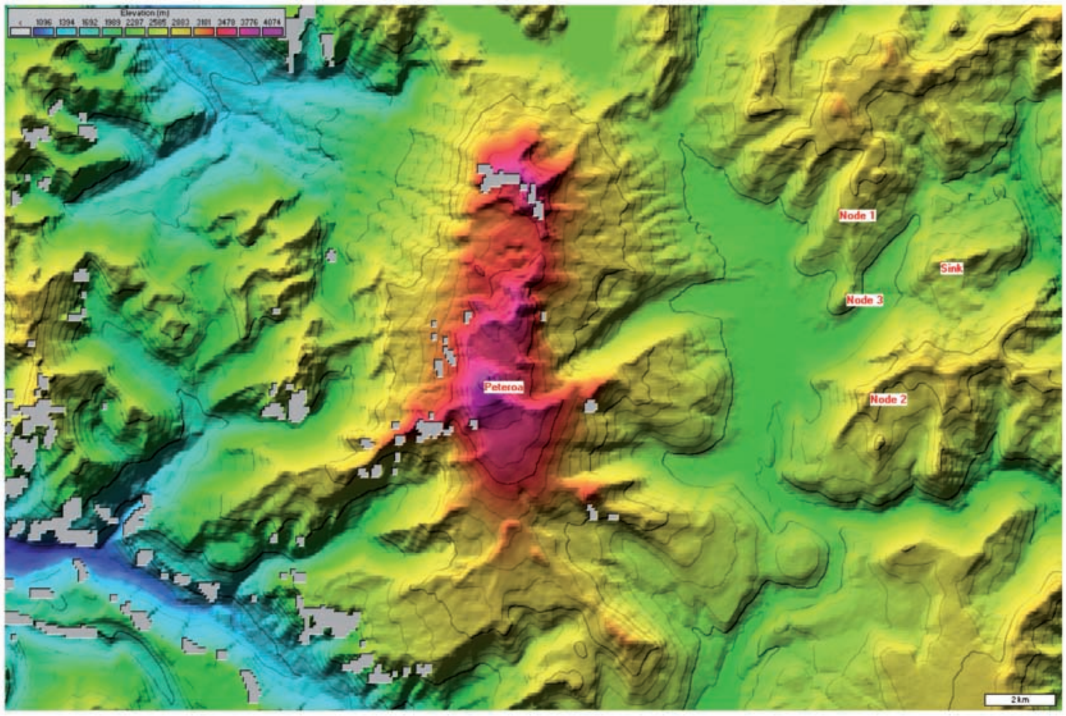


Figure 3. The preliminary node placement.

Thermoelectric devices are being considered as an alternative or complement to solar cells. The power output is lower, but thermoelectric devices can collect energy during the night, and aren't exposed to the elements the way solar cells are.

4. Network Location

Figure 2 shows a picture of the Peteroa volcano. The sensors will be placed on nearby mountains, with direct line-of-sight to the volcano.

Figure 3 shows a proposed sensor placement. The elevation data is from the Shuttle radar topography mission, dataset version 2. The blanks are due to missing data in the dataset. The nodes are marked 1, 2, and 3; the sink node is marked "sink" in the figure. The distances from node 3 (in the center of the network) and nodes 1, 2, and sink are 2.4 km, 2.8 km, and 2.8 km, respectively. Node 3 will access the sink directly; nodes 1 and 2 will access the sink through node 3. The sink node will be connected to the Internet via a long-distance Wi-Fi link.

Due to the lack of infrastructure, the sensors must be self-sufficient in terms of energy supply. Each sensor will be equipped with a solar panel and gel-cell batteries.

The main difficulty in the installation is the lack of access to the location. There is a camp at the base of the Peteroa volcano, but vehicle access is only viable in summer, due to snow and low temperatures. The sensors will be located at altitudes from 2600 m to 3100 m above sea level, between 200 m and 600 m higher than the mentioned camp.

A low-cost long-distance Wi-Fi link will connect the sink node to the Internet. The sink node will be responsible for running the localization algorithm, keeping local data storage and transmitting the results to a server for backup and distribution.

5. Conclusions

Wireless sensor networks are a promising technology for environmental monitoring. We intend to apply the technology to monitor lightning activity over the Peteroa active volcano. In January 2012, we will deploy our first prototype network. In time, we hope wireless sensor networks become an important tool in the volcanologist's toolkit.

6. References

1. W. Rison, R. Thomas, P. Krehbiel, T. Hamlin, and J. Harlin, "A GPS-Based Three-Dimensional Lightning Mapping System: Initial Observations in Central New Mexico," *Geophys. Res. Lett.*, **26**, 23, 1999, pp. 3573-3576.

2. H. Betz, K. Schmidt, P. Oettinger, and M. Wirz, "Lightning Detection with 3-D Discrimination of Intracloud and Cloud-to-Ground Discharges," *Geophys. Res. Lett.*, **31**, 11, 2004, p. L11108.

3. R. L. Dowden, J. B. Brundell, and C. J. Rodger, "VLF Lightning Location by Time of Group Arrival (TOGA) at Multiple Sites," *Journal of Atmospheric and Solar-Terrestrial Physics*, **64**, 7, 2002, pp. 817-830.

4. C. J. Rodger, J. B. Brundell, R. H. Holzworth, and E. H. Lay, "Growing Detection Efficiency of the World Wide Lightning Location Network," American Institute of Physics Conference Proceedings, Coupling of Thunderstorms and Lightning Discharges to Near-Earth Space: Proceedings of the Workshop, Corte, France, 2008.

5. R. Thomas, P. R. Krehbiel, W. Rison, H. E. Edens, G. D. Aulich, W. P. Winn, S. R. McNutt, G. Tytgat, and E. Clark, "Electrical Activity During the 2006 Mount St. Augustine Volcanic Eruptions," *Science*, **315**, 5815, February 23, 2007, p. 1097.

6. "Lightning Mapping Observations of the Mt. Redoubt, Alaska Volcanic Eruptions," available online: http://lightning.nmt.edu/redoubt/.

7. NASA Langley Research Center, "Surface Meteorology and Solar Energy (SSE)," available online: http://eosweb.larc.nasa.gov/sse/.

8. H. D. Betz, U. Schumann, and P. Laroche (eds.), *Lightning: Principles, Instruments and Applications*, New York, Springer, 2009.

9. C. Gómes, J. Paradells, and J. E. Caballero, *Sensors Everywhere: Wireless Network Technologies and Solutions*, Fundación Vodafone, 2010.

Long-Distance, Low-Cost Wireless Data Transmission

E. Pietrosemoli

Abstract

802.11 Wi-Fi technology is commonly used for creating wireless networks with a range of about one hundred meters. With careful planning, external antennas, and modifications to the medium access protocol, the same equipment can be used to make point-to-multipoint links of tens of kilometers, and point-to-point links in the range of hundred of kilometers. This paper presents some experiments at distances of up to 382 km that were performed in Venezuela from April 2006 to July 2007, as well as an affordable instrument setup for long-distance antenna alignment. These experiments paved the way for practical applications in a network to provide connectivity among five of the Galapagos Islands in Ecuador, and in another network built to connect several hospitals to the College of Medicine at the University of Malawi.

1. Introduction

For developing countries, wireless allows leapfrogging over the traditional telecommunications infrastructure. This has been proven in many countries of Africa and Latin America, where the number of mobile phones has greatly surpassed the number of land lines. Although fiber optics offers much greater bandwidth, and satellite systems are unsurpassed for unidirectional broadcast services, neither can compete with land-based radio from a cost perspective for two-way applications.

Furthermore, both fiber-optic and satellite systems require large up-front investments and considerable expertise to properly maintain them. This means that they can only be deployed by large organizations with deep pockets that can wait several years before recovering their investments. On the other hand, terrestrial microwave systems are less capital intensive. The investment is gradual as the network gracefully grows, and can be deployed by smaller organizations and even local communities.

Since the early 1990s [1-3], we have been experimenting with means for providing Internet access through wireless technology, first using packet radio, and later with spread-spectrum techniques, in Mérida, Venezuela. These efforts led to the deployment of a wireless network that spans most of the state of Mérida. This was honored by the organizers of SuperComm 1998 in Atlanta, Georgia, with the SuperQuest Award in the Remote Access category.

With the development of the IEEE 802.11 standard, the cost of wireless data transmission for short distances plummeted. Many people around the world started using devices based on this technology for long-distance communications. By overlaying VoIP (voice over IP) on these networks, telephony services can also be offered in rural or underserved urban areas at a fraction of the cost of wired services. Furthermore, these technologies can be installed by a grassroots community with a moderate amount of technical skills.

For instance, Wi-Fi, the sobriquet for 802.11-standard-based devices, was used by a group of American radio amateurs to demonstrate transmission at a distance of 125 miles in 2004 [4]. Thanks to a favorable topography, Venezuela already had some long-range WLAN links. Since 2001, Fundacite Mérida has operated a 70 km link between Pico Espejo and Canaguà [5]. To test the extreme possibilities of long-distance WLAN, we have successfully used inexpensive Wi-Fi equipment to establish links of 279 km and 382 km. A successful example of the application of these technologies is the network built to provide connectivity to five Islands in the Galapagos archipelago.

2. Connecting Beautiful Islands

In 2007, an international tender offer to design a wireless network for the interconnection of several islands in the Galapagos was issued, and our proposal was selected. The project goals were:

1. Provide data and voice service to the Galapagos Islands organizations that are in charge of protecting the ecosystem in a cost-effective way.

2. Minimize the environmental impact of the structures to be built.

Ermanno Pietrosemoli is with the Abdus Salam International Centre for Theoretical Physics, Trieste, Italy, and the Fundación Escuela Latinoamericana de Redes; e-mail: ermanno@gmail.com, http://www.EsLaRed.org.ve.

This is een invited paper for the Special Section on 'Wireless Sensor Networks'

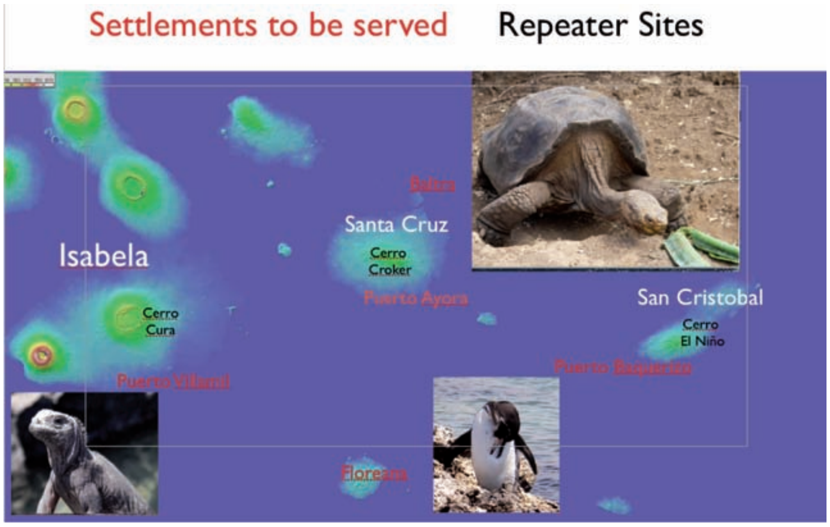


Figure 1. The Galapagos Islands wireless nodes.

3. Minimize the power requirements of the equipment to be deployed.

The sites to be served were:

- Puerto Ayora in Santa Cruz Island
- Airport in Baltra Island
- Puerto Baquerizo Moreno in San Cristobal Island
- Puerto Villamil in Isabela Island
- Port at Floreana Island

Since all these locations were at about sea level, numerous simulations were performed using digital elevation maps to assess the possibilities of several possible repeater locations at high altitudes (favoring existing infrastructure already in place to minimize cost and environmental impact). This led to the identification of some interesting spots, including:

- Cerro Croker in Santa Cruz Island, has visibility to each of the sites.
- El Cura in Isabela Island, has visibility to Baltra, Puerto Ayora and Floreana.
- Cerro El Niño in San Cristobal Island, has visibility towards Baltra, Puerto Ayora, and Puerto Baquerizo Moreno.

Figure 1 shows the layout of all the nodes.

During a trip to the islands, a site survey was performed at each of the locations to be served, and also at prospective repeater sites. This was done to ascertain the existence of line of sight, and to measure the spectrum occupancy in both unlicensed bands at 2.4 and 5 GHz. An environmental impact assessment was also performed by a team of scientists led by Prof. Miguel Acevedo Luciani from the University of Northern Texas.

The next step was installing temporary links to test the feasibility of the proposed solution, measuring the throughput and packet loss. Armed with these data, we proceeded to write up the RFP [request for proposal] for the international bidding process to install the system, which was later built by an Ecuadorian firm [6]. Because all the links were mostly over water, there was concern about fading due to reflections. This was addressed by designing

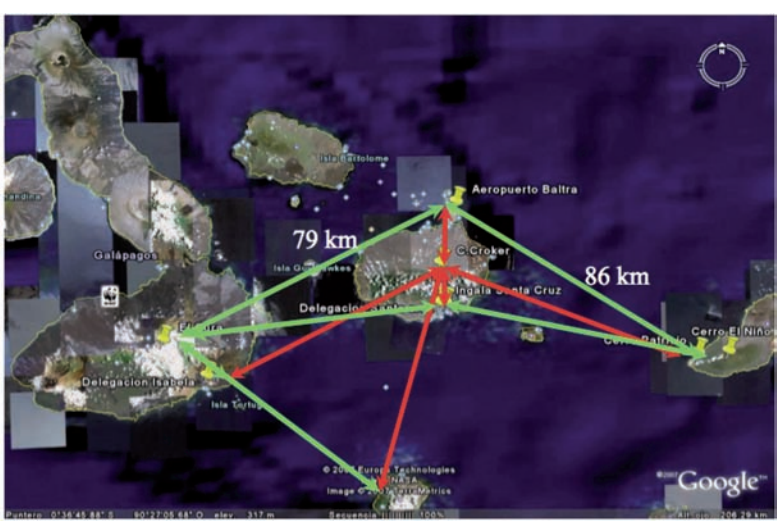


Figure 2. The Galapagos Islands: radial network in red, peripheral links in green.

a redundant network, formed by two topologies: a radial network with the hub at Cerro Croker, and peripheral links from El Cura and Cerro El Niño that provided at least two completely independent paths to each location. The central links radiated from Cerro Croker. At 1800 m altitude, this was the highest spot in Santa Cruz, the most populated island. It was centrally located to the area to be served, providing a clear line of sight to each of the sites that were essentially at sea level. The peripheral links took advantage of additional elevated spots in Isabela (Cerro Cura) and San Cristobal (Cerro El Niño) that provided line of sight and clearance of the first Fresnel zone among Isabela, Puerto Ayora, Baltra, and Floreana, as well as between San Cristobal to Baltra and Puerto Ayora. In this way, each site was served at least by two completely independent links, as seen in Figure 2. The network was later built by another organization, and is now also offering free Wi-Fi in the five islands [7].

3. Linking Health-Maintaining Organizations in Malawi

Some participants in the yearly wireless training activity held at ICTP since 1996 [8] showed great interest in establishing a wireless network in their home institution. The goal was to install a modern communication network to support health provisioning in hospitals and universities in Southern Malawi. After assessing the performance of different long-distance solutions, the Mikrotik [9] solution was chosen. This was because of the proven records of several installations in many countries, at distances of tens of kilometers.

To improve reliability, a completely redundant backbone was planned, each link with eight radios (four at each end), four antennas with dual-polarization feeds (equivalent to four vertical- plus four horizontal-polarization antennas in each link). The radios were installed into four wireless routers (two radios per router) running the Nstreme dual [10] protocol, and housed in weather-resistant enclosures. This provided two independent transmission paths, one with each polarization, served by two simultaneous transmitters and receivers at each end. FDD (frequency-diversity duplexing) was used instead of the TDD (time-division duplexing) specified by the IEEE 802.11 standard. This redundancy was affordable, thanks to the reasonable cost of the mass-produced radios and routers. This has also created a greater demand for antennas, thereby reducing their cost, as well.

On the other hand, for the access network – where one can sacrifice throughput in return for a more-favorable price – we chose to use Ubiquiti Networks Power Stations [11]. These wireless routers were available in both the 2.4 and 5 GHz band. They were housed in an outdoor enclosure with an integrated antenna. This made them very convenient for installation either in towers or in slim masts, given that they were lightweight and offered little wind load. They could be flashed with third-party *Linux*-based software, and could be configured as base station, client, or bridge. All of this was in a device that was very competitively priced. They were IEEE 802.11 compliant, and therefore offered up to 54 Mbps, and were rated at ranges of up to 50 km.

3.1 Network Planning

The most important tool for planning a wireless network is a set of elevation maps of the areas to be served. This is needed to establish the feasibility of any proposed link. Since 1998, we have been using *Radio Mobile* [12]. This is a program built by Roger Coudé that is freely available and makes use of several kinds of digital elevation maps, most notably the maps gathered by the Shuttle Radar Topography Mission (SRTM). These maps cover most of the world with a resolution of three arc sec (about 90 m, worst case) and are very useful for planning long-distance links. Recently, even better resolution digital elevation

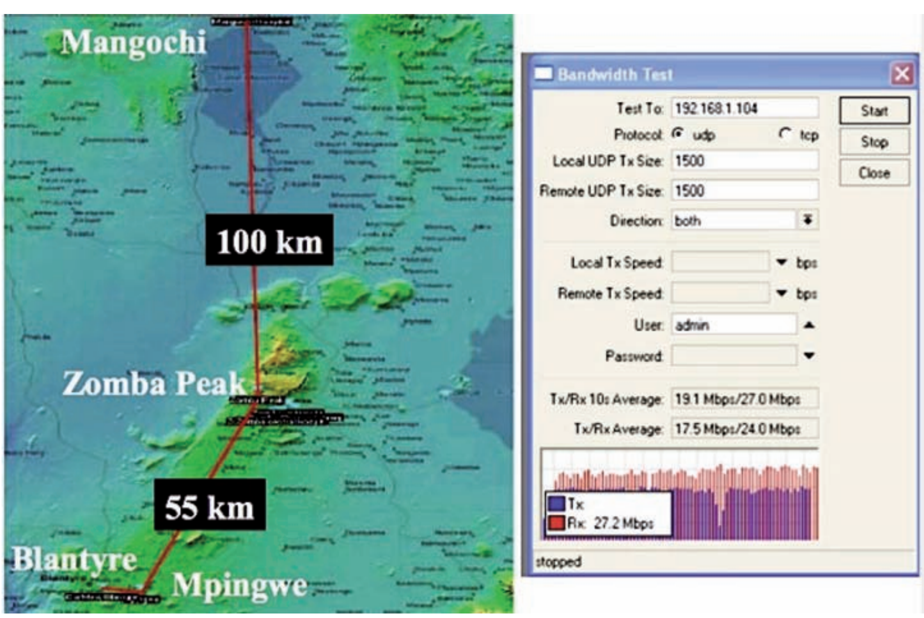


Figure 3. The Malawi backbone layout and performance test.

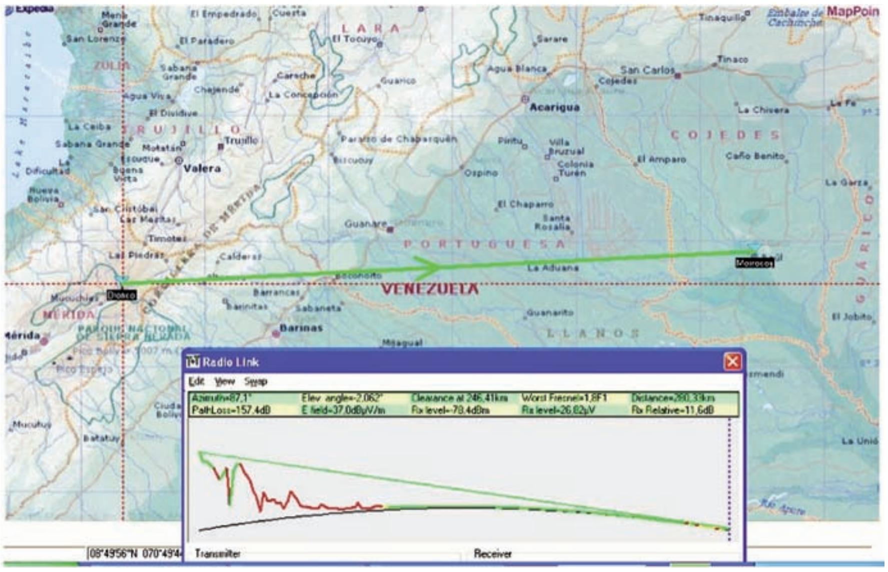


Figure 4. The layout and profile of the 280 km link between Pico del Aguila and Cerro Morrocoy in El Baul.

maps have become available through the ASTER Global Digital Elevation Model (ASTER GDEM) [13], a joint product developed and made available to the public by the Ministry of Economy, Trade, and Industry (METI) of Japan and the United States National Aeronautics and Space Administration (NASA). Of course, the maps cannot provide information about buildings or other structures beyond the nominal resolution, so a site survey is always required to ascertain the viability of a proposed link. *Radio Mobile* uses the Longley-Rice model to predict propagation losses, and we have confirmed good agreement with experimental results. The program calculates the Fresnel-zone clearance and estimates the received signal power, making it easy to assess the effect of different antenna gains and heights.

Using this program, we investigated different alternatives for the backbone layout between the College of Medicine in Blantyre and the Hospital at Mangochi, with an intermediate base station to provide service to different institutions in the city of Zomba.

Zomba Peak, at 2000 m above sea level, is an obvious choice for both the base station to provide service to Zomba city, and also as a repeater point to Mangochi, 100 km away. Although previous attempts to link Zomba Peak with Mangochi were reportedly not successful, after the site survey we were confident that this link would work. We were also confident that the alternative of using two extra repeater points in Ulongwe and Ntaja was not needed. Since Zomba Peak was not visible from the College of Medicine (CoM) in Blantyre, a repeater point was required on the hill of Mpingwe, 7 km east of the College of Medicine and 55 km south from Zomba peak. The end-to-end throughput over the 167 km backbone with two repeater sites was about 40 Mbps, as shown in Figure 3. This was enough to cover the demands of data transfer, VoIP, and medical videoconference among the different sites [14].

In November 2010, maintenance and upgrading of the backbone allowed the network to be used to provide malaria early warnings, based on climate forecasts that could be used to timely deploy preventive measures, as part of the QWeCI FP7 project of the European Commission [15].

The network is being maintained and extended by faculty of the University of Malawi, which has received extensive training at ICTP. During 2011, they were able to extend coverage to St. Martin's Hospital, about 20 km north of Mangochi, and are actively pursuing the coverage of other sites.

The previous deployments were possible thanks to the experience gained through a series of field experiments conducted in Venezuela since 1992. These gave us confidence on the use of low-cost spread-spectrum equipment for long-distance applications [16].

3.2 Long-Distance Trials

To test the limits of a wireless microwave link, it is necessary to find a path with an unobstructed line-of-sight and a clearance of at least 60% of the first Fresnel zone. As the distance between sites increases, the curvature of the Earth becomes a serious obstacle, requiring a higher elevation, at least at one end. Installation on towers or other tall structures is the standard procedure, and the longest-distance links are only possible from high elevations.

When searching for a suitable terrain in Venezuela, with high elevation at the ends and low ground in between, we first focused on the Guayana region. Although plenty of high grounds were to be found – in particular the famous "tepuys" (tall mesas with steep walls) – there were always obstacles in the middle ground. Our attention then shifted to the Andes, the steep slopes of which (rising abruptly from the plains) proved adequate to our requirements. Pico del Aguila had an altitude of 4200 meters and it was a two-hour drive from Mérida. It had clear line-of-sight to the town of El Baúl, in Cojedes State. Using *Radio Mobile*, we found that there was no obstruction on the first Fresnel zone between Pico del Aguila and El Baúl (Figure 4).

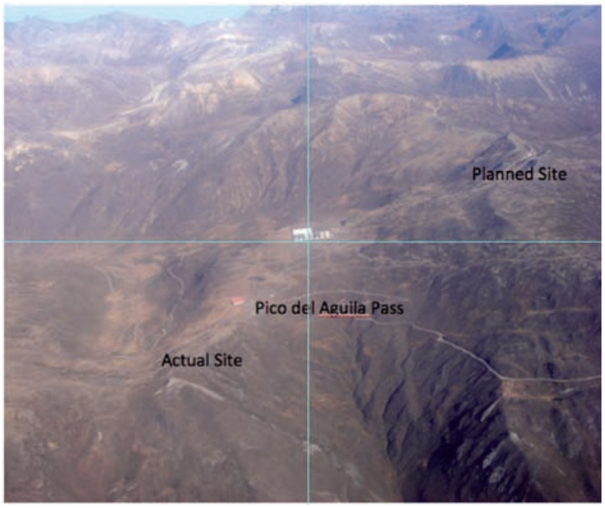


Figure 5. An aerial view of Pico del Aguila in Venezuela.

3.3 Hardware Specifications

Once satisfied with the existence of a suitable trajectory, we looked at the equipment needed to achieve our goal of creating a long-distance link. Up to this point, we had been using Orinoco cards for a number of years. Sporting an output power of 15 dBm and a receiver sensitivity of −84 dBm at 11 Mbps, they were robust and trustworthy. The free-space loss at 282 km was 149 dB, so we would need 30 dBi antennas at both ends, and even that would leave very little margin for other losses.

On the other hand, the popular Linksys WRT54G [17] wireless routers can run *Linux*. The open-source community has written several firmware versions for this router that allow for a complete customization of every transmission parameter. In particular, the *OpenWRT* firmware [18] allows for the adjustment of the acknowledgment time of the MAC layer, as well as the output power. Another piece of firmware, called *DD-WRT* [19], has a graphical user interface (GUI) and a very convenient site-survey utility. Furthermore, the Linksys unit could be located closer to the antenna than a laptop, so we decided to use a pair of them. One was configured as an AP (access point), and the other as a client .


Figure 6. Testing antennas to be deployed at both ends of the link.

The WRT54G could operate at 100 mW output power with good linearity, and could even be pushed up to 200 mW. However, at this value, nonlinearity was very severe and spurious signals were generated, which should be avoided. Although this was consumer-grade equipment and quite inexpensive, after years of using it, we felt confident that it could serve our purpose. Of course, we kept a spare set handy, just in case. By setting the output power to 100 mW (20 dBm), we could obtain a 5 dB power-budget advantage compared to the Orinoco card. We therefore settled for a pair of WRT54Gs as our preferred option for making this link.

3.4 Site Survey

On January 15, 2006, a visit to Pico Águila was carried out to inspect the site that Radio Mobile had reported as suitable. The azimuth towards El Baúl is 86°, but since the magnetic declination is 8° 16’, the antenna would need to be pointed to a magnetic bearing of 94°.

Unfortunately, line of sight was obstructed by an obstacle in the 94° direction that had not been shown by the software, due to the limited resolution of the freely available digital elevation maps which is of 90 m at this latitude. After several hours examining the surrounding area, a more suitable location clear of obstacles was identified, south of the main road and a few kilometers from the originally planned site (Figure 5).

3.5 Antenna Selection

High-gain antennas for the 2.4 GHz band were not available in Venezuela. As importation costs were considerable, we decided instead to recycle a pair of parabolic reflectors (formerly used for satellite service), and replaced the feed with one designed for 2.4 GHz. We tried a 2.4 meter reflector with an offset feed. This offered ample gain, albeit with some difficulties in the aiming of the 3.5° beam. The 22.5° offset meant that the dish appeared to be pointing downwards when it was horizontally aligned, as can be seen in Figure 6. The other antenna was center fed, and had a 2.75 m meshed reflector.

Several tests were performed using various cantennas (a homemade antenna built with a can) and a 12 dBi Yagi-Uda as a feed. The antennas were pointed at a base station of the university wireless network that was located 11 km away on a 3450 m high mountain. We were able to establish a link with the base station at La Aguada, but our efforts to measure the gain of the setup using *Netstumbler* (a popular program that reports the strength of the received Wi-Fi

Figure 7. Geographic compared to magnetic north at El Baúl.

signal) were not successful. There was too much fluctuation on the received power values of live traffic. For a meaningful measurement of the gain, we needed a signal generator and a spectrum analyzer. These instruments were also required for the field trip, in order to properly align the antennas.

In February 2006, during a visit to Trieste, Italy, to partake in the annual wireless training event we have been attending since 1996 [8], the project was discussed with Carlo Fonda, who was immediately thrilled and eager to participate. The collaboration between the Latin American Networking School (EsLaRed) and the Abdus Salam International Centre for Theoretical Physics (ICTP) in the wireless field goes back to 1992, when the first Networking School was held in Mérida with ICTP support. Since then, several activities in which members of both institutions have participated have taken place, notably the yearly training in wireless networking at ICTP, and the activities dedicated to computer networks in general, organized by EsLaRed in several countries of Latin America [20]. Accordingly, it was not difficult to persuade Prof. Sandro Radicella, the head of the Aeronomy and Radio Propagation Laboratory at ICTP, to support Carlo Fonda's trip in early April to Venezuela in order to participate in the experiment.

Back home, we found a 2.75 m parabolic central-fed antenna at a neighbor's house. Mr. Ismael Santos graciously lent his antenna for the experiment. After dismounting and reassembling the parabolic-mesh dish, we changed the feed for one that worked at 2.4 GHz, and trained the antenna to a signal generator. With a spectrum analyzer, we could measure the maximum of the received signal and therefore locate the focus of both antennas, as well as pinpoint the boresight of the offset-fed antenna.

We also compared the power of the received signal with that of a commercial 24 dBi antenna, achieving an improvement of 8 dB, which led us to believe that the overall gain of our antenna was about 32 dBi. Of course, there is some uncertainty in this value since we were receiving reflected signals as well, but the value agreed with the calculations made from the antenna's dimensions.

Once we were satisfied with the proper functioning and aim of both antennas, we decided to do a site survey at the other end of the El Baúl link. Carlo Fonda, Gaya Fior, and I reached the site on April 8. The following day, we found a hill (south of the town) with two telecom towers, which was some 75 m above the surrounding area, about 135 m above sea level. The hill provided an unobstructed view towards El Aguila. There was a dirt road to the top, a must for our purpose, given the weight of the antenna.

3.6 Performing the Experiment

On Wednesday, April 12th, 2006, Javier Triviño and I traveled towards El Baúl with the offset antenna loaded on top of a four-wheel-drive truck. Early on the morning of April 13, we installed the antenna. We pointed it at a compass bearing of 276°, given that the declination was 8°, as can be seen in Figure 7; the true azimuth was 268°.

At the same time, the other team (composed of Carlo Fonda and Gaya Fior from ICTP, with the assistance of Franco Bellarosa, Lourdes Pietrosemoli, and José Triviño) rode to the previously surveyed area at Pico del Aguila in a pickup truck, which carried the 2.7 m mesh antenna. Poor weather is common at altitudes of 4200 m above sea level. The team at El Aguila was barely able to install and point the mesh antenna before the fog and sleet began.

Power for the signal generator that fed the antenna was supplied from the truck by means of a 12-V-dc-to-120-V-ac inverter. At 11 am in El Baúl, we were able to observe a −82 dBm signal at the agreed-upon 2450 MHz frequency using the spectrum analyzer. To be sure we had found the proper source, we asked Carlo to switch off the signal. Indeed, the trace on the spectrum analyzer showed only noise. This confirmed that we were really seeing the signal that originated some 280 km away.

After turning the signal generator on again, we performed a fine alignment in elevation and azimuth at both ends. Once we were satisfied that we had attained the maximum received signal, Carlo removed the signal generator and replaced it with a Linksys WRT54G wireless router, configured as an access point. Javier substituted the spectrum analyzer on our end for another WRT54G, configured as a client.

At once, we started receiving "beacons" but TCP/IP packets did not get through. This was expected, since the propagation time of the radiowave over a 300 km link was 1 ms. It took at least 2 ms for an acknowledgment to reach the original transmitter. Fortunately, the *OpenWRT* firmware allows for adjusting the `ACK` timing. After Carlo tweaked this parameter, we began receiving ICMP packets with a mean delay time of 5 ms.

We proceeded to transfer several `.pdf` files between Carlo's and Javier's laptops, with speeds of about 65 kb/s. The low speed was to be expected, due to the medium access implemented by the CSMA/CA. The transmitter waited a certain amount of time for the `ACK` (designated as `ACK` timeout), and if it did not receive one, it re-sent the original frame. The normal `ACK` timeout was fine for short distances, but completely inadequate for long distances. Thus, modifying the `ACK` timeout would allow for long-distance transmission, but the medium-access method in the point-to-point case was very inefficient: while the transmitter was waiting for an `ACK`, the medium was idle.

3.7 Improving Performance with TDMA

One year after performing this experiment, we found the time and resources to repeat it using commercial 30 dBi antennas [21], and a couple of wireless routers that had been modified by the TIER group, led by Dr. Eric Brewer of Berkeley University [22]. The purpose of the modification of the standard Wi-Fi MAC was to make it suitable for long-distance applications, by replacing the CSMA Media Access Control with TDMA (time-division multiple-access). The latter is better suited for long distance point-to-point links since it does not require the reception of `ACK`s. This eliminates the need to wait for the 2 ms round-trip propagation time for each frame on a 300 km path.

On April 28, 2007, a team formed by Javier Triviño, José Torres, and Francisco Torres installed one of the antennas at the El Aguila site. The second team, formed by Leonardo Gonzalez V., Leonardo Gonzalez G., Alejandro Gonzalez, and Ermanno Pietrosemoli installed the second antenna at the El Baúl site. A solid link was quickly established using the Linksys WRT54G routers flashed with WRT firmware that allowed for the `ACK` timeout modification. This made video transmission possible at a measured throughput of 65 kb/s. With the TDMA routers, the measured throughput increased to 3 Mbps in each direction. This produced a total of 6 Mbps as predicted by simulations done at Berkeley University by the TIER team.

3.8 El Aguila to Platillón: 382 km

Thrilled by these results, which paved the way for really inexpensive long-distance broadband links, the second team moved to another location that we had previously identified at 382 km from El Aguila, in a place called Platillón. Platillón was 1500 m above sea level, and offered an unobstructed first Fresnel zone towards El Aguila (located at 4200 m above sea level). The *Radio Mobile* plot is shown in Figure 8. It is worth noting that over this distance, the Earth's bulge was about 2200 m and the first Fresnel-zone radius was 109 m, so this link could be achieved only thanks to the height of the endpoints and the flatness of the middle ground [23].

Again, the link was quickly established with both the Linksys and the TIER-supplied routers. The Linksys link showed approximately 1% packet loss, with an average roundtrip time of 12 ms. The TIER equipment showed no packet loss. This allowed for good-quality video transmission, but the link was not stable. We noticed considerable signal fluctuations that often interrupted the communication. However, when the received signal was

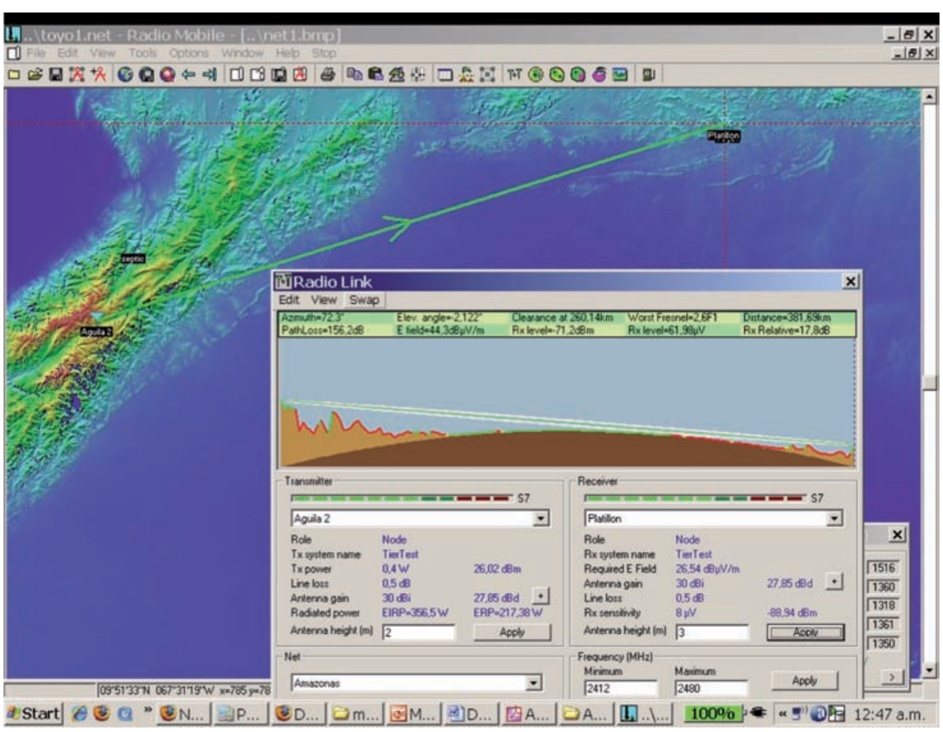


Figure 8. The layout and profile of the 382 km path.

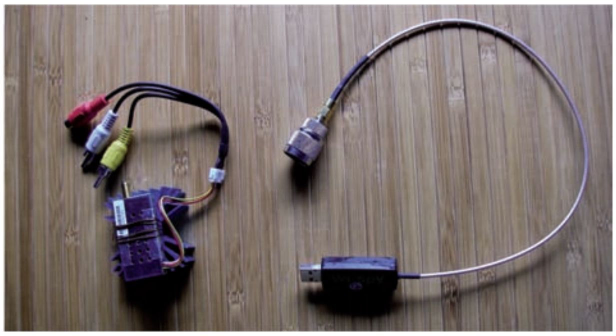


Figure 9. A low-cost antenna alignment set: a signal generator (video sender) and a low-cost spectrum analyzer.

sufficient, the measured throughput was a total of 6 Mbps bidirectional with the TIER routers implementing TDMA. Thus, the preliminary conclusion was that the 280 km link was stable, and the 380 km link was probably at the edge of the 2.4 GHz link capabilities with low-cost equipment and 30 dBi antennas.

3.9 Conclusions of the Experiments

Although further tests must be conducted to ascertain the limits for stable throughput, we are confident that Wi-Fi has a great potential for long-distance broadband communication. It is particularly well suited for rural areas, where the spectrum is still not crowded and interference is not a problem, provided there is enough radio line-of-sight (a clearance of at least 70% of the first Fresnel zone).

It is worth noting that the performance obtained on these long-distance links showed the viability of Wi-Fi as a low-cost alternative to WiMAX for backhaul applications. Similar work performed in Europe [24] confirmed the feasibility of links up to 300 km long using low-cost Wi-Fi radios with modified media-access control. Furthermore, the capabilities of Wi-Fi for point-to-multipoint and even mesh topologies have been demonstrated [25]. This makes it the technology of choice for community-based networks for its low cost and limited-installation-skill requirements, especially in rural areas where the interference problem of unlicensed bands is less severe.

In order to make this technology really affordable, an inexpensive method of aligning antennas when the other end of the link is not visible has to be found. The standard method of using a commercial signal generator on one end and a spectrum analyzer on the other is too expensive. Software-based signal-strength indicators such as *Netstumbler* [26] can be used for short-distance links. However, they are not adequate for long distances, because the Wi-Fi signal is broadband and the received signal must be relatively strong in order to be decoded by standard Wi-Fi radios. A commercial spectrum analyzer is very sensitive. It can effectively measure the received power of a single-frequency signal such as the signal produced by a commercial signal generator, but it requires a considerable investment.

WiSpy [27] is a USB dongle that essentially performs the functions of a spectrum analyzer for the 2.4 GHz band at an affordable price. However, we are still missing an inexpensive signal generator. During the Air Jaldi WSFII in Dharamsala [28], Elektra (Corinna Aichele) mentioned that in Germany they were selling "video senders" – devices meant to transmit analog video signals – which would make for an inexpensive signal generator. After experimenting with many of these cheap concoctions that were transmitting out-of-band or erratically, we finally found one [29] that can really substitute for a signal generator for antenna-alignment purposes. This is because it a) has an antenna connector that allows for the attachment to the antenna to be deployed; b) allows the selection of eight different carrier frequencies in the 2.4 GHz band; c) sports a 1 W (30 dBm) output power, enough to be detected 300 km away; d) is small enough and can be powered by any 12 V source; and, e) is relatively stable in output power and frequency during the time needed to align an antenna. With this, a kit that is suitable for the alignment of antennas at long distances, comprising an inexpensive signal generator and a signal-strength detector (Figure 9), is finally available for the wireless-networking practitioner.

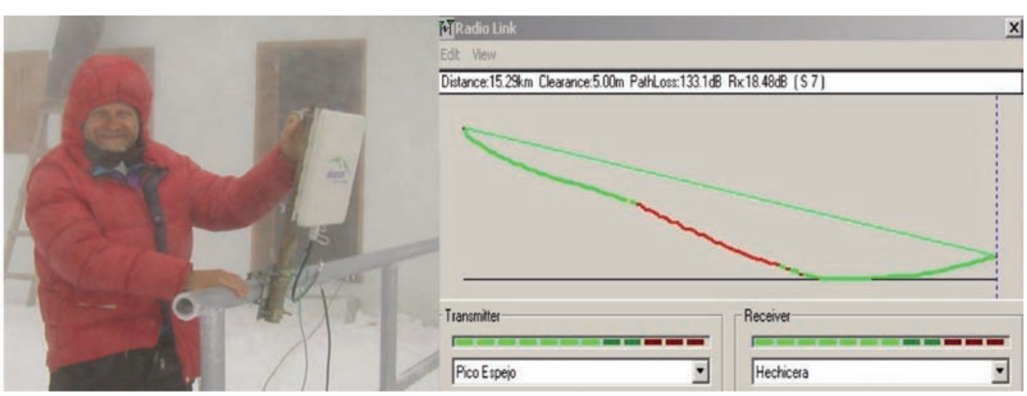


Figure 10. The 5.8 GHz wireless bridge between Pico Espejo (4765 m) and Merida.

4. High-Altitude Link

Prof. Gerd Hochschild lead a team that in 2002 installed a microwave atmospheric laboratory in Merida [30]. The team was looking for a reliable system to transfer the collected data to the University of Los Andes. The requirement was that the radio link would withstand the harsh environment of the 4765 m above sea level site. Operation could not be in the 2.4 GHz band, since this was the IF frequency of the 270 GHz receiver they were using.

After looking at the reliable solutions available, I proposed to use an Alvarion 5.8 GHz wireless bridge of the kind that had been used at high altitude in the Himalayas. The 15 km link from Pico Espejo to Merida, shown in Figure 10, was installed in October 2002, and has been operating ever since.

5. Conclusions

A case has been made for the use of commercially available low-cost equipment in the unlicensed bands at 2.4 and 5 GHz. This can be used to meet the telecommunication needs of sparsely populated regions, where interference from other users of the unlicensed spectrum is less likely [31].

6. References

1. Ermanno Pietrosemoli, "Wireless Data Transmission in the Andes: Networking Merida State," Inet'99, San Francisco, CA, 1999; http://www.isoc.org/inet99/ proceedings/4d/4d_1.htm.

2. Ermanno Pietrosemoli, "Networking in Latin America: View from the Fringe," Connect-World, Issue Latin America IV 2000; http://www.connect-world.com/~cwiml/index.php/magazine/latin-america/item/2231-networking-in-latin-america-view-from-the-fringe.

3. Ermanno Pietrosemoli, "Wide Area Network with Affordable Technologies: The Case of Merida, Venezuela". African Workshop on Use of Radio for ICT in Rural Areas, KCCT Mbagathi-Nairobi, 2004; http://www.saber.ula.ve/bitstream/123456789/15849/1/networking_merida.pdf

4. http://www.wifiworldrecord.com/2005writeup.html: 124.9 miles is the official record.

5. Fundacite Merida: http:/www.funmrd.gob.ve.

6. "Internet Para Todos en las Galápagos. Cooperacion Italiana" Diciembre 2009; http://iscfdem.blogspot.com/ 2009/12/internet-para-todos-en-las.html.

7. http://www.itu.int/ITU-D/sis/newslog/2011/01/16/ GalapagosResidentsAndTouristsHaveFreeWirelessInternetEcuador.aspx.

8. http://wireless.ictp.it.

9. http://www.mikrotik.com/.

10. http://wiki.mikrotik.com/wiki/Nstreme_dual_Step-by-Step.

11. http://ubnt.com.

12. RadioMobile: http://www.cplus.org/rmw/ english1.html.

13. http://www.ersdac.or.jp/GDEM/E/4.html.

14. Rob Flickenger (Hacker Friendly LLC); Steve Okay (Inveneo); Ermanno Pietrosemoli (EsLaRed- ULA); Marco Zennaro (International Centre for Theoretical Physics); Carlo Fonda (International Centre for Theoretical Physics), "Very Long Distance Wi-Fi Networks" NSDR 2008, ACM SIGCOMM 2008 workshop, August 18, Seattle, WA; http:// www.dritte.org/nsdr08/2008/07/session_1_paper_1.html

15. QWeCI – Quantifying Weather & Climate Impact on Health in Developing Countries: http:// www.liv.ac.uk/qweci/.

16. W. Lemstra, V. Hayes, and J. Groenewegen (eds.), *The Innovation Journey of Wi-Fi, The Road to Global Success*, Cambridge, Cambridge University Press, 2011, pp. 218-219

17. homesupport.cisco.com/en-us/wireless/lbc/wrt54G.

18. OpenWrt: http://openwrt.org/.

19. DD-WRT: http://www.dd-wrt.com/.

20. Ermanno Pietrosemoli, "Teaching Information Technologies in Latin America: Lessons Learned in a Ten-Years Experience," SSGRR, L'Aquila, Italy, 2001.

21. http://www.l-com.com/item.aspx?id=21730.

22. TIER (Technology Infrastructure for Emerging Regions): http://tier.cs.berkeley.edu/.

23. Ermanno Pietrosemoli, Case Study: Long Distance 802.11, in R. Flickenger, *Wireless Networking in the Developing World, Second Edition*, 2008, pp. 355-369.

24. D. Trinchero, R. Stefanelli, and A. Galardini, "Reliability and Scalability Analysis of Low Cost Long Distance IP-Based Wireless Networks," Innovations for Digital Inclusions, 2009, K-IDI 2009, ITU-T Kaleidoscope, Mar del Plata, Argentina, 2009.

25. http://freifunk.net/wiki/FreifunkFirmwareEnglish.

26. http://netstumbler.com.

27. http:// www.metageek.com.

28. http://drupal.airjaldi.com/.

29. http://www.microcameras.com/video_transmitters/TM_241800_video_transmitter.htm.

30. Gerd Hochschild, J. Groß, P. Hoffmann, M. Hoock, G. Koop, K. F. Künzi, K. Lindner, M. Penaloza, and M. Quack, "Ground-Based Microwave Observations of Stratospheric Trace Gases at the Tropical Merida Atmospheric Research Station (MARS) in Venezuela," Proceedings of the Sixth European Symposium on Stratospheric Ozone in Göteborg, Sweden, September 2002.

31. Ermanno Pietrosemoli, "Setting Long Distance Wi-Fi Records: Proofing Solutions for Rural Connectivity," *Journal of Community Informatics*, **4**, 1, 2008, http://ci-journal.net/index.php/ciej/article/view/ 487/402.

The Radio Physics of Meteors : High Resolution Radar Methods Offering New Insights

A. Pellinen-Wannberg

Abstract

High-power large-aperture (HPLA) radars have dramatically increased our understanding of meteors during the past two decades. These powerful instruments register echoes throughout the meteor region, extending from 80 to 120 km altitude, at shorter wavelengths and with many orders-of-magnitude higher power density than classical meteor radars. Meteor processes and properties, such as velocity, deceleration, small- and large-scale fragmentation, sudden break-ups, polarization, composition, and plasma-physics phenomena in the vicinity of meteors can thus be investigated with high resolution. Multi-static systems and interferometric phased arrays enable orbit determination with great accuracy. Association of individual meteor properties with the astronomical origin of the meteors provides important new knowledge about our solar system.

1. Introduction

High-power large-aperture (HPLA) radars were originally built to study the very weak quasi-Thomson or incoherent scatter from the ionospheric plasma electrons, up to several thousand kilometers altitude. To make this weak scattering process observable requires megawatt-class transmitters, and antenna apertures of many hundreds of square meters. These large antennas focus the radar beam to a half-power diameter of about a kilometer or less at meteor altitudes. The power density of a high-power large-aperture is thus many orders of magnitude higher than that of a specular-reflection meteor radar (SMR).

High-power large-aperture radars operate at frequencies from 50 MHz to above 1 GHz, thus covering the 25 cm to 6 m wavelength range. Various coding techniques are applied to achieve range resolutions in the tens of meters. Sub-microsecond sampling of the received signals allows resolving the passage of a meteor through the radar's beam into a hundred samples or more. Some high-power large-aperture radars can simultaneously monitor a given volume at different wavelengths. Some are multi-static, and can simultaneously perform observations of a meteor-atmosphere interaction process from different directions. Phased-array facilities offer powerful interferometric capabilities.

Even though none of the existing high-power large-aperture systems was planned or optimized for meteor studies, they have still provided a wealth of new information, and raised many new questions in regard to both trail and head echoes. Hopes are therefore high for the planned EISCAT_3D system in Northern Scandinavia. This is a multi-static, phased-array high-power large-aperture system that is listed on the ESFRI roadmap of future European research infrastructures. It will be the first high-power large-aperture radar to be designed with solar-system dust and meteor studies included as objectives.

After a short review of meteor science, I introduce a few basic concepts essential for an understanding of the subject. I present meteor radars from the perspective of their role in the development of meteor science, and discuss the specific capabilities of high-power large-aperture radars that have enabled recent high-resolution observations. I further discuss the meteoroid environment, i.e., the spatial and size distribution of meteoroids in space, and the problem of determining meteoroid size and mass from head echoes. I list some fundamental meteor parameters that can be studied with the high-power large-aperture method, important results from the different radar facilities and some case studies from the EISCAT radar. Finally, I offer some thoughts on what new insights high-power large-aperture radars can bring to today's meteor science

2. A Short History of Meteor Science

In antiquity, the two phenomena – meteors and aurorae – shown in Figure 1 were considered as being one and the same luminous physical process, occurring "high in the air," and thus called *meteor*. It was not until Galileo named the phenomena in the background *Aurora Borealis* that they were separated. Aurorae, or the Northern Lights,

Asta Pellinen-Wannberg is with the Umeå University and Swedish Institute of Space Physics, Box 812, SE-98128 Kiruna, Sweden; E-mail: asta.pellinen-wannberg@irf.se

This invited paper is based on the General Lecture with the same title given at the XXXth URSI General Assembly and Scientific Symposium, August 13-20, Istanbul, Turkey.

Figure 1. A luminous meteor with aurora in the background (photo: Torbjörn Lövgren, Kiruna).

are created when electrons in the Earth's magnetosphere are accelerated to very high energies through interactions with the solar wind. The electrons are steered by the geomagnetic field into the atmosphere, where they collide with the atmospheric constituents and give up their excess energy, a part of which is converted into the characteristic auroral light. Meteors, also called "shooting stars," are generated when tiny extraterrestrial bodies enter and interact with the Earth's atmosphere. The light emitted by both phenomena peaks at around 100 km altitude, due to the friction caused by the rapid increase of atmospheric density from that altitude and downwards acting on the impacting particles.

Figure 2 shows a classical depiction of how the meteor storm of November 13, 1833, was experienced in eastern North America. People had already noticed more shooting stars than usual the evening before. Later during the night, they were awakened by strong lighting, and rushed out to find meteors raining down from the sky. This went on for several hours. Some thought this was Doomsday, and threw themselves onto the ground to pray; others watched the phenomenon more analytically. It was observed that all the shooting stars seemed to come from a common point in the sky in the constellation *Leo*, the Lion. The event came to be known as the *Leonids*, while the phenomenon as such was named a *meteor shower*. The point in the sky from which the shower meteors appeared to come or radiate was called *radiant*. The radiant is fixed among the stars, and moves with them as seen from the Earth.

