The Radio Science Bulletin

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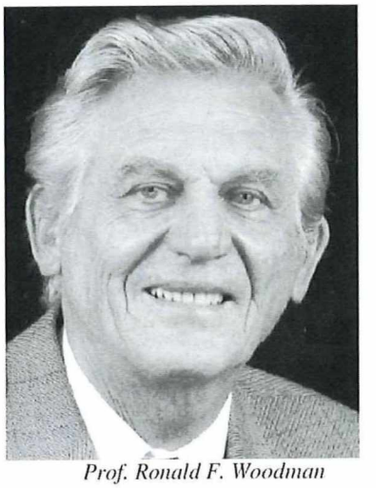
INTERNATIONAL
UNION OF
RADIO SCIENCE

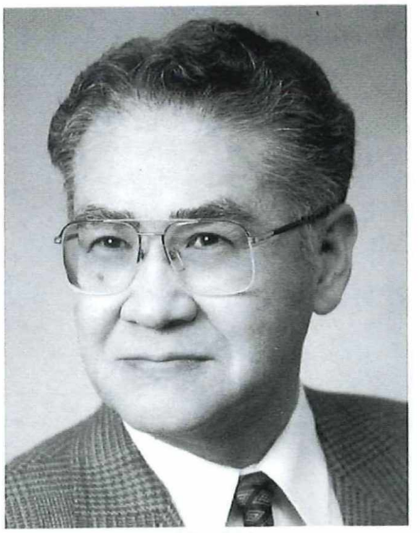
UNION
RADIO-SCIENTIFIQUE
INTERNATIONALE

1999 Awardees

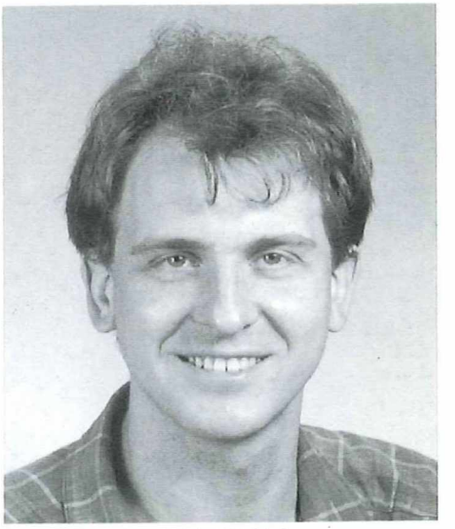
Dr. Shlomo Shamai



Prof. Ronald F. Woodman



Prof. Akira Ishimaru



Prof. Eric Michielssen

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Contents

Front cover : *At the XXVIth URSI General Assembly in Toronto (Canada) next August, the four scientists whose pictures feature on the front cover will be awarded with the traditional URSI Awards. For more information, please turn to page 8 of this bulletin.*

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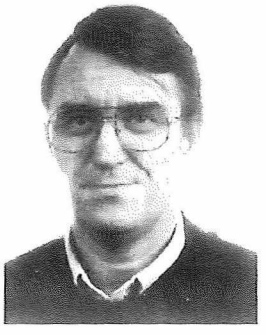
Editorial

Dear URSI Correspondent,

We are now just ahead of our URSI General Assembly. This issue of our Bulletin is the last one before we will have the opportunity to meet next August in Toronto. You will find here a scientific contribution by P. Delogne and M. Bellanger about the link between signal processing and the efficient use of the radio electrical spectrum.

As usual, news from Member Committees is presented. This time this concerns colleagues from central and eastern Europe, as well as from Canada, our hosting country for the GA. Besides this, a new chapter



appears in this issue of the Bulletin. It covers news from ITU-R with contributions from Kevin A. Hughes and Joe Shapira.

The administrative part of our Bulletin contains the usual announcements, calendar and reports about the scientific activities sponsored or supported by URSI. Some of these reports cover the last triennium period.

Last but not least have a look to the URSI Awards 1999 section. Several colleagues will be honoured by famous medals for the contributions in the context of radio science. Congratulations to the recipients!

See you in Toronto!

Piotr Sobieski, Editor

URSI Homepage

Please visit our Homepage from time to time at :

http://www.intec.rug.ac.be/ursi/

Latest changes and links :

- Dates of Business meetings during Toronto General Assembly
- Links to recently established sites of URSI Member Committees
- Links to updated Commission sites
- Full and summary reports of Strategy meeting
- The URSI Conference Calendar (regularly updated, with links to the conference sites)

The XXVIth URSI General Assembly will be held in Toronto, Canada, from 13 to 21 August 1999.
Please visit the site of the Toronto General Assembly, via the URSI Homepage or directly at :

http://www.nrc.ca/confserv/ursi99/welcome.html

We are looking forward to meeting you in Toronto! Everybody interested in radio science is welcome...