Even though the November 13, 1833, event is often considered as the start of the discipline of meteor science, meteor showers have been known at least from the Middle Ages. They appear at the same time every year, sometimes producing many visible meteors, at other times less so. The *Perseids*, also known as the "tears of St. Lawrence," recur every year on or around August 10, offering fine displays that can be enjoyed in the warm summer night. The *Geminids*, appearing on December 13, is one of the most reliable annual showers, and usually puts on a nice show, even if the time of the year is not the best for a stargazing picnic, at least not in the far north.

Figure 2 illustrates a problem that scientists were still faced with as recently as one and a half centuries ago: how to record a visual observation of an optical phenomenon. This picture was not published until 1889: 56 years after the event! However, the development of photographic techniques in the late 1800s quickly made it possible to use cameras and photographic emulsions to record shooting stars and their trails.

The past century also opened a new realm in observations, this time at other than visible wavelengths. After World War II and continuing into the early years of the space age, many redundant military radar systems were converted into meteor radars, and used in systematic observing programs. It had now been realized that meteoroids constituted a potential danger to satellites and manned space missions, and that more information about the particle density in near space was needed in order to evaluate the risks involved. In this context, radar had the advantage of being able to continuously record meteors, without being limited by daylight or bad weather. This eventually led to the discovery of several previously unknown daytime meteor showers.

Figure 2. An artist's rendition of the November 13, 1833, Leonids meteor storm (adapted from the Seventh-day Adventist book, Bible Readings for the Home Circle, 1889).

3. Basic Concepts

Advanced observation techniques have contributed to turn the field of meteor science into a modern research area [1]. Some important basic concepts are outlined below.

A *meteoroid* is a small body moving in space. Since meteoroids generally move with very high velocities (tens of kilometers per second), it is very difficult to collect them in space without destroying their structure. However, cosmic dust grains can be collected in the atmosphere: their structure is often found to be quite porous and “fluffy.”

A *meteor* is the luminous process caused by an extraterrestrial particle penetrating into the atmosphere: cf. the light streak in the middle of Figure 1. A meteor is thus not a body, but a light phenomenon.

After the meteoroid disintegration in the atmosphere, the meteoric material will re-condense into *meteoric smoke* particles. These are believed to play a crucial role in various physical and chemical processes further down in the atmosphere.

A *meteorite* is a body that has survived the passage through the atmosphere. Most of the meteoric mass is atomized in the strong interaction with the atmosphere, but depending on factors such as the composition and velocity, some parts of larger bodies can survive all the way down to the Earth’s surface. Very small particles can also fall through the atmosphere and end up on the ground as *micrometeorites*.

Large meteorite impacts have always excited a lot of interest among the general public, probably due to the hazard they represent. Fortunately, they are very rare – but over millions of years they have still had important effects on the evolution of our planet. Large impacts have changed the climate conditions suddenly and dramatically, causing old species to become extinct, and giving new species a chance to develop. Today, the theory that a large meteorite caused the sudden disappearance of the dinosaurs some 60 million years ago is quite generally accepted [2].

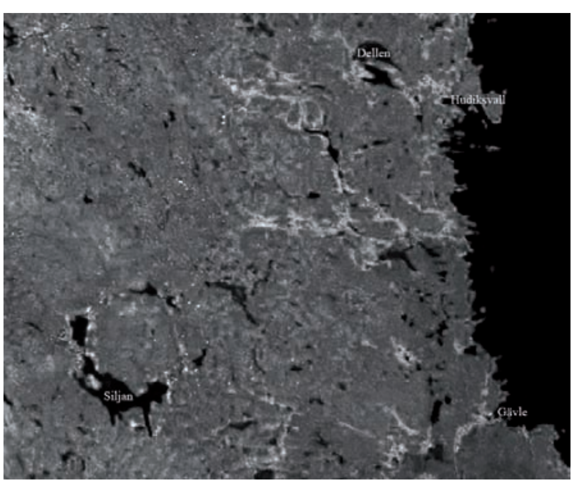


Figure 3. A satellite image showing a 215 km × 170 km area in central Sweden, between latitudes 60° 30’ N and 62° N and longitudes 14° E and 18° E, containing two meteorite craters. Lake Siljan occupies nearly half of the big crater ring at lower left. The irregular crater at upper right is now filled by Lake Dellen (image: ESA).

Earth is old, so even though large meteorite impacts are rare, a great number of identified *meteorite craters* do exist. Everybody is likely to have one or more in her or his neighborhood. The geological formations created by meteorite impacts can be quite different from the surrounding terrain, increasing the diversity and beauty of the landscape. The image in Figure 3 shows a part of central Sweden (215 km × 170 km) with two large impact craters not far from the author’s summer residence. In the lower left corner is Lake Siljan, which is a part of a crater formed by an approximately 4 km-diameter meteorite about 360 million years ago [3]. The central depression is enclosed by a 52 km diameter ring. At upper right, there is another, smaller 19 km crater, formed about 90 million years ago by a kilometer-sized meteorite, which has now become Lake Dellen (Figure 4) [4].

Radars record meteors through reflections from the plasma created in their interaction with the atmosphere. A *trail echo* comes from the ionization left in the meteor’s wake. An overview of the interpretation of trail echoes was recently given by Baggaley [5]. Trails can retain a state of enhanced ionization for quite some time, ranging from seconds to hours, which makes them useful as reflectors for communications purposes. The military, government agencies, radio amateurs, and others have all used meteor trails to establish VHF communication over non-line-of-sight distances. The VHF signals are Bragg-scattered off meteor trails normal to a plane through the two end points of the communication path, and located at or close to the path’s midpoint.

Figure 4. The north beach of Lake Dellen.

The *head echo* is a signal scattered from the plasma coma created in the immediate vicinity of the meteoroid due to its interaction with the atmosphere. A head-echo target moves with the velocity of the meteoroid, and is thus strongly Doppler-shifted. Since it is present only while the meteoroid traverses the radar beam, it is also highly transient, lasting only for some tens of milliseconds when observed by a high-power large-aperture radar system.

Head and trail echoes are both concentrated in the 80-120 km altitude range. Over this range, the atmospheric mean free path decreases from tens of meters at the top to millimeters at the bottom. The penetrating meteoroids thus hit a progressively denser "wall," heat up, ionize, and finally start to glow. This sequence of events produces the observed altitude distributions. The upper-limit altitude is a function of radar frequency, time of day, season, latitude, solar-cycle phase, and other parameters governing the atmospheric-density profiles [6].

After the Leonids storm of 1833, old people recalled that they had seen something similar much earlier, namely in November 1799 at Cape Florida. Assuming a 34-year period, astronomers calculated the orbit of a possible *parent body*, releasing dust along its orbit at each perihelion passage. It was found that such a body would have an orbit extending out to the distance of the planet Uranus. A comet matching these orbital parameters was indeed observed by Tempel, and independently by Tuttle, before its perihelion passage in 1867. The orbit of this comet, 55P/Tempel-Tuttle (Figure 5), intersects the Earth's orbit. As it approaches the sun, the solar wind sweeps ice, dust, and plasma away from the comet in the direction away from the sun. This effect is strongest, and the *comet tail* longest, when the comet is at perihelion, and weakens as the comet continues on its way back out from the inner solar system.

Shower meteors appear to come from a common radiant point in the sky. The meteoroids that generate a meteor shower have been ejected from the comet and move along its orbit, which crosses the Earth's orbit at the same time every year. During a meteor shower, increased amounts of meteors can be observed. If there are more than a thousand shooting stars per hour, it is a *meteor storm*. Otherwise, every clear night, a visual observer would also see an average of about ten shooting stars per hour coming from any direction in the sky. These are called *sporadic meteors*.

The recent spectacular visit of comet McNaught C/2006 P1 demonstrated instructively how the fast switch of the comet tail through the *ecliptic plane* contributed to the spread of the dust. The upper part of Figure 6 shows the comet photographed from the northern hemisphere in January 2007, while the lower part shows the same comet as seen from the southern hemisphere a few days later. Before the ecliptic pass, the comet tail was still quite concentrated, while afterwards the dust was seen to be spread over a large volume in space. Here, the dust was seen in reflected sunlight. If the Earth were to pass through such a dust cloud, it would experience a strong meteor shower, where all the meteors would seem to come from the same point in space. The effect can be likened to the experience of driving a car in a snowfall at night.

There are currently more than 60 known annual meteor showers. This means that Earth's orbit crosses at least as many parent-body orbits. Although most of these bodies are comets, even *asteroids* can develop meteor showers: the parent body of the December Geminids is the Palladian asteroid. One only needs to hint at the possible consequences....

4. Meteor Radars and High-Power Large-Aperture Radars

Already as early as the 1930s, measurements performed at the Bell Telephone Laboratories had associated transient radio echoes from the upper atmosphere with the passage of bright meteors. During World War II, radar operators quickly learned to distinguish between aircraft and meteor-trail targets. Higher meteor-echo rates were observed at lower frequencies, e.g. at 3.5 and 29 MHz, than in the 100 MHz range, while no echoes at all were recorded at still higher frequencies. The best frequency range for meteor detection was determined to be from 15 to 40 MHz. The lower limit lies just above the maximum ionospheric plasma frequency. Below this frequency, ionospherically-reflected signals can mask the echo signals from meteors. The upper limit is set by the ratio of the exploring wavelength to the diameter of the meteor trail, which is larger at higher altitudes due to the longer mean free path there. When the trail diameter exceeds about one-quarter of the probing wavelength, the scattered signal is severely attenuated due to destructive interference between reflections from different parts of the trail. This frequency-dependent effect is known as the *radio meteor ceiling*: trails can be observed by radar only up to, but not above, a certain altitude. For a VHF system, the ceiling is located at 105-110 km, making about 96.5% of all meteors unobservable [7]! In spite of this, high rates of radar meteors are observed. This makes meteor radars powerful tools that can observe independently of weather conditions, and can record daytime meteors and meteor showers as well as a part of the population of very small meteors that cannot be observed with visual methods. Specular-reflection meteor radars have thus revealed many basic properties of the meteor population.

In order to estimate the meteoroid threat to spacecraft, space organizations need to know the meteoroid flux at altitudes above the "meteor zone," where most meteoroids disintegrate. This was particularly important when preparing for the first manned space missions. Fortunately, the meteoroid flux and size distributions proved to be such that the probability of a potentially dangerous hit was very small. This estimate has now been confirmed in practice by over 50 years of space exploration. Following this insight, funding for, and interest in, meteor studies fell sharply for more than three decades [8]. However, networks of meteor radars around the world continued to operate throughout this time.

Observations at 300 MHz at the Royal Radar Establishment, Malvern [9], and at 440 MHz at Millstone Hill [10, 11] in 1960s, showed that UHF frequencies could also be used for meteor studies, but that high-power and large-aperture facilities were required for success. These observations represented the first documented use of high-power large-aperture facilities for meteor studies. The Malvern and Millstone radars also observed some transient echoes. However, the studies were not continued, maybe partly due to the difficulty at the time of recording data with millisecond resolution.

There are today some 10 to 15 high-power large-aperture radars in the world. Most of them were originally designed and built for the purpose of mapping the ionosphere, utilizing the very weak incoherent quasi-Thomson scattering from the quasi-free plasma electrons. Their size and the required high transmitter power made them expensive to construct and makes them expensive to operate, but also enables them to detect very small structures and weak density gradients. Today, these systems are regularly also used for studying coherent echoes from targets such as the polar mesospheric summer echoes (PMSE), meteors and space debris, as well as ionospheric features and phenomena such as auroral scatter, strong sporadic-*E* layers, naturally enhanced ion-acoustic lines, equatorial and auroral electrojets, and spread-F.

In December 1990, the author and colleagues started a project to study the effect of meteoric matter input on sporadic-*E* layers before, during, and after the Geminids meteor shower with the incoherent-scatter technique, using the EISCAT 930 MHz radar [12]. Sporadic-*E* layers can be very thin – less than a kilometer – so we decided to use very short (3 μs) pulses, corresponding to 450 m range resolution. In turn, this required broad filters (176.8 kHz) in the receiver. In addition to several sporadic-*E* layers, the data contained many odd-looking, short-lived, and strongly Doppler-shifted events. The shifts were up to 200 kHz, corresponding to a velocity of 30 km/s. At the time, no such events had been reported by others, even after ten years of EISCAT operations – but they would in any case not have passed through the standard 25 kHz-wide filters used for almost all observations! Since the observed Doppler velocities were in the range of known meteor velocities, we interpreted our events as meteor-head echoes, i.e., targets moving with the velocity of the parent meteor, according to the definition by Millman and McKinley [13].

Towards the end of the 1990s, memories of past Leonids showers resurfaced. At the previous perihelion passage of comet Tempel-Tuttle, in the second half of the 1960s, there were still only relatively few satellites in orbit. However, now near-Earth space had been filled with thousands of orbiting spacecraft, carrying out important communication and surveillance tasks. Space organizations around the world became worried. Great efforts were expended to predict the effect of the Leonids during their 1997 perihelion passage. Global coordinated measurement campaigns, using optical instruments, meteor radars, satellites, aircraft, and, of course, the high-power large-aperture radars were planned.

These efforts were very successful in many regards. For example, simulation methods for predicting meteor bursts greatly improved in accuracy within a few years, thus helping the planning for further observations [14]. Ironically, though, the high-power large-aperture radars did *not* see any increased Leonid rates during the first years of observations.

Much later, low-VHF (50 MHz) high-power large-aperture systems recorded shower meteors [15, 16]. In general, lower-frequency radars see higher meteor rates. The radar beamwidth is proportional to the wavelength-to-antenna-diameter ratio. Thus, for a given size antenna, the scattering volume is larger at lower frequencies, resulting in a larger probability for meteor hits. In addition, lower frequencies are more sensitive to smaller amounts of ionization. However, a lot of new information was also obtained with the UHF radars. The revolution in signal-processing and data-storage capabilities now make the high-power large-aperture radars ideal for recording transient meteors in very high time and space resolution, making it possible to study each event in detail.

5. The Meteoroid Environment

The meteoroid population in the near-Earth environment and the total meteor mass influx into the atmosphere are two highly essential subjects. It is important to know the meteoroid flux in space, and to understand its regular variations as well as the limits of sporadic events, in order to be able to predict and mitigate meteor effects on spacecraft. It has been estimated that every 24 hours, some 40 to 100 metric tons of meteoric matter is dumped into the atmosphere and atomized. A part of this matter feeds a metallic layer in the upper atmosphere, while the rest of the debris continues to slowly sink towards the ground. On its way down, it interacts both physically and chemically with its surroundings. The meteoric atoms form molecules and greater aggregates (smoke particles), and interact with the different atmospheric layers, producing various phenomena in the mesosphere, stratosphere, and the ozone layer. Unfortunately, all observational methods are plagued with biases, making it hard to establish a reliable meteoroid-flux model that can be used for simulations of the various processes in space and the atmosphere [17].

In the beginning, meteoroid masses were estimated from the luminous magnitudes of visual meteors. This is difficult at best, since there are many parameters beside the

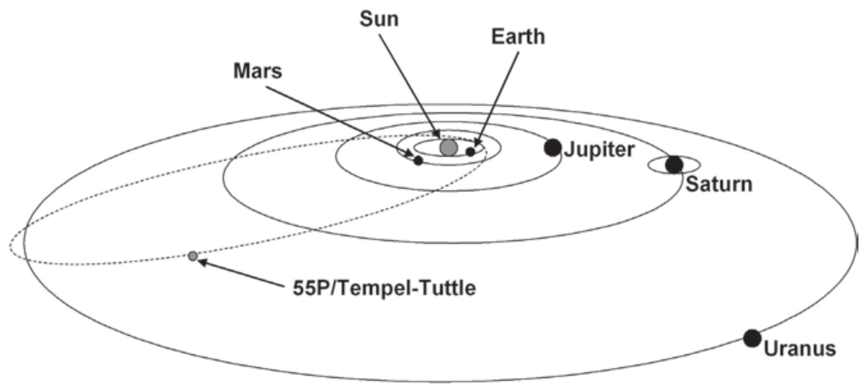


Figure 5. A schematic picture of the solar system and the 33-year period orbit of comet 55P/Tempel-Tuttle (the parent comet of the Leonid meteor shower). The comet's orbit is highly elliptical, with aphelion at the orbit of Uranus. The Earth crosses the orbit every November, passing through the dust left by the comet on previous perihelion passages.

mass that affect the brightness, such as velocity, impact angle, density, chemical composition, and the intensity of the emission lines of the various constituents [18]. Figure 7 shows with which methods meteoroids can be observed as a function of their size. Here, the density was assumed to be 2.5 g/cm^3 . From these data, the meteoroid producing the meteor in Figure 1 can be estimated to be of millimeter-to-centimeter size. This photo also highlights a difficulty specific to luminosity-based size determination: there are four flashes at the end of the trail. How would these contribute to the mass determination?

Large meteoroids *can* destroy satellites: the ESA Olympus satellite was lost due to a control-system failure caused by a Perseid in August 1992, close to the perihelion passage of the 120-year period parent comet 109P/Swift-Tuttle. Even very small particles can have a large momentum due to their high velocities, and can puncture pressurized volumes, such as propellant tanks. The plasma generated by fast meteoroids can induce current pulses with spikes of several amperes, which can damage spacecraft electronics. Such effects may be reinforced by magnetic storms generated by solar activity [19].

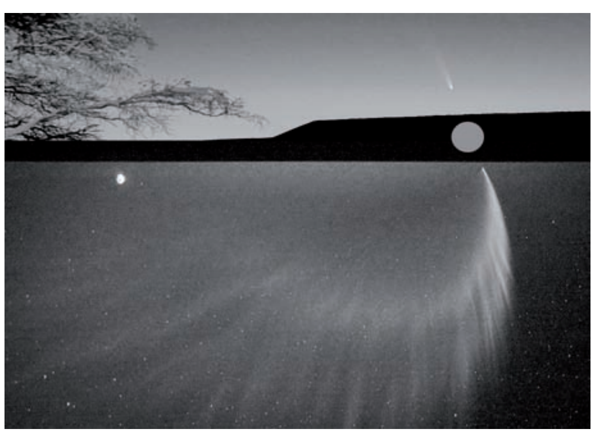


Figure 6. The upper half of this photo collage shows comet McNaught C/2006 P1 photographed from the northern hemisphere in January 2007. The lower half is a photo taken from the southern hemisphere a few days later, showing how the dust in the comet tail was spread out in the swing around the sun and through the ecliptic plane (photos: Torbjörn Lövgren and Sebastian Deiries/ESO).

The cumulative meteoroid-flux distribution is dominated by the smallest particles, ranging to sizes of several tens of nanometers, with a currently unknown detection limit [20]. The mass-flux distribution maximizes at about 1 μg, corresponding to about 50 μm-diameter particles. As shown in Figure 7, the smallest meteoroids (< 1 μm) are observed in space with satellite-impact instruments. Meteoroids larger than millimeter size can be observed with various optical methods. Radar methods work best in the intermediate μm to mm size range. It is very important to cover this mass range properly. It includes the mass-flux maximum and a range of meteoroid sizes, where most of the material remains in the atmosphere for a while, rather than reaching the ground at once. In this range, particles are still quite numerous, and at the same time can have dangerously high kinetic energy and momentum. The momentum of a 1 μg meteoroid is about the same as that of a bullet fired from a small handgun.

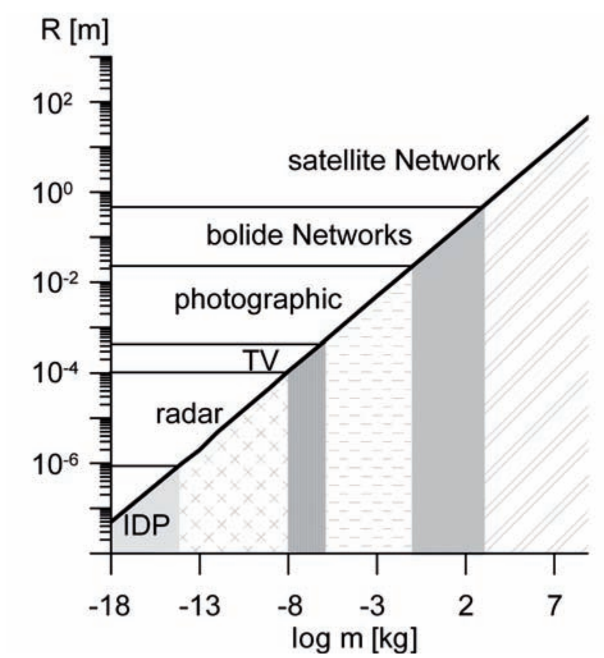


Figure 7. The approximate mass-size ranges of different methods for observing meteoroids (courtesy Olga Popova).

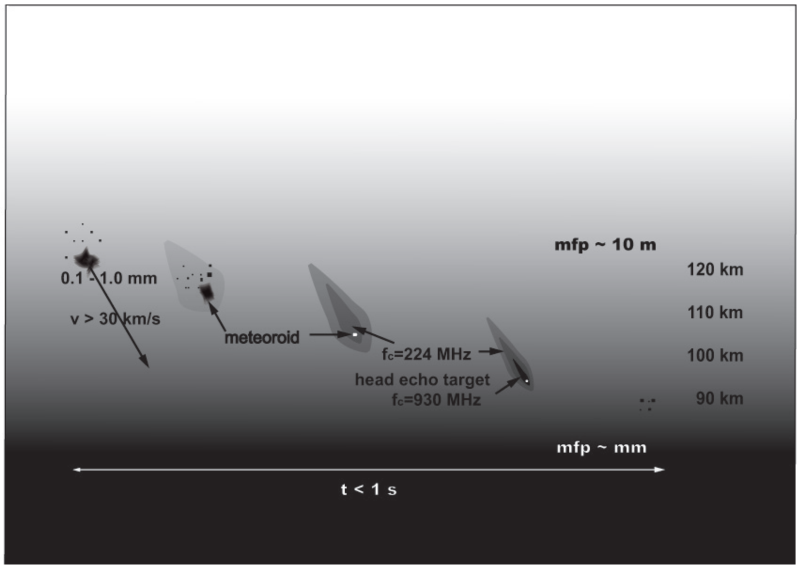


Figure 8. A schematic view of five stages of meteoroid-atmospheric interaction, spanning the altitude range from 120 to 90 km. The third and fourth stages illustrate how the EISCAT VHF and UHF radars detect the meteor target. The interaction is particularly strong in this altitude range, where the atmospheric density increases by several orders of magnitude, causing the mean free path (mfp) to decrease from tens of meters to some millimeters. A meteor-head echo appears first at VHF and then a few kilometers lower down at UHF, as the plasma density in the meteor coma increases through gradually increasing ionization and compression. The whole process takes less than a second.

In monitoring this meteoroid "threat regime" [17], the radar method is hampered by a number of known biases. One of these biases is the radio meteor ceiling effect discussed earlier, which prevents large numbers of meteors from being observed by specular-reflection meteor radars. The resulting gap in the mass-flux curves has been a great worry, and there have been attempts to fill it in by estimating the missing data [21]. Mathews et al. [22] showed that high-power large-aperture radars might be able to fill the gap. Even so, the task of estimating the masses of meteoroids observed as meteors, both with radar and optically, must still deal with a number of unsolved problems.

6. The Head Echo

The concept of a head echo was proposed by Millman and McKinley [13]. It was defined as "an instantaneous echo moving with the velocity of a meteor." This definition also holds for the head-echo targets observed today by high-power large-aperture radars. Head echoes are only rarely seen by specular-reflection meteor-radar systems. In 25 years' worth of specular-reflection meteor-radar data, Jones and Webster [23] identified 700 echoes, a number that can be reached during a few hours with many high-power large-aperture radars. Initially, the appearance of head echoes seemed to be stochastic, since they could not be predicted in terms of meteor showers, brightness, or elevation. The origin of head echoes and the scattering mechanism involved thus remained a mystery for decades.

Since the resumption of high-power large-aperture radar meteor observations in 1990, the size of the head-echo target and its relation to the generating meteoroid have been intensively studied. At EISCAT, we have access to two co-located radars with widely different frequencies, 930 MHz (UHF) and 224 MHz (VHF). These can simultaneously monitor a common volume in the meteor region. Dual-frequency observations of meteor-head echoes with this system showed that the VHF altitude distribution was

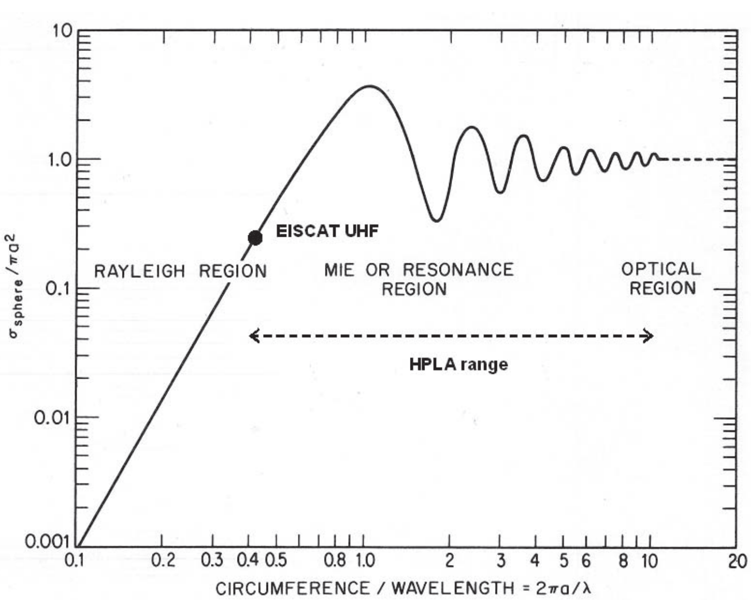


Figure 9. The monostatic radar cross section of a perfectly conducting spherical particle σ_{sphere} as a function of particle radius/wavelength ratio. EISCAT UHF and high-power large-aperture regions in general are added (adapted from Skolnik [27]).

displaced upwards by a few kilometers, relative to the UHF altitude distribution. Individual meteors were detected earlier with VHF than with UHF; every meteor observed at UHF was also seen at VHF; and the VHF cross sections were larger than the UHF cross sections. The VHF event rate was also much higher than the UHF event rate. This could be partly ascribed to the wider VHF beam, but even after taking that into account, the altitude-distribution differences remained [24, 25].

These observations were interpreted in terms of a target resembling a spherical plasma distribution, the average density of which increases successively as the meteoroid penetrates deeper into the atmosphere, and into which the radar wave penetrates deeper the higher the radar frequency. The UHF target would thus appear smaller than the VHF target. Figure 8 shows schematically how this could look at different heights for 225 MHz and 930 MHz. The apparent sizes of these radar targets were estimated to be a few cm in the UHF case, and close to 10 cm in the VHF case. This estimate assumed 0.1-1 mm-size meteoroids. This was in general agreement with Close et al. [26], who concluded that the apparent high-power large-aperture radar head-echo cross section was inversely proportional to radar frequency squared.

Figure 9 shows the well-known relationship between the scattering cross section of a perfectly conducting target and the wavelength of the incident radiation [27]. To the left is the Rayleigh scattering region, where the target is much smaller than the wavelength. In the middle is the Mie or resonance region, where the target is of comparable size. To the right is the optical region, where the target is larger than the wavelength. In the interpretation of the dual-frequency EISCAT data, it was assumed that the scattering took place in the Rayleigh regime, at an over-dense, iso-density surface inside the expanding plasma formed by the ablating meteor. This model was a gross oversimplification of the actual situation, as the concept of a critical frequency did not really apply inside such a small plasma volume, but it still produced results in surprisingly good agreement with the observations. The stringent approach is to perform full-wave integration of the scattering amplitude across the whole expanding plasma distribution. This has been done by Close et al. [28].

High-power large-aperture radars offer very high spatial resolution, but it is also important to consider how their narrow beams restrict the observations. While an optical meteor trail can be up to 30-40 km long (such as the one in Figure 1), high-power large-aperture radars can record only the fraction of this covered by the radar beam, i.e., at most a few kilometers. The parent meteoroids traverse this distance in only 100-200 ms, but during this time the radar can deliver more than 100 individual, uncorrelated measurements of the meteor-atmosphere interaction process. As a meteor undergoing a smooth ablation (as, for example, in the upper part of Figure 1) passes through the beam, one can observe how the head-echo signal traces out the nearly-Gaussian beam shape, first smoothly increasing in strength and then decreasing. However, often a bursty or oscillatory type of temporal development can also be seen, revealing a sudden breakup of the meteoroid [29].

7. Fundamental Parameters to be Observed with the HPLA Method

As with all other types of observing instruments, radar cannot observe all features of the meteor process, but it excels when it comes to studying meteoroids in the μm to mm size range. Specular-reflection meteor-radar systems cover large volumes and very efficiently record trail echoes. They thus are excellent instruments for building meteor-flux

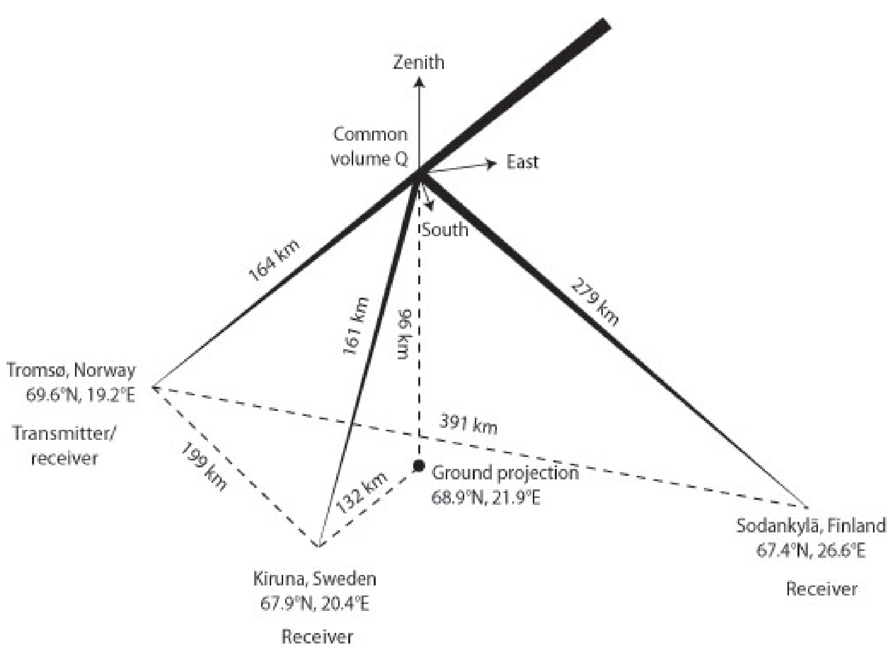


Figure 10. A schematic illustration of the experimental geometry used in many EISCAT tri-static meteor-observing campaigns. Radar pulses transmitted from the Tromsø, Norway, radar site scatter from targets in the common volume Q. The scattered signals are received in Tromsø, in Kiruna, Sweden, and in Sodankylä, Finland.

statistics. With their highly focused beams and high power densities ($\approx$ W/m^2 at 100 km range), high-power large-aperture radars primarily observe head echoes, in very small interaction volumes, but with very high spatial and temporal resolution. They can thus be used to derive detailed information about meteoroid velocity, deceleration, and echo-signal strength.

Radial velocity, i.e., the velocity component along the radar beam, can be obtained in two different ways. It can be obtained either from the Doppler shift, or, since high-power large-aperture radars can record the meteor passage through the radar beam with high time resolution, as a time-of-flight estimate. The two methods have been shown to give the same results to within the measurement accuracy [30]. If the radar beam is pointing to the zenith, the measured radial velocity is, of course, the vertical component of the meteor vector velocity. Monostatic radar systems can only determine the radial velocity, not the full vector velocity, but the radial-velocity estimate is useful for unambiguously identifying a radar echo as being a meteor echo. When detailed data on the radar-beam pattern is available, an azimuthal velocity component can also be determined [31].

There are two methods to measure the full *vector velocity* and instantaneous speed of a meteor. Phased arrays and monopulse-feed dish-antenna systems can resort to *interferometry* by recording the phases of the scattered wavefront as seen by different parts of the array or the different feeds. The other method is based on *multi-static observations* of each event. The 930 MHz EISCAT UHF radar was originally designed to record plasma vector velocities in the ionosphere using this technique, by combining monostatic observations from the transmitting site with observations from two additional receiver sites, 200-400 km from the transmitter. It was never intended for meteor studies and is by no means optimal for meteor observations, due to its high operating frequency and less-than-optimal system geometry. However, it is the world's only multi-static high-power large-aperture radar. It has been able to explore several unique features of the head-echo process by using the observation geometry shown in Figure 10. A common observing volume is located at a point in space, selected so as to minimize the linear dependence of the velocity components measured at the three sites. This point also turns out to be fairly optimal from the point of view of equalizing the strengths of the echoes received at all sites, but at the cost of making the collecting volume smaller than could have been the case with a different geometry. To counteract this as much as possible, the altitude of the common volume was chosen as 96 km, i.e., the altitude at which the head-echo rate maximizes.

Between 2002 and 2005, 24-hour measurement sessions were run in this configuration during one vernal and one autumnal equinox, as well as at one summer and one winter solstice. From a total of 96 hours of data, 410 tri-static meteors were observed, and their properties were carefully analyzed. The vector velocities of the tri-static meteors showed a typical bimodal distribution, with peaks at about 38 km/s and 59 km/s. After deriving the full orbital direction data, the slower population was identified as *prograde* meteoroids, orbiting in the same direction as Earth around the sun and catching up with it. The faster *retrograde* population orbits in the opposite direction, and collides head-on with the Earth [32].

High-power large-aperture radars can also measure the *deceleration* of the head-echo target, i.e., the time rate-of-change of velocity, very accurately. This is an important quantity when attempting to estimate the mass of the meteoroid: the mass of a small body traveling through the atmosphere and being decelerated due to collisions with the atmospheric constituents can be estimated from the deceleration by employing the conservation of the linear momentum in the drag equation [33, pp. 172-174]. This can also be integrated backwards to get an estimate of the velocity of the meteoroid in interplanetary space, before it enters the atmosphere. To estimate its orbital elements, several additional factors must be taken into account. In particular, effects caused by the flattening, rotation, and zenith attraction of the Earth must be integrated over the meteoroid's way down through the atmosphere to its final disintegration. This technique was well described by Szasz et al. [32].

Echo power or *signal-to-noise ratio* is related to the velocity, position, and effective size of the target in the radar beam. Frequently, rapid variations and/or oscillations in signal strength are superimposed on the Gaussian envelope formed by the beam. These are probably caused by small-scale fragmentation, simple and differential ablation, and sudden break-ups. In favorable cases, it is possible to simulate the observed process in detail, assuming that the meteoroid splits into two parts.

8. The Strength of the HPLA Radar Method

During the past two decades, many studies have demonstrated the power of the high-power large-aperture radar method for meteor studies. The Arecibo Observatory's 430 MHz radar, with its huge 300 m spherical-reflector antenna, in Puerto Rico, was the first high-power large-aperture system to show very high event rates [34]. The data were used to study the micrometeoroid mass flux [22], the origin and size distribution of interstellar particles [35, 36], and their orbits and other properties of the meteoroid population [37-39]. Recently, the Arecibo radar has also been the first system to find evidence for differential ablation, in which different elements are deposited at different heights according to their individual sublimation energies [40].

Unlike other high-power large-aperture radars described here – which were all originally built as incoherent scatter systems – the ALTAIR 46 m dish VHF/UHF and

TRADEX 26 m L- and S-band radars on Kwajalein Atoll, Marshall Islands, are part of the Ronald Reagan Test Range, and operated by the US Army for missile-testing purposes. These systems have occasionally been made available to the scientific community for brief observational sessions, and have proven to be extremely versatile instruments for studying meteor-head echoes. Thanks to their very high power (6 MW at VHF/UHF and 2 MW at L/S band) and their interferometric and polarization capabilities, they have made important contributions to the understanding of the head-echo process, in particular the frequency dependence of the scattering process [26].

The Jicamarca 50 MHz radar in Peru is a large phased-array facility, which, in interferometric mode, allows speed and trajectory determinations of every observed meteor. Thanks to its low frequency, its event rate is very high, more than 3000 meteors per hour. This has enabled a statistical study in which six well-known sources of sporadic meteors, previously identified by the specular-reflection meteor-radar method, have for the first time also been clearly detected with the high-power large-aperture method [41]. Jicamarca was also the first high-power large-aperture facility to definitively separate shower meteors from the sporadic background through their known narrow velocity distributions [15].

Another phased-array system is the MU radar at Shigaraki, Japan. This system, which operates at 46.5 MHz, has proven to be excellent for meteor-head-echo studies [42]. The high event rates obtained due to the low frequency allow studies of the detailed structures of meteor showers, such as fine structures and radiant distributions. Since the deceleration and radar cross section of every observed shower meteor can be defined with high accuracy, this radar can get highly improved results compared to specular-reflection meteor-radar studies. The accuracy is of the same order as that of the best optical results, even though the meteors detected by MU are several orders of magnitude smaller [16].

The Advanced Modular Incoherent Scatter Radar (AMISR) facilities in Poker Flat (PFISR) and Resolute Bay (RISR) represent a new generation of incoherent-scatter high-power large-aperture radars. They are phased-array systems, employing thousands of solid-state transceiver modules, one module per array element. This enables them to steer the beam electronically on a pulse-to-pulse basis, by changing the relative phases of the signals driving the different antenna elements. This makes it possible to employ multiple narrow beams pointing in different directions quasi-simultaneously. Alternatively, a wide beam can be generated by deliberately defocusing the array elements. This could be an advantage for meteor studies, as it would increase the observational rates and the probability of catching larger meteors [43].

High-resolution high-power large-aperture radar observations at different facilities have provided the numerical-simulation community with better estimates of the boundary conditions to be used in simulations of different meteor processes. One case in point is the semi-empirical model of the micrometeor input. There, it is important to have a flux model that replicates the actual temporal and geographical variations as well as possible, in order to understand various atmospheric phenomena related to

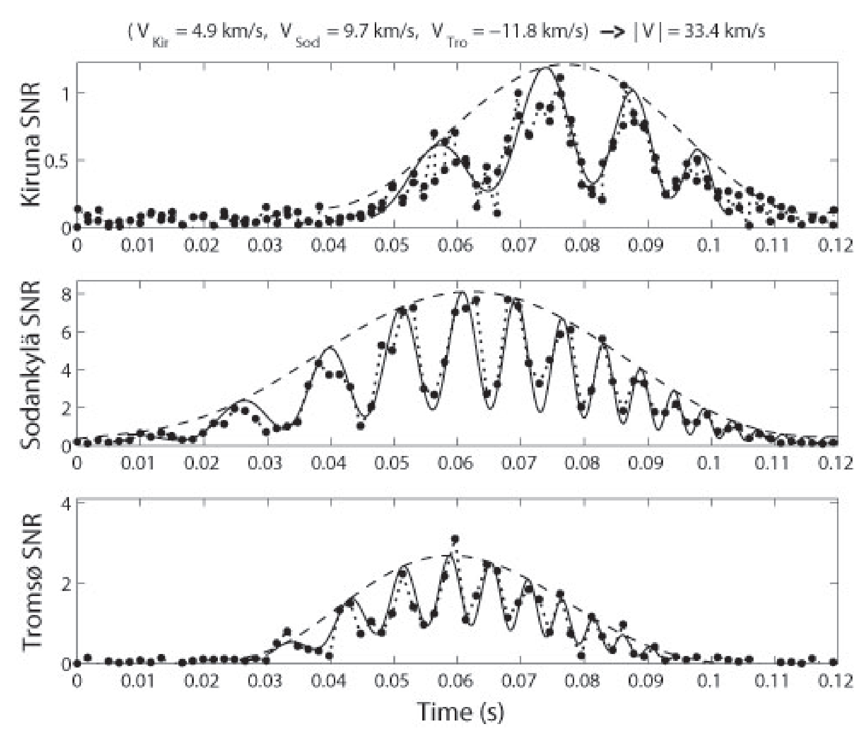


Figure 11. The signal-to-noise ratios as a function of time of a fragmenting meteor as seen at the three receivers. All three curves displayed beat patterns, but at different beat frequencies. The dashed lines show the SNR envelopes defined by the overlap of the antenna-beam patterns with the meteoroid trajectory, the dots are the actually measured SNR values, and the solid lines are modeled two-target interference patterns (adapted from Kero et al. [49]).

ablated meteoric material [44]. Comparisons of plasma and electromagnetic-wave simulations of meteor-head and trail-echo electrodynamics with actual observations have also improved the general understanding of the meteor process [45-47].

In the following sections, I present three examples of meteor studies using some or all of the special capabilities of the tri-static EISCAT UHF high-power large-aperture system to advantage, viz., detailed fragmentation, orbital distribution in the solar system, and polarization studies revealing plasma instabilities.

Evans [10] and Elford and Campbell [48] suggested that oscillations in meteor signal strength could be a sign of fragmentation, where the oscillations were due to interference between two separating fragments. Such a fragmentation event, simultaneously observed with all the three EISCAT receivers, was described in detail in [49]. The data discussed in that paper are shown in Figure 11. The lowest panel shows Tromsø data, the middle panel shows Sodankylä data, and the upper panel shows Kiruna data. The pulse-length-defined range resolution of this experiment was 90 m, but in the special case of interference between two separating meteoroid fragments, four orders-of-magnitude better resolution was reached. The dashed line shows the beam-pattern envelope. Within that envelope, the signal strengths at all three receivers oscillated strongly, but with different frequencies, which showed that the signals did not come from a spinning meteoroid. From the tri-static radar data, the separation distance and differential velocity of the two fragments could be estimated. Destructive interference first appeared in the Sodankylä data at about 17 ms into the event, at a separation distance of 0.24 m. In 100 ms, the fragments then separated by about six meters. The strong fading of the signal in the interference pattern indicated that the effective head-echo radar-target diameters must have been much smaller than the separation between them, in this case of the order of a few mm [49].

The second example illustrates the capability of measuring velocity vectors with EISCAT. The orbit characteristics of 410 tri-static EISCAT UHF meteors, observed during the 2002-2005 solstice and equinox campaigns, were reported by Szasz et al. [32]. With the aid of an ablation model, the observed tri-static velocities were integrated backwards through the atmosphere to obtain estimates of the atmospheric entry velocities. The orbits were then calculated by taking the zenith attraction, Earth's rotation, and obliquity of the ecliptic into account. It is known that in the set of all possible bound solar system orbits there are tendencies towards resonance gaps at semi-major axis values corresponding to commensurabilities with Jupiter (Figure 12). Such tendencies were also seen in this data set: this might have been the first evidence of Jupiter's gravitational influence on the population of small sporadic meteoroids surveyed by radar.

Polarization measurements are a method of deriving information about the shape of the radar target on spatial scales of the radar wavelength. ALTAIR polarization measurements at 160 and 422 MHz gave somewhat mixed indications: while most echoes displayed a high LHC/RHC ratio, indicative of a spherically symmetric target, some showed very low ratios, suggesting a target much larger than the radar wavelength in one direction but much smaller in the orthogonal direction [26]. Tri-static EISCAT UHF observations of head-echo radar-cross-section angular dependence showed close-to-isotropic values out to an aspect angle of 130°, suggesting that the targets were approximately spherical, at least to that viewing angle [50].

In a campaign in October 2009, the tri-static EISCAT UHF system was used by Wannberg et al. [51] to study radar meteor-head echo polarization at 930 MHz. A special receiving mode, separating the received echoes into their horizontally and vertically polarized components, was employed at the receiving sites of Kiruna and Sodankylä.

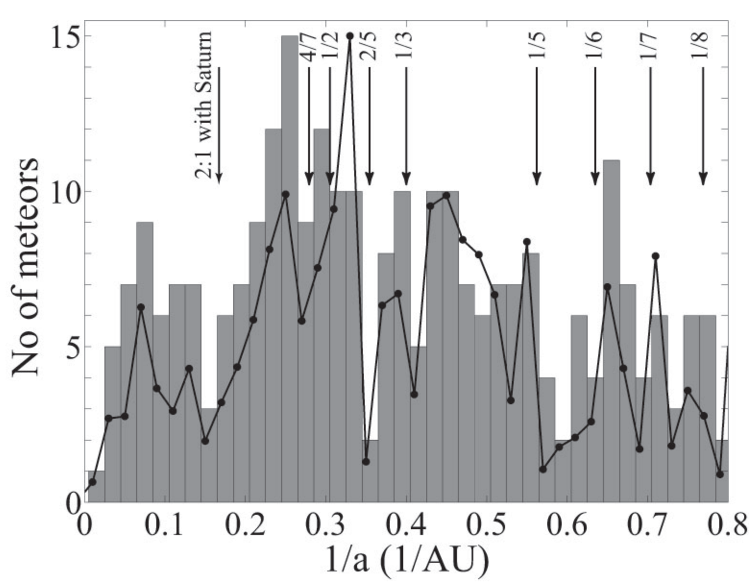


Figure 12. The number of events as a function of the inverse of the orbit's semi-major axis, a, for 410 tri-statically observed meteors. The statistics were low, but there were tendencies towards resonance gaps at some a values corresponding to commensurabilities with Jupiter and Saturn: these are indicated by arrows (adapted from Szasz et al. [32]).

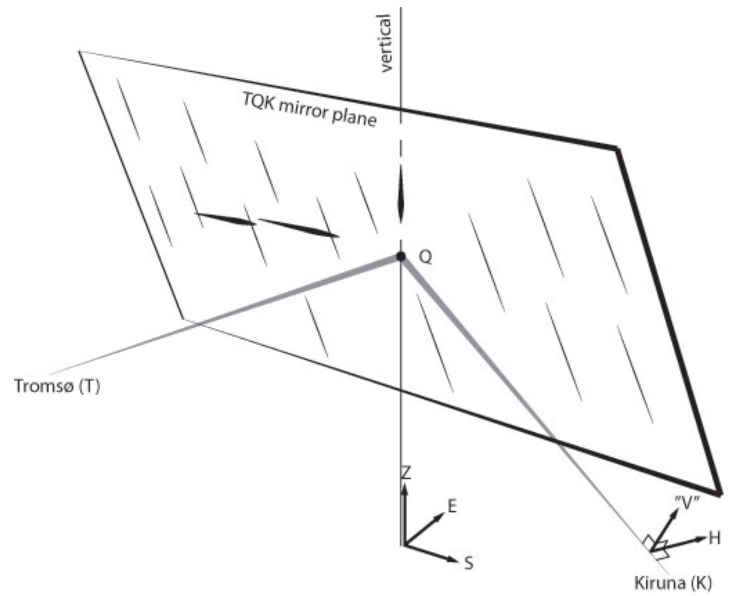


Figure 13. This shows the scattering geometry of the EISCAT UHF tri-static head-echo polarization experiment. Meteors passing through the common volume, Q, scatter the radar pulses transmitted from Tromsø in all directions. A part of the signal is scattered towards Kiruna. The Kiruna antenna-feed system separates the received signal into two orthogonal components along the horizontal and vertical feed probes, H and V. The signal polarization can then be determined by comparing the amplitudes and phases of the component signals. The trajectories of three meteors showing a degree of transverse-to-trajectory polarization are shown, viz., two nearly horizontal trajectories, almost coplanar with the mirror plane, and one nearly vertical trajectory.

This study also supported the earlier notion of most head-echo targets being spherical: 44 tri-static meteors were observed, but only three of these showed polarization features. For two of them, the meteor paths were close to horizontal and almost parallel to the mirror plane, while the third one was almost vertical and thus also close to the mirror plane (Figure 13). The surprising result was that these three events showed a larger effective target cross section transverse to the trajectory than parallel to it. This was interpreted as a signature of a transverse charge-separation resonance in the head-echo plasma immediately behind the meteoroid, reminiscent of the classical transverse cross-section-enhancement effect predicted by Herlofson [52] and experimentally verified in trail-echo experiments by Clegg and Closs [53], but in this case operating on a much smaller spatial scale. While this feature could only be observed in the three meteors close to parallel to the mirror plane, the plasma resonance can of course be present in other meteors as well but pass unobserved, because the special geometry required for its detection is not met. This observation pointed to a wealth of plasma processes that are associated with meteors still to be explored with improved resolution.

In closing, it is also worth mentioning another strong point of the high-power large-aperture radar method, which still has seen very little use in meteor studies, probably because there has been such a great variety of parameters to be studied just from head- and trail-echo observations alone. Most high-power large-aperture radars are capable of making incoherent-scatter measurements of the background atmosphere! These systems were initially designed as incoherent-scatter radars and can monitor electron densities, temperatures, and background electric fields in the ionosphere, and also some mesosphere processes, such as polar mesospheric summer echoes, etc. There have been studies on incoherent scatter from meteor trails [54] and on incoherent scatter from nanometer-size meteor smoke particles [55]. It should be possible to take these one step further, combining high-power large-aperture radar head-echo observations with simultaneous incoherent-scatter measurements. In this way, it should be possible to both follow the meteoroid input flux and to observe its effects on the atmosphere, such as meteor-induced formation of sporadic-*E* layers and other processes lower down.

9. Conclusions

High-power large-aperture radars offer many advantages in observing the meteoroid population and the physics of meteoroid entry into the atmosphere. Their very high temporal, spatial, and Doppler resolutions reveal details of individual meteor-head echoes, such as fragmentation, differential ablation, and/or sudden break-ups.

The high-power large-aperture method offers improved estimates of the total meteoroid rates, important for risk analysis for orbiting satellites: in general, meteors *can* be a threat to satellites. Small meteoroids can cause transient satellite anomalies, especially during magnetic storms, while larger meteoroids can completely destroy whole satellites. It is thus important to know how the flux can vary, and which kind of predictions can be given, especially when manned missions are planned to other planets.

High-power large-aperture data also offer improved estimates of the meteoric mass influx, important for the understanding of the interactions and chemical reactions of meteoric matter on its way through the different atmospheric layers.

Meteors have been studied for centuries, while the dust in the planetary system generating them has become an important part of modern astrophysics much later. A detailed knowledge of the properties of the solar-system dust cloud is important for a fuller understanding of the evolution of the solar system. The very accurate high-power large-aperture radar orbit determinations may contribute to this by improved estimates of the density and spatial distribution of the dust cloud.

10. Acknowledgements

The author thanks Ingrid Mann and Gudmund Wannberg for valuable discussions. EISCAT is supported by China (CRIPR), Finland (SA), Germany (DFG), Japan (NIPR and STEL), Norway (NFR), Sweden (VR), and the UK (NERC).

11. References

1. R. Hawkes, I. Mann, and P. Brown, *Modern Meteor Science*, Dordrecht, Springer, 2005.

2. L. W. Alvarez, W. Alvarez, F. Asaro, and H. V. Michel, "Extraterrestrial Cause for the Cretaceous-Tertiary Extinction," *Science*, **208**, 1980, pp. 1095-1108.

3. N. B. Svensson, "Probable Meteorite Impact Crater in Central Sweden," *Nature, Physical Science*, **229**, 1971, pp. 90-92.

4. N. B. Svensson, "The Dellen Lakes, a Probable Meteorite Impact in Central Sweden," *Transactions of the Geological Society in Stockholm*, **90,** 1968, pp. 314-316.

5. J. Baggaley, "Meteoric Ionization: The Interpretation of Radar Trail Echoes," *URSI Radio Science Bulletin*, No. 239, 2009, pp. 6-20.

6. A. Pellinen-Wannberg, E. Murad, N. Brosch, I. Häggström, and T. Khayrov, "The Solar Cycle Effect on the Atmosphere as a Scintillator for Meteor Observations," Icy Bodies in the Solar System, Proceedings of the IAU Symposium, **263**, 2009, pp. 249-252, doi:10.1017/S1743921310001869.

7. D. Olsson-Steel and W. G. Elford, "The Height Distribution of Radio Meteors: Observations at 2 MHz," *Journal of Atmospheric and Terrestrial Physics*, **49**, 1987, pp. 243-258.

8. N. G. Gilbert, "Growth and Decline of a Scientific Specialty: The Case of Radar Meteor Research," *EOS Transactions AGU*, **58**, 1977, pp. 273-277.

9. J. S. Greenhow, and C. D. Watkins, "The Characteristics of Meteor Trails Observed at Frequency of 300 Mc/s," *Journal of Atmospheric and Terrestrial Physics*, **26**, 1964, pp. 539-558.

10. J. V. Evans, "Radio-Echo Studies of Meteors at 68-Centimeter Wavelength," *Journal of Geophysical Research,* **70**, 1965, pp. 5395-5416.

11. J. V. Evans, "Radar Observations of Meteor Deceleration," *Journal of Geophysical Research*, **71**, 1966, pp. 171-188.

12. A. Pellinen-Wannberg and G. Wannberg, "Meteor Observations with the European Incoherent Scatter UHF Radar," *Journal of Geophysical Research*, **99**, 1994, pp. 11379-11390.

13. P. M. Millman and D. W. R. McKinley, "A Note on Four Complex Meteor Radar Echoes," *Journal of Royal Astronomical Society in Canada*, **42,** 1949, pp. 121-130.

14. R. H. McNaught and D. J. Asher, "Variation of Leonid Maximum Times with Location of Observer," *Meteoritics Planetary Science*, **34**, 1999, pp. 975-978.

15. J. L. Chau and F. R. Galindo, "First Definitive Observations of Meteor Shower Particles Using a High-Power Large-Aperture Radar," *Icarus*, **194**, 2008, pp. 23-29, doi:10.1016/j.icarus.2007.09.021.

16. J. Kero, C. Szasz, T. Nakamura, D. D. Meisel, M. Ueda, Y. Fujiwara, T. Terasawa, H. Miyamoto, and K. Nishimura, "First Results from the 2009-2010 MU Radar Head Echo Observation Programme for Sporadic and Shower Meteors: the Orionids 2009," *Monthly Notices of the Royal Astronomical Society*, 2011, doi:10.1111/j.1365-2966.2011.19146.x.

17. W. J. Cooke, private communication, 2011.

18. Z. Ceplecha, J. Borovicka, W. G. Elford, D. O. Revelle, R. L. Hawkes, V. Porubcan, and M. Simek, "Meteor Phenomena and Bodies," *Space Science Reviews*, **84**, 1998, pp. 327-471.

19. S. T. Lai, E. Murad, and W. J. McNeil, "Hazards of Hypervelocity Impacts on Spacecraft," *Journal of Spacecraft and Rockets*, **39**, 2002, pp. 106-114.

20. I. Mann, A. Pellinen-Wannberg, E. Murad, O. Popova, N. Meyer-Vernet, M. Rosenberg, T. Mukai, A. Czechowski, S. Mukai, J. Safrankova, and Z, Nemecek, "Dusty Plasma Effects in Near Earth Space and Interplanetary Medium," *Space Science Reviews*, **161**, 2011, pp. 1-47, doi: 10.1007/s11214-011-9762-3.

21. D. W. Hughes and T. R. Kaiser, "Meteors," in J. A. M. McDonnell (ed.), *Cosmic Dust*, New York, John Wiley, 1978, Chapter 3.

22. J. D. Mathews, D. Janches, D. D. Meisel, and Q. H. Zhou, "The Micrometeoroid Mass Flux into the Upper Atmosphere: Arecibo Results and a Comparison with Prior Estimates," *Geophysical Research Letters*, **28**, 2001, pp. 1929-1932.

23. J. Jones and A. R. Webster, "Visual and Radar Studies of Meteor Head Echoes," *Planetary and Space Science*, **39**, 1991, pp. 873-878.

24. G. Wannberg, A. Pellinen-Wannberg, and A. Westman, "An Ambiguity-Function-Based Method for Analysis of Doppler Decompressed Radar Signals to EISCAT Measurements of Oblique UHF-VHF Meteor Echoes," *Radio Science*, **31**, 1996, pp. 497-518.

25. A. Westman, G. Wannberg, and A. Pellinen-Wannberg, "Meteor Head Echo Height Distributions and the Height Cutoff Effect Studied with the EISCAT HPLA UHF and VHF Radars," *Annales Geophysicae*, **22**, 2004, pp. 1575-1584.

26. S. Close, M. Oppenheim, S. Hunt, and L. Duryd, "Scattering Characteristics of High-Resolution Meteor Head Echoes Detected at Multiple Frequencies," *Journal of Geophysical Research*, **107**, 2002, doi:10.1029/2002JA009253.

27. M. I. Skolnik, *Radar Handbook*, New York, McGraw-Hill, 1970.

28. S. Close, M. Oppenheim, S. Hunt, and A. Coster, "A Technique for Calculating Meteor Plasma Density and Meteoroid Mass from Radar Head Echo Scattering," *Icarus*, **168**, 2004, pp. 43-52.

29. A. Pellinen-Wannberg, G. Wannberg, J. Kero, C. Szasz, and A. Westman, "The Impact of High-Resolution Radar on Meteor Studies: the EISCAT Perspective," *URSI Radio Science Bulletin*, **324**, 2008, pp. 17-28.

30. G. Wannberg, A. Westman, J. Kero, C. Szasz, and A. Pellinen-Wannberg, "The EISCAT Meteor Code," *Annales Geophysicae*, **26**, 2008, pp. 2303-2309.

31. L. P. Dyrud and D. Janches, "Modeling the Meteor Head Echo Using Arecibo Radar Observations," *Journal of Atmospheric and Solar-Terrestrial Physics*, **70**, 2008, pp. 1621-1632.

32. C. Szasz, J. Kero, D. D. Meisel, A. Pellinen-Wannberg, G. Wannberg, and A. Westman, "Orbit Characteristics of the Tristatic EISCAT UHF Meteors," *Monthly Notices of the Royal Astronomical Society*, **388**, 2008, pp. 15-25, doi: 10.1111/j.1365-2966.2008.13374.x.

33. D. W. R. McKinley, *Meteor Science and Engineering*, New York, McGraw-Hill, 1961.

34. J. D. Mathews, D. D. Meisel, K. P. Hunter, V. S. Getman, and Q. Zhou, "Very High Resolution Studies of Micrometeors Using the Arecibo 430 MHz Radar," *Icarus*, **126**, 1997, pp. 157-169.

35. D. D. Meisel, D. Janches, and J. D. Mathews, "Extrasolar Micrometeors Radiating from the Vicinity of the Local Interstellar Bubble," *The Astrophysical Journal*, **567**, 2002, pp. 323-341.

36. D. D. Meisel, D. Janches, and J. D. Mathews, "The Size Distribution of Arecibo Interstellar Particles and its Implications," *The Astrophysical Journal*, **579**, 2002, pp. 895-904.

37. D. Janches, J. D. Mathews, D. D. Meisel, V. S. Getman, and Q.-H. Zhou, "Doppler Studies of Near-Antapex UHF Radar Meteors," *Icarus*, **143**, 2000, pp. 347-353.

38. D. Janches, J. D. Mathews, D. D. Meisel, and Q. Zhou, "Micrometeor Observations Using the Arecibo 430 MHz Radar: I. Determination of the Ballistic Parameters from Measured Doppler Velocity and Deceleration Results," *Icarus*, **145**, 2000, pp. 53-63.

39. D. Janches, D. D. Meisel, J. D. Mathews, "Orbital Properties of the Arecibo Micrometeoroids at Earth Intersection," *Icarus*, **150**, 2001, pp. 206-218.

40. D. Janches, L. P. Dyrud, S. L. Broadley, and J. M. C. Plane, "First Observation of Micrometeoroid Differential Ablation in the Atmosphere," *Geophysical Research Letters*, **36**, 2009, L06101, doi:10.1029/2009GL037389.

41. J. L. Chau, R. F. Woodman, and F. Galindo, "Sporadic Meteor Sources as Observed by the Jicamarca High-Power Large-Aperture VHF Radar," *Icarus*, **188**, 2007, pp. 162-174. doi:10.1016/j.icarus.2006.11.006.

42. T. Sato, T. Nakamura, and K. Nishimura, "Orbit Determination of Meteors Using the MU Radar," *IEICE Transactions on Communications,* **E83-B**, 2000, pp. 1990-1995.

43. J. L. Chau, F. R. Galindo, C. J. Heinselman, and M. J. Nicolls, "Meteor-Head Echo Observations Using an Antenna Compression Approach with the 450 MHz Poker Flat Incoherent Scatter Radar," *Journal of Atmospheric and Solar-Terrestrial Physics*, **71**, 2009, pp. 636-643, doi:10.1016/j.jastp.2008.08.007.

44. J. T. Fentzke, D. Janches, and J. J. Sparks, "Latitudinal and Seasonal Variability of the Micrometeor Input Function: A Study Using Model Predictions and Observations from Arecibo and PFISR," *Journal of Atmospheric and Solar-Terrestrial Physics*, **71**, 2009, pp. 653-661, doi:10.1016/j.jastp.2008.07.015.

45. Y. S. Dimant and M. M. Oppenheim, "Meteor Trail Diffusion and Fields: 2. Analytical Theory," *Journal of Geophysical Research*, **111**, 2006, A12313, doi:10.1029/ 2006JA011798.

46. L. Dyrud, D. Wilson, S. Boerve, J. Trulsen, H. Pecseli, S. Close, C. Chen, and Y. Lee, "Plasma and Electromagnetic Wave Simulations of Meteors," *Advances of Space Research*, **42**, 2007, pp. 136-142, doi:10.1016/j.asr.2007.03.048.

47. M. M. Oppenheim, A. F. Vom Endt, and L. P. Dyrud, "Electrodynamics of Meteor Trail Evolution in the Equatorial E-region Ionosphere," *Geophysical Research Letters*, **27**, 2000, pp. 3173-3176, doi:10.1029/1999GL000013.

48. W. G. Elford and L. Campbell, "Effects of Meteoroid Fragmentation on Radar Observations of Meteor Trails," *ESA SP*, **495**, 2001, pp. 419-423.

49. J. Kero, C. Szasz, A. Pellinen-Wannberg, G. Wannberg, A. Westman, and D. D. Meisel, "Three-Dimensional Radar Observation of a Submillimeter Meteoroid Fragmentation," *Geophysical Research Letters*, **35**, 2008, L04101, doi:10.1029/2007GL032733.

50. J. Kero, C. Szasz, A. Pellinen-Wannberg, G. Wannberg, and A. Westman, "On the Meteoric Head Echo Radar Cross Section Angular Dependence," *Geophysical Research Letters*, **35**, 2008, L07101, doi:10.1029/2008GL033402.

51. G. Wannberg, A. Westman, and A. Pellinen-Wannberg, "Meteor Head Echo Polarization at 930 MHz Studied with the EISCAT UHF HPLA Radar," *Annales Geophysicae*, **29**, 2011, pp. 1197-1208.

52. N. Herlofson, "Plasma Resonance in Ionospheric Irregularities," *Arkiv Fysik*, **3**, 1951, pp. 247-297.

53. J. A. Clegg and Closs, R. L, "Plasma Oscillations in Meteor Trails," *Proceedings of the Physical Society, B*, **64**, 1951, pp. 718-719, doi:10.1088/0370-1301/64/8/113.

54. A. Pellinen-Wannberg and G. Wannberg, "Enhanced Ion-Acoustic Echoes from Meteor Trails," *Journal of Atmospheric and Terrestrial Physics*, **58**, 1996, pp. 495-506.

55. I. Strelnikova, M. Rapp, S. Raizada, and M. Sulzer, "Meteor Smoke Particle Properties Derived from Arecibo Incoherent Scatter Radar Observations," *Geophysical Research Letters*, **34**, 2007, L15815, doi:10.1029/2007GL030635.

XXXth General Assembly and Scientific Symposium

BUSINESS TRANSACTED BY COMMISSION A

Chair: Dr. W. Davis (U.S.A.)
Vice Chair: Dr. Y. Koyama (Japan)

1. In Memoriam Professor Leschiutta

The members of the Italian URSI Italy were notified of the death of Prof. Siegfried Leschiutta, former Chairman of the Commission A in 2011. Roberto Sorrentino of the Italian URSI reported from the news "Anyone who has had the pleasure and honor to know him, has been impressed by the originality of his bright and briliant mind and by his frank, honest and strict nature. We will miss him as a researcher and as a man". In the Commission A meeting, Dr. P. Banerjee offered a eulogy for Prof. Leschiutta and a short moment of silence for this respected leader of the community.

2 Election of new Vice Chair

The vote for the vice chair of Commission A was very close with Dr. Yasuhiro Koyama of Japan elected to the position. Dr Demetrios Matsakis of the US Naval Observatory offered was a strong competitor and is thanked for his participation.

3. URSI Radio Science Bulletin Associate Editors

Two associate editors were selected to provide improved input to the Radio Science Bulletin. Dr. Banerjee volunteered to continue service to URSI in this role and will team with the Vice Chair, Dr. Koyama, in this role.

A major review paper on the Rotman Lens was published by Weiss and Kilic. Additional papers are in the works from members of the Greek URSI as well as the United States URSI.

4. Discussion of Council Issues

The report of the Long Range Planning Committee was reviewed, but not discussed at length. During this triennium, the Long Range Planning Committee (LRPC), under the chairman ship of Prof. P. Cannon, was quite active through discussions with respective chairs of commissions. The following emerging topics were identified as a focus for Commission A: a) Development of quantum standards; b) GNSS timing systems; c) Nano-metrology; and d) Effects of EM waves on the eco-system (man and environments). The primary technical domain of the commission remains instrumentation and measurement, however with strong support of the measurement concepts needed by other commissions. There should be an emphasis on the social aspects of science and technology and also on navigation. The secondary areas of commission focus are well recognized as antennas, propagation, electromagnetic compatibility, electron devices and systems, laser & electron optics, magnetics, microwave theory and techniques, and optics and optical technology.

There was some discussion of the viability of URSI white papers. To make them meaningful, they should really be distributed beyond URSI once they are approved. That would help URSI be recognized worldwide as a leader in technological concepts and ideas for the future. Related discussion dealt with a short discussion of the importance of URSI and its' relevance to the current world order. URSI needs to be providing a greater contribution to science. The three-year gap between the GASS meetings does not help in the recognition of URSI in the world community. The support of interim meetings and the wider distribution of white papers would help with this visibility.

This discussion led to the issue of hosting technical meetings between the GASS years. It was felt that creating new meetings was not wise when we already have too many meetings. However, several alternatives were suggested:

1) Cosponsor technical meetings being offered by other related groups, such as the IEEE MTT or I&M societies. Some of this support already exists on a country basis, such as the joint IEEE AP-S / URSI meetings typically held in the USA every summer. The IEEE AP-S has found it hard to establish meetings elsewhere due to the existence of other organizations hosting in those regions, and has become inclined to co-sponsor meetings instead;

2) Offer limited topical meetings with a focus on 3rd world countries; and 3) Offer URSI special topic sessions at existing conferences.

There was some discussion of the need for the listserv as mentioned in the Council meetings. It appears that Council has set up commission listservs to complement those that may already exist separately for the commissions.

The Young Scientists were asked to provide feedback about their experiences and how that can be improved in the future. Of particular interest are any suggestions they have for making URSI more relevant to the world today. Some suggestions included URSI considering social networking with a presence in Wikipedia and Facebook, possibly LinkedIn.

Beijing, China was selected for the 2014 GASS from 13-30 August 2014.

5. GASS Session Structure

The issue of attracting folks to the URSI GASS felt may be strongly related to the structure of the meeting. New participants typically end up in poster sessions. It is felt as though this is saying to new individuals that URSI is a good-old-boys network and you have to work your way in, rather than feeling welcome up front. This network feeling is inherent in the mostly invited oral-session structure of the meeting. Several alternatives were discussed, though many felt that the invited structure was necessary base on their country experience, while others felt just the opposite. The alternatives include the following:

1) Have a combination of invited and open sessions. The open sessions would be formed from groupings of the papers submitted as actually was done to fill some of the slots at the 2011 GASS. The open sessions should be based on a recommended list of topics that is easily revised as the emerging areas develop;
2) For some commissions it may be worth considering more parallel sessions rather than simply more posters;
3) There was general support for a nominal registration with each submission to reduce the number of no-shows;
4) There was not much discussion of the need to send an invitation letter indicating no funding available to each corresponding author (as a PDF file); and lastly
5) it may be a draw to specific topics to have them as open sessions, but with a keynote presentation.

A new idea discussed briefly was the establishing of a plenary session with keynote speeches much as already done, but with the added feature of the final student presentations to determine the order of the top three student awards.

6. Paper Reviews for the GASS

It was felt that having a reviewing team or at least additional reviewers for the GASS paper submissions would improve the review process. In some cases it did not appear that the conveners did any review or even pursued paper submissions, while others simply need a second review to confirm the quality of the papers that are desired for the meeting. To go toward a more open structure that is more appealing to first time presenters, it is suggested that a combination of sessions be considered: invited sessions as currently done, special sessions with a keynote speaker, and open sessions formed from the remaining papers submitted and divided by relevant areas.

7. New Terms of Reference

Commission A - ELECTROMAGNETICMETROLOGY, Electromagnetic measurements and standards. The commission promotes research and development of the field of measurement standards and physical constants, calibration and measurement methodologies, improved quantification of accuracy, and traceability, and the intercomparison of such. Areas of emphasis are:\

a) The development and refinement of new measurement techniques and calibration standards
b) Primary standards, including those based on quantum phenomena, and the realization and dissemination of time and frequency standards
c) Characterization of the electromagnetic properties of materials, physical constants, and the properties of engineered materials, including nanotechnology
d) Methodology of electromagnetic dosimetry and measurements for health diagnostics, applications, and biotechnology: including biosensing
e) Measurement validity in advanced communication systems and other applications

The commission fosters accurate and consistent measurements needed to support research, development and exploitation of electromagnetic technologies across the spectrum and for all commissions.

8. Topics for Future GASS Meetings

Potential topics for future assemblies were listed. This list is not closed, but provides a basis for the next meeting. The basic topic list is as follows: Meas/Cal for Remote Sensing; Propagation Meas standards; Sliding correlators, indoor, MIMO, and diversity; Space plasma measurement techniques; Materials: metamaterials, liquids, nanomaterials, wideband engineered materials; Antenna & Field Measurement; Short Pulse measurements; RFID; Wireless Application Antenna Measurements; Biological effects (SAR, HAC, pattern, Z, exposure); Signal enhancement for EM Metrology; Circuit measurements – nonlinear, harmonics; Scattering cal and standards; Optical Techniques; and Freq cal and stability. There are several review or emerging area topics: Basic Measurement Concepts – a Review and Measurements of Physical Quantities: methodology, improved accuracy, traceability. New areas of emerging technology include: Health and climate; Targeted programs: a) Fundamental physical constants, optical stds/freq comparisons; b) Health: diagnostics, therapy, biotech; c) Mechanics including nanotechnology; and d) EM including nanotechnology.

These topics provide an opportunity to join with commissions B, D, E, and K. There is a strong possibility of a joint session with D on optical standards, as well as temperature and other aspects of physical constants.

Invited topics might include:
- Nonlinear microwave device measurements
- Measurement uncertainty
- Nonometrology or Nanoantennas
- Pulsars (follow up to this GASS)

9. Paper Summary

There were 120 oral papers and 8 poster papers presented as part of the Commission A activites. Of these, there were joint session with commissions B(4), C(2), D(3), E(1), F(3) and K(1). There were 10 student papers submitted, of which 2 were related to commission A. A special thanks goes to S. Giblin form the National Physical Laboratory of the UK for his tutorial on "Electron Pumps and Re-definition of the SI Unit Ampere." Overall, there was excellent participation in commission A, though there were some selected no-shows.

10. Closure

Dr Davis on behalf of members of Commission A thanked all participants for their excellent cooperation and all speakers for their participation in Commission A sessions. A special thanks was also given to Dr. Banerjee for his effort not only as the chair of Commission A during the last triennium, but as the interim chair during the previous triennium. He has indeed done extra duty in his service to URSI and Commission A.

BUSINESS TRANSACTED BY COMMISSION B

Chair : Prof. G. Manara (Italy)
Vice-Chair : Prof. A. Sihvola (Finland)

Three Comission B Business Meetings were held on Monday, August 15th, Wednesday, August 17th, and Friday, August 19th.

1. Student Paper Competition

Three Commission B papers were selected for the final session of the Second International URSI Student Paper Competition:

- Y. Kaganowsky, E. Heyman, "Spectral Analysis of the Airy Pulsed Beam"
- G. Safonova, E. Vynogradova, "Rigorous Approach to Analysis of 2-D Electrostatic-Field Problems for Multi-Conductor Systems"
- K. Stavrakakis, T. Vittig, W. Ackermann, T. Weiland, "Model Order Reduction Methods for Multivariate Parameterized Dynamical Systems"

Yan Kaganowsky (Israel) and Kynthia Stavrakakis (Germany) were awarded the second and fifth prize, respectively. G. Sofonova received an Honorable Mention.

2. Bathasar Van der Pol Award

During the GASS Opening Ceremony, Prof. Ehud Heyman (Israel) was awarded the Balthasar Van der Pol Gold Medal. The Issac Koga Gold Medal was awarded to Prof. Andrea Alù (USA).

3. Vice-Chair Election

Four candidates for Vice-Chair have been nominated:

- Kazua Kobayashi, Japan
- Ari Sivhola, Finland
- Don Wilton, USA
- Ayan Altintas, Turkey

Ari Sivhola, Finland, has been elected (and approved by the Council).

4. Commission B Meetings

Two bids to hold the triennial URSI Commission B International Symposium on Electromagnetic Theory (EMTS) in 2016 have been presented: Helsinki, Finland and Versailles, France. Helsinki has been elected.

The 2013 URSI Commission B EMTS will be held in Hiroshima, Japan. Symposium location will be the International Conference Center Hiroshima (ICCH) located in the Peace Memorial Park, downtown Hiroshima.

5. Terms of Reference

The terms or reference of Commission B have been slightly modified during the Istanbul GASS.

6. Commission B paper statistics for GASS 2011

- Oral Session Papers : 95
- Poster Session Papers : 98
- Total Accepted Papers : 193

Oral Sessions (B-Core)

B01 – Electromagnetic Theory, 4 papers
B03 – Hybrid Methods (in memory of Robert G. Kouyoumjian), 11 papers
B04 – Electromagnetic Field Transformations for Measurements and Numerical Methods, 6 papers
B05 – Theoretical and Numerical Issues in Electromagnetics, 6 papers
B06 – Multiscale Modeling and Applications to Composite Materials, 7 papers
B07 – Adaptive Antennas, 10 papers
B10 – Beam Methods, 6 papers
B11 – Inverse Scattering and Imaging, 10 papers
B12 – Novel Mathematical Methods in Electromagnetics, 7 papers

Oral Sessions (Joint Core)

BD1 – Metamaterial Theory, 10 papers
BD2 – Numerical Techniques for Multi-Physics Electromagnetics, 11 papers
BJ – Very Large Antenna Arrays for Radio Astronomy, 6 papers

Oral Sessions (Joint from other Commissions)

AB1 – Antenna Measurement, 7 papers
AB2 – Antenna Measurement, 10 papers
AB3 – Antenna Measurement, 7 papers
ABD – Low Noise Microwave Generation, 7 papers
CB – Antenna Channel Interactions for Future Wireless Communications, 6 papers
CBD – Vehicular Communications, 3 papers
CHGBDJK – Solar Power Satellites and Wireless Power Transmission, 10 papers
DB1 – Modeling of High-Frequency Devices and Circuits, 10 papers
DB2 – Plasmonics, 7 papers
DB3 – Metamaterial Applications, 7 papers
DBC – Signal Processing Antennas, 6 papers
EB – Electromagnetic Modelling for EMC, 10 papers
KB – Uncertainty Management in Numerical Calculation and EM Field Dosimetry, 6 papers
KBE – Non-Ionizing Electromagnetic Breast Imaging, 9 papers

Poster Sessions

BP1, 48 papers
BP2, 49 papers

Tutorial

Passive and Active Metamaterial Constructs and Their Impact on Electrically Small Radiating and Scattering Systems by R. W. Ziolkowsky, University of Arizona, United States

7. Triennial Report

The triennial report given by Commission B Chair Karl J. Langenberg covered Meetings and Symposia (EMTS 2010, Berlin, Germany; the first German-Israeli Workshop on "Advances in Electromagnetics"; URSI GASS 2011, Istanbul, Turkey) and Emerging Issues in Commission B (Young Scientist support, Commission and URSI visibility, new scientific research areas, new applied research areas). A specific working group was formed in the last business meeting (Friday, August 19th) with the objective of organizing a first URSI Commission B School for Young Scientists to be held in combination with the 2013 Electromagnetic Theory Symposium in Hiroshima, Japan.

BUSINESS TRANSACTED BY COMMISSION C

Chair : Prof. M. Luise (Italy)
Vice-Chair : Prof. S. Salous (UK)

The Commission had two open business meetings on 15th and 17th, August 2011.

The following persons were present at least at one meeting, but mostly at both:Prof. A.J. Parfitt, Prof. B.B. Shishkov, Dr. J. Palicot, Dr. W. Mathis, Dr. M. O'Droma,Prof. M. Luise, Prof. K. Itoh, Dr. A.B. Shmelev, Prof. S. Salous, Dr. D. Palmer. Prof. T Ohira and Prof. A. Sibille.

At the opening of the first business meeting, the Chair welcomed everyone to the meeting and attendees introduced themselves.

1. Election Vice-Chair

Six candidates were nominated for the position : Jacques Palicot (France), Erdal Panayirci (Turkey), Sana Salous (UK), Naoki Shinohara (Japan), Angela Slavova Popivanova (Bulgaria), Ran Tao (China). Considering the votes received by e-mail and the votes of the persons atg the meeting, Mrs. **Sana Salous** was elected.

2. Commission C Editor RSB

Sana Salous indicated his willingness to serve as Commission Editor for the RSB for the next triennium.

3. Review of the Last Triennium

The chair reported the activity of Commission C in this triennium as follows:

3.1 International Events Sponsored by URSI Commission C

1) URSI General Assembly (URSI-GA2011), Istanbul, Turkey, website http://www.ursigass2011.org/
2) International Symposium on Signals, Systems, and Electronics ISSSE2010, Nanjing, China, http://www.emfield.org/issse2010/
3) Asia-Pacific Radio Science Conference AP-RASC 2010, Toyama, Japan http://www.ap-rasc10.jp/

3.2 Website

http://www.ursi.org/en/commission.asp?com=C

3.3 Radio Science Bulletin (RSB)

Under the Associate Editorship of Marco Luise, the following papers were published:

1) O. Julien, C. Macabiau, J.-L. Issler, "*Structure and Performances of the Future Galileo Civil Signals*", RSB330, Sept. 2009.
2) A. Abrardo and G. Ferrari, "*A Perspective on Distributed Radio Systems with Cooperative Coding*", RSB330, Sept. 2009.
3) N. Noels, P. Ciblat, and H. Steendam, "*Overview on Performance Lower Bounds for Blind Frequency Offset Estimation*", RSB335, Dec. 2010.
4) J. Pérez-Romero, D. Noguet, M. López-Benítez, F. Casadevall, "*Towards a more efficient spectrum usage: Spectrum Sensing and Cognitive Radio techniques*", RSB336, March 2011.

3.4 Update of Terms of Reference

The Commission promotes research and reviews new development in :

a) Information Theory, Coding, Modulation and Detection
b) Spectrum and Medium Utilization, including cognitive and cooperative techniques
c) Wireless networking
d) Radar, radio localization and navigation systems
e) Green, energy-efficient radio communications

The design of effective radio-communication systems must include scientific, engineering and economic considerations. This Commission emphasises research into the scientific aspects, and provides enabling technologies to other areas of radio science.

4. Role of National Representatives of "C"

Further enhancement of the national and international activity of Commission C should strongly be prompted for the next triennium. While National Representatives are desired to have close contact with Commission C, Commission C also is encouraged to try to cooperate with radio scientists in each country in parallel to National Representatives

5. Plan for the Next Triennium

5.1 Meetings and Symposia

1) General Assembly (URSI-GA2014) August 2014, Beijing, China
2) International Symposium on Signals Systems and Electronics – Organized by Rolf Kraemer in Potsdam, Germany. The idea is to anticipate the ISSSE to 2012 so that Commission C will have one flagship event per year: ISSSE in '12, AP-RAS in '13 (see below) and GASS in '14, and so forth for the next triennia.
3) Asia-Pacific Radio Science Conference (AP-RASC 2013) – Organized by K. Kobayashi in Taipei, Taiwan.
4) An initiative with Commission F (propagation), Prof. Lang, for a possible joint meeting in Ottawa, CA.

5.2 Website

Restructuring of C's website with more visibility for national events

5.3 Radio Science Bulletin (RSB)

The commission continues to contribute to RSB. Sana Salous, Associate Editor, will call for papers so as to obtain 2 Bulletin Reviews per year.

5.4 Development of New National Members

Through our activities, the commission is willing to recruit new national members.

6. National Representatives Roster

We report in the following table the list of the National representatives of commission C. Possible changes have to be reported to the current Commission C chair, Marco Luise.

Argentina	Prof. A. Quijano	**Italy**	Prof. M. Luise
Australia	Prof. A.J. Parfitt	**Japan**	Dr. K. Itoh
Austria	Prof. S.J. Bauer	**Japan**	Prof. T. Ohira
Belgium	Prof. L. Vandendorpe	**Netherlands**	Dr. Ir. M.J. Bentum
Brasil	Prof. M.S. De Alencar	**New Zealand**	Dr. P.T. Gough
Bulgaria	Prof. B.B. Shishkov	**Nigeria**	Prof. M. Onuu
Canada	Mr. C. Despins	**Norway**	Prof. B. Forssell
Chile	Dr. R. Feick	**Peru**	Prof. D. Chavez
China (Cie)	Dr. R. Tao	**Poland**	Prof. M. Piekarski
China (Srs)	Dr. Y-K Tu	**Portugal**	Prof. Dr. J.N. Leitao
Czech Republic	Prof. D. Biolek	**Russia**	Dr. A.B. Shmelev
Denmark	Dr. K.J. Larsen	**Slovakia**	Prof. P. Farkas
Egypt	Prof. S.E. Elkhamy	**South Africa**	Dr. D.D. Mashao
Finland	Prof. R. Wichman	**Spain**	Prof. M. Sierra Perez
France	Dr. J. Palicot	**Sweden**	Dr. E. Englund
Germany	Dr. W. John	**Switzerland**	Prof. M. Rubinstein
Greece	Prof. N. Kalouptsidis	**Turkey**	Dr. E. Panayirci
Hungary	Dr. L. Nagy	**Ukraine**	Prof. V.V. Danilov
Ireland	Dr. M. O'droma	**United Kingdom**	Prof. S. Salous
Israel	Dr. S. Litsyn	**Usa**	Dr. D. Palmer

BUSINESS TRANSACTED BY COMMISSION D

Chair: Prof. S. Tedjini (France)
Vice Chair: Prof. G. Steinmeyer (Germany)

The Commission D Business meetings were held by Prof. Franz Käertner as the Chair and Prof. Smail Tedjini as Vice-Chair, on the following two days (already scheduled in the general program of GASS :

Meeting 1: Monday, August 15th, 17:20-18:40
Meeting 2: Wednesday, August 17th, 17:20-18:20

For each meeting, there are 15 to 20 participants and many points regarding the 2011 GASS and the future 2014 GASS have been discussed. In particular the following issues were discussed and decided upon.

1. Triennial Activity for 2008 – 2011 and program of 2011 GASS

1) One remarkable and very encouraging aspect in the huge evolution in the number of contributed papers for commission D during the 2011 GASS. Indeed, total number of the papers was 128 communications, which represents an increase of 70% when compared to 2008 GASS of Chicago. Some of the papers of commission D was transferred to the sessions of other commissions.
2) The emergence of Nanotechnology in the domain of RFID has changed sensor technology. Increasingly collaboration with other commissions, active in this area, becomes important. The tutorial of commission was focused on that topic and was entitled "Highly Integrated/ Multilayers Packaging for RF and Wireless Applications, Paper Based RFID's. It is important to notice that the multidisciplinary content of RFID technology and its numerous applications fits the reference terms of many URSI commissions, in particular those of commission D. This characteristic will lead to several joint sessions for the next GASS as it has been discussed for the program of the future 2014 GASS.
3) Commission D has supported several new areas of research related to the Nanomaterial, Metamaterial and Plasmonics, and thus, a few issues have emerged. The URSI community working in this area is very large and has different approaches for different applications, but still too dispersed. Commission D needs a concerted effort to have a common action plan together with the other commissions and scientific organizations active in this area.
4) Millimeter and THz wave application is a research area in full development.
5) Traditional topics on Photonics and Microwave are exploiting new concepts by integrating some of the advances in integration and nanotechnologies.
6) Green technologies for sustainable development are gaining in interest and should interest the community of commission D
7) There are discussions on the formation and contribution to a Working Group (WG) on "**RFID Technologies and Privacy of Data** ". Commission D should propose the formation of this WG and invite the other commissions to contribute to the publication of white paper.
8) There is no change in the reference terms of the commission, but green technologies should be considered in the future.

The following conferences were supported by Commission D during the triennium 2008-2011 :

- EMC 2009 VIII International Symposium and Exhibition on Electromagnetic Compatibility and Electromagnetic Ecology, St Petersburg, Russia, June 2009
- META'10, 2nd International Conference on Metamaterials, Photonic Crystals and Plasmonics, 22-25 February, 2010, Cairo, Egypt.
- ISSSE 2010, International Symposium on Signals, Systems and Electronics, Sep 16 -19, 2010, Nanjing, China.
- ICEAA10, International Conference on Electromagnetics in Advanced Applications, September 20-24, 2010, Sydney, Australia.
- AP-RASC 2010 Asia-Pacific Radio Science Conference, September 22-26, 2010, Toyama, Japan.
- APMC 2010 Asia-Pacific Microwave Conference, December 7-10, 2010, Yokohama, Japan.

2. New Chair and Vice Chair for 2011-2014

There were 2 candidates:

1) Prof. Hong Guo, Peking University, Beijing, China

2) Prof. Günter Steinmeyer, Max-Born Institute, Berlin, Germany

The successful candidate was Prof. Günter Steinmeyer.

3. Appointment of Commission D Associate Editor for RSB

Pierre Noel Favennec was appointed to be the new Commission D Associate Editor for the Radio Science Bulletin.

4. Scientific Program for the next GASS

The tentative topics of interest to Commission D for the General Assembly 2014 are :

- RFID technology and applications,
- Lasers,
- Free Electron Lasers,
- Quantum Information Processing
- Microwave Photonics
- Nonlinear Optics and Guided Wave Devices
- Micro and Nanophotonics
- Carbon Based Nanoelectronics
- Hyperspectral Sensing and LIDAR
- Multiphysics Modelling in Radio Frequency Nanoelectronics
- Plasmonics
- Metamaterial Applications
- Signal Processing Antennas,
- Enabling Technology for Millimeter and THz wave Applications,

It has been approved that joint sessions should be encouraged. The previous topics are listed as initial proposal, but the final list of sessions will be defined later.

BUSINESS TRANSACTED BY COMMISSION E

Chair: Prof C. Christopoulos (UK)
Vice Chair: Prof. A P J van Deursen (Netherlands)

1. Election New Vice-Chair

Dr. D. Giri (USA) was elected as Vice-Chair for the next triennium. He will also serve as the Comm. E Editor of the Radio Science Bulletin. The new vice-chairman offered to coordinate new items for the Comm. E website.

2. Working Groups

Commission E activities are carried out by working groups (WG). For the period 2011-2014 Comm. E amended the existing list of WG and their chairs as follows:

E.1 Terrestrial and Planetary Electromagnetic Noise Environment; Co-Chairs A.P. Nickolaenko (Ukraine), C. Price (Israel), K. Hattori (Japan);

E.2 Intentional Electromagnetic Interference; Co-Chairs W. Radasky (USA) and M. Bäckström (Sweden);

E.3 High Power Electromagnetics; Co-Chairs R.L. Gardner (USA) and C.E. Baum (till December 2010, USA) succeeded by Frank Sabath;

E.4 Lightning Discharges and Related Phenomena; Chair dr. S. Yoshida;

E.5 Interaction with, and Protection of, Complex Electronic Systems; Co-Chairs J-P. Parmentier (France), Frank Gronwald (Germany) and H. Reader (South Africa);

E.6 Spectrum Management; Chair : T. Tjelta (Norway) and R. Struzak (Poland);

E.7 Geo-Electromagnetic Disturbances and Their Effects on Technological Systems; Chair : A. Viljanen (Finland);

E.8. Electromagnetic Compatibility and Security in Wired and Wireless Communication Systems; Co-Chairs : J. Gavan (Israel) and A. Zeddam (France).

Also, Commission E designated its representatives to WG jointly operated with other Commissions as follows:

Joint Working Groups

- Inter-commission working group on Solar Power Satellites; Co-Chair for Comm. E: Zen Kawasaki (Japan) and Jacques Gavan (Israel)

- EGH. Seismo Electromagnetics (Lithosphere-Atmosphere-Ionosphere Coupling); Co-Chair for Comm. E M. Hayakawa (Japan)

Other WG topics

E.6 has strong relation with Committee J and with ITU. Closer cooperation will be investigated in the coming triennium. Concerns were expressed that the people that suffer interference due to spectral scarcity are not well represented in the relevant fora. Power line communication, in particular at the high and medium-voltage level spread over a larger area by intended for their implementers. The topic of E.7 has strong relations with E.1 and with joint working group EGH. Also here, closer cooperation might be worthwhile investigating.

3. Terms of Reference

Commission E decided to maintain Chicago 2008-11 version of ToR:

Commission E -ELECTROMAGNETIC ENVIRONMENT AND INTERFERENCE

The Commission promotes research and development in:

a) Terrestrial and planetary noise of natural origin, seismic associated electromagnetic fields;

b) Man-made electromagnetic environment;

c) The composite noise environnements;

d) The effects of noise on system performance;

e) The effects of natural and intentional emissions on equipment performance;

f) The scientific basis of noise and interference control, electromagnetic compatibility;

g) Spectrum management.

4. White Paper

Possible topics for white papers topics were discussed. For the moment several bundled papers on spectral management is the maximum attainable, in view of workload and interests of the authors.

The list of Commission E emerging issues has been discussed thoroughly. Still the text required only little adaptations that will be included in a word version of the LRPC documents. Spectral management becomes an increasingly important issue. Comm. E expresses its concern about wide-spread use of power line communication at frequencies below 30 MHz, in particular in indoor situations where alternatives as WiFi in allocated bands are available and commercially competing options.

5. Support of Meetings

A large number of activities have been organized by national committees. Support had been given to many international symposia and conferences. The triennial report 2008-2011 contains a list. A provisional list of meetings to be supported in the next three-year period is given below. The list will be continuously updated on the Commission's web page. National Representatives are invited to inform the Chair well in advance of meetings suitable for sponsorship in order to be able to plan a budget for future years. At time of writing one had or has:

- International Conference on Electromagnetics in Advanced Applications (ICEAA11), Torino, Italy, 2011.
- EMC Europe, York, UK Sept. 2011.

- Sixth International Beijing Symposium on Electromagnetic Compatibility (EMC'2012/Guilin) to be held in Guilin, China, May 16-20, 2012.
  EMC Europe, Rome, September 2012

- SAfrican URSI Commission E meeting, September 2012. Possibly to be combined with Comm. E business meeting.

- Euroem and Amerem

6. URSI GASS 2011

All GA2011 Comm. E sessions were well attended in general, also by young scientists, and presentations were followed by lively discussions. The E-poster sessions had more no-shows that those of other commissions. Proposal came up to attract more attention, for instance by 2 minutes introductions at the end of the oral session. Space around posters was limited, the acoustic level was high. The GA2011 CD was good; it contained all abstracts, was searchable for author names, and had a direct link to the full papers. A USB version would be useful for participants with laptops that lack a CD-player. Discussion came up to include young scientists in the judge committee for the awards. Recognition that the young scientists were present could be by granting them the title of URSI radio engineer. The GA2011 program was compact; for the 2014 event in Beijing an extension could be reconsidered to more than 6 days, but not necessarily to two full weeks.

BUSINESS TRANSACTED BY COMMISSION F

Chair : Dr. Roger Lang (U.S.A.)
Vice-Chair : Dr. S. Paloscia (Italy)

The Commission F Business Meetings were held on Monday August 15 2011, Wednesday August 17, 2011 and Friday, August 19, 201 and started at 5:20pm.

1. Acceptance of Agenda and Report by the Commission Chair

The agenda was accepted. The Commission chair summarized the highlights of the Commission F activities during the reporting period. The credentials of the voting members were verified.

2. Election of Vice Chair for the Triennium 2011-2014

Commission F elected its new incoming Vice-Chair. The Vice-Chair elect was Dr. Simonetta Paloscia from Italy.

The results of the balloting were (total number of ballots cast: 16)

Animesh Maitra (India)	8
Cesar Amaya (Canada)	14
Simonetta Paloscia (Italy)	24

Simonetta Paloscia (Italy) was thus elected as the in-coming vice-chair for the next triennium. Cesar Amaya (Canada) is the runner-up

Bertram Arbesser-Rastburg (Commission-F, Benelux) kindly counted, tallied and verified the votes. Andreas Danklmayer (observer participant, Germany) served as a witness and assisted with the election procedure.

3. 2011 GASS Program

The question was raised if invited papers should be labeled as ‘invited’ in the conference program. This issue was put to discussion. The consensus of opinion may be summarized as follows: Invited papers should be marked ‘invited’. Room should, however, be left for regularly contributed papers

4. Working Groups

4.1 Commission F Working Groups

- Next-generation radar remote sensing : Action from the last triennial to be continued into the next triennium (2011-2014)
  Conveners: Jean Isnard, Wolfgang Keydel, Emile Schweicher, and Madhu Chandra.

New suggestions under discussion (the named ‘working-group conveners’ are, in the first instance, commission experts who will advise and assist the commission chairs in planning, or carrying-out, scientific activities in the indicated areas):

- Next generation passive microwave remote sensing
  Conveners: Paolo Pampaloni
- Millimeter-wave to THz propagation
  Conveners: Thomas Kürner
- Radio propagation, channel modeling and measurements associated with portable and mobile communications
  Conveners: Robert Bultitude

Intended or Possible Audiences: Policy makers, Funding agencies in various countries/unions, and ITU

4.2 Inter-Commission Working groups

- Working group for coordinating or liaising joint activities between commissions F and C
  Convener: Robert Bultitude

- Working group for coordinating or liaising joint activities between commissions F and G
  Convener: Francois Lefeuvre

5. Radio Science Bulletin

The new incoming vice-chair, Simonetta Paloscia, in keeping with URSI tradition, was named the next editor and facilitator for Commission-F contributions to the Radio Science Bulletin.

In the next triennium, the vice-chair elect together with Prof. Lang (the in-coming chair) will seek contributions from:

i) Dr. Stefan Bueckreuss (DLR, Germany), who will give the commission-F tutorial lecture on Tandem-X;

ii) Prof. P. Pampaloni (commission-F, Italy) on the topic of passive remote sensing;

iii) Dr. Robert Bultitude (Canada), in cooperation with the joint working group, will consider submitting a tutorial paper on mobile and portable radio propagation research, channel modeling, and radio propagation measurements.

6. Interlinking of Commission F with ITU, ISPRS, IEICE and IEEE Societies

The commission discussed the issue and the results are summarized below:

Organization	Persons identified for liaising or promoting links to URSI Commission-F
ITU	Dr. Bertram Arbesser-Rastburg, Prof. Carlo Capsoni
ISPRS	Prof. Francois Lefeuvre, Prof. Tullio Tanzi
IEEE GRSS	Prof. Steven Reising, Dr. David LeVine, Prof. Animesh Maitra
IEEE AP-S, VT-S	Prof. Thomas Kürner
IEICE (Japan)	Prof. Takada

7. Terms of Reference

Commission F comprises two closely related fields, wave propagation and remote sensing and, based on the Terms of Reference updated at the 2005 General Assembly, encourages research in these fields at all frequencies, in particular, the Commission encourages :

a) The study of all frequencies in a non-ionized environment
   i) wave propagation through planetary, neutral atmospheres and surfaces;
   ii) wave interaction with the planetary atmospheres, surfaces (including land, ocean and ice), and subsurfaces;
   iii) characterization of the environment as it affects wave phenomena;
b) The application of the results of these studies, particularly in the areas of remotesensing and communications;
c) The appropriate co-operation with other URSI Commissions and other relevant organizations.

No change was deemed necessary.

8. Sponsorship of Meetings

Type A meetings
MicroRad 2012 in Frascati, Italy
MicroRad 2014 (TBD)
COSPAR 2012 in Mysore, India
IGARSS 2012 in Munich, Germany
IGARSS 2013 in Melbourne, Australia
IGARSS 2014 in Quebec City, Canada
ISAP 2012 (also 2013 and 2014)
EuSAR 2012 in Nuremberg, Germany, April 24-26,2012
International Radar Conference 2012 on October 22-25, 2012 in Glasgow, UK
International Radar Conference 2014 in France
ANTEM 2012 in Toulouse, France
APS/USNC URSI Symposium in Chicago USA July 7-13, 2012
National Conference on Radiocommunication on May 14-16, 2012 at Gdansk University of Technology, Poland
EuCAP 2012 in Prague, Czech Republic, on 26-30 March 2012.

Type B meetings
Triennial Commission F Open Symposium in Ottawa, Canada, Spring 2013
Commission F Specialist Meeting on Remote Sensing / Microwave Signatures in Helsinki, Finland, Fall 2013
AP-RASC 2013 in Taipei, China (SRS) (in addition for sponsorship "A")
Climm'Diff

9. Proposed Commission F meetings for the next triennium

Triennial Commission F Open Symposium
Dr. Robert Bultitude and Dr. Cesar Amaya will host this meeting in Ottawa, Canada in Spring, 2013

Commission F Specialist Meeting on Remote Sensing / Microwave Signatures
Prof. M. Hallikainen will host this meeting in Helsinki, Finland in Fall, 201

10. Commission F proposals for sessions at the next URSI GA in 2011

Suggested (tentative) list of topics:

- Radio channel characterization
- Mobile channel measurements and modeling (see COST 1004) – Dr. Bultitude (Canada)
- GPR and UWB applications
- Terahertz propagation – Dr. Thomas Kuerner (Germany)
- Propagation effects in GPS/GNSS
- Propagation effects in tropical regions – Prof. Animesh Maitra (India), Prof. Ajewole (Nigeria)
- Short-range and indoor microwave propagation – Prof. Takada (Japan)
- Outdoor and indoor optical propagation – Dr. Sizun (France)
- Terrestrial and Earth-space microwave propagation – Dr. Cesar Amaya (Canada)
- Passive microwave remote sensing systems and techniques – Prof. Steven Reising (USA)
- Soil moisture, vegetation and ocean salinity RS from space
- Global observation of the Earth's surface
- Cryosphere
- RS of snowpack: Experiments and modeling – Prof.

Paolo Pampaloni (Italy)
- Radio Frequency Interference (RFI): effects on RS – Prof. Martti Hallikainen (Finland)
  NOTE: Potentially joint with Comm. J
- Multiparameter radar applications – Prof. Madhu Chandra (Germany)
- Education in the area of remote sensing (e-learning)
- Propagation through vegetation – Dr. Saul Torrico (USA)
- Precipitation and atmospheric remote sensing
- RS for disaster management – Prof. Tullio Tanzi (France)
- Ocean surface RS
- Irregular terrains
- Open sessions 1 and 2
- Theoretical developments common to radiocomm and RS

NOTES:
1) ALL proposals must be submitted via e-mail to both Prof. Roger Lang and Dr. Simonetta Paloscia before **March 2013**. They will both be invited to attend a meeting in Gent, Belgium to finalize the list of sessions for URSI GASS 2014.
2) During URSI GASS 2011, we have 9 F-only sessions, 1 FCA, 2 DAF and 1 FG sessions.
3) For URSI GASS 2014, we will need a Commission F Tutorial as well.

12. Representatives to other Organizations

- SCOR: Scientific Committee on Ocean Research (Delaware)
  The incoming vice-chair /D. Weissman
- IUCAF (Scientific Committee on Frequency Allocations for Radio Astronomy and Space Science)
  Steven Reising, Colorado State University,USA.

- COSPAR: Committee on Space Resreach(Paris)
  Bertram Arbesser

Madhu requested to be kept informed

13. Publications and Publicity

- **Radio Science Bulletin (RSB) publication** (Facilitators: Commission Chair and Vice Chair)
- **Radio Science:** Collation and review of full papers submitted following the 12th Commission-F triennial symposium, held during March 2011, in Garmisch-Partenkirchen, Germany. Madhu Chandra will carry out this work as a Guest Editor in consultation with Dr. Paul Canon, Editor-in-Chief of the Radio Science journal

14. Any other business

General Comments regarding GASS 2011

- Business Meeting were well attended and productive

- Poland, perhaps for the first time, took active part in the business meetings

- The important GASS2011 activities sometimes occurred in parallel (e.g Tutorial talks, sessions with award presentation and other actions occurred in parallel)

BUSINESS TRANSACTED BY COMMISSION G

Chair : Prof. J. D. Mathews (U.S.A.)
Vice-Chair : Prof. I. Stanislawska (Poland)

The final business meeting was held on Friday 19 August 2011. Present were the past chair, Mike Rietveld, the new chair, John Mathews, and the newly elected vice-chair, Iwona Stanislawska. We welcomed Iwona who was elected in the Monday business meeting. The Friday meeting was attended by approximately forty commission G members. This report summarizes the results of the Monday 15 August G meeting and the Wednesday joint GH meeting as well as the final meeting on Friday. Discussions were held on the following topics.

1. URSI Board Suggestions & Proposed Resolutions

Proposed Resolution 1. Free access by URSI members and members of the network of Radioscientists, to the proceedings of URSI scientific workshops and symposia.

The resolution proposes to set up a Working Group to look into the possibilities to include a general search engine on the URSI website to improve the archival quality of the proceedings. G response: the resolution was unanimously approved.

Proposed Resolution (from Commission H) 2. Indication of invited paper status in the Program Book of URSI GASS

This resolution proposes to indicate the invited papers of sessions of the appropriate Commissions. The number of invited papers in each session would be limited to encourage submission of contributed papers. G response: 17 support with 12 opposing, the resolution was accepted.

Board Request: The URSI Board requests that commissions take the initiative in "energizing" their membership.

The Chair proposed that, in lieu of more frequent GAs, Commission G more strongly supports existing G-related meetings. These meetings should have an associated working group that will bring new sessions and new members to the GA and, possibly, a student paper competition to that meeting.

Proposed meetings receiving additional Commission G financial support:

1. ISEA (International Symposium on Equatorial Aeronomy); an associated working group will likely be formed.
2. Beacon Satellites meetings and working group.
3. Others?

2. Working Groups

Goal: To review the status of each working group and its outlook. Working Groups should report at each GA and have at least one GA session. The Terms of Reference for each working group should be refined and reported to the Commission on an appropriate basis.

2.1 Working Group Status

G.1: Ionosonde Network Advisory Group
Status: Active

G.2. Studies of the Ionosphere using Beacon Satellites
Status: Active

G.3 Incoherent Scatter
Status: Active

G.4 Ionospheric Research to support radio Systems
Status: Deactivated

G.5 Equatorial and Low-Latitude Aeronomy
Status: To be formed

GH.1. Active Experiments in Plasmas
Status: Active

EGH: Seismo Electromagnetics (Lithosphere-Atmosphere-Ionosphere Coupling)
Status: Active but needs definition

Inter-Commission working group on Solar Power Satellites
Status: G has voted to opt out of this group but can rejoin if a STRONG argument is made to this effect during the triennium.

URSI/IAGLF/ELF remote Sensing of the Ionosphere and Magnetosphere (VA VERSIM)
Status: Active

GF: Middle Atmosphere
Status: Active (MST Workshops) but requires definition.