Commission Business Meetings

During the Toronto General Assembly most scientific commissions will hold business meetings at the following dates :

- **Monday 16 August at 6 p.m.**
- **Wednesday 18 August at 6 p.m.**
- **Friday 20 August at 6 p.m.**

Exceptions are :

- Commission H will have 3 business meetings at the above dates from 6.15 p.m. until 7.15 p.m. (on 18 August there will only be a meeting if business requires, please contact the Chairman for more information).
- Commission K will only have 1 business meeting : on Monday 16 August at 6.15 p.m.

URSI Accounts 1998

The expenditure of URSI is closely linked to the General Assembly and follows therefore a 3 year cycle. In 1998, a year preceding a General Assembly, some costs related to the General Assembly, such as the meeting of coordinating committee, were already incurred. Nevertheless it is very important to avoid a net loss over the year, since 1999, the year of the General Assembly, will probably show a substantial deficit. In general the finances of URSI are sound thanks to our assets which have substantially appreciated over the last year.

Paul Lagasse
Secretary General

Peter J.B. Clarricoats
Treasurer

BALANCE SHEET : 31 DECEMBER 1998

ASSETS	US$	US$	EURO	EURO
Dollars				
Merrill Lynch WCMA	2,919.46		2,501.88	
Generale Bank	26,126.05		22,389.19	
Smith Barney Shearson	183.44		157.20	
		29,228.95		25,048.27
Belgian francs				
Banque Degroof	5,792.39		4,963.89	
Generale Bank	193,706.62		166,000.36	
		199,499.02		170,964.26
Canadian dollars				
Generale Bank	3,262.99		2,796.28	
		3,262.99		2,796.28
French Francs				
Generale Bank	385.31		330,20	
		385.31		330,20
Investments				
Demeter Sicav shares	22,794.75		19,534.37	
Rorento Units	111,084.59		95,195.93	
Aqua Sicav	64,103.22		54,934.40	
Merrill-Lynch Short Term (1320 units)	12,115.28		10,382.41	
Massachusetts Investor Fund	207,247.52		177,604.48	
Reinvestment Massachusetts Investor Fund '98	19,716.60		16,896.49	
355 Rorento units on behalf of van der Pol Fund	12,950.41		11,098.08	
		450,012.36		385,646.16
Other				
Petty cash		1,517.41		1,300.38
Total Assets		**683,906.04**		**586,085.53**

	US$	US$	EURO	EURO
Less creditors				
IUCAF	13,665.31		11,710.73	
ISES	5,835.09		5,000.48	
		-19,500.40		-16,711.22
Balthasar van der Pol Medal Fund (1)		-12,950.41		-11,098.08
NET TOTAL OF URSI ASSETS		**651,455.23**		**558,276.23**
The net URSI Assets are represented by :				
Closure of Secretariat :				
Provision for Closure of Secretariat		50,000.00		42,848.40
Scientific Activities Fund :				
Scientific Activities in 1999	90,000.00		77,127.11	
Publications in 1999	60,000.00		51,418.07	
Young Scientists in 1999	50,000.00		42,848.40	
Administration Fund in 1999	80,000.00		68,557.43	
I.C.S.U. Dues in 1999	15,000.00		12,854.52	
		295,000.00		252,805.53
XXIV General Assembly Fund :				
During 1999 :		100,000.00		85,696.79
Total allocated URSI Assets		**445,000.00**		**381,350.72**
Unallocated Reserve Fund		206,455.23		176,925.51
		651,455.23		**558,276.23**

Statement of Income and Expenditure for the year ended 31 December 1998

I. INCOME

	US$	US$	EURO	EURO
Grant from ICSU/UNESCO Fund	15,000.00		12,854.52	
UNESCO Contracts	0.00		0.00	
Contributions from National Members	186,593.74		159,904.85	
Contributions from Other Members	0.00		0.00	
Special Contributions	0.00		0.00	
Contracts	0.00		0.00	
Sales of Publications, Royalties	201.98		173.09	
Sales of scientific materials	0.00		0.00	
Bank Interest	29,379.03		25,176.89	
Gain on Exchange	11,115.73		9,525.82	
Other Income	24,987.77		21,413.72	
Total Income:		**267,278.25**		**229,048.88**