3. Proposed G - and Joint Sessions for the URSI GASS 2014 in Beijing

G01: Open Session and Latest Results
Conveners: M. Rietveld, J. D. Mathews
mike@eiscat.uit.no, jdmathews@psu.edu

G02: Ionosphere and Plasmasphere Density Profiles
(note: links to IRI working group)
Conveners: Dieter Bilitza, Bodo Reinisch, Lee-Anne McKinnell
dieter.bilitza-1@nasa.gov, Bodo_Reinisch@uml.edu, lmckinnell@sansa.org.za

G03: Advances in Incoherent Scatter Radar
(note: links to ISR working group)
Conveners: F. Lind, I. Haggstrom, M. Milla
flind@haystack.mit.edu, ingemar@eiscat.se,

G04: Studies of Irregularities and Scintillation
(note: links to Beacon Satellite working group)
Conveners: Hal Strangeways and Biagio Forte
h.j.strangeways@ncl.ac.uk, biagio.forte@ung.si

G05: Radio Studies of Polar Aeronomy
Conveners: T. Sato, C. Heinselmann, M. Kosch
tsato@kuee.kyoto-u.ac.jp, craig.heinselman@sri.com, m.kosch@lancaster.ac.uk

G06: Modeling the Geospace Environment
Conveners: M. Foerster, A.A. Namgaladze
mfo@gfz-potsdam.de, namgaladze@gfz-potsdam.de

G07: Impacts of the Ionosphere on Radio Systems
(note: links to the Systems special interest group that may be convened)
Conveners: Iwona Stanislawska, Bruno Zolesi, Mike Warrington (Paul Cannon may help organize)
stanis@cbk.waw.pl, Bruno Zolesi <zolesi@ingv.it>

G08: Radio Studies of Equatorial and Low-Latitude Aeronomy (links to possible new working group on Equatorial and Low-Latitude Aeronomy and to the ISEA meetings)
Conveners: Koki Chau, Anthea Coster
jorge.chau@jro.igp.gob.pe, ajc@haystack.mit.edu

HG1: Drivers, detection, and ionospheric impacts of precipitation from the radiation belts
Conveners: C. Rodger (H), M. Clilverd (G)
crodger@physics.otago.ac.nz, macl@bas.ac.uk

HGE1: Ionospheric, magnetospheric and high energy effects of lightning
Conveners: M. Fullekrug (H), V Pasko (G), E. Rachidi (E)
eesmf@bath.ac.uk, vpasko@psu.edu, farhad.rachidi@epfl.ch

GH1: Active Experiments (note: links to HG working group on this subject.)
Conveners: T. Pedersen (H), M. Kosch (G)
toddrpedersen@gmail.com, m.kosch@lancaster.ac.uk

GH2: The Geospace Environment and Meteors
Conveners: S. Close (G), H: Meers Oppenheim (H)
sigridc@stanford.edu, meerso@bu.edu

GH3: Radio sounding in magnetospheres and ionospheres
Conveners: V . Sonwalkar

GH4: Plasma Waves and Turbulence in the Equatorial E and F Regions (note: some overlap with G09)
Conveners: Erhan Kudeki (H), Christos Haldoupolis (G)
erhan@illinois.edu, chald@physics.uoc.gr

EGH: Seismo-electromagnetics
Conveners: E: Y. Hobara, J. Y. Liu (G)

BUSINESS TRANSACTED BY COMMISSION H

Chair : Prof. O. Santoli (Czech Republic)
Viche-Chair : Prof. M.M. Oppenheim (U.S.A.)

The Commission H Business meetings were held three times during the GA on the following three occasions.

- Business Meeting 1: Monday 15 August 2011 17:20 - 18:40 in room Topkapi B, chaired by Yoshiharu Omura
- Joint Business Meeting 2 G & H: Wednesday 17 August 17:20 - 18:40 in room Topkapi A, chaired by Paul Cannon and Yoshiharu Omura
- Business Meeting 3: Friday Friday 19 August 17:20 - 19:00 in room Topkapi B, chaired by Ondřej Santolík

1. Election Vice-Chair

Meers Oppenheim (USA) was appointed as the new vice-chair of Commission H after voting from the member committees and the commission chair during the first business meeting. The details of the votes are the followings: Meers Oppenheim (USA) 23, Craig Rodger (New Zealand) 22. The vice-chair has been confirmed to become an Associate Editor of Radio Science Bulletin. The chair of Commission H, Yoshiharu Omura (Japan) appointed the former vice-chair Ondřej Santolík (Czech Republic) as the new Chair.

2. Terms of Reference

The new terms of reference of Commission H have been adopted after a discussion during the third business meeting.

The goals of the Commission are:
- To study waves in plasmas in the broadest sense, and in particular:
  - the generation (e.g. plasma instabilities), propagation, and detection of waves in plasmas,
  - wave-wave and wave-particle interactions,
  - plasma turbulence and chaos,
  - spacecraft-plasma interaction,
  - instabilities, heating, and diagnosis of laboratory plasmas;

- To encourage the application of these studies, particularly in the areas of solar/planetary plasma interactions, space weather, and an increased exploitation of space as a research laboratory.

A vote was also taken on narrowing scope to waves in space plasmas, with 16 votes for and 16 votes against. The commission chair therefore decided not to adopt these proposed additional changes and keep the broader scope of the commission expressed by the above terms of reference.

3. Working Groups

Activities of the working groups related to Commission H were reviewed and their organization has been renewed as in the following.

3.1 Joint Working Groups

- *An inter-commission working Group on Solar Power Satellites:* Co-chair for Commission H: K. Hashimoto (Japan), Co-chair for Commission G: K. Schlegel (Germany).
- *EGH: Seismo-Electromagnetics.* Co-chair for Commission G: S. Pulinets (Russia), Co-chair for Commission H: M. Parrot (France)
- *GH: Active experiments in Space Plasmas*: Co-Chair for Commission G: Keith Groves (USA) (USA), Co-Chair for Commission H: B Thide (Sweden)

- *HEJ: Computer Simulations in Space Plasmas:* Co-chair for Commission H: Y. Omura (Japan) and B. Lembege (France), Co-chair for Commission J: K. Shibata (Japan)

3.1 Inter-Union WG

- *URSI/IAGA VLF/ELF remote Sensing of the Ionosphere and Magnetosphere (VERSIM*), URSI Representative (Commission H): Janos Lichtenberger

4. Commission H Recommendation

The Commission H recommendation:"Indication of invited papers in the Program Book of URSI GASS" was voted during the third business meeting by large majority:

Commission H recommends to indicate the invited papers of sessions of the appropriate Commissions. The number of invited papers in each session is limited (4 or less) in order to encourage submission of contributed papers and expansion of the community.

5. Proposed Meetings sponsored by URSI Commission H during 2011-2014

- International Reference Ionosphere (IRI), Hermanus, South Africa, 10-14 Oct 2011, (Commissions G & H, Lee-Anne McKinnell,)

- 13th International Symposium on Equatorial Aeronomy, Paracas, Peru, 12-17 March 2012 (Commissions F, G and H, Jorge L. Chau)

- 5th VERSIM workshop, September 2-8 (tentative), 2012, Sao Paulo, Brazil (Commissions G & H, Fernando Bertoni)

- 11th International School for Space Simulations, July, 2013 (Commission H, Lin-Ni Hau Taiwan)

Further suggestions will be handled by Commission H Chair O. Santolík during the 3 year period.

6. Commission H Tutorial for the 2014 GASS

Yoshiharu Omura will give a tutorial at the next GASS: "Theory and simulations of nonlınear wave-particle interactions in the planetary radiation belts"

7. Science Session Proposals for the 2014 GASS

- H1: Wave-particle Interactions and Their Effects on Planetary Radiation Belts
  (J. Bortnik, C. Rodger, R Horne)
- H2: Boundary layers in terrestrial and planetary environments: Macro/micro-scale kinetic processes (B. Lembège, G. Lakhina, I. Shinohara).
- H3: Plasma interactions with solar system bodies (C. Mazelle, Y. Kasahara)
- H4 : Remote sensing of the Plasmasphere (J. Lichtenberger, C. Rodger, A. Collier)
- H5: Laboratory simulations of space plasma waves (A. Fredriksen , E. Tejero)
- H6: Open session (M. Oppenheim, O. Santolík)
- HGE : Ionospheric, magnetospheric and high energy effects of lightning (M. Fullekrug, V. Pasko, N. Liu)
- HG1: Drivers, detection, and ionospheric impacts of precipitation from the radiation belts (C. Rodger, M. Clilverd)
- GH1: HF-Driven Active Experiments (T. Pedersen, M. Kosch)
- GH2: The Geospace Environment and Meteors (S. Close)
- GH3: Radio sounding in magnetospheres and ionospheres (V . Sonwalkar)

GH4: Plasma Waves and Turbulence in the Equatorial E and F Regions (E. Kudeki, C. Haldoupolis)

Note: Because of the limited time slots for oral sessions at the next GASS, the commission will decide later on reduction of the number of sessions.

8. Emerging Scientific Issues

Commission H discussed Emerging Scientific Issues and possible areas for new emphasis as follows.

- Space Weather
  Impact of the Sun on the Earth's magnetic field and charged particles driven by waves in plasmas
- Space Radiation Environment
  Electron acceleration in solar flares and interplanetary shocks and acceleration of cosmic rays.
- Exploration of planetary environments
  Fundamental science of wave-particle interactions at the Moon, Mars, Jupiter and other planets and other smaller bodies in the Solar System Solar
- Artificial plasma wave excitation in the magnetosphere
  Active experiments with transmitters and laboratory plasmas
- Reconnection processes in space plasmas: associated plasma waves and turbulence

BUSINESS TRANSACTED BY COMMISSION J

Chair : Prof. J. Jonas (South Africa)
Vice-Chair : Prof. W. Baan (the Netherlands)

Commission J business sessions were chaired by Prof Ananthakrishnan on the following two days:

Meeting 1: Monday, 15 August, 17:20 - 18:40
Meeting 2: Wednesday, 17 August, 17:20 - 18:40

Profs Ananthakrishnan and Jonas co-chaired the final business session:

Meeting 3: Friday, 19 August, 17:20 - 18:40

1. Commission J Business Session I on August 15

1.1 Memorial Talk

Prof Ken Kellerman paid tribute to Commission J colleagues who had passed away during the preceding triennium. A number of the early pioneers and prominent radio astronomers died over this period, and amongst them was the Chair-elect for Commission J, Prof Don Backer.

1.2 Election of Vice-Chair

Because of the tragic passing of Don Backer, Justin Jonas was nominated as past Vice-Chair (Jonas was a candidate for Vice-Chair in 2008)

Candidates for Vice-Chair at this GASS were:
1) Richard Bradley – USA
2) Willem Baan – Netherlands

Votes were received from: Brazil, France, India, Italy, Israel, Japan, Netherlands, Nigeria, Russia, South Africa, Sweden, USA, UK

Dr Willem Baan was elected as Vice-Chair for the next triennium

1.3 Comission J Budget, Report on 2008-2011 triennium

Income:

1) Comm J activities grant	€ 9000
2) GASS travel support grant	€ 3000
TOTAL INCOME	**€12000**

Expenditure:
Financial support of meetings:
1) 3rd Workshop on RFI Mitigation in Radio Astronomy Groningen, Netherlands, 17-19 March 2010 : € 750
2) 3rd Asia-Pacific Radio Science Conference Toyama, Japan, 22-25 September 2010 : € 1000
3) "Towards Exploring the Equatorial" – 2011 International Conference on Space Science and Communication Malaysia, 12-13 July 2011-10-31 : € 600

SUBTOTAL € 2350

Travel support for Young Scientists (Post-docs):

1) Dr Wei Wang (China)	€ 1000
2) Dr Urvashi Rao (USA)	€ 1000
3) Dr S Wijnholds (Netherlands)	€ 1000
4) Dr Sarah Spolaor (Australia)	€ 1000
5) Dr Aaron Parsons (USA)	€ 550
SUBTOTAL	€ 4550

Travel support for Young Scientists (Graduate Students):

1) Ronny Levanda (Israel)	€ 900
2) Rurik Primiani (USA)	€ 900
3) A. Raghunathan (India)	€ 900
4) Parisa Noorishad (Netherlands)	€ 900
5) Siemion Andrews (USA)	€ 750
6) Filiba Terry (USA)	€ 750
SUBTOTAL	€ 5100
TOTAL EXPENDITURE	**€ 12000**

1.4 Issues arising from URSI Council (14 August 2011)

1) Concern was raised about fall in attendance and papers at GASS. Suggestions for making the GASS more attractive were solicited. The current format of the URSI sessions, which is very rigid, may be a detractor.
2) The election of the URSI President and Vice-Presidents was noted. Commission J has a representative on the Board now that Prof S. Ananthakrishnan is a Vice-President.

1.5 Resolutions discussed in the Council

Some reservations were expressed about the two proposed Resolutions, and it was thought that more discussions were needed.

1.6 IUCAF

Dr Ohishi briefed the meeting on the activities of IUCAP for the period 2008-2011.

1.7 Long Range Planning Committee

Dr Schilizzi briefed the meeting on discussions and recommendations of the LRPC.

1.8 Publications in the Radio Science Bulletin

1) "The Square Kilometre Array (SKA) Radio Telescope: Progress and Technical Directions", Hall, P.J., Schilizzi, R.T., Dewdney, P.E.F. and Lazio, T.J.W., Radio Science Bulletin, No. 326, p3, Sept., 2008

It was noted that Commission J papers are not being submitted to the RSB and corrective actions were discussed. A call was made for a volunteer to be Associate Editor of RSB.

1.9 Emerging Issues

Topics for emerging issues in radio astronomy were solicited for discussion at the Business Session on 17th August.

1.10 Other items

1) Triennial reports were only received from the following countries: China, France, India, Ireland, Netherlands, Norway, Russia, Sweden, UK.

2) A total of 134 Commission J presentations were presented at the 2011 GASS: 74 oral papers, 21 observatory reports and 39 posters.

2. Commission J Business Session 2 on August 17

2.1 Issues arising from URSI Council (16 August 2011)

1) The acceptance of Profs Justin Jonas and Willem Baan as incoming Chair and Vice-Chair of Commission J was noted.

2) Issues around inter-GA meetings, publication of GASS proceedings and the New Results session were discussed.

2.2 Associate Editor for the Radio Science Bulletin

Dr Jaap Baars accepted nomination as Associate Editor for Commission J

Various papers are in preparation, and new topics were proposed for papers.

2.3 GVWG

Based on the findings of a report by Prof Steven Tingay the GVWG was disbanded.

2.4 URSI Long Range Issues

Emerging Issues in Commission J

The existing list of issues was reviewed and further inclusions were considered.

Other items

Discussion on how to improve URSI GASS attendance, particularly amongst young scientists.

2.5 Awards

Dr Jocelyn Bell-Burnell would be presented with the Grote Reber Gold Medal at 8 am on Friday 19 August, and the presentation would be followed by a lecture by her.

3. Commission J Business Session 3 on August 19

3.1 Issues arising from URSI Council (18 August 2011)

(1) There was support for a "hybrid model" for the GASS, allowing more flexibility in the sessions.

(2) There was support for making Powerpoint slides available on a website, given that permission was obtained from authors.

3.2 GASS 2014, Commission J Programme

(1) The list of emerging issues was reviewed and used as a basis for suggesting sessions.
(2) Suggestions for joint sessions, invited speakers and general lectures were solicited.

3.3 Meetings to be supported by Commission J, 2011-2014

Suggestions for meetings to be supported were solicited.

3.4 Communication with Commission J members

The need for an updated e-mail database of members was identified.

3.5 Council Presentation

Commission J highlights to be presented at the final Council Meeting were discussed. A key message was that Radio Astronomy is a vibrant field, and a high participation rate in Commission J activities at the GASS was proof of this.

BUSINESS TRANSACTED BY COMMISSION K

Chair: Prof. M. Taki (Japan)
Vice-Chair: Prof. J. Wiart (France)

Three Business Meetings were held on:

Monday, 15 Aug 17:20 to 18:40
Wed 17 Aug 17:20 to 18:20
Fri 19 Aug 17:20 to 19:00

1. White Paper on Wireless Communication and Health

Commission K has been preparing for a white paper on "Wireless communication and health". Authors of each chapter have been identified and a draft was supposed to be collected in 2008. The procedure has been delayed, however, due to the delay in the risk assessment in the International EMF Project. A comment has been sent by the coordinator of writing the White Paper that it has become more and more difficult to publish the White Paper due to the confused situation regarding the risk evaluation of radiofrequency electromagnetic fields. Political pressures from several sides have made the confused situation worse. With this background the treatment of the issue of White Paper was discussed at the Business meetings in Istanbul.

There was discussion both for and against cancelling the project but finally Commission K decided as follows.

We continue editing the White Paper but propose a "new" White Paper: "EMF and Health". A set of articles on the state of knowledge in research will be prepared even looking forward future tendency and possibilities. Then those articles will be published on Radio Science Bulletin during next two years. The White Paper will be the compilation of those articles with a collective preface.

To reach the scope a web platform will be rigged in Commission K to share documents, ideas and comments. A group of persons will be identified to manage the selection of authors and promotion of activities with Chair, Vice-chair, Past-chair and RSB editor.

2. Commission K 2008 – 2011 Triennial Report

The Chair reviewed the activity in the triennium of 2008 – 2011. The overview is as follows:

a) Publishing articles in the Radio Science Bulletin,
b) Sponsoring and funding scientific meetings,
c) Organizing and funding a major international symposium (Bordeaux, April 2010),
d) Preparing a white paper on Wireless Communication and Health, pending the recent evaluation of the IARC (WHO - International Agency Research on Cancer) of RF and MW fields carcinogenicity,
e) Running two business meetings in June 2009 at BioEM2009 in Davos (CH) and June 2010 at the annual Bioelectromagnetics Society Meeting in Seul (South Korea),
f) Developing a draft of commission strategic directions.
g) Preparing for the General Assembly and Scientific Symposium of Istanbul, Turkey, with 8 oral sessions and two poster sessions, 2 joint sessions lead by Commission K with Commissions A and E and B and E respectively, 1 joint session lead by Commission K with commission B, for a total of 81 oral presentations and 23 poster presentations.

Details of the activities during the triennium 2008 – 2011 were described in this report (Topics 3, 4, 5, 6),

3. Contributions to the Radio Science Bulletin

It was reported that Commission K contributed two papers of invited papers and six articles on radiofrequency radiation safety and health to RSB.

4. Sponsorship of Scientific Meetings

It was reported that Commission K supported 12 scientific meetings during the triennium and approved.

5. Mid-Triennium Symposium

Commission K held a mid-term scientific meeting in Bordeaux on 26 – 29 May 2010. It was organized in cooperation with the EBEA (European Bio-Electromagnetics Association) and COST BM704.

6. Student Support at URSI

Student support by Commission K during the last triennium was reported and approved.

7. Preparations URSI GASS 2014

Candidates of the venue for GASS 2014, Montreal in Canada, Beijing in China, and Tokyo in Japan were announced and explained according to their proposal documents.

Preference of Commission K for the venue was discussed. Commission K decided to vote for Tokyo, Japan for the first place and Montreal, Canada for the second place.

8. Election of Commission K Vice-Chair Election

Three candidates had been nominated.
- Prof. Gianluca Lazzi (USA)
- Dr. Joe Wiart (France)
- Prof. Jeong-Ki Pack (South Korea)

The voting was made from 17 countries.

Dr. Joe Wiart was elected as the Vice-chair for the triennium 2011 – 2014.

9. Review and Update of Commission Terms of Reference

The terms of reference of Commission K were reviewed and confirmed to keep them as they are.

10. Commission K RSB Associate Editor for the next Triennium

Dr. Erdem Topsakal (USA) was appointed as the Commission K RSB Associate Editor for the next triennium. He is the Chair-elected of US National Commission K.

It was noted that he should contact Prof. Gianluca Lazzi, who was initially supposed to be asked if he could serve for this task.

11. Other issues

Following action items were decided during the business meetings.

- To create collaborative tool on the web (e.g. Google+) dedicated for the national representative of Commission K and people acting for working groups.

- To create “2-page electronic liaison document” to link between national representatives.

- To have a common meeting with existing conference to have scientific mid-term meeting.

STUDENT PAPER COMPETITION AWARD

At the URSI GASS in Istanbul, Turkey, the Second International Student Paper Competition was held. It was chaired by Prof. Steven C. Reising (Colorado State University, Fort Collins, CO, USA and co-chaired by Prof. Birsen Saka (Hacettepe University, Turkey).

Ten finalists were chosen based upon quality, originality and scientific merit. They received free access to the workshop/short course of their choice.

All finalists were recognized and the prizes were presented at the banquet which was held on Wednesday, August 17 in the beautifull garden of the Istanbul Hilton Hotel.

The URSI Panel of Judges consisted of the ten URSI Commission Chairs or their authorized representatives, in case of absence.

In addition, the prizes were awarded based on the clarity of their presentation, accessibility to the broad audience of the ten URSI Commissions and the ability to answer questions on their work.

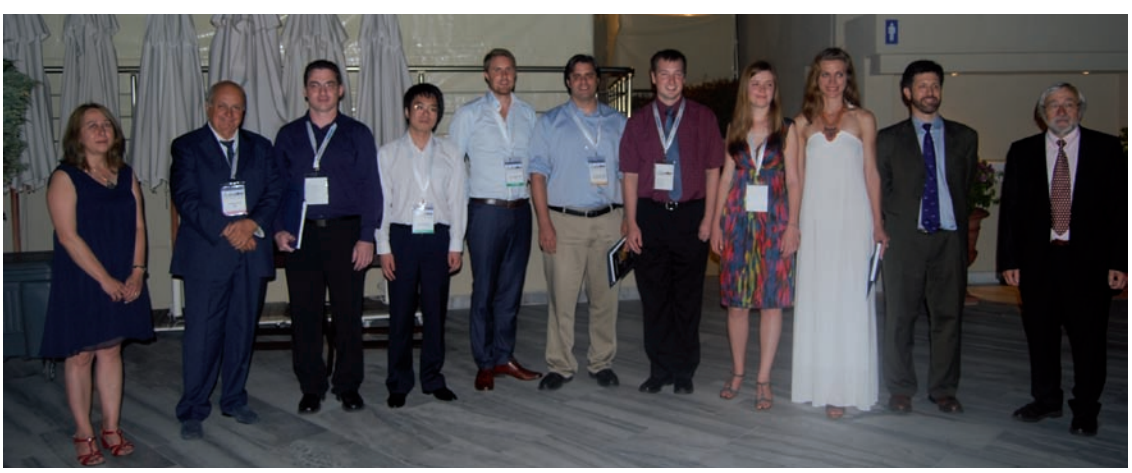
All participants had the option of submitting their full paper manuscripts for review for publication in a special section of the journal Radio Science edited by Prof. Piergiorgio L.E. Uslenghi, Univ. of Illinois at Chicago, IL, USA, 2011 URSI GASS Scientific Program Coordinator.

The **Honorable Mention Awards** were given to :

1) Galyna Safonova of Macquarie University, Australia, for her paper entitled "Rigorous Approach to Analysis of 2-D Electrostatic-Field Problems for Multi-Conductor Systems." Her advisor is Prof. Elena Vynogradova of Macquarie University, Australia.
2) Cheryl Sorace-Agaskar of MIT, USA, for her paper entitled "Accurate Photonic Analog-to-Digital Conversion." Her advisor is Prof. Franz Kaernter of MIT and the University of Hamburg, Germany.
3) Miao Tian of the University of Colorado at Boulder, USA, for his paper entitled "A Unified Microwave Radiative Transfer Model with Jacobian for General Planar Stratified Media." His advisor is Prof. Albin Gasiewski.
4) Xianyue Wu of the University of Birmingham, UK, for his paper entitled "Antenna Design and Channel Measurements for On-body Communications at 60 GHz." His advisor is Prof. P. S. Hall of the University of Birmingham, UK.

The **Top Five Student Paper Awards** were given to :

- The Fifth Prize, with a check for $500 goes to Kynthia Stavrakakis of the Technische Universitaet Darmstadt, Germany, for her paper entitled "Model Order Reduction Methods for Multivariate Parameterized Dynamical Systems." Her advisor is Prof. Thomas Weiland of the Technische Universitaet Darmstadt, Germany.
- The Fourth Prize, with a check for $750, goes to Thomas Gjesteland of the University of Bergen, Norway, for his paper entitled "Confining the Angular Distribution of Terrestrial Gamma-Ray Flash Emission." His advisor is Prof. Nikolai Ostgaard of the University of Bergen, Norway.
- The Third Prize, with a check for $1000, goes to Ryan Volz, of Stanford University, USA, for his paper entitled "A Compressed Sensing Approach to Observing Distributed Radar Targets." His advisor is Prof. Sigrid Close of Stanford University, USA.
- The Second Prize, with a check for $1250, goes to Yan Kaganovsky, of Tel Aviv University, Israel, for his paper entitled "Spectral Analysis of the Airy Pulsed Beam." His advisor is Prof. Ehud Heyman of Tel Aviv University, Israel.
- The First Prize, with a check for $1500, goes to Jonathan Cox of MIT, USA, for his paper entitled "A Femtosecond-Precision, Fiber-Optic Timing Transfer System with Long-Term Stable, Polarization Maintaining Output." His advisor is Prof. Franz Kaertner of MIT, USA and the University of Hamburg, Germany.



Book Reviews for Radioscientists

Electromagnetic Reverberation Chambers

by Philippe Besnier and Bernard Démoulin, London, ISTE-Wiley, 2011, 427+xxiii pp.; ISBN: 978-1-848-21293-0

Reverberant cavities, originally developed for industrial use, were proposed as measurement tools for the assessment of the electromagnetic compatibility (EMC) of electronic products in the seventies of the last century. The development of the technique – and especially, its acceptance among the EMC standards for civilian applications – has taken a fairly long time, and technical activities on this topic have boomed only in the last decade. Up to very recently, all the progress in the field had been documented by journal papers and several reports. This book by Besnier and Démoulin represents only the second attempt to systematize the knowledge about reverberation chambers (RCs).

The authors of this book are two well-known and experienced professionals in EMC. In particular, Prof. Démoulin (now Emeritus at Lille University) built his first reverberation chamber within the Laboratory for Radiowave Propagation (currently, IEMN-TELICE Lab) while Philippe Besnier was a student at the same lab. Since then, Prof. Démoulin has conducted several studies and provided education on reverberation chambers.

This book presents the physical principles of reverberation chambers in a very progressive manner. Building on electromagnetic theory and statistics, the fundamentals of the operation of reverberation chambers and the characteristic parameters are illustrated, together with various applications related to EMC and antennas. The basic operational rules of reverberation chambers, including their calibration procedures, are illustrated in detail. The relationship of reverberation chambers to other conventional test systems (TEM cells, anechoic chambers) is also well discussed in the book.

Before a chapter-by-chapter illustration of the book's content, it is worth mentioning the Foreword, written by Prof. Paolo Corona, who was one of the worldwide initiators of reverberation-chamber studies. His enjoyable testimony provides a synthetic history of reverberation-chamber developments, and some accounts of the pioneering activities in the field.

The material of this book can be ideally subdivided in three parts, namely the reverberation-chamber fundamentals, the use of the chambers, and the recent research work on open issues.

The first four chapters refer to reverberation-chamber fundamentals. In particular, Chapter 1 deals with "Reverberation Chambers Among Usual Testing Methods." It discusses the plane-wave representation, and its limitations for describing fields in metallic enclosures. Chapter 2, on "Main Physical Features of Electromagnetic Cavities," shows that the field distribution in an electromagnetic cavity, oversized with respect to operation wavelengths, behaves like a stochastic process. Hence, the electrical quantities measured inside the chamber can be assimilated to random variables.

Chapter 3 discusses the "Statistical Behavior of Stirred Waves in Oversized Cavities." It provides the statistical tools needed to describe the field inside the chamber. It also provides the metrics necessary to classify the measurements taken inside a reverberation chamber, and to verify if they belong to the expected statistical distributions. Chapter 4, on "Control of Physical and Technical Parameters of a Reverberation Chamber," approaches reverberation chambers from the design point of view. It discusses the empirical rules and parameters that are commonly employed to build a reverberation chamber.

The second part of the book illustrates the use of reverberation chambers in three chapters.

Chapter 5, on "Radiated Immunity Tests in a Reverberation Chamber," addresses the tests for which reverberation chambers are most frequently employed. It is very intuitive that an environment with high-intensity fields illuminating a device from all directions is very well suited to verify the "electromagnetic robustness" of the device itself. This chapter carefully discusses the chamber's calibration procedure, and the requirements for reproducibility of tests.

Chapter 6 deals with "Emissivity Tests in a Reverberation Chamber." It clearly points out the concept that the reverberation chamber enables us to measure the total radiated power from a device. However, as the chapter progresses, space is given to the more recent uses of reverberation chambers for the evaluation of less-global antenna parameters.

Chapter 7 is devoted to "Measurement of the Shielding Effectiveness in Reverberation Room." After a careful definition of the shielding effectiveness, the authors discuss the use of reverberation chambers for measurements of cables, connectors, enclosures, and materials.

Finally, the last chapter – Chapter 8, on the "Reverberation Chamber as a Topic of Research Activities" – gives an account of open issues (in particular, those related to measurements showing non-ideal statistical properties) and of reverberation-chamber applications outside the field of EMC. Appendices include a rich set of statistics and electromagnetics formulas that are handy to have available for the understanding of reverberation-chamber theory, and for processing their measurements.

This book is recommended both as a reference for researchers and professionals working with reverberation chambers, and as a textbook for a course on reverberation chambers.

Reviewed by:
Flavio Canavero
Politecnico di Torino
E-mail: flavio.canavero@polito.it

Conferences

CONFERENCE REPORTS

ISROSES II - 2nd International Symposium on Recent Observations and Simulations of the Sun-Earth System

Borovets, Bulgaria, 11 - 16 September 2011

A very successful second International Symposium on Recent Observations and Simulations of the Sun-Earth System (ISROSES II) was held in Borovets, Bulgaria, from 11 to 16 September 2011. This Symposium was chaired by Dr. Vania Jordanova, Los Alamos National Laboratory (LANL), USA

The main sponsors of the symposium were the International Union of Radio Science (URSI) and the US National Science Foundation (NSF). It also received collaboration and support from the International Association of Geomagnetism and Aeronomy (IAGA), the US National Aeronautics and Space Administration (NASA), the LANL Institute for Geophysics and Planetary Physics (IGPP), Sofia University, Bulgaria, and the ICT Cluster, Bulgaria.

The purpose of the symposium was to bring together cross-disciplinary scientists from the solar, heliospheric, magnetospheric, and earth sciences communities worldwide to have focused discussions on fundamental problems related to the space environment of the Earth and the Sun-Earth Connection.

The ISROSES II scientific program consisted of an introductory keynote lecture, invited as well as contributed talks, and posters. The symposium had 15 oral and two poster sessions which gathered more than 100 participants for fruitful discussions. An international panel convened to discuss "Space Science Research Perspectives and International Collaborations".

Leading scientists from the worldwide research community presented the latest advancements in Space Weather studies. Among the ISROSES II participants were distinguished speakers from US universities and research centers, the European Union, Canada, Japan, Norway, Russia, and other countries. For further information about the symposium, please visit the official website: http://www.isroses.lanl.gov/.

Report on 2011 International Conference on Electromagnetics in Advanced Applications and 2011 IEEE AP-S Topical Conference on Antennas and Propagation in Wireless Communications

Torino, Italy, 12 - 16 September 2011

The 13th edition of the International Conference on Electromagnetics in Advanced Applications (ICEAA), and the first edition of the IEEE AP-S Topical Conference on Antennas and Propagation in Wireless Communications (IEEE APWC), were held at Torino, Italy, September 12-16, 2011. ICEAA has the IEEE Antennas and Propagation Society, the Istituto Superiore Mario Boella, and the Torino Wireless Foundation as principal cosponsors. Other technical cosponsors of this edition of ICEAA 2011 were the International Union of Radio Science (URSI), the IEEE ED and MTT Societies, the IEEE Italy Section, and the IEEE North Italy AP, ED and MTT Joint Chapter. IEEE APWC was the first conference of the IEEE Antennas and Propagation Society held outside the North American continent. Following the memorandum of understanding between ICEAA and IEEE AP-S finalized in September 2010 at Sydney, Australia, the two conferences shared a common registration, organizing and scientific committees, venue, reception, and banquet, and social events.

The 579 submissions received by the two conferences were reviewed by an international scientific committee composed of scientists from thirteen countries. The 381 accepted papers were scheduled in 45 technical sessions, 31 sessions in ICEAA (including 16 special sessions) comprising 270 papers, and 14 sessions in APWC (including seven special sessions) comprising 111 papers. Most published papers came from Italy (14%), the USA (12.6%), Germany (11.6%), Japan (5.8%), and France and the UK, with 5.5% each. There were 364 registered attendees and several

Figure 1. Rodolfo Zich and Roberto Graglia at the opening ceremony.

Figure 2. Magdalena Salazar-Palma, AP-S President, at the opening ceremony.

accompanying persons from 47 countries. The proceedings of the conferences were published on two CDs and on IEEE Xplore. There was a short course on "A Hybrid Domain-Decomposition-Based Numerical and Ray Technique for Analysis/Synthesis of Large Conformal Phased Arrays on Complex Platforms," taught by Jin-Fa Lee and Prabhakar Pathak of The Ohio State University.

The ICEAA technical sessions covered topics such as nano-magnetism and magnetic materials; future challenges in mathematical and computational electromagnetics; modeling of devices and circuits; applications of electromagnetic precursors; electromagnetic theory; network methods applied to electromagnetic field computation; numerical methods in electromagnetics; multi-physics modeling and simulation; electromagnetism and signal processing for distributed radar sensing; electromagnetic measurements; advances in analysis and synthesis of large-scale antenna arrays; optical, sub-millimeter, and millimeter technologies; frequency-selective surfaces; printed and conformal antennas; hybrid ray, beam, and numerical methods; numerical methods for multi-scale problems; radar cross section and imaging; antennas and arrays; mathematical advances in electromagnetics; electromagnetic applications to nanotechnology; metamaterials; fields and waves; integral equations and hybrid methods; finite methods; high-power electromagnetics; electromagnetic analysis of packages and boards; inverse scattering and remote sensing; EMC/EMI/EMP; propagation models for VLF to SHF waves; electrodynamics of nanowires and nanotubes; and electromagnetic applications to biomedicine.

The topics covered in IEEE APWC technical sessions were: combining electromagnetic propagation models with sensing and geolocation; low-profile and UWB antennas; antenna design for cognitive-radio applications; active and smart antennas; RFID technologies; advances in wireless communications and their applications; electromagnetic propagation; wideband and multi-band antenna technologies; cognitive radio and wireless networks; channel modeling; antennas for wireless applications; ultra-wideband body-area networks and medical applications; topics in physical-layer communications; and antennas with FSS, AMC, and periodic structures.

Figure 3. (l-r) Marco Gilli, Magdalena Salazar-Palma, Roberto Graglia, and Riccardo Tascone at the opening ceremony.

Figure 4. The reception in the courtyard of Castello di Pavone

Figure 5. (l-r) Peter Russer, Poman So, George Uslenghi, and Werner Wiesbeck at the reception.

Figure 6. Kurt Oughstun (l) and Don Wilton at the reception.

As in previous ICEAA editions, the number of parallel sessions was limited to four, in order to facilitate the exposure of attendees to a variety of scientific topics. Catered gourmet luncheons allowed for informal and lively interactions among participants. Coffee breaks were held in the industrial exhibit area. The social program included wine-tasting and chocolate-tasting parties.

Sunny skies and uncommonly warm weather allowed participants and accompanying persons to enjoy the museums, shops, restaurants, and environment of Torino. At the opening ceremony, several dignitaries addressed the participants: Roberto Graglia, Chair of the Organizing Committee; Rodolfo Zich, President of the Istituto Superiore Mario Boella and of the Torino Wireless Foundation (Figure 1); Magdalena Salazar Palma, President of the IEEE Antennas and Propagation Society (Figure 2); Marco Gilli, Vice-Rector of the Politecnico di Torino; Riccardo Tascone, Director of the IEIIT Laboratory of the Italian National Research Council (Figure 3); and George Uslenghi, Chair of the Scientific Committee and URSI representative. In addition, David Davidson made a presentation of the next conferences' venue in Cape Town, South Africa.

The reception and gala dinner were grandiose affairs held at the Castello di Pavone, a restored medieval castle at the foot of the Alps near Torino (Figures 4-8). At the reception, the Young Scientist Best Paper Award was given; it consisted of a certificate and a monetary prize of 800 Euros. The awards committee, composed of David Davidson, Paul Smith, and Don Wilton, selected the winner among entrants less than thirty-six years old on the basis of the originality, clarity, and timeliness of their contribution. There were a number of outstanding entries from young scientists. The winner was Nicolas Gagnon of the Communications Research Centre, Ottawa, Canada, for his paper entitled, "In-Depth Examination of a 3-Layer Phase Shifting Surface (PSS) and its Use in a Thin Fresnel Lens Design," co-authored with A. Petosa and D. A. McNamara (Figure 9). The committee also awarded a special recognition, consisting of a 50% discount on registration at the next ICEAA – IEEE APWC conferences, to Ignace Bogaert of Ghent University, Belgium, for his paper, "Low-Frequency Scaling of the Mixed MFIE for Scatterers with a Non-Simply Connected Surface," coauthored with K. Cools, F. P. Andriulli, and D. De Zutter.

Figure 7. (l-r) Paul Smith, Magdalena Salazar Palma, Silvio Barbin, and David Davidson at the gala dinner.

Figure 8. Hisamatsu Nakano (third from right) with several colleagues at the gala dinner.

Figure 9. Nicolas Gagnon receiving the Young Scientist Best Paper Award: (l-r) David Davidson, George Uslenghi, Nicolas Gagnon, Roberto Graglia, Magdalena Salazar Palma, and Paul Smith.

The next edition of ICEAA – IEEE APWC will be held at the Cape Sun Hotel in downtown Cape Town, South Africa, September 2-7, 2012. It will be in coordination with the first Electromagnetic Environment and Interference Symposium (EEIS), organized by Commission E of URSI. The three conferences will have a common venue, registration, luncheons, banquet, and social program. The Chair of the Local Organizing Committee is Prof. David B. Davidson of the University of Stellenbosch.

Piergiorgio L. E. Uslenghi
Chair of the ICEAA – IEEE APWC Scientific Committee
University of Illinois at Chicago
E-mail: uslenghi@uic.edu

EMC 2011 - 9th International Symposium and Exhibition on Electromagnetic Compatibility and Electromagnetic Ecology

St. Petersburg, Russia, 13 - 16 September 2011

The 9th International Symposium and Exhibition on Electromagnetic Compatibility and Electromagnetic Ecology (EMC 2011) was held at the St. Petersburg State Electrotechnical University “LETI” on September 13-16, 2011 and was co-organized by the St. Petersburg State Electrotechnical University "LETI", the St. Petersburg Scientific and Technical Society of Radio Engineering, Electronics and Communication named after A.S. Popov, the Radio Frequency Center of the North-Western Federal Area and the Discone-centre Ltd.

This Symposium was supported by the Ministry of Education and Science of the Russian Federation, the Russian Academy of Sciences, the St. Petersburg State Polytechnical University, the St. Petersburg State University of Telecommunications named after M.A. Bonch-Bruevich, the St. Petersburg State Maritime Technical University, the Moscow Technical University of Communication and Information Science, the Research Institute of Radio, the Research Institute of Pulse Engineering, the Research Test Centre for EMC, the Research-and-production Enterprise “Proryv”, the Kedah Electronics Engineering Ltd, the IEEE Russian (North-West) Section, the Russian Branch of IEEE “Engineering-management” and Elemcom Ltd.

Other technical co-sponsors at EMC 2011 were Rohde&Schwarz, URSI International Union of Radio Science, ZAO «Modern wireless technologies» and the all-Russian scientific institute of automatics of N.L. Duhiva. A Technical Exhibition was organized in parallel with the Symposium.

Victor Malyshev, Professor of the St. Petersburg State Electrotechnical University "LETI", was Chair of the Organizing Committee, Nicolay Korovkin, Professor of St. Petersburg State Polytechnic University, was Chair of the Scientific Committee and Vera Larkina, Professor of IZMIRAN, was the URSI representative.

The conference received approximately 200 submissions that were reviewed by the Scientific Committee. The 145 accepted papers were scheduled in 27 sessions.

The technical sessions covered a wide variety of topics, such as Theoretical problems of EMC & EME, EMC in radio-electronic systems and equipment, Spectrum management and monitoring EMC in electrical engineering and power systems, Especial problems EMC & EME in mobile

Figure 1. The Presidium of EMC 11
Victor Malyshev, Mishel Janosh (Switzerland), Vladimir Kutuzov, Nicolay Korovkin.

Figure 2a and 2b. An overview of the exhibition hall and the separate stands

objects (vessels, planes, railways and others), Research of natural electromagnetic radiations (GIC, lightning, and others), Equipment design with regard to EMC & EME, technology, materials and components, Electromagnetic monitoring, measurement, certification and test equipment, EME problems: influence of electromagnetic radiation on biological, objects, admissible norms of radiation and ecological protection EMC & EME education, Popov's scientific and educational radio-technical school. The conference was attended by 145 registered participants from 7 countries. The scientific and financial success of conference was due in no small part to the tireless work of the local organizers.

At the opening ceremony the Chairman of the Local Organising Committee thanked the sponsors and handed over the diplomas for the intellectual contribution. See (Figure 1)

A Technical Exhibition was organized in parallel with the Symposium. Firms "Rohde&Schwarz", the all-Russian scientific institute of automatics of N.L. Duhiva, "Modern wireless technologies", "Dipole", Research-and-production Enterprise "Proryv" have shown the products and devices. The exhibition has caused the big interest of participants of conference. (see figure 2).

Professor V.I. Larkina
URSI representative at EMC 2011

Figure 3. Some of the Conference participants during the Opening Ceremony

EMC Europe 2011

York, UK, 26 - 30 September 2011

The latest edition of EMC Europe, co-organised by the University of York and the University of Nottingham, was held at the University of York Campus in the period 26-30 September 2011. The Symposium was sponsored by URSI, IEEE and IET. Since last year, EMC Europe is held annually and is the pre-eminent EMC conference in Europe. The next EMC Europe will be held in Rome in 17-21September 2012.

The Symposium received over 200 contributions of which 160 were accepted for presentation. They were organized in 35 oral sessions and two poster sessions. The technical coverage was very wide covering the usual spectrum of EMC interests from lightning threats to the use of nano material technologies for enhanced EMC performance. A particular feature of the Symposium were the Workshops (15 in total) offering a more applied and comprehensive treatment of important topics in EMC. In parallel, a series of Lectures intended for Young Scientists were delivered by leading experts under the auspices of the HIRF EU project. These were attended by many including some not so young scientists. Attendance at the sessions was very good throughout the duration of the Symposium.

In parallel with the technical sessions an exhibition was also held where 19 companies presented their latest EMC test equipment.

More than 300 delegates attended the Symposium representing most EU countries, Russia, Ukraine, Algeria, Japan, China, Korea, Australia, USA and Canada. The Keynote speech was given by Professor Heyno Garbe on "Upcoming EMC Challenges". His presentation emphasized the diversity and multi-functionality of modern equipment and the challenges this presents in compatibility and interoperability of systems. The example of a hand-held device was given which combines the functions of a phone, camera, GPS receiver, radio etc. Another recurring theme during the symposium was the treatment of uncertainties in current and future systems and how this problem can best be addressed in measurements and simulations. As ever,

Figure 1. The Chairman of the ISC Professor J. L. ter Haseborg giving his Opening Address

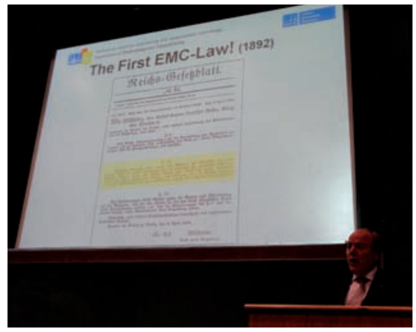


Figure 2. Professor Heyno Garbe delivering his Keynote Speech.

the importance of Standards and the way basic science can influence their development was stressed.

The Welcome Reception was held on Tuesday 27th September at the National Railway Museum, York UK and it was a memorable event. Delegates were able to view the very rich collection of exhibits including Stevenson's rocket in a very agreeable setting stressing the continuity of engineering innovation through the ages. A Brass Band provided the musical background to this event and was enjoyed by all.

The Symposium Banquet was held at the University of York where the prize for the best paper was awarded. The paper selected was 'HPM detection system for mobile and stationary use' by Michael Suhrke, Christian Braun,

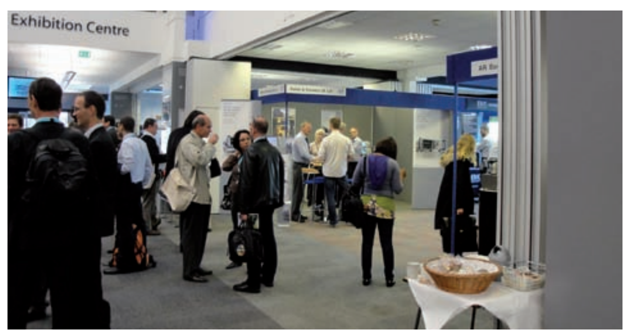


Figure 3: Delegates networking in the Exhibition Area during a break.

Hans-Ulrich Schmidt, Christian Adami, Peter Clemens and Achim Taenzer from the Fraunhofer INT, Germany. During the Banquet the Erica quartet entertained the delegates .

We were fortunate enough to have throughout the Symposium excellent weather which made possible to enjoy the charms of this beautiful city under the best possible conditions. Its rich Roman and Viking heritage and a beer culture second to none were much appreciated by all the delegates. This was a well organized event which offered a rich and varied technical content and a memorable cultural experience. Ci vediamo a Roma!

Prof. Christos Christopoulos

URSI CONFERENCE CALENDAR

March 2012

ISEA13 - 13th International Symposium on Equatorial Aeronomy
Parasas, Peru, 12-17 March 2012
Contact: Jorge L. Chau, Radio Observatorio de Jicamarca, Instituto Geofísico del Perú, Apartado 13-0207, Lima 13 – Peru, T: +51-1-3172313, F: +51-1-3172312, E-mail isea13@jro.igp.gob.pe, http://jro.igp.gob.pe/isea13/

April 2012

AES'12 - Advanced Electromagnetics Symposium
Paris, France, 16-19 April 2012
Contact: Prof. Said Zouhdi, AES 2012 General Chair, Paris-Sud University, France, Tel.: + 33 1 69 85 16 60, Fax.: + 33 1 69 41 83 18, E-mail: said.zouhdi@supelec.fr, http://www.mysymposia.org/index.php/aes/AES12

META'12 - 3nd International Conference on Metamaterials, Photonic Crystals and Plasmonics
Paris, France, 19-22 April 2012
Contact: Prof. Said Zouhdi, META 2012 General Chair, Paris-Sud University, France, Tel.: + 33 1 69 85 16 60, Fax.: + 33 1 69 41 83 18, E-mail: said.zouhdi@supelec.fr, http://metaconferences.org/ocs/index.php/META/META12

June 2012

FEM2012 - 11th International Workshop on Finite Elements for Microwave Engineering
Estes Park, Colorado, USA, 4-6 June 2012
Contact: Dr. Branislav M. Notaros, Department of Electrical and Computer Engineering, Colorado State University, 1373 Campus Delivery, Fort Collins, CO 80523-1373, USA, Fax: +1 (970) 491-2249, E-mail: notaros@colostate.edu, http://www.regonline.com/builder/site/default.aspx?EventID=1017993

July 2012

EUROEM 2012 - European Electromagnetics
Toulouse, France, 2 - 6 July 2012
Contact: Dr. Jean-Philippe Parmantier, ONERA, DEMR/CEM, BP 74025, Avenue Edouard Belin, 31055 TOULOUSE Cedex 4, FRANCE, Fax : +33 5 62 25 25 77, E-mail: euroem2012@onera.fr, http://www.euroem.org/

IEEE 2012 AP-S/URSI - IEEE International Symposium on Antennas and Propagation and USNC/URSI National Radio Science Meeting
Chicago, IL, USA, 8-13 July 2012
Contact: Prof. Danilo Erricolo, General Chair, IEEE 2012 AP-S/URSI, University of Illinois at Chicago, Dept of Electrical and Computer Eng, 1020 SEO (MC 154), 851 S. Morgan Street, Chicago, IL 60607-7053, USA,Fax: (+1) 312 996 6465, E-mail: erricolo@ece.uic.edu, http://www.ece.uic.edu/2012aps-ursi/

39th COSPAR Scientific Assembly and Associated Events
Mysore, India, 14-22 July 2012
Contact: Secretariat LOC-COSPAR 2012, Space Science Office, ISRO Headquarters, Antariksh Bhavan, New BEL Road, Bangalore – 560 231 , India, Email : cospar2012@isro.gov.in, cospar2012@gmail.com, Fax : +91-80-23418209/ +91-80-23419190, http://www.cospar2012india.org/Default.aspx

International School of Physics «Enrico Fermi», Metrology and Physical Constants
Varenna, Italy, 17-27 July 2012
Contact: Prof. Elio Bava, strada delle cacce 91, I-10135 Torino, Italy, Fax +39 011 346384, E-mail: Elio Bava e.bava@inrim.it, http://www.sif.it/SIF/en/portal/attivita/scuola_fermi

Sepember 2012

ICEAA2012-IEEEAPWC2012-EEIS2012-International Conference on Electromagnetics in Advanced Applications
Cape Town, South Africa, 2-7 September 2012
Contact: ICEAA - IEEE 2012 Conference, ConsultUS (Pty) Ltd, PO Box 19063, Tygerberg, 750, Fax +27 21 933 2649, E-mail: iceaa12@iceaa.polito.it, http://www.iceaa-offshore.org

EMC Europe 2012 - International Symposium on Electromagnetic Compatibility
Rome, Italy, 17 - 21 September 2012
Contact: Marcello D Amore, Department of Electrical Engineering, Sapienza University of Rome, Rome, Italy, Via Eudossiana 18, I-00184 Rome, Italy, marcello.damore@uniroma1.it, http://www.emceurope2012.it

October 2012

ISAP2012 - 2012 International Symposium on Antennas and Propagation
Nagoya, Japan, 29 October - 2 November 2012
Contact: Professor Koichi Ito, General Chair of ISAP2012, Chiba University, 1-33 Yayoi-cho, Inage-ku, Chiba-shi, Chiba 263-8522, Japan, Fax: +81-43-290-3327, E-mail: ito.koichi@faculty.chiba-u.jp, http://www.isap12.org

News from the URSI Community

NEWS FROM A MEMBER COMMITTEE

FRANCE

Journées Scientifiques : Champs Electromagnétiques de la Disimétrie à la Santé Humaine

les 3 et 4 avril 2012, CNAM, Saint-Martin, PARIS

3ème Journées Scientifiques

Les Journées Scientifiques 2012 d'URSI-France, placées sous le haut patronage de l'Académie des sciences, auront pour thème « Champs électromagnétiques : de la dosimétrie à la santé humaine ». Organisées cette année en partenariat avec la section « Rayonnements non ionisants » de la Société française de radioprotection (SFRP), ces journées se tiendront au Conservatoire national des arts et métiers (Cnam) à Paris les 3 et 4 avril 2012.

Les technologiques utilisant des champs électromagnétiques sont nombreuses et s'appliquent aussi bien au transport de l'électricité, aux communications sans fil, à la détection, à l'imagerie, à l'éclairage qu'aux applications thérapeutiques. Les personnes sont exposées aux champs électromagnétiques émis par ces différentes sources dans le cadre de la vie quotidienne et/ou professionnelle.

Des études épidémiologiques, humaines et expérimentales (animales et cellulaires) sont réalisées pour examiner les effets biologiques et sanitaires des champs électromagnétiques. Elles nécessitent des approches pluridisciplinaires qui font appel à la physique, la biologie, la toxicologie et la médecine. La dosimétrie est essentielle pour ces études, aussi bien pour caractériser les systèmes d'exposition et les niveaux d'exposition expérimentaux, que pour évaluer l'exposition des personnes grâce au développement d'outils de mesure et de simulation.

L'évaluation du risque sanitaire est fondée sur l'analyse de ces travaux. Elle est régulièrement conduite par différentes institutions (ICNIRP, OMS, ANSES, CIRC…) qui émettent des avis et/ou des recommandations en termes d'axes recherche et de gestion du risque.

Dans le domaine médical, les propriétés des champs électromagnétiques et les interactions ondes-matières sont mises à profit pour le développement de nouvelles applications à visée thérapeutique ou diagnostique tels que l'electrochimiothérapie, l'IRM fonctionnelle ou encore de nouveaux capteurs implantables par exemple.

Les Journées Scientifiques 2012 seront l'occasion d'évoquer toutes ces questions dans le cadre interdisciplinaire d'URSI France au cours de quatre sessions:

- La dosimétrie et l'exposition des personnes ;
- Les effets biologiques et sanitaires ;
- L'évaluation et la gestion du risque ;
- Les applications médicales.

Les Journées scientifiques se tiendront au Cnam, 292 rue Saint-Martin, Paris 3ème, les mardi 3 et mercredi 4 avril 2012. Elles seront suivies le mercredi 4 avril, vers 16h par l'Assemblée générale d'URSI-France.

Elles sont organisées autour de sessions orales ou de posters animées par des spécialistes reconnus du domaine. Les sessions orales seront introduites par des conférences invitées présentant soit l'état de l'art, soit de nouveaux développements intéressant l'ensemble de la communauté. Les communications seront sélectionnées par le comité scientifique. La sélection tiendra compte de l'équilibre des sujets présentés dans chaque session.

Sauf exception, la langue de travail est le français toutefois les planches accompagnant les présentations pourront être en anglais.

Comité Scientifique

Présidente : Anne Perrin, IRBA-CRSSA, Grenoble
Emmanuelle Conil, Orange Labs / Whist Lab, Paris
René de Sèze, INERIS, Verneuil en Halatte
François Gaudaire, CSTB, Grenoble
Isabelle Lagroye, Laboratoire BioEM EPHE, Bordeaux
Yves Le Dréan, IRSET, Inserm, Rennes
Philippe Lévêque, XLIM - UMR 6172 CNRS, Limoges

Lluis M. Mir, UMR 8203 CNRS-IGR, Villejuif
Mustapha Nadi, Université de Lorraine, Nancy
Christian Person, Whist Lab/LabSTICC/Télécom Bretagne, Brest
Martine Souques, EDF-SEM, Levallois Perret
Bernard Veyret, Laboratoire IMS, Université Bordeaux
Joe Wiart, Orange Labs / Whist Lab, Paris
Catherine Yardin, CHU/Faculté de Médecine, Limoges

Comité d'organisation

Présidente : Anne Perrin, IRBA-CRSSA
Maurice Bellanger, CNAM
Joël Hamelin, URSI-France
Isabelle Lagroye, Laboratoire BioEM EPHE
Christian Person, Télécom Bretagne
Alain Sibille, Télécom-ParisTech
Hervé Sizun, URSI France
Martine Souques, EDF-SEM
Michel Terré, CNAM
Joe Wiart, Orange Labs / Whist Lab,

Prix

Un prix « URSI », de 500 euros, sera attribué par le comité scientifique à la meilleure communication présentée par un doctorant.

Publications – Éditions

Les textes des conférences invitées et des communications seront consultables en ligne sur le site d'URSI-France : http://ursifrance.institut-telecom.fr

Après avis du Comité scientifique, certains auteurs seront invités à publier un article, soit dans un numéro thématique des Comptes rendus Physique de l'Académie des sciences, soit dans un dossier de la Revue de l'électricité et de l'électronique (REE). Responsable des publications is Anne Perrin

Instructions aux Auteurs

Les propositions de communications seront soumises en ligne via le site : https://intellagence.eu.com/bin/usrlogin_ursif2012? lang=1 sous la forme d'un texte clair et concis d'une à deux pages, permettant une bonne évaluation scientifique. Les informations concernant le format des propositions de communication sont disponibles sur le site.

Dates à retenir

- 13 janvier 2012 : clôture de réception des propositions de communications.
- 17 février : réponse du Comité scientifique aux proposants.
- 17 mars : date limite de dépôt en ligne des textes des communications.
- 3 et 4 avril : Journées scientifiques.
- 4 avril : liste des communications sélectionnées pour publication.

Inscription

Une participation aux frais de 185 € est demandée à tous les participants. Elle comprend les collations et pauses café. Un tarif réduit de 80 € est accordé aux étudiants et aux seniors.

Pour 47 € supplémentaires le numéro thématique des Comptes rendus Physique de l'Académie des sciences, reprenant les principales contributions de ces journées, vous sera adressé dès sa parution début 2013

Les inscriptions aux Journées scientifiques sont à effectuer en ligne avant le 27 mars sur le site : https://intellagence.eu.com/bin/IA/inscr?lang=0&ref=URSI/**15**

Informations Complémentaires

Vous pourrez trouver toutes informations utiles relatives aux Journées scientifiques 2012 sur le site d'URSI-France : http://ursi-france.institut-telecom.fr

SWEDEN
Report on Symposium in Memory of Östen Mäkitalo

Östen Mäkitalo (1938-2011, Figure 1), officially retired, was a guest professor at his alma mater, KTH, the Royal Institute of Technology in Stockholm. Wireless@ KTH gave us the sad news, as follows:

> We were devastated to learn that Östen Mäkitalo suddenly passed away on Thursday, June 16, at the age of 73. He was recuperating from a heart condition and was supposed to be back at the office shortly, when his heart failed him again. In Scandinavia, he was well known as the "father of mobile telephony." Since his retirement as head of research and CTO of TeliaSonera, his has been a part-time guest professor at Wireless@ KTH. He has, over the years, been an inspiration to us all: sharing his vast experience in both the technical and the business domain. We miss you, Östen!

Östen Mäkitalo was a nationally and internationally known radio engineer, who knew that investments in telecommunications technology were beneficial to all. He used the "Swedish model," where government/defense, national enterprises, research institutes, universities, and industry work closely together. In the Swedish Telecom Radio Laboratory, he led research and development helping his country to attain a world-leading position. Swedish Telecom now and then changed its company names and organization schemes; it also merged with Sonera. However, Mäkitalos' role did not change: he just carried on, eventually rising to CTO.

Figure 1. Östen Mäkitalo, doctor honoris causa, Swedish radio pioneer and "Father of Modern Mobile Telephony" (photo: TeliaSonera).

Figure 2. Station SAQ around 1925 (photo: Gustaf Björkström, Varberg county museum).

The first fully automatic first-generation cellular system was NMT, the Nordic Mobile Telephony system (NMT). This was the first network featuring both handover and international roaming. Östen Mäkitalo started to work on this vision in 1966. He is considered to be the father of the NMT system, and some also consider him to be the father of the cellular phone.

Mäkitalo was a pioneer and driving force behind three generations of mobile systems: NMT, GSM, and UMTS. He also worked with many different radio systems, the most important perhaps being his pioneering work in digital television. At the IBC (International Broadcasting Convention) trade show in Amsterdam in 1992, the Swedish HD Divine prototype was shown. This was built in Mäkitalo's lab in cooperation with the Nordic telecom and television companies. The prototype showed its superiority over the old analog technology, more or less instantaneously

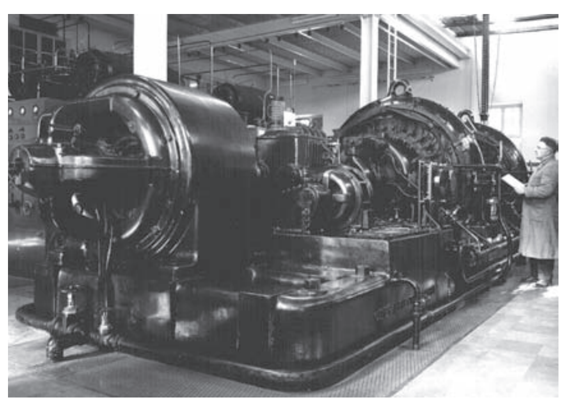


Figure 3. The Alexanderson 200 kW alternators (photo: Technical museum, Stockholm).

Figure 4. Prof. Gerhard Kristenson chaired the symposium (photo: Åke Hedevärn).

Figure 5. Over a hundred persons listened in the auditorium at KVA (photo: Åke Hedevärn).

turned over public opinion, and pushed through an all-digital European standard for television.

For decades, Östen Mäkitalo was an active member of SNRV, the Swedish National Committee of URSI, an expert body working under the auspices of KVA, the Royal Swedish Academy of Sciences. He was one of the initiators of NRS, the Nordic Radio Society, a foundation cooperating with SNRV to promote scientific research and education. At his funeral in the church of Grödinge, August 5, he was honored nationally and internationally by SNRV through a worldwide transmission from the vintage VLF station SAQ Varberg Radio at Grimeton, a UNESCO World Heritage site (Figures 2, 3).

One week before passing away, Mäkitalo promised me he would chair a mobile telephony and data symposium, to be sponsored by SNRV and held at KVA. The event went as announced, with SNRV chair Prof. Gerhard Kristensson acting as moderator (Figures 4, 5). The symposium included an overview of the underlying technology. It covered the Nordic cooperation and entrepreneurship that led to a formidable success, far beyond what was anticipated. The first generation ("1G") was the analog NMT, a joint development by Denmark, Finland, Iceland, Norway, and Sweden with a subscriber database, ultramodern AXE switches, automatic handover and roaming all over these countries (more were to come). Mäkitalo already then had a vision of pocket-sized cell phones for world-wide use, including data access. He also said, "Everything we can imagine will be possible." He was right: the symposium made this clear.

Figure 6. The speakers: (l-r) Haug, Thorngren, Zetterberg, Öhrvik, Zander (photo: Åke Hedevärn)

The symposium speakers (Figure 6), were members of KVA, IVA, SNRV, and/or NRS:

- Lars H. Zetterberg, Professor Emeritus, KTH
- Thomas Haug, Licentiate of Technology, Swedish Telecom (retired)
- Sven-Olof Öhrvik, Professor Emeritus, Lund University
- Bertil Thorngren, Associate Professor, Stockholm School of Economics, Swedish Telecom Strategy Director
- Jens Zander, Professor, KTH

Haug was a switching expert, and chaired the Nordic NMT group and the European GSM group. He and Mäkitalo were a winning team. The symposium (in Swedish) was televised live. It is available at http:// kva.screen9.tv/#PP8fD7uMjMsvpRSgoKFhfg.

In 1987, Haug and Mäkitalo were awarded the Gold Medal of IVA, the Royal Swedish Academy of Engineering Sciences. In 1994, he received the KTH Great Prize with Åke Lundqvist and Öhrvik (CEO and CTO Ericsson Radio). In 1991, Mäkitalo and Lundqvist were conferred honorary doctorates by Chalmers University of Technology in Gothenburg. In 2001, Östen Mäkitalo received H. M. the King's Medal.

TeliaSonera has instituted a scholarship of SEK 100,000 to the memory of Östen Mäkitalo. This will be awarded annually and biennially to a scientist, and biennially to a contractor.

RIP Östen: the radio waves will be there forever.

Carl Walde
SNRV secretary
E-mail: info@walde.se

BOOK PUBLISHED FOR URSI RADIOSCIENTISTS

Electromagnetic Fields in Biological Systems

by by James C. Lin, Boca Raton, FL, CRC Press, October 2011, 430 pp.;
ISBN13:9781439859995; ISBN10:143985999X

Contents

Global interest and widespread use of wireless communication devices such as cellular mobile telephones have grown significantly during the past two decades. As a consequence, for the first time in human history, a source of electromagnetic radiation is located right next to the head or body. This trend will likely continue, and promises to expand at a greater rate in the near future. Almost all human beings will soon become immersed a vast milieu of electromagnetic fields, waves, or radiation generated by human activity. Aside from cellular mobile telephones, these may come from, among others, the hubs (base stations) that enable wireless connections of all mobile and location-fixed devices, smart grids associated with the distribution and delivery of electricity, and the global positioning systems (GPS) employed for navigation to enable and facilitate mobility with safety and reliability.

Without question, the man-made electromagnetic radiation will increase, both in strength and in spread of the frequency spectrum. The fact that electromagnetic fields and radiation can interact with biological systems is beyond debate. Observe that nuclear magnetic resonance takes place in a biological medium under the influence of a radio-frequency field to allow imaging and spectroscopy of tissues inside the human body. Clearly, a biological effect is a prerequisite to any potential medical application. However, an unintended or deleterious biological effect of electromagnetic fields and radiation may also indicate grounds for health and safety precautions in the communication, industrial, scientific, and medical use of electromagnetic fields and radiation. Regardless, to help advance our knowledge of the biological effects and to exploit potential medical applications, it is essential to describe the characteristics of not only the applied electromagnetic fields and radiation, but also the resulting electromagnetic fields and radiation inside the biological system. A quantitative relationship between applied and induced electromagnetic fields and radiation would relate them to specific responses of the biological system. It should also facilitate an understanding of the biological responses.

It is noted that the induced field is the primary source of energy driving the interaction of electromagnetic energy with biological systems. While it may contribute to the formulation of mechanism(s) of interaction, it is independent of any mechanism of interaction. Moreover, knowledge of applied and induced fields would aid in analyzing relationships among various observed biological effects in different experimental models and subjects. It could also serve as an index for comparison and extrapolation of experimental results from cell to cell, tissue to tissue, tissue to animal, and from animal to animal, animal to human, and human to human exposures.

The objective of this book is to provide a comprehensive discussion of electromagnetic fields and radiation in biological systems, spanning static fields to terahertz waves in seven chapters. Each chapter includes materials written by scientists who have made major contributions to the relevant subjects. A particular emphasis is placed on the coupling of electromagnetic fields and radiation into biological systems. While each chapter focuses on induced fields and absorbed energy from an applied or exposure field, a review of the literature is included to explain the motivation for the chapter. The relevant literature is summarized so that the reader will understand why the topic is of interest or importance. The chapter discusses current progress on the subject. The aim is to achieve a quantitative understanding of the relationships between the applied and induced electromagnetic fields and radiation that cause biological effects and enable medical applications.

International Geophysical Calendar 2012

	S	M	T	W	T	F	S
JANUARY	1	2	3	4	5	6	7
	8	9 F	10	11	12	13	14
	15+	16+	17+	18*+	19*+	20+	21+
	22+	23 N+	24+	25+	26+	27+	28+
	29+	30+	31+	1+	2+	3+	4+
FEBRUARY	5+	6+	7 F+	8+	9+	10+	11+
	12+	13+	14+	15+	16+	17	18
	19	20	21 N*	22*	23	24	25
	26	27	28	29	1	2	3
MARCH	4	5	6	7	8 F	9	10
	11	12	13	14	15	16	17
	18	19	20	21*	22 N*	23	24
	25	26	27	28	29	30	31
	1	2	3	4	5	6 F	7
APRIL	8	9	10	11	12	13	14
	15	16	17	18*	19*	20	21 N
	22	23	24	25	26	27	28
	29	30	1	2	3	4	5
MAY	6 F	7	8	9	10	11	12
	13	14	15	16	17	18	19
	20 N	21	22*	23*	24	25	26
	27	28	29	30	31	1	2
	3	4 F	5	6	7	8	9
JUNE	10	11	12+	13+	14+	15+	16
	17	18	19 N*	20*	21	22	23
	24	25	26	27	28	29	30
	S	M	T	W	T	F	S

S	M	T	W	T	F	S	
1	2	3 F	4	5	6	7	JULY
8	9	10	11	12	13	14	
15	16	17	18*	19 N*	20	21	
22	23	24	25	26	27	28	
29	30	31	1	2 F	3	4	AUGUST
5	6	7	8	9	10	11	
12	13	14	15*	16*	17 N	18	
19	20	21	22	23	24	25	
26	27	28	29	30	31 F	1	SEPTEMBER
2	3	4+	5+	6+	7+	8	
9	10	11	12	13	14	15	
16 N	17	18*	19*	20	21	22	
23	24	25	26	27	28	29	
30 F	1	2	3	4	5	6	OCTOBER
7	8	9	10	11	12	13	
14	15 N	16*	17*	18	19	20	
21	22	23	24	25	26	27	
28	29 F	30	31	1	2	3	NOVEMBER
4	5	6	7	8	9	10	
11	12	13 N*	14*	15	16	17	
18	19	20	21	22	23	24	
25	26	27	28 F	29	30	1	DECEMBER
2	3	4	5	6	7	8	
9	10	11+	12*+	13 N*+	14+	15	
16	17	18	19	20	21	22	
23	24	25	26	27	28 F	29	
30	31	1	2	3	4	5	2013 JANUARY
6	7	8	9	10	11 N	12	
13	14	15*	16*	17	18	19	
20	21	22	23	24	25	26	
27 F	28	29	30	31			
S	M	T	W	T	F	S	

N NEW MOON F FULL MOON

17 Regular World Day (RWD)

18 Priority Regular World Day (PRWD)

21 Quarterly World Day (QWD) also a PRWD and RWD

4 Regular Geophysical Day (RGD)

12 13 World Geophysical Interval (WGI)

\+ Incoherent Scatter Coordinated Observation Day
(The period Jan 15-Feb 16 is a Stratwarm Alert interval with a fallback interval of Feb 7-12.)

20 Days of Solar Eclipse May 20 annular & Nov 13/14 total

18 19 Airglow and Aurora Period

18* Dark Moon Geophysical Day (DMGD)

This Calendar continues the series begun for the IGY years 1957-58, and is issued annually to recommend dates for solar and geophysical observations, which cannot be carried out continuously. Thus, the amount of observational data in existence tends to be larger on Calendar days. The recommendations on data reduction and especially the flow of data to World Data Centers (WDCs) in many instances emphasize Calendar days. The Calendar is prepared by the International Space Environment Service (ISES) with the advice of spokesmen for the various scientific disciplines. For some programs, greater detail concerning recommendations appears from time to time published in IAGA News, IUGG Chronicle, URSI Information Bulletin and other scientific journals or newsletters.

The Calendar provides links to many international programs, giving an opportunity for scientists to become involved with data monitoring and research efforts. International scientists are encouraged to contact the key people and join the worldwide community effort to understand the Sun-Earth environment.

The definitions of the designated days remain as described on previous Calendars. Universal Time (UT) is the standard time for all world days. Regular Geophysical Days (RGD) are each Wednesday. Regular World Days (RWD) are three consecutive days each month (always Tuesday, Wednesday and Thursday near the middle of the month). Priority Regular World Days (PRWD) are the RWD which fall on Wednesdays. Quarterly World Days (QWD) are one day each quarter and are the PRWD which fall in the World Geophysical Intervals (WGI). The WGI are fourteen consecutive days in each season, beginning on Monday of the selected month, and normally shift from year to year. In 2012 the WGI are March, June, September, and December.

2012 Solar Eclipses:
The year 2012 has one annular and one total eclipse:

1) 2012 May 20, an annular solar eclipse begins at sunrise in Asia and ends at sunset in the United States. Annularity begins in southeast China, including Macau and Hong Kong, which has 3 m 52 s of annularity at a 10° altitude. It crosses northernmost Taiwan, including Taipei with 2 min 10 s of annularity, before crossing the Pacific Ocean. Partial phases range from northeast Indonesia, including Borneo and Celebes, and with the sun rising partially eclipsed in Bangladesh, Sikkim, Bhutan, Myanmar, Thailand, Cambodia, Vietnam, Laos, and China, where Beijing will have a 67° eclipse. Partial phases can also bee seen in eastern Kazakhstan, in Mongolia and in Siberia. In mid-Pacific, Honolulu, Hawaii, will have an 18° eclipse, and Anchorage, Alaska, will have a 68% eclipse. The path of annularity will hit the United States from south of Eureka, California, which will have about 95% coverage for 3 min 51 s, to slightly north of Grants Pass, Oregon, with similar coverage for 2 min 56 s. Annularity includes Cartson City, Nevada; St. George, Utah; Zion National Park in Utah,the Grand Canyon in Arizona; Canyon De Chelly National Monument; and Albuquerque, New Mexico; ending eastward of Lubbock, Texas. The Sun's diameter will be 90% covered in San Francisco; 85% covered in Los Angeles; 93% covered in Flagstaff, Arizona; and 90% covered in El Paso, Texas. To the north of the path of annularity, the Sun's diameter will be 70% covered in Calgary, Alberta, Canada; 78% covered in Bozeman, Montana; 61% covered in Winnipeg, Manitoba, Canada; and, at sunset, 67% covered in Minneapolis, Minnesota, 68% covered in Chicago. The eastern extent of the partial eclipses's visibility is in a line extending northeast from Pensacola, Florida; through Ashville, Tennessee; to Altoona, Pennsylvania; to Utica, NY. Buffalo will have close to a 60% eclipse at sunset; and Montreal about a 53% eclipse at sunset. Most of Mexico will also see sunset partial phases.

2) 2012 Nov 13/14, total solar eclipse, magnitude 1.050, 04m02s max duration, eclipse visible in Australia, NZ, s Pacific, s S. America (total: n Australia, s Pacific). The 2012 November 13/14 total solar eclipse will be visible as total only in northwestern Australia on November 13, local time, within an hour of sunrise. Annularity begins at sunrise in Arnhem Land, east of Darwin. In Queensland, the centerline goes south of Port Douglas. Totality will be visible from Innesfall along the coast through Cairns and Port Douglas, and north about halfway to Cooktown. Totality will last 2 min 5 s at its centerline, crossing Oak Beach; it will last 2 min 0 s at Cairns and 2 min 3 s at Port Douglas. The path of totality then extends over the Pacific Ocean, not including any other land. All of Australia will see partial phases, ranging from 40% at sunrise in Perth, Western Australia, to 69% coverage of the Sun's diameter in Sydney. Christchurch, New Zealand, will have 68% coverage, and all of New Zealand will have a similar partial eclipse. Partial phases will also be seen at sunset, weather permitting, from most of Chile and western Argentina. The sun will set about 80° eclipsed at Santiago, Chile. The partial phases will end just west of Lima, Peru; San Juan, Peru, and the Paracas National Reserve are just within the western edge of partial-phase visibility.

Information from Jay M. Pasachoff, Williams College (Williamstown, Massachusetts), Chair, International Astronomical Union's Working Group on Eclipses, based on information and maps provided by Fred Espenak and Xavier Jubier.

Eclipse References:

- Fred Espenak, Fifty Year Canon of Solar Eclipses: 1986-2035, NASA Reference Publication 1178 Revised, July 1987.
- Leon Golub and Jay M. Pasachoff, The Solar Corona, Cambridge University Press, 1998.
- Jay M. Pasachoff and Alex Filippenko, The Cosmos: Astronomy in the New Millennium, Brooks/Cole Publishers, 2002, 2004 and 2006.
- Leon Golub and Jay M. Pasachoff, Nearest Star: The

Exciting Science of Our Sun, Harvard University Press, 2001.
- Jay M. Pasachoff, The Complete Idiot's Guide to the Sun, Alpha Books, 2003

2012 Meteor Showers

(Dates selected from the International Meteor Organization Shower Calendar 2012. Peak times provided by A. McBeath.):

a) Meteor outbursts are unusual showers (often of short duration) from the crossing of relatively recent comet ejecta. Dates are for the year 2012.
   No predicted events.
b) Regular meteor showers: The dates (based on UT in year 2012) for regular meteor showers are:
   - Dec 28-Jan 12, peak Jan 04 07h20m UT (Quadrantids);
   - Apr 16-Apr 25, peak Apr 22 05h25m UT (Lyrids);
   - Apr 19-May 28, peak May 05 19h00m UT (Eta Aquariids);
   - May 22-Jul 02, peak Jun 07 05h UT (Daytime Arietids);
   - May 20-Jul 05, peak Jun 09 05h UT (Daytime Zeta Perseids);
   - Jun 05-Jul 17, peak Jun 28 04h UT (Daytime Beta Taurids);
   - Jul 12-Aug 23, peak Jul 29/30 (Southern Delta Aquariids);
   - Jul 17-Aug 24, peak Aug 12 12h00m to 14h30m UT (Perseids);
   - Sep 09-Oct 09, peak Sep 27 04h UT (Daytime Sextantids);
   - Oct 02-Nov 07, peak Oct 21 (Orionids);
   - Nov 06-Nov 30, peak Nov 17 09h35m UT (Leonids);
   - Dec 07-Dec 17, peak Dec 13 07h00m - Dec 14 04h15m UT (Geminids);
   - Dec 17-Dec 26, peak Dec 22 03h00m UT (Ursids).

Meteor Shower Websites:

- Shower activity near-real time reports -- International Meteor Organization
- Meteor shower activity forecast from your own location -- Peter Jenniskens
- Shower names and data -- IAU Meteor Data Center Announcements and reports of meteor outbursts -- Minor Planet Center
- Shower outburst activity forecast -- Institut de Mecanique celeste et de calcul des ephemerides

References:

Peter Jenniskens, Meteor showers and their parent comets. Cambridge University Press, 2006, 790 pp.

Real Time Space Weather and Earth Effects

The occurrence of unusual solar or geophysical conditions is announced or forecast by ISES through various types of geophysical "Alerts" (which are widely distributed via the internet on a current schedule). Stratospheric warmings (STRATWARM) were also designated for many years. The meteorological telecommunications network coordinated by the World Meteorological Organization (WMO) carries these worldwide Alerts once daily soon after 0400 UT. For definitions of Alerts see ISES "Synoptic Codes for Solar and Geophysical Data", March 1990 and its amendments. For many years Retrospective World Intervals were selected and announced by MONSEE (Monitoring of the Sun-Earth Environment) and elsewhere to provide additional analyzed data for particular events studied in the ICSU Scientific Committee on Solar-Terrestrial Physics (SCOSTEP) programs.

RECOMMENDED SCIENTIFIC PROGRAMS (FINAL EDITION)

(The following material was reviewed in 2011 by spokesmen of IAU, IAGA, WMO and URSI as suitable for coordinated geophysical programs in 2012.)

Airglow and Aurora Phenomena.

Airglow and auroral observatories operate with their full capacity around the New Moon periods. However, for progress in understanding the mechanism of many phenomena, such as low latitude aurora, the coordinated use of all available techniques, optical and radio, from the ground and in space is required. Thus, for the airglow and aurora 7-day periods on the Calendar, ionosonde, incoherent scatter, special satellite or balloon observations, etc., are especially encouraged. Periods of approximately one weeks' duration centered on the New Moon are proposed for high resolution of ionospheric, auroral and magnetospheric observations at high latitudes during northern winter.

Atmospheric Electricity.

Non-continuous measurements and data reduction for continuous measurements of atmospheric electric current density, field, conductivities, space charges, ion number densities, ionosphere potentials, condensation nuclei, etc.; both at ground as well as with radiosondes, aircraft, rockets; should be done with first priority on the RGD each Wednesday, beginning on 4 January 2012 at 0000 UT, 11 January at 0600 UT, 18 January at 1200 UT, 25 January at 1800 UT, etc. (beginning hour shifts six hours each week, but is always on Wednesday). Minimum program is at the same time on PRWD beginning with 18 January at 1200 UT. Data reduction for continuous measurements should be extended, if possible, to cover at least the full RGD including, in addition, at least 6 hours prior to indicated beginning time. Measurements prohibited by bad weather should be done 24 hours later. Results on sferics and ELF are wanted with first priority for the same hours, short-period measurements centered around minutes 35-50 of the hours indicated. Priority Weeks are the weeks that contain a PRWD; minimum priority weeks are the ones with a QWD. The World Data Centre for Atmospheric Electricity, 7 Karbysheva, St. Petersburg 194018, USSR, is the collection point for data and information on measurements.

Geomagnetic Phenomena.

It has always been a leading principle for geomagnetic observatories that operations should be as continuous as possible and the great majority of stations undertake the same program without regard to the Calendar.

Stations equipped for making magnetic observations, but which cannot carry out such observations and reductions on a continuous schedule are encouraged to carry out such work at least on RWD (and during times of MAGSTORM Alert).

Ionospheric Phenomena.

Special attention is continuing on particular events that cannot be forecast in advance with reasonable certainty. These will be identified by Retrospective World Intervals. The importance of obtaining full observational coverage is therefore stressed even if it is only possible to analyze the detailed data for the chosen events. In the case of vertical incidence sounding, the need to obtain quarter-hourly ionograms at as many stations as possible is particularly stressed and takes priority over recommendation (a) below when both are not practical.

For the vertical incidence (VI) sounding program, the summary recommendations are:

a) All stations should make soundings on the hour and every quarter hour;
b) On RWDs, ionogram soundings should be made at least every quarter hour and preferably every five minutes or more frequently, particularly at high latitudes;
c) All stations are encouraged to make f-plots on RWDs; f-plots should be made for high latitude stations, and for so-called "representative" stations at lower latitudes for all days (i.e., including RWDs and WGIs) (Continuous records of ionospheric parameters are acceptable in place of f-plots at temperate and low latitude stations);
d) Copies of all ionogram scaled parameters, in digital form if possible, be sent to WDCs;
e) Stations in the eclipse zone and its conjugate area should take continuous observations on solar eclipse days and special observations on adjacent days. See also recommendations under Airglow and Aurora Phenomena.

For the **2012 incoherent scatter observation program**, every effort should be made to obtain measurements at least on the Incoherent Scatter Coordinated Observation Days, and intensive series should be attempted whenever possible in WGIs, on Dark Moon Geophysical Days (DMGD) or the Airglow and Aurora Periods. The need for collateral VI observations with not more than quarter-hourly spacing at least during all observation periods is stressed.

Special programs include:

- **Strat-Warming** Dynamics and Temperature of the Lower Thermosphere During Sudden Stratospheric Warming Key objectives are: To measure neutral wind (zonal and meridional components) and electron and ion temperatures in the lower thermosphere before and during sudden stratospheric warming. To compare variations in temperature and winds to average variations observed by ISRs during the winter. To compare variations in temperatures and winds to mesospheric response as given by MF and meteor radars and lidars. To extend studies of stratospheric warming effects to the lower thermosphere and investigate possible coupling with the ionosphere. To examine the mechanisms responsible for variations in lower thermospheric dynamics and temperatures and investigate to what degree they can be related to sudden stratospheric warming. Observation length is a 10 day interval beginning in the period January 15-February 15. The decision to start will be based on predictions of stratospheric warming by Larisa Goncharenko. In the case of no SSW event, the World Day will fall back to a 5 day run at the end of the alert period, February 7-12. (L. Goncharenko -- lpg@haystack.mit.edu).
- **Synoptic** These synoptic experiments are intended to emphasize wide coverage of the F-region, with some augmented coverage of the topside or E-region to fill in areas of the data bases that have relatively little data. (J. Sojka -- sojka@cc.usu.edu).
- **AO** -- Arecibo Observatory;
- **JRO** -- Jicamarca Radio Observatory.
- **Special programs**: Dr. Ingemar Haggstrom, EISCAT, Box 812, SE-98128 Kiruna, Sweden; tel: +46 98079155;Fax: +46 98079159; e-mail ingemar@eiscat.se; URSI Working Group G.5. See the 2012 Incoherent Scatter Coordinated Observation Days (URSI-ISWG) webpage for complete 2012 definitions.
- For the **ionospheric drift** or wind measurement by the various radio techniques, observations are recommended to be concentrated on the weeks including RWDs.
- For **travelling ionosphere disturbances**, propose special periods for coordinated measurements of gravity waves induced by magnetospheric activity, probably on selected PRWDs and RWDs.
- For the **ionospheric absorption program** half-hourly observations are made at least on all RWDs and half-hourly tabulations sent to WDCs. Observations should be continuous on solar eclipse days for stations in the eclipse zone and in its conjugate area. Special efforts should be made to obtain daily absorption measurements at temperate latitude stations during the period of Absorption Winter Anomaly, particularly on days of abnormally high or abnormally low absorption (approximately October-March, Northern Hemisphere; April-September, Southern Hemisphere).
- For **back-scatter and forward scatter programs**, observations should be made and analyzed at least on all RWDs.
- For **synoptic observations** of mesospheric (D region) electron densities, several groups have agreed on using the RGD for the hours around noon.
- For **ELF noise** measurements involving the earth-ionosphere cavity resonances any special effort should be concentrated during WGIs.

It is recommended that more intensive observations in all programs be considered on days of unusual meteor activity.

Meteorology.

Particular efforts should be made to carry out an intensified program on the RGD -- each Wednesday, UT. A desirable goal would be the scheduling of meteorological rocketsondes, ozone sondes and radiometer sondes on these days, together with maximum-altitude rawinsonde ascents at both 0000 and 1200 UT.

During **WGI and STRATWARM Alert Intervals**, intensified programs are also desirable, preferably by the implementation of RGD-type programs (see above) on Mondays and Fridays, as well as on Wednesdays.

Global Atmosphere Watch (GAW)

The World Meteorological Organization (WMO) Global Atmosphere Watch (GAW) integrates many monitoring and research activities involving measurement of atmospheric composition, and serves as an early warning system to detect further changes in atmospheric concentrations of greenhouse gases, changes in the ozone layer and in the long range transport of pollutants, including acidity and toxicity of rain as well as of atmospheric burden of aerosols (dirt and dust particles). Contact WMO, 7 bis avenue de la Paix, P.O. Box 2300, CH-1211 Geneva 2, Switzerland or wmo[at]wmo.int.

Solar Phenomena.

Observatories making specialized studies of solar phenomena, particularly using new or complex techniques, such that continuous observation or reporting is impractical, are requested to make special efforts to provide to WDCs data for solar eclipse days, RWDs and during PROTON/FLARE ALERTS. The attention of those recording solar noise spectra, solar magnetic fields and doing specialized optical studies is particularly drawn to this recommendation.

CAWSES (Climate and Weather of the Sun-Earth System)

Program within the SCOSTEP (Scientific Committee on Solar-Terrestrial Physics): 2004-2008. Its focus is to mobilize the community to fully utilize past, present, and future data; and to produce improvements in space weather forecasting, the design of space- and Earth-based technological systems, and understanding the role of solar-terrestrial influences on Global Change. Contact is Susan Avery (susan.avery@colorado.edu), Chair of CAWSES Science Steering Group. Program theme areas are:

- Solar Influence on Climate -- M. Lockwood and L. Gray (UK);
- Space Weather: Science and Applications -- J. Kozyra (USA) and K. Shibata (Japan);
- Atmospheric Coupling Processes -- F. Luebken (Germany) and J. Alexander (USA);
- Space Climatology -- C. Frolich (Switzerland) and J. Sojka (USA); and
- Capacity Building and Education -- M.A. Geller (USA), S.-T. Wu (USA), and J. H. Allen (USA).
- See the CAWSES website for more information.

ILWS (International Living With a Star) International effort to stimulate, strengthen, and coordinate space research to understand the governing processes of the connected Sun-Earth System as an integrated entity. Contact info@ilwsonline.org.

ISWI (International Space Weather Initiative) a program of international cooperation to advance space weather science by a combination of instrument deployment, analysis and interpretation of space weather data from the deployed instruments in conjunction with space data, and communicate the results to the public and students. ISWI is a follow-up activity to the successful IHY 2007, but focusing exclusively on space weather. The goal of the ISWI is to develop the scientific insight necessary to understand the science, and to reconstruct and forecast near-Earth space weather. This includes instrumentation, data analysis, modeling, education, training, and public outreach. Contact J. Davila at Joseph.M.Davila@nasa.gov.

Space Research, Interplanetary Phenomena, Cosmic Rays, Aeronomy.

Experimenters should take into account that observational efforts in other disciplines tend to be intensified on the days marked on the Calendar, and schedule balloon and rocket experiments accordingly if there are no other geophysical reasons for choice. In particular it is desirable to make rocket measurements of ionospheric characteristics on the same day at as many locations as possible; where feasible, experimenters should endeavor to launch rockets to monitor at least normal conditions on the Quarterly World Days (QWDs) or on RWDs, since these are also days when there will be maximum support from ground observations. Also, special efforts should be made to assure recording of telemetry on QWDs and Airglow and Aurora Periods of experiments on satellites and of experiments on spacecraft in orbit around the Sun.

Meteor showers.

Of particular interest are both predicted and unexpected showers from the encounter with recent dust ejecta of comets (meteor outbursts). The period of activity, level of activity, and magnitude distributions need to be determined in order to provide ground truth for comet dust ejection and meteoroid stream dynamics models. Individual orbits of meteoroids can also provide insight into the ejection circumstances. If a new (1-2 hour duration) shower is observed due to the crossing of the 1-revolution dust trail of a (yet unknown) Earth threatening long-period comet, observers should pay particular attention to a correct determination of the radiant and time of peak activity in order to facilitate predictions of future encounters. Observations of meteor outbursts should be reported to the I.A.U. Minor Planet Center (mpc@cfa.harvard.edu) and International Meteor Organization (visual@imo.net). The activity curve, mean orbit, and particle size distribution of minor annual showers need to be characterised in order to understand their relationship to the dormant comets among near-Earth objects. Annual shower observations should be reported to national meteor organizations, or directly to the International Meteor Organization. Meteoroid orbits are collected by the IAU Meteor Data Center.

The International Space Environment Service (ISES) is a permanent scientific service of the International Union of Radio Science (URSI), with the participation of the International Astronomical Union and the International Union Geodesy and Geophysics. ISES adheres to the Federation of Astronomical and Geophysical Data Analysis Services (FAGS) of the International Council of Scientific Unions (ICSU). ISES coordinates the international aspects of the world days program and rapid data interchange.

This Calendar for 2012 has been drawn up by R. Fiori and H.E. Coffey, of the ISES Steering Committee, in association with spokesmen for the various scientific disciplines in SCOSTEP, IAGA and URSI and other ICSU organizations. Similar Calendars are issued annually beginning with the IGY, 1957-58, and are published in various widely available scientific publications. PDF versions of the past calendars are available online.

Published for the International Council of Scientific Unions and with financial assistance of UNESCO for many years.

Copies are available upon request to ISES Chairman, Dr. David Boteler, Geomagnetic Laboratory, Natural Resources Canada, 2617 Anderson Road, Ottawa, Ontario, Canada, K1A 0E7, FAX (613)824-9803, e-mail dboteler at NRCan.gc.ca, or ISES Secretary for World Days, Ms. Robyn Fiori, Geomagnetic Laboratory, Natural Resources Canada, 2617 Anderson Road, Ottawa, Ontario, Canada, K1A 0E7, FAX (613)824-9803, e-mail rfiori at NRCan.gc.ca. Beginning with the 2008 Calendar, all calendars are available only in digital form.

The website for the International Geophysical Calendar, including recent versions, can be fount at the here.

List of URSI Officials

Note: an alphabetical index of names, with coordinates and page references, is given on pages 93-108.

Honorary President

Prof. J. Van Bladel (Belgium)

Board of Officers

President : Dr. P. Wilkinson (Australia)
Past President : Prof. F. Lefeuvre (France)
Vice-Presidents : Prof. S. Ananthakrishnan (India)
Prof. M. Ando (Japan)
Prof. P. Cannon (U.K.)
Dr. P.L.E. Uslenghi (U.S.A.)
Secretary General: Prof. P. Lagasse (Belgium)

URSI Secretariat

Secretary General: Prof. P. Lagasse
Assistant S.G. : Prof. P. Van Daele
Dr. W.R. Stone (Publications)
Secretary : Ms. I. Heleu
Ms. I. Lievens

Standing Committees

Standing Publications Committee

Chair : Dr. W.R. Stone (U.S.A.)
Members : Prof. P. Cannon (U.K.)
Prof. P. Favennec (France)
Prof. P. Lagasse (Belgium)
Prof. S.C. Reising (USA)
Dr. P. Wilkinson (Australia)

Standing Committee on Young Scientists

Chair : Prof. K. Schlegel (Germany)
Members : Mr. J. Hamelin (France)
Prof. E.V. Jull (Canada)
Prof. P. Van Daele (Belgium)

Long Range Planning Committee

Chair : Prof. Y. Omura (Japan)
Members : Prof. S. Ananthakrishnan (India)
Dr. P. Banerjee (India)
Prof. M. Chandra (Germany)
Prof. C. Christopoulos (U.K.)
Prof. G. D'Inzeo (Italy)
Prof. F. Kaertner (U.S.A.)
Prof. P. Lagasse (Belgium) (ex officio)
Prof. K.J. Langenberg (Germany)
Prof. F. Lefeuvre (France)
Prof. H. Matsumoto (Japan)
Prof. T. Ohira (Japan)
Prof. K. Schlegel (Germany)
Dr. W.R. Stone (U.S.A.)
Dr. P. Wilkinson (Australia)

URSI ad hoc groups

Advisory Panel on Future General Assemblies

Members : Prof. P. Lagasse (Belgium)
Prof. F. Lefeuvre (France)
Prof. H. Serbest (Turkey)
Dr. W.R. Stone (U.S.A.)
Prof. P.L.E. Uslenghi (U.S.A.)
Prof. P. Van Daele (Belgium)

Scientific Programme XXXIth General Assembly

Coordinator : Prof. H. Serbest (Turkey)
Associate Coordinator : TBD

SCIENTIFIC COMMISSIONS

Commission A : Electromagnetic Metrology

Chair : Dr. W.A. Davis (U.S.A.)
Vice-Chair : Prof. Y. Koyama (Japan)
Official Members :

Australia : Prof. M.E. Tobar
Austria :
Belgium : Prof. E. Van Lil
Brazil : Prof. L. Alencar
Bulgaria : Prof. A. Lazarov
Canada : Prof. A.P. Freundorfer
China CIE (Beijing) : Dr. M. Liu
China SRS (Taipei) : Prof. D.C. Chang
Czech Rep.: Dr. J. Roztocil
Egypt : Prof. M. Fahmy
Finland : Dr. A. Manninen
France : Dr. C. Zerrouki
Germany : Dr. U. Stumper
Greece : Prof. G.A. Kyriacou
Hungary : Prof. M. Kenderessy
India : Dr. P. Banerjee
Ireland : Prof. P. Murphy
Israel : Dr. J. Halevy-Politch
Italy : Dr. P. Tavella
Japan : Dr. Y. Koyama
Netherlands :
New Zealand : Dr. T.R. Armstrong
Nigeria : Dr. T.C. Chineke
Norway : Dr. H.A. Froystein
Peru : Ing. M. Mayorga Montoya
Poland : Dr. K. Radecki
Portugal : Prof. N.B. Carvalho
Russia : Dr. V.N. Zhogun
Saudi Arabia : Dr. A. Al-Rajehi
Slovakia : Prof. I. Kneppo
South Africa : Mr. R.E. Dressler
South Korea : Prof. H.J. Lee
Spain : Prof. E. Martin Rodriguez
Sweden : Dr. J. Johansson
Switzerland :
Turkey : Dr. E. Yazgan
Ukraine :
United Kingdom : Prof. L.R. Arnaut
U.S.A. : Prof. O. Kilic

Observers :

Argentina: Ing. H.F. Mazza
Chile : Prof. F. Noel
Denmark:

Commission B : Fields and Waves

Chair : Prof. G. Manara (Italy)
Vice-Chair : Prof. A. Sihvola (Finland)
Official Members :

Australia : Prof. P. Smith
Austria : Dr. H. Arthaber
Belgium : Prof. H. Rogier
Brazil : Prof. E. Costa
Bulgaria : Prof. E. Ferdinandov
Canada : Mr. A. Petosa
China CIE (Beijing) : Dr. D. Su
China SRS (Taipei) : Prof. H.C. Chang
Czech Rep. : Prof. Z. Skvor
Egypt : Prof. H.M. El-Hennawy
Finland : Prof. A. Sihvola
France : Dr. A. Priou
Germany : Prof. L. Klinkenbusch
Greece : Prof. T. Tsiboukis
Hungary : Dr. Gy. Veszely
India : Dr. S.K. Koul
Ireland : Prof. V.F. Fusco
Israel : Prof. R. Kastner
Italy : Prof. G. Manara
Japan : Prof. T. Sato
Netherlands : Prof. Dr. A. Yarovoy
New Zealand : Dr. R. Vaughan
Nigeria : Dr. A.B. Rabiu
Norway : Prof. U. Osterberg
Peru : Dr. M. Yarlequé Medena
Poland : Prof. M. Mrozowski
Portugal : Prof. A.M. Barbosa
Russia : Dr. A.P. Kurochkin
Saudi Arabia :
Slovakia : Prof. L. Sumichrast
South Africa : Prof. A.R. Clark
South Korea : Prof. Y.K. Cho
Spain : Dr. M. Martinez Burdalo
Sweden : Prof. A. Karlsson
Switzerland : Prof. A.K. Skrivervik
Turkey : Dr. A. Altintas
Ukraine : Prof. O.A. Tretyakov
United Kingdom : Dr. C. Mias
U.S.A. : Prof. N. Engheta

Observers :

Argentina: Prof. V. Trainotti
Chile : Prof. B. Jacard
Denmark: Prof. O. Breinbjerg

Commission C : Radiocommunication Systems and Signal Processing

Chair : Prof. M. Luise (Italy)
Vice-Chair : Prof. S. Salous (U.K.)
Official Members :

Australia : Prof. A.J. Parfitt
Austria : Prof. O. Koudelka
Belgium : Prof. L. Vandendorpe
Brazil : Prof. M. Alencar
Bulgaria : Prof. B. Shishkov
Canada : Mr. C. Despins
China CIE (Beijing) : Dr. R. Tao
China SRS (Taipei) : Dr. Y-K Tu
Czech Rep. : Prof. D. Biolek
Egypt : Prof. S.E. El-Khamy
Finland : Prof. R. Wichman
France : Dr. J. Palicot
Germany : Dr. W. John
Greece : Prof. N. Kalouptsidis
Hungary : Dr. L. Nagy
India :
Ireland : Dr. M. O'Droma
Israel : Dr. S. Litsyn
Italy : Prof. M. Luise
Japan : Prof. K. Itoh
Netherlands : Dr. Ir. M.J. Bentum
New Zealand : Dr. P.T. Gough
Nigeria : Prof. M. Onuu
Norway : Prof. B. Forssell
Peru : Ing. D. Chávez Muñoz
Poland : Prof. M. Piekarski
Portugal : Prof. Dr. A. Rodrigues
Russia : Dr. A.B. Shmelev
Saudi Arabia :
Slovakia : Prof. P. Farkas
South Africa : Dr. D.D. Mashao
South Korea :
Spain : Prof. M. Sierra Perez
Sweden : Mr. K.A. Markstrom
Switzerland : Prof. M. Rubinstein
Turkey : Dr. E. Panayirci
Ukraine : Prof. V.V. Danilov
United Kingdom : Prof. S. Salous
U.S.A. : Dr. A. Zaghloul

Observers :

Argentina: Prof. A. Quijano
Chile : Dr. R. Feick
Denmark : Dr. K.J. Larsen

Commission D : Electronics and Photonics

Chair : Dr. S. Tedjini (France)
Vice-Chair : Prof. G. Steinmeyer (Germany)
Official Members :

Australia : Prof. A. Parker
Austria : Prof. W. Bösch
Belgium : Prof. P. Van Daele
Brazil : Prof. H.J. Kalinowski
Bulgaria : Prof. M. Nenchev
Canada : Dr. C. Caloz
China CIE (Beijing) : Dr. H. Guo
China SRS (Taipei) : Prof. Y.-K. Su
Czech Rep. : Prof. O. Wilfert
Egypt : Prof. M. Saad
Finland : Prof. H. Lipsanen
France : Dr. C. Tetelin
Germany : Prof. H. Klar
Greece : Dr. Em. Kriezis
Hungary : Prof. V. Szekely
India : Prof. Thyagarajan
Ireland : Prof. T. Brazil
Israel : Prof. Y. Nemirovsky
Italy : Prof. S. Selleri
Japan : Prof. T. Nagatsuma
Netherlands : Ir. F.L.M. Van Den Bogaart
New Zealand : Dr. M.K. Andrews
Nigeria :
Norway : Prof. A. Rönnekleiv
Peru : Mr. P. Paz Retuerto
Poland : Prof. B. Mroziewicz
Portugal : Prof. F.J.O. Restivo
Russia : Prof. V. Kuznetsov
Saudi Arabia :
Slovakia : Dr. J. Novak
South Africa : Prof. B.M. Lacquet
South Korea :
Spain : Dr. I. Molina Fernandez
Sweden : Prof. A. Rydberg
Switzerland : Dr. C. Dehollain
Turkey : Dr. S. Demir
Ukraine : Prof. V.G. Litovchenko
United Kingdom : Dr. M. Cryan
U.S.A. : Prof. J. Papapolymerou

Observers :

Argentina: Dr. M. Garavaglia
Chile :
Denmark :

Commission E : Electromagnetic Environment and Interference

Chair : Dr. A.P.J. Van Deursen (the Netherlands)
Vice-Chair : Dr. D. Giri (U.S.A.)
Official Members :

- Australia : Dr. J. O'Sullivan
- Austria :
- Belgium : Prof. G. Vandenbosch
- Brazil : Prof. J-P Raulin
- Bulgaria : Prof. E. Nickolov
- Canada : Prof. B. Kordi
- China CIE (Beijing) : Dr. Y. Wen
- China SRS (Taipei) : Dr. K.-H. Lin
- Czech Rep. : Dr. M. Svoboda
- Egypt : Prof. M. El-Hadidi
- Finland : Dr. A. Viljanen
- France : Prof. F. Paladian
- Germany : Dr. F. Sabath
- Greece : Prof. C. Capsalis
- Hungary : Dr. G. Varju
- India :
- Ireland : Dr. K. Mc Carthy
- Israel : Mr. O. Hartal
- Italy : Prof. S. Selleri
- Japan : Prof. R. Koga
- Netherlands : Dr. A.P.J. Van Deursen
- New Zealand : Prof. R.L. Dowden
- Norway : Dr. J. Tjelta
- Peru : Dr. C.V. Velasquez-Lopez
- Poland : Prof. M. Wnuk
- Portugal : Eng. J.P. Borrego
- Russia : Prof. V.I. Larkina
- Saudi Arabia :
- Slovakia : Prof. V. Smiesko
- South Africa : Prof. H.C. Reader
- South Korea :
- Spain : Dr. J.D. Gallego Pujol
- Sweden : Dr. M. Bäckström
- Switzerland : Mr. F. Rachidi
- Turkey : Dr. L. Gürel
- Ukraine : Prof. N.T. Cherpak
- United Kingdom : Dr. M. Fullekrug
- U.S.A. : Prof. D. Erricolo

Observers :

- Argentina: Eng. O.M. Beunza
- Chile :
- Denmark : Prof. O. Breinbjerg

Commission F : Wave Propagation and Remote Sensing

Chair : Dr. R.H. Lang (U.S.A.)
Vice-Chair : Dr. Simonetta Paloscia (Italy)
Official Members :

- Australia : Ms. C. Wilson
- Austria : Dr. M. Schönhuber
- Belgium : Prof. P. Sobieski
- Brazil : Prof. M.S. de Assis
- Bulgaria : Prof. D. Radev
- Canada : Dr. C. Amaya
- China CIE (Beijing) : Prof. Q. S. Dong
- China SRS (Taipei) : Prof. K. S. Chen
- Czech Rep. : Assoc. Prof. S. Zvanovec
- Egypt : Prof. M.A. Aboul-Dahab
- Finland : Prof. M.T. Hallikainen
- France : Dr. M. Dechambre
- Germany : Dr. M. Chandra
- Greece : Prof. D.P. Chrissoulidis
- Hungary : Dr. R. Seller
- India : Prof. A. Maitra
- Ireland : Dr. C. Brennan
- Israel : Prof. A. Cohen
- Italy : Dr. P. Pampaloni
- Japan : Prof. Y. Yamaguchi
- Netherlands : Prof. L.P. Lighthart
- New Zealand : Dr. E.M. Poulter
- Nigeria : Dr. I.A. Adimula
- Norway : Dr. J. F. Hjelmstad
- Peru : Dr. M.F. Sarango
- Poland : Dr. W. Pawlowski
- Portugal : Prof. Dr. J.C. da silva Neves
- Russia : Dr. A.A. Chukhlantsev
- Saudi Arabia : Dr. A. Al-Rajehi
- Slovakia : Dr. V. Stofanik
- South Africa : Prof. M.R. Inggs
- South Korea :
- Spain : Prof. J. Margineda Puigpelat
- Sweden : Dr. J.F. Johansson
- Switzerland : Mr. D. Vergeres
- Turkey : Dr. O. Arikan
- Ukraine : Prof. G.P. Kulemin
- United Kingdom : Dr. D. Bebbington
- U.S.A. : Prof. A. Gasiewski

Observers :

- Argentina: Dr. D.A. Gagliardini
- Chile : Mr. R. Aguilera
- Denmark : Prof. N. Skou

Commission G : Ionospheric Radio and Propagation

Chair : Prof. J.D. Mathews (U.S.A.)
Vice-Chair : Prof. I. Stanislawska (Poland)
Official Members :

- Australia : Dr. P. Wilkinson
- Austria : Prof. K.M. Torkar
- Belgium : Mr. R. Warnant
- Brazil : Dr. I.S. Batista
- Bulgaria : Dr. N. Kilifarska
- Canada : Prof. P.T. Jayachandran
- China CIE (Beijing) : Dr. Z. Zhao
- China SRS (Taipei) : Prof. Y.H. Chu
- Czech Rep. : Dr. J. Boska
- Egypt : Prof. K. Awadallah
- Finland : Dr. P. Aikio
- France : Dr. F. Pitout
- Germany : Dr. M. Förster
- Greece : Prof. J. Kanellopoulos
- Hungary : Dr. P. Bencze
- India : Prof. A. Bhattacharya
- Ireland : Prof. M.C. Sexton
- Israel : Dr. Z. Houminer
- Italy : Dr. B. Zolesi
- Japan : Prof. S. Watanabe
- Netherlands : Dr. R.P. Cerdeira
- New Zealand : Prof. W.J. Baggaley
- Nigeria : Dr. V.U. Chukwuma
- Norway : Prof. A. Brekke
- Peru : Dr. J.L. Chau
- Poland : Dr. I. Stanislawska
- Portugal : Cap. T.E. Bolas
- Russia : Prof. Yu. Ya. Ruzhin
- Saudi Arabia : Dr. A. Al-Rajehi
- Slovakia : Dr. R. Kudela
- South Africa : Dr. E. Mravlag
- South Korea :
- Spain : Prof. J.L. Pijoan Vidal
- Sweden : Dr. G. Wannberg
- Switzerland :
- Turkey : Dr. Y. Tulunay
- Ukraine : Prof. Y.M. Yampolsky
- United Kingdom : Prof. F. Honary
- U.S.A. : Dr. F. Lind

Observers :

- Argentina: Prof. S.M. Radicella
- Chile : Dr. A. Foppiano
- Denmark : Prof. P. Høeg

Commission H : Waves in Plasmas

Chair : Dr. O. Santolik (Czech Republic)
Vice-Chair : Prof. M.M. Oppenheim (U.S.A.)
Official Members :

- Australia : Assoc. Prof. C. Waters
- Austria : Prof. H. Rucker
- Belgium : Dr. V. Pierrard
- Brazil : Dr. J.A. Bittencourt
- Bulgaria : Prof. I. Zhelyazkov
- Canada : Prof. P.T. Jayachandran
- China CIE (Beijing) : Dr. J. Cao
- China SRS (Taipei) : Prof. L. C. Lee
- Czech Rep. : Assoc. Prof. O. Santolik
- Egypt : Prof. A. El-Sherbini
- Finland : Prof. K. Mursula
- France : Dr. C. Mazelle
- Germany : Dr. G. Mann
- Greece : Prof. J.L. Vomvoridis
- Hungary : Prof. C. Ferencz
- India : Dr. N. Chakrabarti
- Ireland : Prof. M.C. Sexton
- Israel : Prof. M. Mond
- Italy : Dr. D. Farina
- Japan : Prof. T. Okada
- Netherlands :
- New Zealand : Dr. C.J. Rodger
- Nigeria :
- Norway : Prof. J. Trulsen
- Peru : Dr. W.R. Guevara Day
- Poland : Prof. A. Wernik
- Portugal : Prof. M.E. Manso
- Russia : Dr. Y.V. Chugunov
- Saudi Arabia :
- Slovakia :
- South Africa : Prof. A.R.W. Hughes
- South Korea :
- Spain : Prof. M. Sancho Ruiz
- Sweden : Prof. B. Thidé
- Switzerland :
- Turkey : Dr. Y. Baykal
- Ukraine : Prof. A.G. Zagorodniy
- United Kingdom : Prof. M.W. Dunlop
- U.S.A. : Dr. W.E. Amatucci

Observers :

- Argentina: Prof. A. Giraldez
- Chile : Prof. L. Gomberoff
- Denmark : Prof. J.J. Rasmussen

Commission J : Radio Astronomy

Chair : Prof. J.L.Jonas (South Africa)
Vice-Chair : Prof. W. Baan (the Netherlands)
Official Members :

Australia :
Austria : Prof. H. Rucker
Belgium : Dr. F. Clette
Brazil : Prof. P. Kaufmann
Bulgaria : Prof. P. Velinov
Canada : Dr. S. Claude
China CIE (Beijing) : Dr Y. Yan
China SRS (Taipei) : Prof. T-P Ho
Czech Rep. : Dr. K. Jiricka
Egypt : Prof. S. El-Ramly
Finland : Dr. M. Tornikoski
France : Mr. A. Deschamps
Germany : Prof. Dr. E. Fürst
Greece : Prof. J.H. Seiradakis
Hungary : Prof. I. Fejes
India : Dr. H.C. Ishwarchandra
Ireland : Prof. A. Murphy
Israel : Dr. N. Brosch
Italy : Dr. R. Ambrosini
Japan : Prof. H. Kobayashi
Netherlands : Prof. A. Van Ardenne
New Zealand : Prof. S. Gulyaev
Nigeria : Dr. F.B. Sigalo
Norway : Prof. P. Lilje
Peru : Dr. J. Heraud
Poland : Prof. S. Gorgolewski
Portugal : Prof. L. Cupido
Russia : Dr. I.I. Zinchenko
Saudi Arabia : Dr. A. Al-Rajehi
Slovakia :
South Africa : Prof. J.L. Jonas
South Korea :
Spain : Dr. C.M. Gutierrez de la Cruz
Sweden : Dr. M. Lindqvist
Switzerland : Dr. M. Güdel
Turkey : Dr. I. Küçük
Ukraine : Prof. A.A. Konovalenko
United Kingdom : Prof. R. Davis
U.S.A. : Prof. J.M. Cordes

Observers :

Argentina : Dr. E. Bajaja
Chile : Prof. H. Alvarez
Denmark : Prof. J. Knude

Commission K : Electromagnetics in Biology & Medicine

Chair : Dr. M. Taki (Japan)
Vice-Chair : Prof. J. Wiart (France)
Official Members :

Australia :
Austria : Prof. N. Leitgeb
Belgium : Prof. A.I. Franchois
Brazil : Prof. J.R. Cardoso
Bulgaria : Prof. A. Slavova-Popivanova
Canada : Prof. M. Okoniewski
China CIE (Beijing) : Dr. J. Tian
China SRS (Taipei) : Prof. J-S Lee
Czech Rep. : Prof. J. Vrba
Egypt : Prof. E. Hashish
Finland : Prof. R. Ilmoniemi
France : Dr. A. Perrin
Germany : Prof. F. Kaiser
Greece : Prof. N.K. Uzunoglu
Hungary : Dr. L.D. Szabo
India : Prof. J. Behari
Ireland : Dr. M. Ammann
Israel : Prof. R. Korenstein
Italy : Prof. P. Bernardi
Japan : Dr. T. Shigemitsu
Netherlands : Prof. A.P.M. Zwamborn
New Zealand :
Nigeria :
Norway : Prof. B.A.J. Angelsen
Peru : Ing. L. Vilcahuaman Cajacuri
Poland : Dr. J. Karpowicz
Portugal : Prof. P. Clemente
Russia : Dr. O.V. Betskiy
Saudi Arabia :
Slovakia : Prof. I. Frollo
South Africa : Prof. P.J. Cilliers
South Korea : Prof. Y.M. Gimm
Spain : Prof. J.L. Sebastian Franco
Sweden : Prof. Y. Hamnerius
Switzerland : Prof. N. Kuster
Turkey : Dr. Z. Ider
Ukraine : Prof. Y. O. Zozulya
United Kingdom : Dr. M.P. Robinson
U.S.A. : Prof. S. Hagness

Observers :

Argentina : Prof. V.H. Padula-Pintos
Chile :
Denmark : Prof. J. B. Andersen

WORKING GROUPS

Working Groups 2011-2014

D.1 RFID Technologies and Privacy of data
Chair : Dr. S. Tedjini (France)
Vice-Chair : Dr. G. Marrocco (Italy)

E.1. Terrestrial and Planetary Electromagnetic Noise Environment
Co-Chairs : Y. Hobara (Japan), K. Hattori (Japan), A.P. Nickolaenko (Ukraine), C. Price (Israel),

E.2. Intentional Electromagnetic Interference
Co-Chairs : M. Bäckström (Sweden) and W. Radasky (U.S.A);

E.3. High Power Electromagnetics
Co-Chairs : R.L. Gardner (U.S.A.) and F. Sabath (Germany)

E.4. Lightning Discharges and Related Phenomena
Chair : S. Yoshida (Japan), Co-Chair: Dr. V. Rakov (U.S.A.)

E.5. Interaction with, and Protection of, Complex Electronic Systems
Co-Chairs : J-P. Parmentier (France); F. Gronwald (Germany) and H. Reader (South Africa)

E.6. Spectrum Management
Chair: T. Tjelta (Norway); Co-Chair : R. Struzak (Poland)

E.7. Geo-Electromagnetic Disturbances and Their Effects on Technological Systems
Chair : A. Viljanen (Finland);

E.8. Electromagnetic Compatibility and Security in Wired an Wireless Communication Systems
Co-Chairs : J. Gavan (Israel) and A. Zeddam (France);

F.1. Education and Training in Remote Sensing and Related Aspects of Propagation/Next-generation radar remote sensing
Chair: M. Chandra (Germany), Co-Chairs: J. Isnard (France), W. Keydel, E. Schweicher (Belgium)

G.1. Ionosonde Network Advisory Group (INAG)
Chair : I. Galkin (USA), Vice-Chair : to be nominated
INAG Editor : P. Wilkinson (Australia);

G.2. Studies of the Ionosphere Using Beacon Satellites
Chair (Honorary) : R. Leitinger (Austria)
Vice-Chairs : P. Doherty (U.S.A.) , P.V.S. Rama Rao (India) and M. Hernandez-Pajares (Spain)

G.3 Incoherent Scatter
Chair : M. McCready (USA), Vice-Chair: TBD

G4; Equatorial and Low-Latitude Aeronmy
Chair : TBD

Joint Working Groups

EGH. Seismo Electromagnetics (Lithosphere-Atmosphere-Ionosphere Coupling)
Co-Chair for Commission E : M. Hayakawa (Japan)
Co-Chair for Commission G : S. Pulinets (Russia)
Co-Chair for Commission H : M. Parrot (France)

FG. Atmospheric Remote Sensing using Satellite Navigation Systems
Co-Chairs for Commission F : B. Arbesser-Rastburg (the Netherlands)
Co-Chair for Comm. G : C. Mitchell (United Kingdom)

GF. Middle Atmosphere
Co-Chair for Comm. F : C.H. Liu (China, SRS)
Co-Chair for Comm. G : TBD

GH. Active Experiments in Plasmas
Co-Chair for Comm. G : K. Groves (USA)
Co-Chair for Commission H : B. Thidé (Sweden)

Inter-Commission Data Committee
Interim Chair: Dr. P. Wilkinson (Australia)

Inter-Commission Working Group on Natural and Human Induced Hazards and Disasters
Co-Chair for Commission E : W.A. Radasky (U.S.A.)

Inter-Commission Working Group on Solar Power Satellites
Chair : Prof. H. Matsumoto (Japan)
Co-Chair for Commission E : Z. Kawasaki (Japan) and J. Gavan (Israel)
Co-Chair for Commission H : K. Hashimoto (Japan)
Co-Chair for Commission G : K. Schlegel (Germany)
Inter-Commission Working Group on Radio Science Services
Co-Chair for Commission E : T. Tjelta (Norway)
Co-Chair for IUCAF : Dr. W. Van Driel (France)(ex officio)

HEJ. Computer Simulations in Space Plasmas
Co-Chair for Commission H : Y. Omura (Japan) and B. Lembege (France)
Co-Chair for Commission J: K. Shibata (Japan)

Inter-Union Working Groups

URSI/IAGA VLF/ELF Remote Sensing of the Ionospheric and Magnetosphere (VERSIM)
Co-Chair for IAGA Commissions 2 and 3 : C.J. Rodger (New Zealand)
Co-Chair for URSI Commissions H : J. Lichtenberger (Hungary)
Co-Chair for URSI Commission G : TBD

URSI/COSPAR on International Reference Ionosphere (IRI)
Chair : L-A McKinnel (South Africa)
Vice-Chair for URSI : S. Watanabe (Japan)
Vice-Chair for COSPAR : V. Truhlik (Czech Republic)
Secretary: D. Bilitza (U.S.A.)

URSI MEMBER COMMITTEES

AUSTRALIA	President : Prof. A.J. Parfitt
AUSTRIA	President : Prof. H. Rucker
BELGIUM	President : Prof. M. Van Lil
	Secretary : Prof. M. Piette
BRAZIL	President : Prof. M.S. Assis
	Secretary : Prof. D. Consonni
BULGARIA	President : Prof. B. Shishov
	Secretary : Prof. M. Nenchev
CANADA	President : Dr. F. Prato
	Secretary : Dr. A.D. Gray
CHINA (CIE)	President : Dr. J. Wu
	Secretary : Mr. R-H Lin
CHINA (SRS)	President : Prof. L-C Lee
	Secretary : Prof. H.C. Yeh
CZECH REP.	President : Prof. M. Mazanek
	Secretary : Assoc. Prof. O. Fiser
EGYPT	President : Prof. S.E. El-Khamy
	Secretary : Prof. E.M. Saad
FINLAND	President : Prof. A. Sihvola
	Secretary : Dr. H. Wallén
FRANCE	President : Dr. J. Wiart
	Secretary : Mr. J. Hamelin
GERMANY	President : Dr. W. Mathis
	Secretary : Dr. E. Bogenfeld
GREECE	President : Prof. N.K. Uzunoglu
	Secretary: Dr. T. Samaras
HUNGARY	President : Prof. L. Zombory
	Secretary : Dr. L. Nagy
INDIA	President : Prof. S. Ananthakrishnan
	Secretary : Dr. P. Banerjee
IRELAND	President : Dr. M. O'droma
	Secretary : Dr. C. Downing
ISRAEL	President : Prof. E. Heyman
	Secretary : Prof. R. Kastner
ITALY	President : Prof. R. Sorrentino
	Secretary : Dr. P. Tavella
JAPAN	President : Prof. K. Kobayashi
	Secretary : Prof. T. Yamasaki
NETHERLANDS	President : Prof. A. Van Ardenne
	Secretary : Dr. Ir. M.J. Bentum
NEW ZEALAND	President : Prof. N.R. Thomson
	Secretary : Mr. J. Weston
NIGERIA	President : Prof. M.O. Ajewole
	Secretary : Dr. V.U. Chukwuma
NORWAY	President : Prof. J. Trulsen
	Secretary : Ms. Brynildsen
PERU	President : Dr. R. Woodman
	Secretary : Ing. D. Chavez Munoz
POLAND	President : Prof. S. Hahn
	Secretary : Dr. T. Kosilo
PORTUGAL	President : Eng. M.L. Mendes
	Secretary: Ms. H.P. Prazeres
RUSSIA	President : Dr. Yu. V. Gulyaev
	Secretary : Dr. G.I. Chukhray
SAUDI ARABIA	President : Dr. M.I. Suwaiyel
	Secretary : Mr. M. Al-Badrani
SLOVAKIA	President : Prof. L. Sumichrast
	Secretary : Dr. Z. Krajcuskova
SOUTH AFRICA	President : Dr. L-A McKinnell
	Secretary : Ms. L. Ngwenya
SOUTH KOREA	President : Prof. Y-K Cho
	Secretary : Prof. H.-Y. Lee
SPAIN	President : Prof. F. Ares-Pena
	Secretary : Prof. J. Rodriguez-Gonzales
SWEDEN	President : Prof. G. Kristensson
	Secretary : Mr. C.-H. Walde
SWITZERLAND	President:Prof. A. Skrivervik
TURKEY	President : Prof. H. Serbest
	Secretary: Dr. B. Saka
UKRAINE	President : Prof. A.N. Pogorily
	Secretary : Dr. O.M. Kuzmak
UNITED KINGDOM	President : Dr. C.C. Constantinou
	Secretary : Dr. Ian Glover
U.S.A.	President : Dr. Y. Rahmat-Samii
	Secretary : Prof. S.C. Reising

Associate Member Committees

ARGENTINA	President : Mr. N.A. Dominguez
	Secretary : Ing. A. Garbini
CHILE	President : Prof. J. May
DENMARK	President : Prof. P. Hoeg

REPRESENTATIVES IN SCIENTIFIC ORGANISATIONS

COSPAR (Committee on Space Research) :
Dr. Z. Klos (Poland)

ICG (International Committee on Global Navigation Satellite Systems)
Prof. B. Arbesser-Rastburg (the Netherlands)

ICSU (International Council of Scientific Unions) :
Dr. P. Wilkinson (Australia)
Prof. F. Lefeuvre (France)

ICSU World Data System
Dr. D. Bilitza (U.S.A.)

IGBP (International Geosphere-Biosphere Programme)
Dr. P. Bauer (France)

ISES (International Space Environment Service) :
Dr. D. Boteler (Canada)(Director)
Dr. R. Pirjola (Finland, Com. E)
Prof. I. Stanislawska (Poland, Com. G)

IUCAF (Scientific Committee on Frequency Allocations for Radio Astronomy and Space Science) :
Dr. M. Ohishi (Chairman, Japan)
Prof. S. Ananthakrishnan (India, Com J)
Dr. W.A. Baan (ex officio)
Prof. I. Häggström (U.S.A., Com. G)
Prof. S.C. Reising (U.S.A, Com. F)
Dr. A.T. Tzioumis (Australia, Com. J)
Dr. W. Van Driel (France, Com. J)

IUGG/IAGA (International Union of Geodesy and Geophysics/International Association of Geomagnetism and Aeronomy)
Dr. P. Wilkinson (Australia)

SCAR (Scientific Committee on Antarctic Research) :
Dr. M. Clilverd (U.K.)

SCOR (Scientific Committee on Oceanic Research) :
Dr. R.H. Lang (U.S.A.)

SCOSTEP (Scientific Committee on Solar-Terrestrial Physics):
Dr. L-A McKinnel (South Africa)

WHO EMF (World Health Organisation - Electromagnetic Field Programme)
Prof. B. Veyret (France)

EDITORS OF URSI PUBLICATIONS

Radio Science Bulletin
Editor-in-Chief : Prof. P. Lagasse
Editor : Dr. W. R. Stone
Senior Associate Editors:
Prof. J. Volakis
Associate Editor for Abstracts:
Prof. P.A. Watson
Associate Editor for Book Reviews:
Prof. K. Schlegel
Editorial Advisory Board : Prof. F. Lefeuvre
Associate Editors:
Dr. P. Banerjee, Mr. Y. Koyama (Com. A)
Prof. G. Manara, Dr. A. Sihvola (Com. B)
Prof. M. Luise, Prof. S. Salous (Com. C)
Dr. P-N Favennec (Com. D)
Dr. David Giri (Com. E)
Dr. S. Paloscia, Dr. R. Lang (Com. F)
Prof. I. Stanislawska (Com. G)
Prof. M.M. Oppenheim (Com. H)
Dr. J. Baars (Com. J)
Dr. E. Topsakal (Com. K)

Review of Radio Science (ceased publication in 2002)
Editor : Dr. W. R. Stone

Records of URSI General Assemblies
Editor : Secretary General

ALPHABETICAL INDEX AND CO-ORDINATES

BAGGALEY, Prof. W.J., Department of Physics and Astronomy, University of Canterbury, Private Bag, CHRISTCHURCH 1, NEW ZEALAND, Tel. +64 3-364-2558, Fax +64 3-364-2469, E-mail jack.baggaley@canterbury.ac.nz (88)

BAJAJA, Dr. E., Inst. Arg. de Radioastronomia, CC. No 5, 1894 VILLA ELISA, B.A., ARGENTINA, Tel. +54 221 4254 909 Fax +54 221-4824903, E-mail bajaja@irma.iar.unlp.edu.ar (89)

BANERJEE, Dr. P., National Physical Laboratory, Dr. K.S. Krishnan Marg, NEW DELHI 110 012, INDIA, Tel. +91 11 45608391 / 45609240, Fax +91 11 25841506, E-mail pbanerjee@mail.nplindia.ernet.in (84, 85, 91)

BARBOSA, Prof. A.M., Instituto Superior Técnico, Instituto de Telecomunicações, Avenida Rovisco Pais n°1, 1049-001 LISBOA CODEX, PORTUGAL, Tel. +351 21 841 8482, Fax +351 21 841 8472, E-mail afonso.barbosa@lx.it.pt (85)

BATISTA, Dr. I.S., INPE - Instituto Nacional de Pesquisas Espaciais, Av. dos Astronautas 1758, Jd. da Granja, 12227-010 Sao José dos Campos, SP, BRAZIL, Tel. +55 12 39456000, E-mail inez@dae.inpe.br (88)

BAUER, Dr. P., 17, Route des Bardis, F-31320 Rebigue, FRANCE, E-mail pierre.bauer@meteo.fr (92)

BAYKAL, Dr. Y., Department of Electrical and Electronics Engineering, Faculty of Engineering, çankaya University, Ögretmenler Cad. No. 14, Balgat, ANKARA, TURKEY, Tel. +90 312 2844500 ext. 132, Fax +90 312 285 9631, E-mail y.baykal@cankaya.edu.tr (88)

BEBBINGTON, Dr. D., School of Computer Science & Electronic Engineering, University of Essex, Wivenhoe Park, Colchester, CO4 3SQ, UNITED KINGDOM, E-mail david@essex.ac.uk (87)

BEHARI, Prof. J., Jawaharlal Nehru University, School of Environmental Sciences, New Mehruali Road, NEW DELHI, 110 067, INDIA, Tel. +91 11-2670 4323, 2671 7538, Fax +91 11-26717586, E-mail jbehari2000@yahoo.co.in, behari@mail.jnu.ac.in (89)

BENCZE, Prof. P., Geof. Kut. Labor, MTA (Hungarian Academy of Sciences), Csatkai E. u. 6, H-9400 SOPRON, HUNGARY, Tel. +36 99-314291, Fax +36 99-313267, E-mail bencze@ggki.hu (88)

BENTUM, Dr. Ir. M.J., Fac. of Electrical Eng. Mathematics & Computer Science, University of Twente, Postbus 217, 7500 AE Enschede, NETHERLANDS, Tel. +31 53 489 2108/3856, Fax +31 53 489 5640, E-mail m.j.bentum@utwente.nl (86,91)

BERNARDI, Prof. P., Department of Electronic Engineering, University La Sapienza, Via Eudossiana 18, 000184 ROME, ITALY, Tel. +390 6-4458 5855, Fax +390 6-474 2647, E-mail bernardi@die.uniroma1.it (89)

BETSKIY, Dr. O.V., FIRE, Russian Academy of Sciences, Vvedenskogo pl. 1, Fryasino, Moscow Region 141120, RUSSIA, Tel. +7 495 629 33 80, Fax +7 495 629 3678, E-mail ehf@cplire.ru (89)

BEUNZA, Eng. O.M., Cnel. Ramon L. Falcon 1535, 3rd floor, Apt. A, C1407GND BUENOS AIRES, ARGENTINA, Tel. +54 1-772-1471, Fax +54 11 4776 0410, E-mail postmast@caerce.edu.ar (87)

BHATTACHARYA, Prof. A., , Director, Indian Institute of Geomagnetism, Plot No. 5, Sector 18, Kalamboli Highway, Kalamboli, NEW PANVEL, 410 218, INDIA, Tel. +91 22 27400700, Fax +91 22 27450703, E-mail abh@iigs.iigm.res.in (88)

BILITZA, Dr. D., Raytheon ITSS/NSSDC, Goddard Space Flight Center, Code 632, 10136 CRESTWOOD RD, Greenbelt, MD 20771, USA, Tel. +1 301 286-0190, Fax +1 301 286-1771, E-mail dieter.bilitza-1@nasa.gov (90, 92)

BIOLEK, Prof. D., Brno University of Technology/University of Defence Brno, Kounicova 65, BRNO 616 00, CZECH REPUBLIC, Tel. +420 973 442 487, Fax +420 541 149 192, E-mail dalibor.biolek@unob.cz (86)

BITTENCOURT, Dr. J.A., INPE - Instituto Nacional de Pesquisas Espaciais, Av. dos Astronautas 1758, Jd. da Granja, 12227-010 Sao José dos Camos, S.P, BRAZIL, Tel. +55 12-39456000, E-mail jabittencourt@hotmail.com (88)

BOGENFELD, Dr. E., T-Systems Enterprise Services GmbH, Mobile & Wireless Solutions Systems Integration, TZ Engineering Networks, Products and Services Deutsche-Telekom-Allee 7, D-64295 DARMSTADT, GERMANY, Tel. +49 6151 937 5834, Fax +49 6151 937 4611, E-mail eckard.bogenfeld@telekom.de (91)

BOLAS, Prof. T.E., LCDR, DITIC, Rua do Arsenal, 1149-001 LISBOA, PORTUGAL, Tel. +351 9177 44 784, E-mail ludovico.bolas@marinha.pt (88)

BORREGO, Eng. J.P., ICP-ANACOM, Centro de Monitorizaçao e Controlo do Espectro do Sul, Alto do Paimão, 2730-216 BARCARENA, PORTUGAL, Tel. +351 21 434 85 00, Fax +351 21 434 85 90 , E-mail jose.borrego@anacom.pt (87)

BÖSCH, Prof. W., Institute of Microwave and Photonic Engineering, Graz University of Technology, Inffeldgasse 12, 8010 Graz, AUSTRIA, Tel. +43 316 873 3301, Fax +43 316 873 3302, E-mail wolfgang.boesch@tugraz.at (86)

BOSKA, Dr. J., Institute of Atmospheric Physics, Academy of Sciences of Czech Republic, Bocni II-1401, PRAGUE 4 141 31, CZECH REPUBLIC, Tel. +420 272 016 065, Fax +420 272 762 528, E-mail boska@ufa.cas.cz (88)

BOTELER, Dr. D.H., Director, ISES, Geomagnetic Laboratory, 7 Observatory Crescent, OTTAWA, ON K1A 0Y3, CANADA, Tel. +1 613 837-2035, Fax +1 613 824-9803, E-mail boteler@geolab.nrcan.gc.ca (92)

BRAZIL, Prof. T., UCD School of Electrical, Electronic and Mechanical Engineering, University College Dublin, DUBLIN, BELFIELD 4, IRELAND, Tel. +353 1 716 1929, Fax +353 1 283 0921, E-mail Tom.Brazil@ucd.ie (86)

BREINBJERG, Prof. O., OERSTED-DTU, Electromagnetic Systems, Technical University of Denmark, Oersteds Plads, Bldg. 348, DK-2800 LYNGBY, DENMARK, Tel. +45 4525 3814, Fax +45 4593 1634 (85, 87)

BREKKE, Prof. A., Institute for Physics and Technology, University of Tromso, N-9037 TROMSO, NORWAY, Tel. +47 77 645167, E-mail asgeir.brekke@uit.no (88)

BRENNAN, Dr. C., School of Electronic Engineering, Dublin City University, DUBLIN 9, IRELAND, Tel. +353 1 7007649, E-mail BrennanC@eeng.dcu.ie (87)

BROSCH, Dr. N., Wise Observatory, Tel Aviv University, Chayim Levanon St., Ramat Aviv, 69978 TEL AVIV, ISRAEL, Tel. +972 3 640-7413, Fax +972 3 640-8179, E-mail noah@wise.tau.ac.il (89)

BRYNILDSEN, Ms. , Institute of Theoretical Astrophysics, P.O. Box 1029 Blindern, N-0315 OSLO, NORWAY, Tel. +47 22 856502, Fax +47 22 856505, E-mail nilsbr@astro.uio.no (91)

CALOZ, Dr. C., Pavillon Lassonde, M-6025, École Polytechnique, 2500, Chemin de Polytechnique, Montréal, Québec H3T IJ4, CANADA, Tel. +1 514 340 4711 ext. 3326, Fax +1 514 340 5892, E-mail christophe.caloz@polymtl.ca (86)

CANNON, Prof. P.S., RF Operating Environments, QinetiQ, St. Andrews Road, MALVERN WR14 3PS, UNITED KINGDOM, Tel. +44 1684 896468, Fax +44 1684 895646, E-mail pcannon@qinetiq.com (84)

CAO, Dr. J., Beijing University of Aeronautics&Astronautics, XueYuan Road No.37, Haidan District, Beijing, CHINA CIE, Tel. +86 10 6258 2644, E-mail jbcao@buaa.edu.cn (88)

CAPSALIS, Prof. C., Division of Information Transmission Systems and Material Technology, School of Electrical and Computer Engineering, National Technical University of Athens, Iroon Polytechniou 9, GR-15773 ATHENS, GREECE, Tel. +30 210 772 3517, Fax +30 210 772 2281, E-mail ccaps@central.ntua.gr (87)

CARDOSO, Prof. J. R., Escola Politecnica, Departamento de Engenharia de Energia e Automoçao Elétrica, Universidade de Sao Paulo, Av. Professor Luciano Gualberto, tv. 3, N. 158, Cidade Universitaria, 05508-900 Sao Paulo, SP, BRAZIL, Tel. +55 11 30915415, Fax +55 11 38144013, E-mail jose.cardoso@poli.usp.br (89)

CARVALHO, Prof. Instituto de Telecomunicacoes, Universidade de Aveiro, Campus Universitario, 3810-193 Aveiro, PORTUGAL, Tel. +351 234377900, Fax +351 234377901, E-mail nbcarvalho@ua.pt (84)

CERDEIRA, Dr. R.P., ESA-ESTEC, TEC-EEP, Postbus 299, 2200 AG NOORDWIJK, NETHERLANDS, Tel. +31 71 565 8658, E-mail roberto.prieto.cerdeira@esa.int (88)

CHAKRABARTI, Dr. N., 1/AF, Bidhannagar, Kolkata, 700064, INDIA, Tel. +91 33 23375345, Fax +91 33 23374637, E-mail nikhil.chakrabarti@saha.ac.in (88)

CHANDRA, Prof. M., Microwave Engineering and Photonics, Electrical Eng & Information, T.U. Chemnitz, Reichenhainer Strasse 70, D-09126 CHEMNITZ, GERMANY, Tel. +49 371 531 24340, Fax +49 371 531 24349, E-mail madhu.chandra@etit.tu-chemnitz.de (84, 87, 90)

CHANG, Prof. D-C, Oriental institute of Technology, 58,Sec.2,Sihchuan Rd.,Pan-Chiao City, Taipei County 22061, TAIWAN, E-mail dcchang@mail.oit.edu.tw (84)

CHANG, Prof. H-C, Department of Electrical Engineering, National Taiwan University, No. 1, Roosevelt Road Sec. 4, TAIPEI 106, CHINA (SRS), Tel. +886-2-23635251ext.51, Fax +886-2-23638247, E-mail hcchang@cc.ee.ntu.edu.tw (85)

CHAU, Dr. Jorge L., Jicamarca Radio Observatory, Instituto Geofisico del Peru, Apartado 13-0207, LIMA 13, PERU, Tel. +51 1-3172313, Fax +51 1-4344563, E-mail jchau@jro.igp.gob.pe (88)

CHÁVEZ MUÑOZ, Ing. D., Departamento de Ingenierìa, Universidad Católica del Perú, Grupo de Telecomunicaciones Rurales , Av.Universitaria 1801, San Miguel, LIMA 32, PERU, Tel. +51-1-626-2452, Fax +51-1-626-2116, E-mail dchavez@pucp.edu.pe (86, 91)

CHEN, Prof. K-S, Center for Space and Remote Sensing Research, National Central University, No. 300, Jung-da Road, Jhongli City, TAOYUAN 320, CHINA (SRS), Tel. +886-3-4227151 ext7617, Fax +886-3-4273586, E-mail dkschen@csrsr.ncu.edu.tw (87)

CHERPAK, Prof. N.T., A. Usikov Institute of Radiophysics and Electronics, NASU, 12, ac. Proskura Str., KHARKOV 61085, UKRAINE, Tel. +380 72 448508, E-mail cherpak@ire.kharkov.ua (87)

CHINEKE, Dr. T.C., Department of Physics and Industrial Physics, Imo State University, Owerri, Imo State, NIGERIA, Tel. 234 803 722 9905, E-mail chidiezie@yahoo.com (85)

CHO, Prof. Y.K., School of Electrical Engineering and Computer Science, Kyungpook National University, Sankyuk-dong, Buk-gu, DAEGU 702-701, SOUTH KOREA, Tel. +82 53-950-5536, Fax +82 53-950-5536, E-mail ykcho@ee.knu.ac.kr (85, 91)

CHRISSOULIDIS, Prof. D.P., Division of Telecommunications, Dept. of Electrical and Computer Eng., Aristotle University of Thessaloniki, P.O. Box 1562, GR- 54124 THESSALONIKI, GREECE, Tel. +30 231 099 6334, Fax +30 231 099 6334, E-mail dpchriss@eng.auth.gr (87)

CHRISTOPOULOS, Prof. C., George Green Institute for Electromagnetics Research, School of EEE, University of Nottingham, University Park, NOTTINGHAM, NG7 2RD, UNITED KINGDOM, Tel. +44 115 846 8296, Fax +44 115 951 5616, E-mail christos.christopoulos@nottingham.ac.uk, kathryn.sanderson@nottingham.ac.uk (84)

CHU, Prof. Y-H, Secretary General Office, National Central University, No. 300, Jungda Road, CHUNG-LI, TAOYUAN 320, CHINA (SRS), Tel. +886 3-4227151 ext. 57010, Fax +886 3-4254842, E-mail yhchu@jupiter.ss.ncu.edu.tw (88)

CHUGUNOV, Prof. Yu.V., Institute of Applied Physics, Russian Academy of Sciences, Ul'yanova Street 46, NIZHNY NOVGOROD 603600, RUSSIA, Tel. +7 8314 384 232, Fax +7 8314 362 061, E-mail chugun@appl.sci-nnov.ru (88)

CHUKHLANTSEV, Dr. A.A., Institute of Radio-engineering and Electronics, Russian Academy of Sciences, 1 Acad. Vvedensky Sq, Fryazino, Moscow Region, 141190, RUSSIA, E-mail chukhlantsev@ms.ire.rssi.ru (87)

CHUKHRAY, Dr. G.I., Institute of Radioengineering and Electronics (IRE), Russian Academy of Science, Mokhovaya str. 11, MOSCOW 125009, RUSSIA, Tel. +7 495 311 6978, Fax +7 495 629 3678, E-mail australia2@yandex.ru, ursi@cplire.ru (91)

CHUKWUMA, Dr. V.U., Department of Physics, Olabisi Onabanjo University , P.O. Box 351, Ago Iwoye, NIGERIA, Tel. 234 805 507 5270, E-mail victorchukwuma@yahoo.com (88, 91)

CILLIERS, Dr. P.J., Hermanus Magnetic Observatory, Physic Department, Rhodes University, P.O. Box 32, 7200 HERMANUS, SOUTH AFRICA, Tel. +27 28 312 1196, Fax +27 28 312 2039, E-mail pjcilliers@hmo.ac.za (89)

CLARK, Prof. A.R., School of Electrical and Information Eng., University of Witwatersrand, Room CM4-236, 3050 WITS, SOUTH AFRICA, Tel. +27 11 717 7223, Fax +27 11 403 1929, E-mail alanrobertclark@gmail.com (85)

CLAUDE, Dr. S., National Research Council Canada, Herzberg Institute of Astrophysics, 5071 West Saanich Road, VICTORIA, BC V9E 2E7, CANADA, Tel. +1 250 363 0030, Fax +1 250 363 0045, E-mail Stephane.Claude@nrc-cnrc.gc.ca (89)

CLEMENTE, Prof. P., Director do Serviço de Otorrinolaringologia, Faculdade de Medicina do Porto, Hospital S. João, Alameda Professor Hernâni Monteiro, 4200-319 PORTO, PORTUGAL, Tel. +351 91 756 0195, E-mail pais.clemente@mail.telepac.pt (89)

CLETTE, Dr. F., SIDC - Solar Physics, Royal Observatory of Belgium, 3, avenue Circulaire, 1180 Bruxelles, Belgium, Tel. (322) 373-0233, Fax (322) 374-9822, E-mail frederic.clette@oma.be (89)

CLILVERD, Dr. M.A., British Antarctic Survey, High Cross, Madingley Road, CAMBRIDGE, CB3 0ET, UNITED KINGDOM, Tel. +44 1223 221541, Fax +44 1223 221226, E-mail macl@bas.ac.uk (92)

COHEN, Prof. A., The Institute of Earth Science, The Hebrew University, Givat-Ram, P.O.B. 9137, 91091 JERUSALEM, ISRAEL, Tel. +972 2-658 6645, Fax +972 2-662 581, E-mail ariel@vms.huji.ac.il (87)

CONSONNI, Prof. D., Av. Tietê, 730, apto. 22, Campestre, 09070-310 Santo André, SP, BRAZIL, Tel. +55 11 37333758, Fax , E-mail dconsonni@uol.com.br (91)

CONSTANTINOU, Dr. CC, School of Electrical & Electronic Engineering, University of Birmingham, Edgbaston, BIRMINGHAM B15 2TT, UNITED KINGDOM, Tel. +44 121 4144 303, Fax +44 121 4144 291, E-mail C.Constantinou@bham.ac.uk (91)

CORDES, Prof J.M., Department of Astronomy, Cornell University, 520 Space Sciences Bldg, Ithaca, NY 14853-6801, USA, Tel. +1 607 255 0608, Fax +1 607 255 8803, E-mail cordes@astro.cornell.edu (89)

COSTA, Dr E., Centro Técnico-Cientifico, Centro de Estudos em Telecommunicaçoes, Pontificia Universidade Catolica do Rio de Janeiro, CETUC-PUC/Rio, Rua Marquês de São Vicente 225, Gavea, 22453 - 900 Rio de Janeiro, Brazil, Tel. +55 21 311 41618, Fax , E-mail epoc@cetuc.puc-rio.br (85)

CRYAN, Dr. M., Dept. of Electrical and Electronic Engineering, University of Bristol, Merchant Venturers Building, Woodland Road, Bristol, BS8 1UB, UNITED KINGDOM, E-mail m.cryan@bristol.ac.uk (86)

CUPIDO, Prof. L., IPFN - Aveiro, Instituto de Telecomunicaçoes Polo de Aveiro, Campus Universitario de Santiago, P- 3810-193 AVEIRO, PORTUGAL, Tel. +351 23 437 02 00, E-mail cupido@ua.pt (89)

D'INZEO, Prof. G., DIET, University of Rome La Sapienza, Via Eudossiana, 18, I-00184 ROME, ITALY, Tel. +39 06 4458 5853, Fax +39 06 4742 647, E-mail dinzeo@die.uniroma1.it (84)

DANILOV, Prof. V.V., Radiophysical Department, T. Shevchenko Kiev National University, 2 Glushkova avenue, Building 5, KIEV 03127, UKRAINE, Tel. +380 44 5260551, E-mail danilov@univ.kiev.ua (86)

DAVIS, Dr W.A., VA Tech, 302 Whittemore Hall - 0111, Blacksburg, VA 24061, USA, Tel. +1 540-231-6307, Fax +1 540-231-3362, E-mail wadavis@vt.edu (85)

DAVIS, Prof. R., JBCA, School of Physics and Astronomy, University of Manchester, Alan Turing Building, Manchester M13 9PL, UNITED KINGDOM, Tel. +44 161 275 4164, Fax +44 161 275 4247, E-mail richard.davis@manchester.ac.uk (89)

DECHAMBRE, Dr. M., LATMOS, Quartier des garennes, 11 boulevard d'Alembert, F-78280 GUYANCOURT, FRANCE, Tel. + 33 1 80 28 50 80, E-mail monique.dechambre@latmos.ipsl.fr (87)

DEHOLLAIN, Dr. C., EPFL, STI, IMM, LEG, ELB-Ecublens, Station 11, CH-1015 LAUSANNE, SWITZERLAND, Tel. +41 21 693 69 71, Fax +41 21 693 36 40, E-mail catherine.dehollain@epfl.ch (86)

DEMIR, Dr. S., Department of Electrical and Electronics Engineering, Faculty of Engineering, Middle East Technical University , Balgat, Ankara 06531, TURKEY, Tel. +90 312 210 2371, Fax +90 312 210 1261, E-mail (86)

DESCHAMPS, Mr. LERMA, Obseratoire de Paris, 61 Avenue de l'Observatoire, F-75014 PARIS, FRANCE, Tel. +33 140 51 52 43, E-mail andre.deschamps@obspm.fr (89)

DESPINS, Mr. C., President, PromptQuebec, 1010 Sherbrooke Quest, Bureau 1800, MONTREAL, QUE H3A 2R7, CANADA, Tel. +1 514 875 0032, Fax +1 514 875 0082, E-mail cdespins@promptinc.org (86)

DOHERTY, Prof. P., Co-Director/Research Scientist, Institute for Scientific Research, Boston College, 140 Commonwealth Avenue, CHESTNUT HILL, MA 02467, USA, Tel. +1 617 552 8767, Fax +1 617 552 2818, E-mail Patricia.Doherty@bc.edu (90)

DOMINGUEZ, Eng. N.A., CORCA, Avenida del Liberta dor 327, 1638 VICENTE LOPEZ, B.A., ARGENTINA, Tel. +54 1-772-1471, Fax +54 11 4776 0410, E-mail postmast@caerce.edu.ar (91)

DONG, Mr. Q-S, China Research Institute of Radio Wave Propagation, Beijing Research Center, PO Box 6301, 102206 BEIJING, CHINA (CIE), Tel. +86 37 3371 2001, E-mail qsdong22s@sina.com (87)

DOWDEN, Prof. R.L., LF-EM Research Ltd, , 161 Pine Hill Rd., DUNEDIN, PINE HILL 9001, NEW ZEALAND, Tel. +64 3 473 0524 (2000-0900 UT only), Fax +64 3 473 0526 (any time), E-mail dowdenz@physics.otago.ac.nz (87)

DOWNING, Dr. C., School of Electronic & Communications Engineering, Dublin Institute of Technology, Kevin Street, DUBLIN 2, IRELAND, Tel. +353 1 4024578, Fax +353 1 4024690, E-mail cdowning@dit.ie (91)

DRESSLER, Mr. R.E., National Metrology Institute of South Africa, , Private Bag X34, , Lynnwood Ridge, 0040, SOUTH AFRICA, Tel. +27 12 8414342, Fax +27 12 8412131, E-mail redressler@nmisa.org (85)

DUNLOP, Prof. M.W., Space Sciences Division, SSTD, Rutherford Appleton Laboratory, Chilton, Didcot, Oxfordshire, OX11 0QX, UNITED KINGDOM, E-mail malcolm.dunlop@stfc.ac.uk (88)

EL-HADIDY, Prof. M., Faculty of Engineering, Cairo University, Giza, EGYPT, E-mail hadidi@eun.eg (87)

EL-HENNAWY, Prof. H.M., Faculty of Engineering, Ain Shams University, 1 El-Sarayat Street, Abassio, Cairo, EGYPT, Tel. +202 2682 1800, Fax +202 26850617, E-mail helhennawy@ieee.org (85)

EL-RAMLY, Prof. S.H., Faculty of Engineering, Ain Shams University, 25 Badie Khairy Street, HELIOPOLIS, CAIRO, EGYPT, Tel. +2012 3329404, Fax +202 26850617, E-mail sramlye@netscape.net (89)

EL-SHERBINI, Prof. A., Faculty of Engineering, Cairo University, GIZA, EGYPT, Tel. +2012 3229955, E-mail sherbini@mcit.gov.eg (88)

ELKHAMY, Prof. S.E., Dept. of Electrical Engineering, Alexandria University - Faculty of Engineering, Abou-Keer Street, ALEXANDRIA 21544, EGYPT, Tel. +2010-1497360, Fax +203 5971853, E-mail elkhamy@ieee.org, said.elkhamy@gmail.com (86, 91)

ENGHETA, Prof. N., Electrical and Systems Engineering Department, University of Pennsylvania, 200 South 33rd Street, Philadelphia, PA 19104-6314,USA, Tel. +1 215 898 9777, Fax +1 215 - 573 - 2068, E-mail engheta@ee.upenn.edu (85)

ERRICOLO, Prof. D., Department of Electrical and Computer Engineering, University of Illinois at Chicago, 1120 Science and Engineering Offices, 851 S. Morgan Street, Chicago, IL 60607-7053, USA, Tel. +1 - 312 - 996 5771, Fax +1 - 312 - 996 6465, E-mail erricolo@ece.uic.edu (87)

FAHMY, Prof. Dr M., Faculty of Engineering, Assiut University, 71515 Assiut,EGYPT, E-mail fahmy@aun.eun.eg (85)

FARINA, Dr. D., Istituto di Fisica del Plasma 'Piero Caldirola', Dipartimento Energia e Trasporti, Consiglio Nazionale delle Ricerche, Via Roberto Cozzi 53, 20125 Milano,ITALY, E-mail farina@ifp.cnr.it (88)

FARKAS, Prof. P., Fac. of Electrical Eng.&Information Technology, Slovak University of Technology, Ilkovicova 3, BRATISLAVA 812 19, SLOVAKIA, Tel. +421-2-60 29 18 44, Fax +421-2-68 27 96 01, E-mail p.farkas@ieee.org (86)

FAVENNEC, Dr. P.N., 2, impasse Krec'h Liarch, Beg Leguer, F-22300 LANNION, FRANCE, Tel. +33 6-8155 8392, E-mail pierre-noel.favennec@wanadoo.fr (84, 92)

FEICK, Dr. R., Depto. de Electronica, Universidad Técnica Federido Santa Maria, Casillo 110 V, VALPARAISO, CHILE, Tel. +56 32-626 364 ext. 209, Fax +56 32-665 010, E-mail rodolfo.feick@usm.cl (86)

FEJES, Prof I., Moriczzs. u. 16/A, SOLYMAR 2083, HUNGARY, Tel. +36 27 374 980, Fax +36 27 374 982, E-mail fejes@gpsnet.hu (89)

FERDINANDOV, Prof. E., Technical University of Sofia, 8, Kliment Ohridski Str., 1756 SOFIA, BULGARIA, Tel. +359 2 965 3275 (85)

FERENCZ, Prof. Cs., ELTE Department of Geophysics, Space Research Group, Pazmany Peter setany 1/A, H-1117 BUDAPEST, HUNGARY, Tel. +36 1 209 0555/6652, Fax +36 1 372 2927, E-mail spacerg@sas.elte.hu, csaba@sas.elte.hu (88)

FISER, Assoc. Prof. O., Institute of Atmospheric Physics, Academy of Sciences of the Czech Republic, Bocní II - 1401, PRAGUE 4 141 31, CZECH REPUBLIC, Tel. +420 272 016 038, Fax +420 272 763 745, E-mail ondrej@ufa.cas.cz (91)

FOPPIANO, Dr. A., Departamento de Geofisica, Universidad de Concepción, Casilla 160-C, Correo 3, CONCEPCION, CHILE, Tel. +56 41-312 413, Fax +56 41-312 863, E-mail alberto.foppiano@dgeo.udec.cl (88)

FORSSELL, Prof. B., Department of Electronics and Telecommunications, NTNU O.S., Bragstads plass 2, N-7491 TRONDHEIM, NORWAY, E-mail borje.forssell@iet.ntnu.no (86)

FÖRSTER, Dr. M., Department 2.3, Geo Forschungs Zentrum (GFZ) Potsdam, Telegrafenberg, Haus C3, 14473 POTSDAM, GERMANY, Tel. +49 89 30000 3525, Fax +49 89 30000 3569, E-mail mfo@mpe.mpg.de (88)

FRANCHOIS, Prof. A.I., Information Technology (INTEC), Ghent University, Sint Pietersnieuwstraat 41 , 9000 GHENT, BELGIUM, Tel. +32 9 264 89 37, Fax +32 9 264 99 69, E-mail Ann.Franchois@intec.ugent.be (89)

FREUNDORFER, Prof. A.P., Electrical & Computer Engineering Dept., Walter Light Hall, Queen's University, KINGSTON, ON K7L 3N6, CANADA, E-mail freund@post.queensu.ca (85)

FROLLO, Prof. I., Institute of Measurement, Slovak Academy of Sciences, Dubravska Cesta 9, BRATISLAVA 841 04, SLOVAKIA, Tel. +421 2-5477 4033, Fax +421 2-5477 5943, E-mail frollo@savba.sk (89)

FRØYSTEIN, Dr. H.A., Justervesenet, Festveien 99, N-2007 Kjeller, NORWAY, Tel. +47 64 848484, Fax +47 64 848485, E-mail haf@justervesenet.no (85)

FULLEKRUG, Dr M., Dept. of Electronic and Electrical Engineering, Centre for Space, Atmospheric and Oceanic Science, University of Bath, 2 East 3.8, Claverton Down, Bath, BA2 7AY, UNITED KINGDOM, E-mail eesmf@bath.ac.uk (87)

FÜRST, Prof. Dr. E., Max-Planck-Institut fur Radioastronomie, Observatorium Effelsberg, Max-Planck-Strasse 28, D-53902 BAD MUENSTEREIFEL-EFFELSBERG, GERMANY, Tel. +49 2257 301 120, Fax +49 2257 301 105, E-mail efuerst@mpifr-bonn.mpg.de (89)

FUSCO, Prof. V.F., ECIT Institute, The Queen's University of Belfast, Northern Ireland Science Park, Queens Road, Queen's Island, BELFAST BT3 9DT, NORTHERN IRELAND, Tel. +44 28 9097 1700, Fax +44 28 9097 1702, E-mail michelle.mccusker@ecit.qub.ac.uk (85)

GAGLIARDINI, Dr. D.A., Julian Alvarez 1218, 1414 BUENOS AIRES, ARGENTINA, Tel. +54 1-772-1471, Fax +54 11 4776 0410, E-mail postmast@caerce.edu.ar (87)

GALKIN, Mr. I.A., CENTER FOR ATMOSPHERIC RESEARCH, UNIVERSITY OF MASSACHUSETTS, 600 SUFFOLK STREET, LOWELL, MA 01854, USA, Tel. +1 978 934-4912, Fax +1 978 459-7915, E-mail ivan_galkin@uml.edu (90)

GALLEGO PUJOL, Dr. J.D., Observatorio Astronomico Nacional, Apdo 1143, ALCALA DE HENARES, 28800 MADRID, SPAIN, Tel. +34 91 885 5060, Fax +34 91 885 5062, E-mail gallego@oan.es (87)

GARAVAGLIA, Dr. M., Centro de Invest. Opticas (CIOP), CC. 124, 1900 LA PLATA, B.A, ARGENTINA, Tel. +54 21-840 280/842 957, Fax +54 21-530 189, E-mail garavagliam@ciop.unlp.edu.ar (86)

GARBINI, Ing. A., CORCA, Avenida del Liberta dor 327, 1638 VICENTE LOPEZ, B.A., ARGENTINA, Tel. +54 11 4772 1471, Fax +54 11 4776 0410, E-mail postmast@caerce.edu.ar (91)

GARDNER, Dr. R.L., 6152 Manchester Park Circle, ALEXANDRIA, VA 22310-4957, USA, Tel. +1 703-924-9370, Fax +1 703-313-4179, E-mail Robert.L.Gardner@verizon.net (90)

GASIEWSKI, Prof. A.J., Department of Electrical and Computer Engineering, University of Colorado, 0425 UCB, Boulder, CO 80309-0425, USA, Tel. +1 303 492 9688, Fax +1 303 492 2758, E-mail al.gasiewski@colorado.edu (87)

GAVAN, Prof. J., Sami Shamoon College of Engineering, Jabutinsky 84, ASHDOD, ISRAEL, E-mail jacobg@sce.ac.il (90)

GIMM, Prof. Y.M., School of Electronics and Electrical Engineering, Dankook University, Jukjeon-dong 126, Suji-gu, YONGIN-SI 448-701, SOUTH KOREA, Tel. +82 2 793 8732, Fax +82 2 793 1150, E-mail gimm@dku.edu (89)

GIRALDEZ, Prof. A., LIARA, avda. del Libertador 327, 1638 VICENTE LOPEZ, B.A., ARGENTINA, Tel. +54 1-791-5001, Fax +54 1-776-0410, E-mail (88)

GIRI, Dr. D.V., Pro-Tech, 11 C Orchard Court, ALAMO, CA 94507 1541, USA, Tel. +1 925 552 0510, Fax +1 925 552 0532, E-mail Giri@DVGiri.com (87, 92)

GLOVER, Dr. I.A., Dept. of Electronic and Electrical Engineering, Royal College Building, Institute of Communications & Signal Processing, 204 George Street, GLASGOW, G1 1XW, UNITED KINGDOM, Tel. +44 141 548 4458, Fax +44 141 552 4968, E-mail ian.glover@eee.strath.ac.uk (91)

GOMBEROFF, Prof. L., Depto de Fisica - Facultad de Ciencias, Universidad de Chile, Casilla 653, SANTIAGO, CHILE, Tel. +56 2-271 2865, Fax +56 2-271 3882, E-mail lgombero@abello.dic.uchile.cl (88)

GORGOLEWSKI, Prof. S., Katedra Radioastronomii, Uniwersytet M. Kopernika, ul. Gagarina 11, 87-100 TORUN, POLAND, Tel. +48 56-611 3033, Fax , E-mail sgo@astro.uni.torun.pl (89)

GOUGH, Dr. P.T., Dept. of Electrical and Computer Engineering, University of Canterbury, Private Bag 4800, CHRISTCHURCH 1, NEW ZEALAND, Tel. +64 3 364-2297, Fax +64 3 364-2761, E-mail peter.gough@canterbury.ac.nz (86)

GRAY, Dr. A.D., National Research Council Canada, Herzberg Institute of Astrophysics, Dominion Radio Astrophysical Observatory, P.O. Box 248, PENTICTON, BC V2A 6J9, CANADA, Tel. +1 250 497 2313, Fax +1 250 497 2355, E-mail Andrew.Gray@nrc-cnrc.gc.ca (91)

GRONWALD, Dr. F., Inst. for Fundamental Electr. Eng. & EMC, Faculty of Electrical Engineering & Informa&tion Technology, Universitätzplatz 2 , 39106 MAGDEBURG, GERMANY, Tel. +49 391 671 14 36, Fax +49 391 671 12 36, E-mail frank.gronwald@et.uni-magdeburg.de (90)

GROVES, Dr K., US Air Force Research Laboratory, AFRL/VSBXI, 29 Randolph Road, Hanscom AFB, MA 1731, USA, E-mail keith.groves@hanscom.af.mil (90)

GÜDEL, Dr. M., PSI, CH-5232 VILLIGEN, SWITZERLAND, Tel. + 41 44 632 71 29, Fax + 41 56 310 21 99, E-mail manuel.guedel@psi.ch (89)

GUEVARA DAY, Dr. W.R., National Commission on Aerospace Research and Development (CONIDA), Felipe Villaran 1069, San Isidro, LIMA 27, PERU, Tel. +51 1-4429973, Fax +51 1-4419081, E-mail walter@conida.gob.pe (88)

GULYAEV, Prof. S., Centre for Radiophysics and Space Research, School of Mathematical Sciences, Auckland University of Technology, AUCKLAND 1020, NEW ZEALAND, Tel. +64 9 921 9999 ext 8709, 9541, Fax +64 9 921 9973, E-mail sergei.gulyaev@aut.ac.nz (89)

GULYAEV, Dr. Yu. V., Institute of Radioengineering and Electronics, Russian Academy of Sciences (IRE RAS), Mokhovoja Street 11, MOSCOW 125009, RUSSIA, Tel. +7 495 629 3591, Fax +7 495 629 3678, E-mail gulyaev@cplire.ru (91)

GUO, DR. H., School of Electronics Eng. & Computer Science, Peking University, Beijing, 100871, CHINA (CIE), Tel. +86 10 6275 7035, E-mail hongguo@pku.edu.cn (86)

GÜREL, Dr. L., Department of Electrical & Electronics Engineering, Bilkent University, Faculty of Engineering, 06800 ANKARA, TURKEY, Tel. +90 312 290 2096, Fax +90 312 290 2439, E-mail lgurel@bilkent.edu.tr (87)

GUTIERREZ DE LA CRUZ, Dr. C.M., Instituto de Astrofisica de Canarias, C/ Via Lactea, s/n, 38205 LA LAGUNA, TENERIFE, SPAIN, E-mail cgc@iac.es (89)

HÄGGSTRÖM, Prof. I., EISCAT Scientific Association, Box 812, S-981 28 KIRUNA, SWEDEN, Tel. +46 9807 87 01, Fax +46 9807 87 09, E-mail ingemar@eiscat.se (92)

HAGNESS, Prof. S.C., Department of Electrical and Computer Engineering, University of Wisconsin - Madison, 1415 Engineering Drive, Madison, WI 53706, USA, Tel. +1 608 265 57 39, Fax +1 608 262 12 67, E-mail hagness@engr.wisc.edu (89)

HAHN, Prof. S., ul. Sady Zoliborskie 17 m. 26, 01-772 WARSZAWA, POLAND, Tel. +48 22-663 90 56 (pr.), Fax +48 22-825 52 48, E-mail hahn@ire.pw.edu.pl (91)

HALEVY-POLITCH, Dr. J., P.O. Box 7205, 31071 HAIFA, ISRAEL, Tel. +972 4-879 4862, Fax +972 4-879 4875, E-mail aeryapo@tx.technion.ac.il (85)

HALLIKAINEN, Prof. M.T., Dept. of Radio Science and Engineering, Aalto University, P.O. Box 13000, FI-00076 AALTO, FINLAND, Tel. +358 9 470 22371, Fax +358 9 470 22152, E-mail Martti.Hallikainen@tkk.fi (87)

HAMELIN, Mr. J., 10 rue Marthe Edouard, F-92190 MEUDON, FRANCE, Tel. +33 1 4534 2137, E-mail hamelinj@club-internet.fr (84, 91)

HAMNERIUS, Prof. Y., Signals and Systems, Chalmers University of Technology, 412 96 GÖTEBORG, SWEDEN, Tel. +46 31 772 19 05, Fax +46 31 772 17 48, E-mail yngve.hamnerius@chalmers.se (89)

HARTAL, Mr. O., RAFAEL, P.O. Box 2250, 31021 HAIFA, ISRAEL, Tel. +972 4-8792931, Fax +972 4-8795329 (87)

HASHIMOTO, Prof. K., Research Institute for Sustainable Humanosphere, Kyoto University, Gokasho, Uji, KYOTO 611-0011, JAPAN, Tel. +81 774 383 807, Fax +81 774 383 836, E-mail kozo@rish.kyoto-u.ac.jp (90)

HASHISH, Prof. E., Faculty of Engineering, Cairo University, CAIRO, EGYPT (89)

HATTORI, Dr. K., Department of Earth Sciences, Faculty of Science, Chiba University, Yaoi, 1-33, Inage, CHIBA 263-8522, JAPAN, Tel. +81 43 290 28 01, Fax +81 43 290 28 59, E-mail hattori@earth.s.chiba-u.ac.jp (90)

HAYAKAWA, Prof. M., Dept. of Electronic Engineering, The University of Electro-Communications, 1-5-1 Chofugaoka, Chofu, TOKYO 182-8585, JAPAN, Tel. +81 424-43 5159, Fax +81 424-43 5783, E-mail hayakawa@whistler.ee.uec.ac.jp (90)

HELEU, Mrs. I., URSI, c/o INTEC, Sint-Pietersnieuwstraat 41, B-9000 GHENT,BELGIUM, Tel. +32 9-264.33.20, Fax +32 9-264.42.88, E-mail info@ursi.org (84)

HERAUD, Dr. J., Instituto de Radioastronomia INRAS-PUCP, Pontificia Universidad Catolica del Peru, Av. Universitaria 1801, San Miguel, LIMA 32, PERU, Tel. +51 1 6262000 (ext. 4735), E-mail jheraud@pucp.edu.pe (89)

HERNANDEZ-PAJARES, Dr M., Technical University of Catalonia (GAGE/UPC), Mod. C3 Campus Nord UPC, Jordi Girona 1, 08034 Barcelona, Spain, Tel. +34 93 4016029, Fax +34 93 4015981, E-mail manuel@mat.upc.es (90)

HEYMAN, Prof. E., The Iby and Aladar Fleischman Faculty of Engineering, Tel Aviv University, 69978 TEL AVIV, ISRAEL, Tel. +972 3 6408738/8736/8147, Fax +972 3 6407221, E-mail heyman@tau.ac.il (91)

HJELMSTAD, Dr. J.Fr., Department of Electronics and Telecommunications, NTNU, O.S. Bragstads plass 2, 7491 TRONDHEIM, NORWAY, Tel. +47 45 249613, E-mail jens@hjelmstad.no (87)

HO, Prof. T.P., Academia Sinica, Institute of Astronomy and Astrophysics, P.O. Box 23-141, TAPEI 106, TAIWAN, Tel. +886 2 33652200 x700, Fax +886 2 23677849, E-mail pho@asiaa.sinica.edu.tw (89)

HOBARA, Dr. Y., Automatic Control and Systems Engineering, The University of Sheffield, Room: B22, Amy Johnson Building, Sheffield S10 2TN, UNITED KINGDOM, Tel. +44 (0)114 222 5234, Fax +44 (0)114 222 5661, E-mail Y.Hobara@shef.ac.uk (90)

HONARY, Prof F., Physics Department, Lancaster University, Lancaster, LA1 4YB, UNITED KINGDOM, E-mail f.honary@lancaster.ac.uk (88)

HOUMINER, Dr. Z., Asher Space Research Institute, Technion, Israel Institute of Technology, 32000 HAIFA, ISRAEL, Tel. +972 4-829 3512, Fax +972 4-823 0956, E-mail zwih@tx.technion.ac.il (88)

HØEG, Prof. P., DTU Space, Technical University of Denmark, National Space Institute, Department for Geodesy, Juliane Maries Vej 30, 2100 Copenhagen, DENMARK, Tel. +45 3532 5702, E-mail hoeg@space.dtu.dk , per.hoeg@gmail.com (88, 91)

HUGHES, Prof. A.R.W., School of Physics, University of KwaZulu-Natal, 4041 DURBAN, SOUTH AFRICA, Tel. +27 31-260 3158, Fax +27 31-261 6550, E-mail hughes@ukzn.ac.za (88)

IDER, Dr. Y.Z., Dept. of Electr. & Electronics Eng., Bilkent University, Faculty of Engineering, 06800 ANKARA, TURKEY, Tel. +90-312-290 2339, Fax +90 312-266 4192, E-mail ider@ee.bilkent.edu.tr (89)

ILMONIEMI, Prof. , Dept. Biomedical Eng. and Computational Science, Aalto University, P.O. Box 12200, FI-00067 AALTO, Finland, Tel. +358 50 5562964, Fax +358 9 470 23182, E-mail risto.ilmoniemi@tkk.fi (89)

INGGS, Prof. M.R., Dept. of Electrical Engineering, University of Cape Town, Private Bag, 7701 RONDEBOSCH, SOUTH AFRICA, Tel. +27 21-650-2799, Fax +27 21-650-3465, E-mail mikings@gmail.com (87)

ISHWARCHANDRA, Dr. H.C., National Centre for Radio Astrophysics, Pune University Campus, Ganeshkhind, Pune 411 007, INDIA, Tel. +91 20 25719228, Fax +91 20 25697257, E-mail ishwar@ncra.tifr.res.in (89)

ISNARD, Dr. J.J., CNFRS, 28, avenue de Breteuil, F-75007 PARIS, FRANCE, Tel. +33 1-45 66 55 99, Fax +33 1 45 66 55 99, E-mail jisnard-isti@club-internet.fr (90)

ITOH, Dr. K., Kanazawa Institute of Technology, 7-1 Ohgigaoka, Nonoichi, Ishikawa 921-8501, JAPAN, Tel. +81 76 248 9109, Fax +81 76 294 6711, E-mail itoh.kenji@ieee.org (86)

JACARD, Prof. B., Depto. de Ingenieria Electrica, Universidad de Chile, Casilla 412-3, SANTIAGO 3, CHILE, Tel. +56 2-698 2071 ext. 204, Fax +56 2-695 3881, E-mail (85)

JAYACHANDRAN, Mr. P.T., Department of Physics, University of New Brunswick, 8 Bailey Drive, P.O. Box 4440, Fredericton, NB E3B 5A3, CANADA, Tel. +1 506 447 3330, Fax +1 506 453 4583, E-mail jaya@unb.ca (88)

JIRICKA, Dr. K., Astronomical Institute, Academy of Sciences of the Czech Republic, Fricova 1, ONDREJOV 251 65, CZECH REPUBLIC, Tel. +420 323 620 154, Fax +420 323 620 110, E-mail jiricka@asu.cas.cz (89)

JOHANSSON, Dr. J, SP, P.O. Box 857, SE-501 15 Boras, SWEDEN, Tel. +46 10 516 55 04, Fax +46 33 12 50 38, E-mail jan .johansson@sp.se (85)

JOHANSSON, Dr. J.F., RUAG Space AB, SE-405 15 GÖTEBORG, SWEDEN, Tel. +46 31 735 4286, Fax +46 31 735 4000, E-mail joakim.johansson@ruag.com (87)

JOHN, Dr. W., Institut für Theoretische Elektrotechnik, Leibniz Universität Hannover, Appelstrasse 9A, 30167 HANNOVER, GERMANY, Tel. +49-511-762-3202, Fax +49-511-762-3204, E-mail john@tet.uni-hannover.de (86)

JONAS, Prof J., Department of Physics and Electronics, Rhodes University, PO Box 94, 6140 GRAHAMSTOWN, SOUTH AFRICA, Tel. +27 46 603 8452, Fax +27 46 622 5049, E-mail j.jonas@ru.ac.za (89)

JULL, Prof. E.V., Department of Electrical Engineering, University of British Columbia, 2356 Main Mall, VANCOUVER, BC V6T 1W5, CANADA, Tel. +1 604-822 3282/2872, Fax +1 604-822 5949, E-mail jull@ece.ubc.ca (84)

KAERTNER, Prof. F.X., Massachusetts Institute of Technology, Room 36-351, 77 Massachusetts Avenue, CAMBRIDGE, MA 02139-4307, USA, Tel. +1 617 452 3616, Fax +1 617 253 9611, E-mail kaertner@mit.edu (84)

KAISER, Prof. F., Technische Hochschule Darmstadt, Inst. für Angewandte Phys., Nichtlineaire Dyn., Hochschulstrasse 41A, D-64289 DARMSTADT, GERMANY, Tel. +49 6151 16 5279, Fax +49 6151 16 3279, E-mail friedemann.kaiser@physik.tu-darmstadt.de (89)

KALINOWSKI, Prof. H.J., Depog - Departamento de Pos Graduaçao e Pesquisa, Universidade Tecnologica Federal do Parana, Av. Sete de Setembro 3165, Rebouças, 80230-901 CURITIBA, PR, BRAZIL, Tel. +55 41 33104689, Fax +55 41 33104683, E-mail hjkalin@gmail.com (86)

KALOUPTSIDIS, Prof. N., Division of Communications and Signal Processing, Dept. of Informatics, University of Athens, TYPA Buildings, Panepistimiopolis, GR-15771 ILISSIA, ATHENS, GREECE, Tel. +30 210 727 5304, Fax +30 210 727 5601, E-mail kalou@di.uoa.gr (86)

KANELLOPOULOS, Prof. J., Division of Information Transmission Systems and Material Technology, School of Electr. & Computer Eng., National Technical University of Athens, Iroon Polytechniou 9, GR-15773 ATHENS, GREECE, Tel. +30 210 772 3524, Fax +30 210 772 2281, E-mail ikanell@cc.ece.ntua.gr (88)

KARLSSON, Prof. A., Electrical and Information Technology, Lund University, P.O Box 118, SE -221 00 LUND, SWEDEN, Tel. +46 222 40 89, E-mail Anders.Karlsson@eit.lth.se (85)

KARPOWICZ, Dr. J., Acoustic and Electromagnetic Hazards, Central Institute for Labour Protection, ul. Czerniakowska 16, 00-701 WARSAW, POLAND, Tel. +48 22-623 4601, Fax +48 22-623 3693, E-mail jokar@ciop.pl (89)

KASTNER, Prof. R., Dept. Electrical Eng.-Physical Electronics, Tel Aviv University , 243 Wolfson Electrical Eng Bldg, 62978 TEL AVIV, ISRAEL, Tel. +972 3-640 7447, Fax +972 3-642 3508, E-mail kast@eng.tau.ac.il (85, 91)

KAUFMANN, Prof. P., CRAAM/CRAAE (Mackenzie, Inpe,USP,Unicamp), Universidade Presbiteriano Mackenzie, Rua da Consolacao 896, 1321907 Sao Paulo, BRAZIL, Tel. +55 11 236 8331, Fax +55 11 214 2300, E-mail kaufmann@craam.mackenzie.br, pierrekau@gmail.com (89)

KAWASAKI, Dr. Z., Dept. of Communications Engineering, Osaka University, Graduate School of Engineering, Yamada-Oka 2-1, Suita, OSAKA 565-087, JAPAN, Tel. +81 6 879-7690, Fax +81 6 879-7774, E-mail Zen@comm.eng.osaka-u.ac.jp (90)

KENDERESSY, Prof. M., Ribary u. 7, H-1022 BUDAPEST, HUNGARY, Tel. +36 1-461-3348 (85)

KILIC, Prof. O., Electrical Engineering and Computer Science Department, The Catholic University of America, 620 Michigan Avenue NE, Washington, DC 20064, USA, Tel. +1 202 319 5261, Fax +1 202 319 5195, E-mail kilic@cua.edu (85)

KILIFARSKA, Dr. N., National Institute of Geophysics, Geodesy and Geography (NIGGG), Bulgarian Academy of Sciences, Acad. G. Bonchev St., bl. 3, 1113 SOFIA, BULGARIA, Tel. +359 2 979 3329, E-mail nkilifarska@geophys.bas.bg (88)

KLAR, Prof. H., Technische Universitaet Berlin, Institut fuer Mikroeletronik, Sekr. EN4, Einsteinufer 17, D-10587 BERLIN, GERMANY, Tel. +49 30 314-25435, Fax +49 30 314 24597, E-mail klar@mikro.ee.tu-berlin.de (86)

KLINKENBUSCH, Prof L., Computational Electromagnetics Group, University of Kiel, Kaiserstr. 2, D-24143 Kiel, GERMANY, Tel. +49 431 880 62 52, Fax +49 431 880 62 53, E-mail lbk@tf.uni-kiel.de (85)

KLOS, Dr. Z., Space Research Center, Polish Academy of Sciences, ul. Bartycka 18A, 00-716 WARSAW, POLAND, Tel. +48 22-8511810, +48 39-121273, Fax +48 22-8511810, E-mail klos@cbk.waw.pl (92)

KNEPPO, Prof. I., University of Trencin, Studentska 2, TRENCIN 911 50, SLOVAKIA, Tel. +421 32 7400 100, Fax +421 32 7400 102, E-mail kneppo@tnuni.sk (84)

KNUDE, Dr. J., Astronomical Observatory, University of Copenhagen, Juliane Maries Vej 30, DK 2100 COPENHAGEN DENMARK, Tel. +45 3532 5986, Fax +45 3532 5989, E-mail indus@astro.ku.dk (89)

KOBAYASHI, Prof. H., National Astronomical Observatory of Japan, 2-21-1 Osawa, Mitaka, TOKYO 181-8588, JAPAN, Tel. +81 422 34 3914, Fax +81 422 34 3814, E-mail hideyuki.kobayashi@nao.ac.jp (89)

KOBAYASHI, Prof. K., Department of Electrical, and Communication Engineering, Chuo University, 1-13-27 Kasuga, Bunkyo-ku, TOKYO, 112-8551, JAPAN, Tel. +81 3 3817 1846/69, Fax +81 3 3817 1847, E-mail kazuya@tamacc.chuo-u.ac.jp (91)

KOGA, Prof. R., Division of Industrial Innovation Sciences, Graduate School of Natural Science and Technologies, Okayama University, 1-1, Tsushima-Naka-3, OKAYAMA 700-8530, JAPAN, Tel. +81 86 251 8135, Fax +81 86 251 8255, E-mail koga@cne.okayama-u.ac.jp (87)

KONOVALENKO, Prof. A.A., Institute of Radioastronomy, NASU, ul. Krasnoznamennaya 4, KHARKOV 61002, UKRAINE, Tel. +380 572-47-1134, Fax +380 572-47-6506, E-mail rian@rian.kharkov.ua (89)

KORDI, Dr. B., Department of Electrical & Computer Engineering, E1-556, University of Manitoba, 75A Chancellors Circle, Winnipeg, MB R3T5V6, CANADA, Tel. +1 204 474 7851, Fax +1 204 261 4639, E-mail bkordi@ee.umanitoba.ca (87)

KORENSTEIN, Prof. R., School of Medical Science, Dept. of Physiology, Tel-Aviv University, Ramat-Aviv, 69978 TEL AVIV, ISRAEL, Tel. +972 3640 6042, Fax +972 3640 9113, E-mail korens@post.tau.ac.il (89)

KOSILO, Dr. T., Warsaw University of Technology, Institute of Radioelectronics, ul. Nowowiejska 15/19, 00-665 WARSAW, POLAND, Tel. +48 22-660 7576, Fax +48 22-825 5248, E-mail t.kosilo@ire.pw.edu.pl (91)

KOUDELKA, Prof. O., Institute of Communication Networks and Satellite Communications, Graz University of Technology, Inffeldgasse 12, 8010 Graz, AUSTRIA, Tel. +43 316 873 7440, Fax +43 316 873 7941, E-mail koudelka@tugraz.at (86)

KOUL, Dr. S.K., Centre for Applied Research in Electronics, Indian Institute of Technology, Hauz Khas, NEW DELHI, 110 016, INDIA, Tel. +91 11 26591101/26591104 (O), Fax +91 11 26596219/26863165, E-mail shiban_koul@hotmail.com (85)

KOYAMA, Mr. Y., Space-Time Standards Group, New Generation Network Research Center, National Institute of Information and Communication Technology (NICT), 4-2-1, Nukuikitamachi, Koganei, TOKYO 184-8795, JAPAN, Tel. +81 42 327 7557, Fax +81 42 327 6834, E-mail koyama@nict.go.jp (85, 92)

KRAJCUSKOVA, Dr. Z., Fac. of Electrical Eng.&Information Technology, Slovak University of Technology, Ilkovicova 3, BRATISLAVA 812 19, SLOVAKIA, Tel. +421-2-6029 1137, Fax +421-2-6542 9683, E-mail zuzana.krajcuskova@stuba.sk (91)

KRIEZIS, Prof. E., Dept. of Electrical and Computer Engineering, Aristotle University of Thessaloniki, GR- 54124 THESSALONIKI, GREECE, Tel. +30 2310 995920, Fax +30 2310 996312, E-mail mkriezis@auth.gr (86)

KRISTENSSON, Prof. G., Electrical and Information Technology, Lund University, P.O. Box 118, 221 00 LUND, SWEDEN, Tel. +46 46 222 45 62, E-mail gerhard.kristensson@eit.lth.se (91)

KÜCÜK, Dr. I., Department of Astronomy and Space Sciences, Faculty of Science, Erciyes University, Kayseri, TURKEY, Tel. +90 352 437 4901, Fax +90 352 437 4933, E-mail kucuk@erciyes.edu.tr, ikucuk99@gmail.com (89)

KUDELA, Prof. K., Institute of Experimental Physics, Slovak Academy of Science, Watsonova 47, KOSICE 043 53, SLOVAKIA, Tel. +421 55-622 4554, Fax +421 55-633 6292, E-mail kkudela@kosice.upjs.sk (88)

KULEMIN, Prof. G.P., Institute of Radiophysics and Electronics, NASU, 12, ac. Proskura Str., KHARKOV 61085, UKRAINE, Tel. +380 572-448508, E-mail secretar@ire.kharkov.ua (87)

KUROCHKIN, Dr. A.P., , NPO VEGA, Kutuzovsky Prospekt 34, MOSCOW 121170, RUSSIA, Tel. +7 499 249 4308, Fax +7 499 258 2504, E-mail kurochkin@vega.ru (85)

KUSTER, Prof. N., IT'IS Foundation, Zeughausstraße 43, CH-8004 ZURICH, SWITZERLAND, Tel. +41 44 245 96 96, Fax +41 44 245 96 99, E-mail nk@itis.ethz.ch (89)

KUZMAK, Dr. O.M., Institute of Magnetism, NASU, 36-b, Vernadsky Blvd., KIEV 03142, UKRAINE, Tel. +380 44-4249095, Fax +380 44 4241020, E-mail kuzmak@imag.kiev.ua (91)

KUZNETSOV, Prof. Yu. V., Theoretical Radio Engineering Department, State University of Technology, Volorjkfvcrjt shosse 4, MOSCOW 125993, RUSSIA, Tel. +7 499 158 68 39, Fax +7 499 158 68 39, E-mail kuznetsov@mai-trt.ru (86)

KYRIACOU, Prof. G.A., Lab. of Microwaves, Dept. of Electrical and Computer Engineering, Demokritos University of Thrace, Vas. Sofias 12 , 67 100 XANTHI, GREECE, Tel. +30 5410 795 93, Fax +30 5410 272 64, E-mail gkyriac@ee.duth.gr (85)

LACQUET, Prof. B.M., School of Electrical and Information Engineering, University of Witwatersrand, Private Bag 3, 3050 WITS, SOUTH AFRICA, Tel. +27 11 717 7205, Fax +27 11 403 1929, E-mail b.lacquet@ee.wits.ac.za (86)

LAGASSE, Prof. P., URSI c/o INTEC, Ghent University, Sint-Pietersnieuwstraat 41, B-9000 GENT, BELGIUM, Tel. +32 9-264 33 20, Fax +32 9-264 42 88, E-mail lagasse@intec.ugent.be (84, 92)

LANG, Dr R.H., Dept of Electrical Eng. & Computer Science, George Washington University, Phillips Hall, Washington, DC 20052, USA, Tel. +1 202-994-6199, Fax +1 202-994-0227, E-mail lang@gwu.edu (87, 92)

LANGENBERG, Prof. K.J., Electromagnetic Theory, FB 16, University of Kassel, Wilhelmshöher Allee 71, D-34121 KASSEL, GERMANY, Tel. +49 561-804 6368, Fax +49 561-804 6489, E-mail langenberg@uni-kassel.de (84)

LARKINA, Prof. V.I., IZMIRAN, Moscow Region, TROITSK, MOSCOW REGION 142092, RUSSIA, Tel. +7 496 751 9742, Fax +7 496 751 0124, E-mail larkina@izmiran.ru (87)

LARSEN, Dr. K.J., DTU Fotonik, Denmarks Technical University, Building 343, room 022, DK 2800 Lyngby,DENMARK, Tel. +45 4525 3629, Fax +45 4593 6581, E-mail knjl@fotonik.dtu.dk (86)

LAZAROV, Prof. A., Bourgas Free University (BFU), , 62 San Stefano Str., BG-8000 BOURGAS, BULGARIA, Tel. +359 56 900 485, E-mail lazarov@bfu.bg (85)

LEE, Prof. H.J., School of Engineering, Information and Communications University, P.O. Box 77, Yusong, DAEJEON 305-600, SOUTH KOREA, Tel. +82 42-866-6143, Fax +82 42-866 -6227, E-mail hjlee@icu.ac.kr (85)

LEE, Prof. L-C, President Office, National Central University, No. 300, Jhongda Road, Jhongli City, Taoyuan, CHUNG-Li, TAOYAN 320, CHINA (SRS), Tel. +886 3 422 7151ext. 57000, Fax +886 3 425 4842, E-mail loulee@cc.ncu.edu.tw (88, 91)

LEE, Prof. H.Y., EE Department, Ajou University, Wonchon-dong, Yongtong-gu, SUWON 443-749, SOUTH KOREA, Tel. +82 31 219 2367, Fax +82 31 212 9531, E-mail hylee@ajou.ac.kr (91)

LEE, Prof. J-S, Research Center for Integrative Neuroimaging and Neuroinformatics, National Yang-Ming University, No. 155, Sec. 2, Linong Street, Beitou District, TAPEI 112, TAIWAN, Tel. +886 2 28267134, Fax +886 2 28224860, E-mail jslee@ym.edu.tw (89)

LEFEUVRE, Prof. F., LPCE/CNRS, , 3A, av. de la Recherche Scientifique, F-45071 ORLEANS CEDEX 2, FRANCE, Tel. +33 2-38-255284, Fax +33 2-38-631234, E-mail lefeuvre@cnrs-orleans.fr (84, 92)

LEITGEB, Prof. N., Institute of Health Care Engineering with European Notified Body of Medical Devices, Graz University of Technology, Kopernikusgasse 24/1, 8010 Graz, AUSTRIA, Tel. +43 316 873 7397, Fax +43 316 873 4412, E-mail norbert.leitgeb@tugraz.at (89)

LEITINGER, Prof. R., Institute for Geophysics, Astrophysics and Meteorology, University of Graz, Universitaetsplatz 5, A-8010 GRAZ,AUSTRIA, Tel. +43 316 380 5257, Fax +43 316 380 9825, E-mail reinhart.leitinger@kfunigraz.ac.at (90)

LICHTENBERGER, Dr. J., Pazmany Peter Setany 1/a, H-1111 BUDAPEST, HUNGARY, Tel. +36 1 209 0555 x6654, Fax +36 1 372 2927, E-mail lityi@sas.elte.hu (90)

LIEVENS, Mrs. I., URSI, c/o INTEC, Sint-Pietersnieuwstraat 41, B-9000 GENT,BELGIUM, Tel. +32 9-264.33.20, Fax +32 9-264.42.88, E-mail ingeliev@intec.ugent.be (84)

LIGTHART, Prof. dr. ir. L.P., Director IRCTR, Delft University, Microwaves Laboratory, Mekelweg 4, NL-2628 CD DELFT, NETHERLANDS, Tel. +31 15-278 1034, Fax +31 15-278 4046, E-mail l.p.ligthart@irctr.tudelft.nl (87)

LILJE, Prof. P., Institute of Theoretical Astrophysics, University of Oslo, P.O. Box 1029 Blindern, N-0315 OSLO, NORWAY, Tel. +47 22 856517, E-mail per.lilje@astro.uio.no (89)

LIN, Dr. K-H, Dept. of Electrical Engineering, National Sun Yat-Sen University, 70 Lien Hai Road, KAOHSIUNG 80424, CHINA SRS, Tel. +886 7 5252000 ext 4165, E-mail khlin@mail.nsysu.edu.tw (87)

LIN, Mr. R-H, , Chinese Institute of Electronics, P.O. Box 165, Beijing 100036, CHINA CIE, Tel. +86 10 6827 6577, E-mail lin_runhua@ciecloud.org.cn (91)

LIND, Dr. F.D., MIT Haystack Observatory, Route 40, WESTFORD, MA 01886, USA, Tel. +1 781 - 981 - 5570, Fax +1 781 - 981 - 5766, E-mail flind@haystack.mit.edu (88)

LINDQVIST, Dr. M., Onsala Space Observatory, Chalmers University of Technology, SE-439 92 ONSALA, SWEDEN, Tel. +46 31 772 55 08, Fax +46 31 772 55 90, E-mail Michael.Lindqvist@chalmers.se (89)

LIPSANEN, Prof. H., Dept. of Micro and Nanosciences, Aalto University, P.O. Box 13500, FI-00067 AALTO, FINLAND, Tel. +358 9 470 23123, Fax +358 9 470 23128, E-mail Harri. Lipsanen@tkk.fi (86)

LITOVCHENKO, Prof. V.G., Institute of Physics of Semiconductors, NASU, prosp. Nauki 45, KIEV 03039, UKRAINE, Tel. +380 44-265-6290, Fax +380 44-265-8342, E-mail mickle@semicond.kiev.ua (86)

LITSYN, Dr. S., Dept. Electrical Eng./Faculty of Engineering, Tel Aviv University, Ramat-Aviv, 69978 TEL AVIV, ISRAEL, Tel. +972 3-631 4139, Fax +972 3-642 3508, E-mail litsyn@ eng.tau.ac.il (86)

LIU, Prof. C.H., National Central University, No. 300, Jung-da Rd., CHUNG-LI 320, CHINA (SRS), Tel. +886 3-4227151 ext. 7000,7001, Fax +886 3-425-4842, E-mail chliu@cc.ncu. edu.tw (90)

LIU, Dr. M., 514th Institute , China Academy of Space Technology, Zhichun Road, Haidan District, BEIJING 100086, CHINA (CIE), Tel. +86 10 687 44 667, Fax +86 10 683 78 158, E-mail run_low@sina.com (85)

LUISE, Prof. M., Department of Information Engineering, University of Pisa, Via Diotisalvi 2, I-56122 PISA, ITALY, Tel. +390 50-569662, Fax +390 50-568522, E-mail marco. luise@iet.unipi.it (86)

MAITRA, Prof A.J.S., Institute of Radio Physics, University of Calcutta, 92 Acharya Prafulla Chandra Road, Kolkata, WB, 700009, India, Tel. +91 33 23509115, E-mail animesh. maitra@gmail.com (87)

MANARA, Prof G., Dipartimento di Ingegneria dell'Informazione, Universita di Pisa, Via G. Caruso 16, 56122 Pisa, Italy, E-mail g.manara@iet.unipi.it (85)

MANN, Dr. G., Solare Radioastronomie, Astrophysikalisches Institut Potsdam, An der Sternwarte 16, D-14482 POTSDAM, GERMANY, Tel. +49 331 749 9292, Fax +49 331 749 9352, E-mail gmann@aip.de (88)

MANNINEN, Dr. A., Centre for Metrology and Accreditation, PO Box 9, Tekniikantie 1, FI-02151 ESPOO, FINLAND, Tel. +358 10 6054 416, Fax +358 10 6054 498, E-mail antti. Manninen@mikes.fi (85)

MANSO, Prof. M.E., Centro de Fusão Nuclear do IST, Avenida Rovisco Pais, 1049 LISBOA CODEX, PORTUGAL, Tel. +351 21 841 76 96, E-mail emilia@cfn.ist.utl.pt (88)

MARGINEDA PUIGPELAT, Prof. J., Facultad de Quimica - Dpto. Fisica, Universidad de Murcia, Apdo. 4021, 30071 ESPINARDO, MURCIA, SPAIN, Tel. +34 968 367374, Fax +34 968 364148, E-mail jmargi@um.es (87)

MARKSTROM, Mr. K.-A., AF Technology AB, SE-169 99 STOCKHOLM, SWEDEN, Tel. +46 10 505 40 62, Fax +46 10 505 00 10, E-mail karl-arne.markstrom@afconsult.com (86)

MARROCCO, Dr. G., Dipartimento di Informatica Sistemi e Produzione, University of Roma Tor Vergata, Via del Politecnico, 1, 00133 Roma, ITALY, E-mail marrocco@disp. uniroma2.it (90)

MARTIN RODRIGUEZ, Prof. E., Facultad de Quimica - Dpto. Fisica, Universidad de Murcia Apdo. 4021, 30071 ESPINARDO, MURCIA, SPAIN, Tel. +34 968 367373, Fax +34 968 364148, E-mail ernesto@um.es (85)

MARTINEZ BURDALO, Dra. M., Dpt. Radiacion Electromagnetica, Instituto de Fisica Aplicada, Serrano 144, 28006 MADRID, SPAIN, Tel. +34 91 562 5083, Fax +34 91 562 5083, E-mail mercedes@iec.csic.es (85)

MASHAO, Dr. D.D., SITA: CTO, 7701 Rondebosch, SOUTH AFRICA, Tel. +27 (012) 482 2484, Fax +27 (012) 367 4917, E-mail daniel.mashao@sita.co.za (86)

MATHEWS, Prof J.D., Communications and Space Sciences Lab (CSSL), The Pennsylvania State University, 323A, EE East, University Park, PA 16802-2707, USA, Tel. +1(814) 777-5875, Fax +1 814 863 8457, E-mail JDMathews@psu.edu (88)

MATHIS, Dr. W., Fachgebiet Theoretische Elektrotechnik, Universität Hannover, Appelstrasse 9A, D-30167 HANNOVER, GERMANY, Tel. +49 511 762 3201, Fax +49 511 762 3204, E-mail mathis@tet.uni-hannover.de (91)

MATSUMOTO, Prof. H., President , Kyoto University, Yoshida-Honmachi, Sakyo-ku, KYOTO 606-8501, JAPAN, Tel. +81 75 753 2001, Fax +81 75 753 2091, E-mail matsumoto@ hq.kyoto-u.ac.jp (90)

MAY, Prof. J., Depto. de Astronomia, Universidad de Chile, Casilla 36-D, SANTIAGO DE CHILE, CHILE, Tel. +56 2-229 4002, Fax +56 2-229 4101, E-mail jmay@das.uchile.cl (91)

MAYORGA MONTOYA, ing. M., Departamento de Ingenierìa, Universidad Católica del Perú, Sección Ingeniería de las Telecomunicaciones, Av.Universitaria 1801, San Miguel, LIMA32, PERU, Tel. +51-1-626-2452, Fax +51-1-626-2116, E-mail mayorga.ma@pucp.edu.pe (84)

MAZANEK, Prof. M., Faculty of Electrical Engineering, Czech Technical University, Technická 2, PRAGUE 6 166 27, CZECH REPUBLIC, Tel. +420 224 352 282, Fax +420 233 339 958, E-mail mazanekm@feld.cvut.cz (91)

MAZELLE, Mr. C., CESR, 9, avenue du Colonel Roche, F-31400 TOULOUSE CEDEX,FRANCE, Tel. +33 5 61 55 66 50, E-mail christian.mazelle@cesr.fr (88)

MAZZA, Ing. H.F., INTI, CC. 157, , 1650 SAN MARTIN - B.A.,ARGENTINA, Tel. +54 1-753 4064, Fax +54 1-755 2102 (85)

McCARTHY, Dr. K., Dept. of Electrical and Electronic Engineering, University College Cork, CORK, IRELAND, Tel. +353 21 490 2214, Fax +353 1 283 0921/830 921, E-mail K.McCarthy@ucc.ie (87)

McCREADY, Ms. M., The Center for Geospace Studies, SRI International, 333 Ravenswood Avenue, Menlo Park, CA 94025, USA, Tel. +1 650 859 5084, Fax +1 650 322 2318, E-mail mary.mccready@sri.com (90)

McKINNELL, Dr. L.A., South African National Space Agency (SANSA), Space Science, P.O. Box 32, 7200 HERMANUS, SOUTH AFRICA, Tel. +27 28 312 1196, Fax +27 28 312 2039, E-mail lmckinnell@sansa.org.za (90, 91, 92)

MENDES, Eng. M.L., ICP-ANACOM, Av. José Malhoa 12, 1099-017 LISBOA, PORTUGAL, Tel. +351 21 721 2222, Fax +351 21 721 1006, E-mail ursi.por@anacom.pt (91)

MIAS, Dr. C., School of Engineering, University of Warwick, COVENTRY CV4 7AL, UNITED KINGDOM, Tel. +44 2476 522343, Fax +44 2476 418922, E-mail christos.mias@ warwick.ac.uk (85)

MITCHELL, Dr. C.N., Electronic and Electrical Engineering, University of Bath, Clavertown Down, BATH, BA2 7AY, UNITED KINGDOM, Tel. +44 1225 82 66 10, Fax +44 1225 82 63 05, E-mail c.n.mitchell@bath.ac.uk (90)

MOLINA FERNANDEZ, Dr. I., Departamento de Ingenieria de Communicaciones, E.T.S.I. Telecomunicacion, Universidad de Malaga, Campus Universitario de Taetinos s/n, E-29071 MALAGA, SPAIN, Tel. +34 952 13 13 11, Fax +34 952 13 20 27, E-mail imolina@uma.es (86)

MOND, Prof. M., Dept of Electrical and Computer Eng., Ben Gurion University, P.O. Box 653, 84105 BEER SHEVA, ISRAEL, Fax +972 7 6472990, E-mail mond@menix.bgu. ac.il (88)

MRAVLAG, Dr. E., School of Physics, University of KwaZula-Natal, King George V Avenue, 4041 DURBAN, SOUTH AFRICA, Tel. +27 31-260 1280, Fax +27 31-261 6550, E-mail mravlag@ukzn.ac.za (88)

MROZIEWICZ, Prof. B., Institute of Electron Technology, Al. Lotnikow 32/46, 02-668 WARSZAWA, POLAND, Tel. +48

22-843 78 10, Fax +48 22-847 06 31, E-mail bomro@ite.waw.pl (85, 86)

MROZOWSKI, Prof. M., Faculty of Electronics, Telecommunications and Informatics, Gdansk University of Technology, ul. Gabriela Narutowicza 11/12, 80-952 Gdansk-Wrzeszcz, POLAND, Tel. +48 58 347 25 49, E-mail mim@pg.gda.pl (85)

MURPHY, Prof. P., Dept. of Electrical Eng. & Microelectronics, National University of Ireland, CORK, IRELAND, Tel. +353 21 490 2214, Fax +353 21 427 1698, E-mail P.Murphy@ucc.ie (85)

MURPHY, Prof. A., Dept. of Experimental Physics, National University of Ireland Maynooth, , CO. KILDARE, IRELAND, Tel. +351 1 6285 222 ext. 209, Fax +351 1 708 3771, E-mail anthony.murphy@nuim.ie (89)

MURSULA, Prof. K., Department of Physical Sciences, University of Oulu, P.O. Box 3000, FI-90014 OULU, FINLAND, Tel. +358-8-5531366, Fax +358-8-5531287, E-mail Kalevi.Mursula@oulu.fi (88)

NAGATSUMA, Prof. T., Division of Advanced Electronics and Optical Science, Graduate School of Engineering Science, Osaka University, 1-3 Machikaneyama, Toyonaka, Osaka 560-8531, JAPAN, Tel. +81 6 6850 6335, Fax +81 6 6850 6335, E-mail nagatuma@ee.es.osaka-u.ac.jp (86)

NAGY, Dr. L., Department of Broadband Infocommunication Systems, BME - Budapest University of Technology and Economics, Goldmann Gyorgy ter 3 , 1111 BUDAPEST, HUNGARY, Tel. +36 1 463 15 59, Fax +36 1 463 32 89, E-mail nagy@mht.bme.hu (86, 91)

NEMIROVSKY, Prof. Y., Dept. of Electrical Engineering, Technion - Israel Institute of Technology, 32000 HAIFA, ISRAEL, Tel. +972 4-829 3450, Fax +972 4-832 3041, E-mail nemirov@ee.technion.ac.il (86)

NENCHEV, Prof. M., Technical University of Sofia, , 8, Kliment Ohridi Str., 1756 SOFIA, BULGARIA, Tel. +359 32 659 711, E-mail marnenchev@yahoo.com (86, 91)

NEVES, Prof. Dr. J.C. da Silva, Instituto de Telecomunicaçoes, Universidade de Aveiro, Campus Universitario, 3810-193 AVEIRO, PORTUGAL, Tel. +351 23 437 7900, Fax +351 23 437 7901, E-mail jneves@av.it.pt (87)

NGWENYA, Ms. L., Programme Officer, SA International Council for Science, Meiring Naude Road Brummeria, P.O. Box 2600, PRETORIA 0001,SOUTH AFRICA, E-mail lynn.ngwenya@nrf.ac.za (91)

NICKOLAENKO, Prof. A., Remote Sensing, Inst. for Radio-Physics and Electronics Nat. Acad. of Sciences of the Ukraine, 12 Acad. Proskura street, KHARKOV 61085, UKRAINE, Tel. +380 572 437 220, Fax +380 572 441 105, E-mail sasha@ire.kharkov.ua (90)

NICKOLOV, Prof. E., National Institute of Geophysics, Geodesy and Geography, Bulgarian Academy of Sciences, Acad. G. Bonchev St., bl. 3, 1113 SOFIA, BULGARIA, Tel. +359 2 987 4624, E-mail eugene.nickolov@cu.bas.bg (87)

NOEL, Prof. Fernando, Depto de Astronomia, Universidad de Chile, Casilla 36-D, SANTIAGO, CHILE, Tel. +56 2-229 4002, Fax +56 2-229 4101, E-mail fnoel@das.uchile.cl (85)

NOVAK, Dr. J., Institute of Electrical Engineering, Slovak Academy of Sciences, Dubravska cesta 9, BRATISLAVA 84104, SLOVAKIA, Tel. +421 2-59222761, Fax +421 2-54775816, E-mail jozef.novak@savba.sk (86)

O'DROMA, Dr. M., Director Telecommunications Research Centre, Dept. of Electrical & Computer Eng., Electrical and Computer Eng Dept, University of Limerick, LIMERICK, IRELAND, Tel. +353-61-202364, Fax +353-61-338176, E-mail mairtin.odroma@ul.ie (86, 91)

O'SULLIVAN, Dr J.D., Australian Telescope National Facility, CSIRO Astronomy and Space Science, PO Box 76, Epping, NSW 1710, AUSTRALIA, Tel. +612 9372 4604, E-mail john.osullivan@csiro.au (87)

OHIRA, Prof. T., Toyohashi University of Technology (TUT), Tempaku, Toyohashi City 441-8580, JAPAN, Tel. +81-532-44-6761, Fax +81-532-44-6757, E-mail ohira@tut.jp (84)

OHISHI, Dr. M., National Astronomical Observatory of Japan, 2-21-1, Osawa, Mitaka, Tokyo, 181-8588, Japan, Tel. +81 422 34 3575, Fax +81422 34 3840, E-mail iucafchair@iucaf.org (92)

OKADA, Prof T., Department of Information Systems Engineering, Toyama Prefectural University, Kurokawa 5180, Imizu-shi, Toyama 939-0398, Japan, Tel. +81 766 56 7500, Fax +81 766 56 8137, E-mail okada@pu-toyama.ac.jp (88)

OKONIEWSKI, Prof. M., Electrical and Computer Engineering, ICT 354, University of Calgary, 2500 University Drive NW, CALGARY, ALBERTA, T2N 1N4, CANADA, Tel. +1 403 220 6175, E-mail okoniews@ucalgary.ca (89)

OMURA, Prof. Y., Laboratory of Computer Space Science, Kyoto University - RISH, Gokasho, Uji , KYOTO 611-0011, JAPAN, Tel. +81 774 38-3811, Fax +81 744 31-8463, E-mail omura@rish.kyoto-u.ac.jp (84, 90)

ONUU, Prof. M., Electronics & Computer Technology Unit, Department of Physics, University of Calabar, GPO 2772, Calabar, Cross River State, NIGERIA, Tel. 234 803 507 2076, E-mail michaelonuu@yahoo.com (86)

OPPENHEIM, Dr. M., Center for Space Physics, Astronomy Dept., Boston University, Commonwealth Ave. 725, BOSTON, MA 02215, USA, Tel. +1 617 353 61 39, Fax +1 617 353 57 04, E-mail meerso@bu.edu (88, 92)

ØSTERBERG, Prof. U., Department of Electronics and Telecommunications, NTNU, O.S. Bragstads plass 2, N-7491 Trondheim, NORWAY (85)

PADULA-PINTOS, Prof. V.H., Director Dept. Coord. R&D, Instituto Tecnologico de Buenos Aires, Pena 2446, 7"A", 1125 BUENOS AIRES, ARGENTINA, Tel. +54 1-314 7779 ext. 263, Fax +54 1-314 0270, E-mail vpadula@itba.edu.ar (89)

PALADIAN, Prof. F., Université Blaise Pascal, LASMEA, 24, avenue des Landais, F-63177 Aubière Cedex, FRANCE, Tel. +33 4 73 40 72 09, E-mail paladian@lasmea.univ-bpclermont.fr (87)

PALICOT, Dr. J., Supélec, Avenue de la Boulaie, CS 47601, F-35576 Cesson-Sévigné, FRANCE, Tel. +33 2 99 84 45 41, E-mail jacques.palicot@supelec.fr (86)

PALOSCIA, Dr. S., CNR-IFAC, Via Madonna del Piano, 10, I - 50019 Sesto Fiorentino, FIRENZE, ITALY, E-mail S.Paloscia@ifac.cnr.it (87)

PAMPALONI, Dr. PAOLO, Institute of Applied Physics , IFAC-CNR, Via Madonna Del Piano 10, 50019 Sesto Fiorentino, FIRENZE, ITALY, Tel. +39 055 4235205, Fax +39 055 4235290 or +39 055 410893, E-mail P.Pampaloni@ifac.cnr.it (87)

PANAYIRCI, Dr. E., Dept. of Electr. & Electronics Eng., Kadir Has University, Faculty of Engineering, Cibali Merkez Kampusu, 34230-01 CIBALI, ISTANBUL, TURKEY, Tel. +90 212 533 6532, E-mail eepanay@khas.edu.tr, eepanay@Princeton.edu (86)

PAPAPOLYMEROU, Prof. J., School of Electrical and Computer Engineering, Georgia Institute of Technology, TSRB 417, 777 Atlantic Drive NW, Atlanta, GA 30332-0250, USA, Tel. +1 404 385 6004, Fax +1 404 894 4641, E-mail papapol@ece.gatech.edu (86)

PARFITT, Prof. A.J., Pro Vice Chancellor, Division of ITEE, University of South Australia, Mawson Centre, MAWSON LAKES, SA 5095, AUSTRALIA, Tel. +61 8 8302 3310, Fax +61 8 8302 3873, E-mail andrew.parfitt@unisa.edu.au (86, 91)

PARKER, Prof. T., Collaborative Nonlinear Electronics Research Facility, Macquarie University, North Ryde, NSW 2109, AUSTRALIA, Tel. +61 2 9850 9131, Fax +61 2 9850 9128, E-mail tonyp@ics.mq.edu.au (86)

PARMENTIER, Dr. , ONERA, DEMR (Electromagnetics & Radar Department), CDE group (Electromagnetic Compatibility & Detection), BP 4025, Avenue Edouard Belin, 31055 TOULOUSE Cedex 4, FRANCE, Tel. +33 5 62 25 27 89, Fax +33 5 62 25 25 77, E-mail hipar@onecert.fr, hipar@onera.fr (90)

PARROT, Dr. M., CNRS/LPCE, 3A, avenue de la Recherche Scientifique, F-45071 ORLEANS CEDEX 2, FRANCE, Tel. +33 2-3825 5291, Fax +33 2-3863 1234, E-mail mparrot@cnrs-orleans.fr (90)

PAWLOWSKI, Dr. W., Instytut Telekomunikacji, Politechnika Gdanska, ul. Narutowicza 11/12, 80-952 GDANSK - WRZESZCZ, POLAND, Tel. +48 58-347 1588, Fax +48 58-347 1971, E-mail radiokom@eti.pg.gda.pl (87)

PAZ RETUERTO, Mr. P., Comisión Nacional de Investigación y Desarrollo Aeroespacial CONIDA, Av. Luis Felipe Villarán 1069, San Isidro - LIMA 27, PERU, Fax + 51 1 441 9081 (86)

PERRIN, Dr. A., CRSSA, 24, avenue des Maquis du Grésivaudan, F-38702 LA TRONCHE CEDEX, FRANCE, Tel. +33 4 76 63 68 79, E-mail aperrin.crssa@gmail.com (89)

PETOSA, Mr. A., Communications Research Centre, , 3701 Carling Avenue P.O. Box 11490, Station H, OTTAWA, ON K2H 8S2, CANADA, Tel. +1 613 991-9352, Fax +1 613 990-8369, E-mail aldo.petosa@crc.ca (85)

PIEKARSKI, Prof. M., Institute of Telecommunication & Acoustics, Wroclaw University of Technology, ul. Wybrzeze Wyspianskiego 27, 50-370 WROCLAW, POLAND, Tel. +48 71-320 35 29, Fax +48 71-320 35 29, E-mail Marian.Piekarski@pwr.wroc.pl, mpiek@pwr.wroc.pl (86)

PIERRARD, Dr. V., Belgisch Instituut voor Ruimte-Aëronomie (BIRA), , Ringlaan 3, 1180 BRUSSEL, BELGIUM, Tel. +32 2 3730 418, Fax +32 2 374 84 23, E-mail viviane.pierrard@aeronomie.be (88)

PIETTE, Prof. M., KMS/CISS, Hobbemastraat 8, 1000 BRUSSEL, BELGIUM, Tel. +32 2 742 66 25, Fax +32 2 742 66 22, E-mail Marc.Piette@rma.ac.be (91)

PIJOAN VIDAL, Prof. J.L., Dpto. Comunicaciones y Teoria de la Senal, Universidad Ramon Llull, Escuela Tecnica Superior de Ingenieria e Informatica La Salle, 08022 BARCELONA, SPAIN, Tel. +34 93 290 24 00, Fax +34 93 290 24 70, E-mail joanp@salle.url.edu (88)

PIRJOLA, Dr. R.J., Finnish Meteorological Institute, P.O. Box 503 , FI-00101 HELSINKI, FINLAND, Tel. +358 919 29 46 52, +358-50-5996893, Fax +358-9-19294604, E-mail risto.pirjola@fmi.fi (92)

PITOUT, Mr. F., Institut de Recherche en Astrophysique et Planétologie, 9, rue de Colonel Roche, BP 44346, 31028 TOULOUSE Cedex 4, FRANCE, Tel. +33 5 61 55 66 81, E-mail pitout@cesr.fr (88)

POGORILY, Prof. A.N., Institute of Magnetism, NASU, 36-b, Vernadsky Blvd., KIEV 03142, UKRAINE, Tel. +380 44 4249095, Fax +380 44 4241020, E-mail apogorily@aol.com (91)

POULTER, Dr. E. M., National Institute of Water and Atmospheric Research Ltd, NIWA, P.O.Box 14-901, Kilbirnie, Wellington, NEW ZEALAND, Tel. +64-4-386-0560, Fax +64-4-386-2153, E-mail m.poulter@niwa.cri.nz (87)

PRATO, Dr. F., Nuclear Medicine Dept, Room B5-224, Lawson Health Research Institute, 268 Grosvenor Str., LONDON, ON N6A 4V2, CANADA, Tel. +1 519-646-6100x64140, Fax +1 519-646-6135, E-mail prato@lawsonimaging.ca (91)

PRAZERES, Eng. H. P., ICP-ANACOM, Av. José Malhoa 12, 1099-017 LISBOA, PORTUGAL, Tel. +351 21 721 2232, Fax +351 21 721 1006, E-mail ursi.por@anacom.pt, helena.prazeres@anacom.pt (91)

PRICE, Prof C.G., Geophysics and Planetary Sciences, Tel Aviv University, Levanon Road, 69978 Tel Aviv, Israel, Tel. +972-36406029, Fax +972-3-6409282, E-mail cprice@flash.tau.ac.il (90)

PRIOU, Dr. A., LEME, University Paris Ouest Ville d'Avray, 50 rue de Sèvres, 92794 Ville d'Avray, FRANCE, Tel. +33 1 40 97 41 00, E-mail alain.priou@u-paris10.fr (85)

PULINETS, Prof. S.A., IZMIRAN, Russian Academy of Sciences, Troitsk, Moscow Region 142190, RUSSIA, E-mail pulya1@hotmail.com (90)

QUIJANO, Prof. A., Calle 48 y 116, 1900 LA PLATA, B.A., ARGENTINA, Tel. (54) 21-243 709, Fax (54) 21-250 804, E-mail adrian.quijano@gmail.com (86)

RABIU, Dr. A.B., Department of Physics, Federal University of TEchnology, Akure, Ondo State, NIGERIA, Tel. 234 803 070 5787, E-mail tunderabiu@yahoo.com (85)

RACHIDI, Prof F., EPFL-STI-LRE, Swiss Federal Institute of Technology, Station 11, CH 1015 Lausanne, Switzerland, Tel. +41-21-693 26 20, Fax +41-21-693 46 62, E-mail Farhad.Rachidi@epfl.ch (87)

RADASKY, Dr. W.A., Metatech Corporation, 358 S. Fairview Ave., Suite E, Goleta, CA 93117, USA, Tel. +1-805-683-5681, Fax +1-805-683-3023, E-mail Wradasky@aol.com (90)

RADECKI, Dr. K., Warsaw University of Technology, Institute of Radioelectronics, ul. Nowowiejska 15/19, 00-665 WARSZAWA, POLAND, Tel. +48 22-825 39 29, Fax +48 22-825 52 48, E-mail radecki@ire.pw.edu.pl (84)

RADEV, Prof. D., Ruse University, Angel Kanchev, 8 Studentska str., 7017 RUSE,BULGARIA, Tel. +359 82 888 673, E-mail dradev@abv.bg (87)

RADICELLA, Prof. S.M., Julian Alvarez 1210, 1414 BUENOS AIRES, ARGENTINA, Tel. +54 1-772-1471, Fax +54 11 4776 0410, E-mail postmast@caerce.edu.ar (88)

RAHMAT-SAMII, Prof. Y., Electrical Engineering Department, University of California at Los Angeles, 6731K Boelter Hall, Los Angeles, CA 90095-1594, USA, Tel. +1-310 - 206 2275, Fax +1-310 - 206 4833, E-mail rahmat@ee.ucla.edu (91)

Prof V. RAKOV, Univ. of Florida, 553 Eng. Bldg. 33, Gainesville, FL 32611-6130, USA, E-mail : rakov@ece.ufl.edu (90)

RAMA RAO, Mr. P.V.S., Space Physics Laboratory, Department of Physics, Andhra University, VISAKHAPATNAM 530 003, INDIA, Tel. +91 891 539049, Fax +91 891-555 547 (90)

RASMUSSEN, Prof. J., RISOE, Optics & Fluid Dynamics Department, P.O. Box 49, DK 4000 ROSKILDE, DENMARK, Tel. +45 4677 4537, Fax +45 4677 4565, E-mail jens.juul.rasmussen@risoe.dk (88)

RAULIN, Prof. J-P, Escola de Engenharia, Centro de Radio-Astronomia e Astrofisica Mackenzie - CRAAM, Universidade Presbiteriana Mackenzie, Rua da Consolaçao 896, Consolaçao, 01302-907 Sao Paulo, SP, BRAZIL, Tel. +55 11 21148724, Fax +55 11 21142300, E-mail raulin@craam.mackenzie.br (87)

READER, Prof. H.C., Dept. of Electrical & Electronic Eng., University of Stellenbosch, Private Bag XI, 7602 MATIELAND, SOUTH AFRICA, Tel. +27 21-808-3623/4478, Fax +27 21-808-4981, E-mail hcreader@ing.sun.ac.za (87, 90)

REISING, Prof S.C., Electrical and Computer Engineering Department, Colorado State University, 1373 Campus Delivery, Fort Collins, CO 80523-1373,USA, Tel. +1 970 491 2228, Fax +1 970 491 2249, E-mail Steven.Reising@ColoState.edu (84, 91, 92)

RESTIVO, Prof. Dr. F.J.O., Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, PORTUGAL, Tel. +351 22 508 18 39/70, Fax +351 22 508 14 43, E-mail fjr@fe.up.pt (86)

ROBINSON, Dr. M.P., Department of Electronics, University of York, Heslington, YORK, YO10 5DD, UNITED KINGDOM, Tel. +44 1904 432 385, Fax +44 1904 433 224, E-mail mpr@ohm.york.ac.uk (89)

RODGER, Dr. C.J., Department of Physics, University of Otago, 730 Cumbreland St, Dunedin 9001, NEW ZEALAND, Tel. +64 3 479 4120, Fax +64 3-479 0964, E-mail crodger@physics.otago.ac.nz (88, 90)

RODRIGUES, Prof. Dr. A., Instituto Superior Técnico, Instituto de Telecomuniçoes, Avenida Rovisco Pais n°1, 1096 LISBOA CODEX, PORTUGAL, Tel. +351 2 8418484, E-mail antonio.rodrigues@lx.it.pt (86)

RODRIGUEZ-GONZALEZ, Prof. J., Dpto. Fisica Aplicada, Facultad de Fisica, Universidad de Santiago de Compostela, 15782 Santiago de Compostela, SPAIN, Tel. +34 8818 140 28, Fax +34 8818 140 72, E-mail ja.rodriguez@usc.es (91)

ROGIER, Prof. H., Information Technology, Ghent University, Sint-Pietersnieuwstraat 41, 9000 Ghent, Belgium, Tel. (329) 264-3343, Fax (329) 264-9969, E-mail hendrik.rogier@intec.ugent.be (85)

RÖNNEKLEIV, Prof. Arne, Department of Electronics and Telecommunications, NTNU, O.S. Bragstads plass 2, N-7491 TRONDHEIM, NORWAY, Tel. +47 73-594413, E-mail arne.ronnekleiv@iet.ntnu.no (86)

ROZTOCIL, Dr. J., Facukty of Electrical Engineering, Czech Technical University, Technická 2, PRAGUE 6 166 27, CZECH REPUBLIC, Tel. +420 224 352 869, Fax +420 233 339 929, E-mail roztocil@feld.cvut.cz (85)

RUBINSTEIN, Prof. M., Ecole d'ingénierie et de Gestion du Canton , de Vaud (HEIG-Vd), Route de Cheseaux 1, 1400 Yverdon-les-bains, SWITZERLAND, Tel. +41 24 557 6296, E-mail rubinstein.m@gmail.com (86)

RUCKER, Prof. H.O., Space Research Institute, Schmiedlstrasse 6, A-8042 Graz, AUSTRIA, Tel. +43 316 4120 601, Fax +43 316 4120 390, E-mail helmut.rucker@oeaw.ac.at, rucker@oeaw.ac.at (88, 89, 91)

RUZHIN, Prof. Yu. Ya., IZMIRAN, TROITSK, MOSCOW REGION 142092, RUSSIA, Tel. +7 496 751 0291, Fax +7 496 751 0124, E-mail ruzhin@izmiran.ru (88)

RYDBERG, Prof. A., Angstrom Laboratory, Uppsala University, Dept. of Engineering Sciences, P.O. Box 534, SE-751 21 UPPSALA, SWEDEN, Tel. +46 18 471 32 28, Fax +46 18 55 50 95, E-mail anders.rydberg@angstrom.uu.se (86)

SAAD, Prof. E.M., Comm., Electronics and Comp. Eng. Department, Faculty of Engineering, University of Helwan, Helwan, Cairo, EGYPT, Tel. +202 5048291, Fax +202 2558294, E-mail elsayedmos@hotmail.com (86, 91)

SABATH, Dr. F., Wehrwissenschaftliches Institut für Schutztechnologien, ABC-Schutz, Postfach 1142, D-29623 MUNSTER, GERMANY, Tel. +49 5192 136 606, Fax +49 4172 98 8084, E-mail FrankSabath@bwb.org (87, 90)

SAKA, Prof. B., Dept. of Electrical & Electronics Engineering, Hacettepe University, Faculty of Engineering, 06532 BEYTEPE, ANKARA, TURKEY, Tel. +90 312 297 7045, Fax +90 312 299 2125, E-mail birsen@hacettepe.edu.tr (91)

SALOUS, Prof. S., School of Engineering, Centre for Communication Systems, University of Durham, DURHAM, DH1 3LE, UNITED KINGDOM, Tel. +44 191 334 2532, Fax +44 191 334 2408, E-mail sana.salous@durham.ac.uk (86, 92)

SAMARAS, Prof. T., Dept. of Physics, Radiocommunications Lab., Aristotle University of Thessaloniki, GR-54124 THESSALONIKI, GREECE, Tel. +30 2310 998232, Fax +30 2310 998069, E-mail theosama@auth.gr (91)

SANCHO RUIZ, Prof. M., Dep. Fisica Aplicada III - Fac. de Fisicas, Universidad Complutense, 28040 MADRID, SPAIN, Tel. +34 91 394 4388, Fax +34 91 394 5196, E-mail msancho@fis.ucm.es (88)

SANTOLIK, Assoc. Prof. O., Institute of Atmospheric Physics, Academy of Sciences of the Czech Republic, Bocni II, 1401, 141 31 PRAGUE 4, CZECH REPUBLIC, Tel. +420 267 103 083, Fax +420 272 762 528, E-mail os@ufa.cas.cz (88)

SARANGO, Dr. Martin F., M Sarango CT, Industrias Tecnologicas, Av. Javier Prado Este 3040 Piso 4, San Borja, LIMA 41, PERU, Tel. +51 1-3588700, Fax +51 1-2500969, E-mail ursiperu@msarangoct.com (87)

SATO, Prof. T., Department of Communications and Computer Engineering, Graduate School of Informatics, Kyoto University, Sakyo-ku, KYOTO 606-8501, JAPAN, Tel. +81 75 753 3362, Fax +81 75 753 3342, E-mail tsato@kuee.kyoto-u.ac.jp (85)

SCHLEGEL, Prof. K., Copernicus Gesellschaft e.V., Max-Planck-Str. 13, D-37191 KATLENBURG-LINDAU, GERMANY, Tel. +49 5556-979451/468, Fax +49 5556-979240, E-mail kristianschlegel@web.de, KS-URSI@email.de (84, 90, 92)

SCHÖNHUBER, Dr. M., Joanneum Research, , Steyrergasse 17-19, 8010 Graz,AUSTRIA, Tel. +43 316 876 2511, Fax +43 316 8769 92511, E-mail Michael.Schoenhuber@joanneum.at (87)

SCHWEICHER, Prof. E., 79, rue de Bruxelles, 1480 TUBIZE, BELGIUM, Tel. +32 2 355 0636, E-mail schweicher.emile@gmail.com (90)

SEBASTIAN FRANCO, Prof. J.L., Dpto. Fisica Aplicada III, Facultad de Ciencias Fisicas, Universidad Complutense de Madrid, 28040 MADRID, SPAIN, Tel. +34 91-394-4393, Fax +34 91-394-5196, E-mail jlsf@fis.ucm.es (89)

SEIRADAKIS, Prof. J.H., Department of Physics, Section Astrophysics, Astronomy and Mechanics, Aristotle University of Thessaloniki, GR-54124 THESSALONIKI, GREECE, Tel. +30 2310 998173, Fax +30 2310 995384, E-mail jhs@astro.auth.gr (89)

SELLER, Dr. R., Department of Broadband Infocommunication Systems, BME - Budapest University of Technology and Economics, Goldman Gyorgy ter 3, 1111 BUDAPESt, HUNGARY, Tel. +36 1 463 3687, Fax +36 1 463 3289, E-mail seller@mht.bme.hu (87)

SELLERI, Prof. S., Dip. di Ingegneria dell'Informazione, University of Parma, Viale G.P. Usberti 181/A, 43124 Parma, ITALY, E-mail stefano.selleri@unipr.it (86, 87)

SERBEST, Prof. H., Department of Electrical and Electronics Engineering, Cukurova University , Faculty of Engineering and Architecture, Balcali, ADANA, TURKEY, Tel. +90 322 338 7237, Fax +90 322 338 6326, E-mail serbest@cu.edu.tr, hamitserbest@gmail.com (84, 91)

SEXTON, Prof. M.C., University College Cork, 6 Brighton Villas, Western Road, CORK, IRELAND, Tel. +353 21 490 2893/2210, Fax +353 21 427 1698, E-mail eleceng@ucc.ie (88)

SHIBATA, Prof. K., Kwasan Observatory, Kyoto University, Yamashina, KYOTO 607-8471, JAPAN, Tel. +81 75-581 1235, Fax +81 75-593 9617, E-mail shibata@kwasan.kyoto-u.ac.jp (90)

SHIGEMITSU, Dr. T., Japan EMF Information Center, 2-9-11 Shiba, Minato-ku, TOKYO 105-0014, JAPAN, Tel. +81 3 5444 2631, Fax +81 3 5444 2632, E-mail shigemitsu@jet.or.jp (89)

SHISHKOV, Prof. B.B., Institute of Mathematics & Informatics Bulgarian Academy of Sciences, Acad. G. Bonchev Str., bl. 8, 1618 SOFIA, BULGARIA, Tel. +359.2.9793858, Fax +359 2 971 3649, E-mail bshishkov@math.bas.bg (86, 91)

SHMELEV, Dr. A.B., Radiotechn. Inst. by name of Academic Mints, OAO, 8 Marta Street, bld. 10, MOSCOW 125083, RUSSIA, Tel. +7 495 614 2841, Fax +7 495 614 0662, E-mail abshmelev@yahoo.com (86)

SIERRA PEREZ, Prof. M., Dpto. Senales, Sistemas y Radiocomunicaciones, Universidad Politecnica de Madrid, Escuela Tecnica Superior de Ingenierios de Telecomunicacion, 28040 MADRID, SPAIN, Tel. +34 91 549 5700, Fax +34 91 543 2002, E-mail manolo@gr.ssr.upm.es (86)

SIGALO, Dr. F.B., Department of Physics, Rivers State University of Science and Technology, PMB 5080, Port Harcourt, Rivers State, NIGERIA, Tel. 234 803 342 7133, Fax , E-mail fbsigalo@hotmail.com (89)

SIHVOLA, Prof. A., Dept. Radio Science & Engineering, Aalto University, PO Box 13000, FI-00067 AALTO, FINLAND, Tel. +358 9 470 22261, Fax +358 9 470 22267, E-mail Ari.Sihvola@aalto.fi (85, 91, 92)

SKRIVERVIK, Prof. A.K., STI-LEMA, Ecole Polytechnique Fédérale de Lausanne, Station 11, CH-1015 LAUSANNE, SWITZERLAND, Tel. +41 21 693 46 35, Fax +41 21 693 26 73, E-mail Anja.Skrivervik@epfl.ch (85, 91)

SKOU, Prof. N., Electromagnetic Systems, Denmarks Technical University , Oersted Plads, Building 348, DK 2800 LYNGBY,DENMARK, Tel. (454) 525-3768, Fax (454) 593-1654, E-mail ns@space.dtu.dk (87)

SKVOR, Prof. Z., Faculty of Electrical Engineering, Czech Technical University, Technická 2, PRAGUE 6 166 27, CZECH REPUBLIC, Tel. +420 224 352 278, Fax +420 233 339 958, E-mail skvor@feld.cvut.cz (85)

SLAVOVA-POPIVANOVA, Prof. A., Institute of Mathematics and Informatics, Bulgarian Academy of Sciences, Acad. G. Bonchev St., bl. 8, 1113 SOFIA, BULGARIA, Tel. +359 2 979 2841, E-mail slavova@math.bas.bg (89)

SMIESKO, Prof. V., Fac. of Electrical Eng. & Information Technology, Slovak University of Technology, Ilkovicova 3, BRATISLAVA 812 19, SLOVAKIA, Tel. +421 2-60291894, Fax +421 2-65429600, E-mail viktor.smiesko@stuba.sk (87)

SMITH, Prof. P.D., Department of Mathematics, EA7 402, Macquarie University, North Ryde, NSW, 2109, AUSTRALIA, Tel. +61 2 9850 8944, Fax +61 2 9850 8114, E-mail paul.smith@mq.edu.au (85)

SOBIESKI, Prof. P., U.C.L. - TELE, Bâtiment Stévin, Place du Levant, 2, 1348 LOUVAIN-LA-NEUVE,BELGIUM, Tel. +32 10-47 23 03, Fax +32 10-47 20 89, E-mail Piotr.Sobieski@uclouvain.be (87)

SORRENTINO, Prof. R., Department of Electronic and Information Eng., University of Perugia, Via Duranti 93, I-06125 PERUGIA, ITALY, Tel. +390 75-585 3658, Fax +390 75-585 3568, E-mail sorrentino@diei.unipg.it, r.sorrentino@ieee.org, r. sorrentino@eumwa.org (91)

STANISLAWSKA, Dr. I., Space Research Centre, ul. Bartycka 18 A, 00-716 WARSAW, POLAND, Tel. +48 22 840 37 66 ext. 380, E-mail stanis@cbk.waw.pl (88, 92)

STEINMEYER, Prof. G., Max-Born-Institut (MBI), Department C2, Haus C, 3.7, Max-Born-Straße 2 A, 12489 BERLIN, GERMANY, E-mail steinmey@mbi-berlin.de (86)

STOFANIK, Dr. V., Fac. of Electrical Engineering & Information Technology, Slovak University of Technology, Ilkovicova 3, BRATISLAVA 81219, SLOVAKIA, Tel. +421 2 60 2 91 394, Fax +421 2 654 29 683, E-mail vladimir.stofanik@stuba.sk (87)

STONE, Dr. W.R., 840 Armada Terrace, San Diego, CA 92106, USA, Tel. +1-619 222 1915, Fax +1-619 222 1606, E-mail r.stone@ieee.org (84, 92)

STRUZAK, Dr. R.G., Powstancow Slaskich 163-14, WROCLAW, POLAND, Tel. +48 515195562, Fax +48 713614474, E-mail r.struzak@ieee.org (90)

STUMPER, Dr. U., Physikalisch-Technische Bundesanstalt, Bundesallee 100, D-38023 BRAUNSCHWEIG, GERMANY, Tel. +49 531-592-2220, Fax +49 531-592-2228, E-mail ulrich.stumper@ptb.de (85)

SU, Prof. Y-K, Office of Academic Affairs, National Cheng Kung University, No. 1, Ta-Hsueh Road, TAIWAN 701, CHINA (SRS), Tel. +886-6 2757575ext50109, E-mail yksu@mail.ncku.edu.tw (86)

SU, Dr. D., Beijing University of Aeronautics & Astronautics, XueYuan Road No.37, HaiDian District, Beijing, CHINA (CIE), Tel. +86 10 8231 7224, E-mail sdl@buaa.edu.cn (85)

SUMICHRAST, Prof. L., Fac. of Electrical Eng.&Information Technology, Slovak University of Technology, Ilkovicova 3, BRATISLAVA 812 19, SLOVAKIA, Tel. +421-2-65423502, Fax +421-2-65420415, E-mail lubomir.sumichrast@stuba.sk (85, 91)

SUWAIYEL, Dr. M.I., Directorate of International Cooperation, KACST, P.O. Box 6086, RIYADH 11442, SAUDI ARABIA, Tel. +966 1 488 3555 ext 3490, Fax +966 1 4813441, E-mail int_coop@kacst.edu.sa (91)

SVOBODA, Dr. M., Czech Metrology Institute, Hvozdanska 3, PRAGUE 4 148 01, CZECH REPUBLIC, Tel. +420 271 192 125, Fax +420 272 934 560, E-mail msvoboda@cmi.cz (87)

SZABO, Dr. L.D., National Research Institute, for Radiobiology and Radiohygiene, Pentz K. u. 5, H-1221 BUDAPEST, HUNGARY, Tel. +36 1-1264 160, Fax +36 1-2266 974 (89)

SZEKELY, Prof. V., Department of Electron Devices, BME Budapest University of Technology and Economics, Goldmann Gy. tér 3., H-1111 BUDAPEST, HUNGARY, Tel. +36 1-463-2703, Fax +36 1-463-2973, E-mail szekely@eet.bme.hu (86)

TAKI, Prof. M., Department of Electrical Engineering, Tokyo Metropolitan University, 1-1 Minami-osawa, Hachioji, TOKYO 192-0397, JAPAN, Tel. +81 426 77 2763, Fax +81 426 77 2756, E-mail masao@tmu.ac.jp (89)

TAO, Dr. R., Department of Electronic Engineering, Beijing Institute of Technology, Beijing, 100081, CHINA (CIE), Tel. +86 10 6891 4257, E-mail rantao@bit.edu.cn (86)

TAVELLA, Dr. P., INRIM, Strada delle Cacce 91, 10135 TORINO, ITALY, E-mail tavella@inrim.it (85, 91)

TEDJINI, Dr. S., INPG-ESISAR, LCIS, 50, rue B. de Laffemas, BP 54, F-26902 VALENCE CEDEX 9, FRANCE, Tel. +33 4 75 75 9420, Fax +33 4 75 43 5642, E-mail smail.tedjini@lcis.grenoble-inp.fr (86, 90)

TETELIN, Dr. C., Centre National de Référence RFID, Portes de Rousset, Bâtiment E102, Avenue Olivier Perroy, BP 47870, F-13106 Rousset Cedex, FRANCE, Tel. +33 4 42 37 09 39, E-mail ctetelin@centrenational-rfid.com (86)

THIDE, Prof. Bo, Angström Lab, Uppsala University, P.O. Box 537, 751 21 UPPSALA, SWEDEN, Tel. +46 18 471 59 14, Fax +46 18 471 59 05, E-mail bt@irfu.se (88, 90)

THOMSON, Dr. N.R., Department of Physics, University of Otago, P.O. Box 56, DUNEDIN, NEW ZEALAND, Tel. +64 3-479 7802, Fax +64 3-479 0964 , E-mail n_thomson@physics.otago.ac.nz (91)

THYAGARAJAN, Prof. K., Department of Physics, Indian Institute of Technology, Hauz Khas, NEW DELHI, 110 016, INDIA, E-mail ktrajan2903@yahoo.com, ktrajan@physics.iitd.ernet.in (86)

TIAN, Dr. J., Institute of Automation, Chinese Academy of Sciences, 95 Zhongguancun East Road, 100190 Beijing, CHINA CIE, Tel. +86 10 8261 8465, Fax , E-mail tian@ieee.org (89)

TJELTA, Dr. T., Telenor GBDR, Snaroyveien 30, 1331 FORNEBU, NORWAY, Tel. +47 90 786424, E-mail terje.tjelta@telenor.com (87, 90)

TOBAR, Prof. M.E., School of Physics M013, Frequency Standards and Metrology Research Group, University of Western Australia, 35 Stirling Highway, CRAWLEY, WA 6009, AUSTRALIA, Tel. +61 8 6488 3443, Fax +61 8 6488 1235, E-mail mike@physics.uwa.edu.au (85)

TOPSAKAL, Dr. E., Mississippi State Universitiy, 405 Simhall Hall, Hordy Street, MS State, MS, 39762, United States, Tel. (662) 325-3669, Fax (662) 325-2298, E-mail topsakal@ece.msstate.edu (92)

TORKAR, Prof. K.M., Space Research Institute, Schmiedlstrasse 6, A 8042 Graz, AUSTRIA, Tel. +43 316 4120 531, Fax +43 316 4120 590, E-mail klaus.torkar@oeaw.ac.at (88)

TORNIKOSKI, Dr. M., Metsähovi Radio Observatory, Helsinki University of Technology, Metsähovintie 114, 02540 KYLMÄLÄ, FINLAND, Tel. +358 9-2564 831, Fax +358 9-2564 531, E-mail Merja.Tornikoski@tkk.fi (89)

TRAINOTTI, Prof. V., Bernardo de Irigoyen 650 2° 10, 1072 BUENOS AIRES,ARGENTINA, Tel. +541 4334 3529, Fax +541 4709 3210, E-mail vtrainotti@ieee.org (85)

TRETYAKOV, Prof. O.A., Department of Theoretical Radio Physics, Kharkov National University, Svoboda Sq. 4, Kharkov 61077, UKRAINE, Tel. +380 572-457163/457257, Fax +380 572-476506, E-mail Oleg.A.Tretyakov@univer.kharkov.ua (85)

TRUHLIK, Dr. V., Institute of Atmospheric Physics, Bocni II, 141 31 Praha 4, CZECH REPUBLIC, E-mail vtr@ufa.cas.cz (90)

TRULSEN, Prof. J., Institute of Theoretical Astrophysics, University of Oslo, P.O. Box 1029 Blindern, N-0315 OSLO, NORWAY, Tel. +47 22 856540, Fax +47 22 856505, E-mail jan.trulsen@astro.uio.no (88, 91)

TSIBOUKIS, Prof. T., Division of Telecommunications, Dept. of Electrical & Computer Eng., Aristotle University of Thessaloniki, GR-54124 THESSALONIKI, GREECE, Tel. +30 23 1099 6323, Fax +30 23 1099 6312, E-mail tsibukis@auth.gr (85)

TU, Dr. Y-K, Chunghwa Telecom Laboratories, 12, Lane 551, Min-Tsu Road, Sec. 5, TAOYUAN 326, TAIWAN, Tel. +886 3 4244202, Fax +886 3 4244208, E-mail yktu@cht.com.tw (86)

TULUNAY, Dr. Y., Department of Aerospace Engineering, Middle East Technical University, Faculty of Engineering, 06531 Balgat, ANKARA, TURKEY, Tel. +90 312 210 2471, Fax +90 312 210 4250, E-mail ytulunay@metu.edu.tr (88)

TZIOUMIS, Dr. A., CSIRO, Australia Telescope National Facility, PO Box 76, EPPING, NSW 2121, AUSTRALIA, Tel. +61 2 9372 4350, Fax +61 2 9372 4310, E-mail Tasso.Tzioumis@csiro.au, atzioumi@atnf.csiro.au (92)

USLENGHI, Prof. P.L.E., Dept. of ECE (MC 154), University of Illinois at Chicago, 851 S. Morgan Street, CHICAGO, IL 60607-7053, USA, Tel. +1 312 996-6059, Fax +1 312 996 8664, E-mail uslenghi@uic.edu (84)

UZUNOGLU, Prof. N.K., Division of Information Transmission Systems and Material Technology, School of Electrical and Computer Eng., National Technical University of Athens, Iroon Polytechniou 9, GR-15773 ATHENS, GREECE, Tel. +30 210 7722289, E-mail nuzu@cc.ece.ntua.gr (89, 91)

VAN ARDENNE, Prof. Ir. A., ASTRON, Oude Hogeveensedijk 4, Postbus 2, NL-7990 AA DWINGELOO, NETHERLANDS, Tel. +31 521 595 134, Fax +31 521 595 101, E-mail Ardenne@astron.nl, brink@astron.nl (89, 91)

VAN BLADEL, Prof. J., G. De Smetlaan 22, B-9831 DEURLE, BELGIUM, Tel. +32 9-282 4488, Fax +32 9-264 4288, E-mail hvanbladel@skynet.be (84)

VAN DAELE, Prof. DR. P., Dept. of Information Technology (INTEC), IBBT - Ghent University, Gaston Crommenlaan 8 bus 201, B-9050 GENT,BELGIUM, Tel. +32 9 331 49 06, Fax +32 9 331 48 99, E-mail peter.vandaele@intec.Ugent.be (84, 86)

VAN DEN BOGAART, Ir. F.L.M., TNO Defence, Security and Safety, Postbus 96864, 2509 JG 'S-GRAVENHAGE, NETHERLANDS, Tel. +31 70 374 0042, Fax +31 70 374 0653, E-mail frank.vandenbogaart@tno.nl (86)

VAN DEURSEN, Prof. A.P.J., Faculteit Electrotechniek, Technische Universiteit Eindhoven, PO Box 513, NL-5600 MB EINDHOVEN,NETHERLANDS, Tel. +31 40 247 4434/3993, Fax +31 40 245 0735, E-mail A.P.J.v.Deursen@tue.nl (87)

VAN DRIEL, Dr. W., GEPI, Observatoire de Paris, 5, Place Jules Janssen, F-92195 MEUDON CEDEX, FRANCE, Tel. +33 1 4507 7731, Fax +33 1 4507 7709, E-mail wim.vandriel@obspm.fr (90, 92)

VAN LIL, Prof. E., DIV. ESAT-TELEMIC, K.U. Leuven, Kasteelpark Arenberg 10, B-3001 HEVERLEE, BELGIUM, Tel. +32 16-32 1113, Fax +32 16-32 1986, E-mail Emmanuel.VanLil@esat.kuleuven.be (85, 91)

VANDENBOSCH, Prof. G.A.E., ESAT, Katholieke Universiteit Leuven, Kasteelpark Arenberg 10 , 3001 LEUVEN, BELGIUM, Tel. +32 16 32 11 10, Fax +32 16 32 19 86, E-mail Guy.Vandenbosch@esat.kuleuven.be (87)

VANDENDORPE, Prof. L., UCL, TELE, Batiment Stévin, Place du Levant, 2, 1348 LOUVAIN-LA-NEUVE, BELGIUM, Tel. + 32 10-47 23 12, Fax + 32 10-47 20 89, E-mail Vandendorpe@tele.ucl.ac.be (86)

VARJU, Dr. G., Department of Electric Power Systems, BME - Budapest University of Technology and Economics, H-1521 BUDAPEST, HUNGARY, Tel. +36 1-463 3016, Fax +36 1-463 3013, E-mail varju@vmt.bme.hu (87)

VAUGHAN, Prof. R., Engineering Science, Simon Fraser University, 8888 University Drive, Burnaby, BC V5A 1S6, CANADA, Tel. , Fax +001 604 291 4951, E-mail rvaughan@sfu.ca (85)

VELASQUEZ-LOPEZ, Dr. C. V., Director General de la Secretaria de Comunicaciones, Ministerio de TRansportes y Comunicaciones, Jiron Zorritos N° 1203, LIMA, PERU, Tel. +51 1 615 7800, E-mail cavaldez@mtc.gob.pe (87)

VELINOV, Prof. P., Institute for Space and Solar Terrestrial Research, Bulgarian Academy of Sciences, 6 Moskovska Str., 1000 SOFIA, BULGARIA, Tel. +359 2 979 3434, E-mail pvelinov@bas.bg (89)

VERGERES, Mr. D., Chef de section, Office Fédéral de la Communication, Gestion des fréquences radio, Rue de l'Avenir 44, 2501 BIENNE, SWITZERLAND, Tel. +41 32 327 57 20, Fax +41 32 327 57 77, E-mail daniel.vergeres@bakom.admin.ch (87)

VESZELY, Dr. Gy., Department of Broadband Infocommunication Systems, BME - Budapest University of Technology and Economics, H-1521 BUDAPEST, HUNGARY, Tel. +36 1-463-3188, Fax +36 1-463-3189, E-mail Veszely@evt.bme.hu (85)

VEYRET, Dr. B., Laboratoire PIOM CNRS / EPHE, Université de Bordeaux 1, ENSCPB, 16, Av. Pey Berland, F-33607 PESSAC CEDEX, FRANCE, Tel. +33 5 40 00 66 29, Fax +33 5 40 00 66 29, E-mail b.veyret@icnirp.org (92)

VILCAHUAMAN CAJACURI, Prof. L., Seccion Electricidad y Electricidad, Pontificia Universidad Catolica del Peru, Av. Universitaria 1800, San Miguel, LIMA 32, PERU, Tel. +51 1 6262000 (ext. 5030), E-mail lvilcah@pucp.edu.pe (89)

VILJANEN, Dr. A., Finnish Metereological Institute, Arctic Research, P.O. Box 503, 00101 HELSINKI, FINLAND, Tel. +358 9 1929 4668, Fax +358 9 1929 4603, E-mail Ari.Viljanen@fmi.fi (87, 90)

VOLAKIS, Prof J.L., Electroscience Lab, The Ohio State University, 1320 Kinnear Rd., Columbus, OH 43212, USA, Tel. +1 614-292-5846, E-mail volakis@ece.osu.edu (92)

VOMVORIDIS, Prof. I., School of Electrical & Computer Eng., National Technical University of Athens, Iroon Polytechniou 9, GR-15773 ATHENS, GREECE, Tel. +30 210 7723684, Fax +30 210 7723513, E-mail vomvor@central.ntua.gr (88)

VRBA, Prof. J., Faculty of Electrical Eng., Czech Technical University, Technická 2, PRAGUE 6 166 27, CZECH REPUBLIC, Tel. +420 224 352 298, Fax +420 233 339 958, E-mail vrba@fel.cvut.cz (89)

WALDE, Mr. C.-H., Nordic Radio Society, Tornvägen 7, 183 52 TÄBY, SWEDEN, Tel. +46 8 756 61 60, E-mail info@walde.se (91)

WALLEN, Dr. H., Dept. Radio Science and Engineering, Aalto University, P.O. Box 13000, FI-00067 AALTO, FINLAND, Tel. +358 9 470 25668, Fax +358 9 470 22267, E-mail henrik.wallen@aalto.fi (91)

WANNBERG, Dr. G., Swedish Institute of Space Physics, Box 812, 981 28 KIRUNA,SWEDEN, Tel. +46 980 790 54, Fax +46 980 790 50 (88)

WARNANT, Mr. R., Royal Observatory of Belgium, Avenue Circulaire 3 , 1180 BRUSSELS,BELGIUM, Tel. +32 2 373 02 51, Fax +32 2 374 98 22, E-mail r.warnant@oma.be (88)

WATANABE, Dr S., Department of Cosmosciences, Hokkaido University, Sapporo 060-0810, JAPAN, Tel. +81 11 706 2757, Fax +81 11 706 2760, E-mail shw@ep.sci.hokudai.ac.jp (88, 90)

WATERS, Assoc. Prof. C., Centre for Space Physics, School of Mathematical and Physical Sciences, University of Newcastle, University Drive, CALLAGHAN NSW 2308, AUSTRALIA, Tel. +61 2 4921 6907, Fax +61 2 4921 5421, E-mail colin.waters@newcastle.edu.au (88)

WATSON, Prof. P.A., Cairnlea, Littleworth, Winchcombe, Gloucestershire,GL54 5BT, UNITED KINGDOM, E-mail peter.watson43@btinternet.com (92)

WEN, Dr. Y., EMC Lab of School of Electronic and Information Engineering, Beijing Jiaotong University, Beijing 100044, CHINA CIE, Tel. +86 10 5168 8096, E-mail yhwen@bjtu.edu.cn (87)

WERNIK, Prof. A.W., Space Research Center, Polish Academy of Sciences, Ul. Bartycka 18 A, 00-716 WARSAW, POLAND, Tel. +48-22-8403766 ext.379, Fax +48-22-8403131, E-mail aww@cbk.waw.pl (88)

WESTON, Dr. J., International Affairs, The Royal Society of New Zealand, PO Box 598, Wellington 6140, NEW ZEALAND, Tel. +64 4 472 7421, Fax +64 4 473 1841, E-mail jez.weston@royalsociety.org.nz (91)

WIART, Dr. J., Orange Labs, 38-40, rue du Général Leclerc, F-92131 ISSY LES MOULINEAUX CEDEX, FRANCE, Tel. +33 1 45 29 58 44, E-mail joe.wiart@orange-ftgroup.com (89, 91)

WICHMAN, Prof. R., Dept. of Signal Processing and Acoustics, Aalto University, FI-00067 AALTO, FINLAND, Tel. +358 9 470 22484, Fax +358 9 452 3614, E-mail Risto.Wichman@tkk.fi (86)

WILFERT, Prof. O., Brno University of Technology, Purkynova 118, BRNO 612 00, CZECH REPUBLIC, Tel. +420 541 149 130, Fax +420 541 149 224, E-mail wilfert@feec.vutbr.cz (86)

WILKINSON, Dr. Phil, Dept. of Industry, Tourism and Resources, IPS Radio and Space Services, P.O. Box 1386, Haymarket, NSW 1240, AUSTRALIA, Tel. +61 2-9213 8003, Fax +61 2-9213 8060, E-mail phil@ips.gov.au (84, 88, 90, 92)

WILSON, Mrs C., Propagation and Spectrum Wireless Technologies Lab., CSIRO ICT Centre, P.O. Box 76, EPPING, NSW 1710, AUSTRALIA, Tel. +61 29 372 42 64, Fax +61 29 372 44 90, E-mail carol.wilson@csiro.au (87)

WNUK, Prof. M., Military University of Technology, 2 Kaliskiego Street, 00-908 WARSAW,POLAND, E-mail mwnuk@wat.edu.pl (87)

WOODMAN, Dr. R.F., Jicamarca Radio Observatory, Instituto Geofisico del Peru, Calle Badajoz 169, Urb. Mayorazgo 4ta Etapa, Ate, Apartado 13-0207, LIMA 13, PERU, Tel. +51-1-3172320, E-mail ronw@geo.igp.gob.pe (91)

WU, Dr. Jian, LEME/CRIRP, P.O. Box 6301, 102206 BEIJING, CHINA (CIE), Tel. +86 10 8072 5510, E-mail jian.wu@263.net (91)

YAMAGUCHI, Prof. Y., Department of Information Engineering, Niigata University, Ikarashi 2-8050, Niigata-shi, NIIGATA, 950-2181, JAPAN, Tel. +81 25 262 6752, Fax +81 25 262 6752, E-mail yamaguch@ie.niigata-u.ac.jp (87)

YAMASAKI, Mr. T., Department of Electrical Engineering, Nihon University, 1-8-14 Surugadai, Kanda, Chiyoda-ku, TOKYO 101-8308, JAPAN, Tel. +81 3 3259 0771, Fax +81 3 3259 0771, E-mail yamasaki@ele.cst.nihon-u.ac.jp (91)

YAMPOLSKY, Prof. Yu. M., Institute of Radioastronomy, NASU, ul. Krasnoznamennaya 4, KHARKOV 310002, UKRAINE, Tel. +380 572-44-8579, Fax +380 572-44-6506, E-mail yampol@rian.kharkov.ua (88)

YAN, Dr. Y., National Astronomical Observatories, Chinese Academy of Sciences, A20 Datun Road, Chaoyang District, BEIJING 100012, CHINA (CIE), Tel. +86 10 6485 1674, Fax +86 10 6486 3314, E-mail yyh@nao.cas.cn (89)

YARLEQUE MEDINA, Dr. M., Departamento de Ingenierìa, Pontificia Universidad Católica del Perú, Sección Ingeniería de las Telecomunicaciones , Av.Universitaria 1801, San Miguel, LIMA32, PERU, Tel. +51-1-626-2452, Fax +51-1-626-2116, E-mail myarleq@pucp.edu.pe (85)

YAROVOY, Prof. dr. A., Faculteit Elecktotechniek, Wiskunde en Informatica, Technische Universiteit Delft, Mekelweg 4, 2628 CD DELFT, NETHERLANDS, Tel. +31 15 278 2496, Fax +31 15 278 4046, E-mail a.yarovoy@ewi.tudelft.nl (85)

YAZGAN, Dr. E., Department of Electrical and Electronics Engineering, Faculty of Engineering, Haceteppe University, 06532 BETEYPE, ANKARA, TURKEY, Tel. +90 312 297 7050, Fax +90 312 299 2125, E-mail yazgan@hacettepe.edu.tr (85)

YEH, Prof. H-C, Graduate Institute of Space Science, National Central University, No. 300 Jungda Road, CHUNG-LI, TAOYUAN 320, TAIWAN, Tel. +886 3 422 8374, Fax +886 3 422 4394, E-mail yeh@jupiter.ss.ncu.edu.tw (91)

YOSHIDA, Mr. S., YOKOWO CO., LTD., 1112 KANOHARA, TOMIOKA, GUNMA, 370-2495, JAPAN, Tel. +81-274-62-7133, Fax +81-274-62-7133, E-mail mc@yokowo.co.jp (90)

ZAGHLOUL, Dr. A., 7121 Arrowood Rd, Bethesda, MD, 20817, United States, Tel. (301) 325-7099, E-mail amirz@vt.edu (86)
ZAGORODNIY, Prof. A.G., Institute for Theoretical Physics , NASU, 14b, Metrologichna street, KIEV 03143, UKRAINE, Tel. +380 44 492 1423, Fax +380 44 526 5998, E-mail azagorodny@bitp.kiev.ua (88)
ZEDDAM, Dr. A., FT R&D, DTD/SFE, 2 avenue Pierre Marzin, BP 40, F-22307 LANNION CEDEX, FRANCE, Tel. +33 2-9605 3938, Fax +33 2-9605 3427, E-mail ahmed.zeddam@orange-ftgroup.com (90)
ZERROUKI, Dr. C., Laboratoire de Physique, 2, rue Conté, F-75003 PARIS cedex, FRANCE, Tel. +33 1 58 80 84 34, E-mail chouki.zerrouki@cnam.fr (85)
ZHAO, Prof. Z., Wuhan University, Wuhan 430072, CHINA CIE, Tel. +86 27 6875 6343, E-mail dicilab@yahoo.com.cn (88)
ZHELYAZKOV, Prof. I., Faculty of Physics, Sofia University, 5 James Boucher Blvd., BG-1164 SOFIA, BULGARIA, Tel. +359 2 816 1641, E-mail izh@phys.uni-sofia.bg (88)
ZHOGUN, Dr. V.N., VNIIFTRI, Mendeleevo, Moscow Region, 141570, RUSSIA, Tel. +7 495 744 81 21, Fax +7 499 720 9334, E-mail zhogun@vniiftri.ru (84)
ZINCHENKO, Dr. I.I., Institute of Applied Physics, Russian Academy of Sciences, Ul'yanova Street 46, NIZHNY NOVGOROD 603600, RUSSIA, Tel. +7 814 234 9983, Fax +7 814 346 0867, E-mail zin@appl.sci-nnov.ru (89)
ZOLESI, Dr B., Istituto Nazionale di Geofisica e Vulcanologia, via di Vigna Murata 605, 000143 Roma, Italy, Tel. +39 06 51860320, Fax +39 06 51860397, E-mail zolesi@ingv.it (88)
ZOMBORY, Prof. L., Department of Broadband Infocommunication Systems, BME - Budapest University of Technology and Economics, Goldmann Gy. tér 3., H-1111 BUDAPEST, HUNGARY, Tel. +36 1-463-1559/1824, Fax +36 1-463-3289, E-mail zombory@mht.bme.hu (91)
ZOZULYA, Prof. Yu.O., Academy of Medical Sciences of Ukraine, Inst. of Neurosurgery, Acad. A. Romodanov, 32, Manuilsky st., KIEV 04050, UKRAINE, Tel. +380 44-213 9573, Fax +380 44-213 9573, E-mail brain@neuro.kiev.ua (89)
ZVANOVEC, Assoc. Prof. S., Faculty of Electrical Engineering, Czech Technical university, Technicka 2, Prague 6 16627, Czech Republic, Tel. +420 224 355 966, Fax +420 233 339 958, E-mail xzvanove@fel.cvut.cz (87)
ZWAMBORN, Prof. dr. ir A.P.M., TNO Defence, Security and Safety, Postbus 96864, 2509 JG 'S-GRAVENHAGE, NETHERLANDS, Tel. +31 70 374 0033, Fax +31 70 374 0653, E-mail Peter.Zwamborn@tno.nl (89)

Information for authors

Content

The *Radio Science Bulletin* is published four times per year by the Radio Science Press on behalf of URSI, the International Union of Radio Science. The content of the *Bulletin* falls into three categories: peer-reviewed scientific papers, correspondence items (short technical notes, letters to the editor, reports on meetings, and reviews), and general and administrative information issued by the URSI Secretariat. Scientific papers may be invited (such as papers in the *Reviews of Radio Science* series, from the Commissions of URSI) or contributed. Papers may include original contributions, but should preferably also be of a sufficiently tutorial or review nature to be of interest to a wide range of radio scientists. The *Radio Science Bulletin* is indexed and abstracted by INSPEC.

Scientific papers are subjected to peer review. The content should be original and should not duplicate information or material that has been previously published (if use is made of previously published material, this must be identified to the Editor at the time of submission). Submission of a manuscript constitutes an implicit statement by the author(s) that it has not been submitted, accepted for publication, published, or copyrighted elsewhere, unless stated differently by the author(s) at time of submission. Accepted material will not be returned unless requested by the author(s) at time of submission.

Submissions

Material submitted for publication in the scientific section of the *Bulletin* should be addressed to the Editor, whereas administrative material is handled directly with the Secretariat. Submission in electronic format according to the instructions below is preferred. There are typically no page charges for contributions following the guidelines. No free reprints are provided.

Style and Format

There are no set limits on the length of papers, but they typically range from three to 15 published pages including figures. The official languages of URSI are French and English: contributions in either language are acceptable. No specific style for the manuscript is required as the final layout of the material is done by the URSI Secretariat. Manuscripts should generally be prepared in one column for printing on one side of the paper, with as little use of automatic formatting features of word processors as possible. A complete style guide for the *Reviews of Radio Science* can be downloaded from http://www.ips.gov.au/IPSHosted/NCRS/reviews/. The style instructions in this can be followed for all other *Bulletin* contributions, as well. The name, affiliation, address, telephone and fax numbers, and e-mail address for all authors must be included with All papers accepted for publication are subject to editing to provide uniformity of style and clarity of language. The publication schedule does not usually permit providing galleys to the author.

Figure captions should be on a separate page in proper style; see the above guide or any issue for examples. All lettering on figures must be of sufficient size to be at least 9 pt in size after reduction to column width. Each illustration should be identified on the back or at the bottom of the sheet with the figure number and name of author(s). If possible, the figures should also be provided in electronic format. TIF is preferred, although other formats are possible as well: please contact the Editor. Electronic versions of figures *must* be of sufficient resolution to permit good quality in print. As a rough guideline, when sized to column width, line art should have a minimum resolution of 300 dpi; color photographs should have a minimum resolution of 150 dpi with a color depth of 24 bits. 72 dpi images intended for the Web are generally *not* acceptable. Contact the Editor for further information.

Electronic Submission

A version of Microsoft *Word* is the preferred format for submissions. Submissions in versions of T_EX can be accepted in some circumstances: please contact the Editor before submitting. *A paper copy of all electronic submissions must be mailed to the Editor, including originals of all figures.* Please do *not* include figures in the same file as the text of a contribution. Electronic files can be send to the Editor in three ways: (1) By sending a floppy diskette or CD-R; (2) By attachment to an e-mail message to the Editor (the maximum size for attachments *after* MIME encoding is about 7 MB); (3) By e-mailing the Editor instructions for downloading the material from an ftp site.

Review Process

The review process usually requires about three months. Authors may be asked to modify the manuscript if it is not accepted in its original form. The elapsed time between receipt of a manuscript and publication is usually less than twelve months.

Copyright

Submission of a contribution to the *Radio Science Bulletin* will be interpreted as assignment and release of copyright and any and all other rights to the Radio Science Press, acting as agent and trustee for URSI. Submission for publication implicitly indicates the author(s) agreement with such assignment, and certification that publication will not violate any other copyrights or other rights associated with the submitted material.

APPLICATION FOR AN URSI RADIOSCIENTIST

I have not attended the last URSI General Assembly, and I wish to remain/become an URSI Radioscientist in the 2011-2013 triennium. Subscription to *The Radio Science Bulletin* is included in the fee.

(please type or print in BLOCK LETTERS)

Name : Prof./Dr./Mr./Mrs./Ms. ____

Family Name First Name Middle Initials

Present job title: ____

Years of professional experience: ___________

Professional affiliation: ____

I request that all information be sent to my ☐ home ☐ business address, i.e.:

Company name: ____

Department: ____

Street address: ____

City and postal/zip code: ____

Province/State: ______________________ Country: ______________________

Phone: ______________________ ext. _______ Fax: ______________________

E-mail: ____

Areas of interest (Please tick)

☐ A Electromagnetic Metrology

☐ B Fields and Waves

☐ C Radio-Communication Systems & Signal Processing

☐ D Electronics and Photonics

☐ E Electromagnetic Environment & Interference

☐ F Wave Propagation & Remote Sensing

☐ G Ionospheric Radio and Propagation

☐ H Waves in Plasmas

☐ J Radio Astronomy

☐ K Electromagnetics in Biology & Medicine

I would like to order :)

☐ An electronic version of the RSB downloadable from the URSI web site

(The URSI Board of Officers will consider waiving the fee if a case is made to them in writing.) 40 Euro

Method of payment : VISA / MASTERCARD (we do not accept cheques)

Credit card No ☐☐☐☐ ☐☐☐☐ ☐☐☐☐ ☐☐☐☐ Exp. date ___________

CVC Code: ___________ Date : ______________ Signed ______________

Please return this signed form to :

The URSI Secretariat
c/o Ghent University / INTEC
Sint-Pietersnieuwstraat 41
B-9000 GHENT, BELGIUM
fax (32) 9-264.42.88