	US$	US$	EURO	EURO
II. **EXPENDITURE**				
a1) Scientific Activities		35,055.27		30,041.24
General Assembly 1996	49.29		42.24	
Scientific meetings: Symposia/Colloquia	34,681.39		29,720.84	
Working Groups/Training Courses	0.00		0.00	
Representation at scientific meetings	324.59		278.16	
Data Gather/Processing	0.00		0.00	
Research Projects	0.00		0.00	
Grants to Individuals/Organizations	0.00		0.00	
Other	0.00		0.00	
Less covered by UNESCO Contracts	0.00		0.00	
a2) Routine Meetings		38,262.63		32,789.85
Bureau/Executive committee	38,262.63		32,789.85	
Other	0.00		0.00	
a3) Publications		22,179.20		19,006.86
b) Other Activities		10,426.00		8,934.75
Contribution to ICSU	8,426.00		7,220.81	
Contribution to other ICSU bodies	2,000.00		1,713.94	
Activities covered by UNESCO Contracts	0.00		0.00	
c) Administrative Expenses		62,016.21		53,145.90
Salaries, Related Charges	46,369.05		39,736.79	
General Office Expenses	6,092.07		5,220.71	
Office Equipment	4,335.20		3,715.13	
Audit Fees	2,191.24		1,877.82	
Bank Charges	3,028.65		2,595.46	
Loss on Exchange	0.00		0.00	
Total Expenditure :		**167,939.31**		**143,918.60**
Excess of Income over Expenditure		99,338.94		85,130.28
Accumulated Balance at 1 January 1998		552,116.29		473,145.95
Accumulated Balance at 31 December 1998		**651,455.23**		**558,276.23**

Rates of exchange :			
1 January 1998	$1 =	BEF 36.90	0.914727 EUR
	$1 =	CAD 1.42	
	$1 =	FRF 5.99	
31 December 1998:	$1 =	BEF 34.57	0.856968 EUR
	$1 =	CAD 1.54	
	$1 =	FRF 5.62	

	US$	US$	EURO	EURO
Observation :				
The account indicated with (1) is represented by :				
355 Rorento Shares : market value on 31 December 1998 = $		**24,644.12**		**21,119.22**
(Acquisition value : US$ 12,950.41)				
Market value investments December 31, 1998 ($1 = 34.57 BEF) :				
DEMETER SICAV :	51,047.38		43,745.97	
RORENTO UNITS (2) :	451,230.32		386,689.90	
AQUA-SICAV :	78,451.03		67,230.01	
M-L SHORT TERM :	10,190.00		8,732.50	
MASSACHUSETTS INVESTOR FUND :	244,116.60		209,200.09	
		835,035.32		**715,598.48**

(2) including the 355 Rorento of v. d. Pol Fund

APPENDIX : Detail of Income and Expenditure

I. INCOME				
Other Income				
Sale of Smith Barney Utilities Fund	13,983.94		11,983.79	
Sale of Smith Barney Grade Bond	6,590.27		5,647.65	
Reimbursement Travel expenses	515.16		441.48	
Reimbursement URSI Support to Cancelled Meetings	3,898.40		3,340.80	
		24,987.77		21,413.72
II. EXPENDITURE				
General Assembly 1996				
Correspondents Cards (Printing + Mailing)	49.29		42.24	
		49.29		42.24
Symposia/Colloquia/Working Groups :				
Commission A	2,053.80		1,760.04	
Commission B	9,550.00		8,184.04	
Commission C	4,234.89		3,629.16	
Commission D	4,234.89		3,629.16	
Commission E	2,169.51		1,859.20	
Commission F	3,019.96		2,588.01	
Commission G	1,600.00		1,371.15	
Commission H	0.00		0.00	
Commission J	0.00		0.00	
Commission K	3,310.96		2,837.39	
Other	4,507.38		3,862.68	
		34,681.39		29,720.84
Contribution to other ICSU bodies				
IUCAF (98)	2,000.00		1,713.94	
		2,000.00		1,713.94
Publications :				
Printing The Radio Science Bulletin (No. 284 - 286)	9,281.57		7,954.01	
Mailing The Radio Science Bulletin (No. 283 - 286)	12,897.63		11,052.86	
		22,179.20		19,006.86

URSI Awards 1999

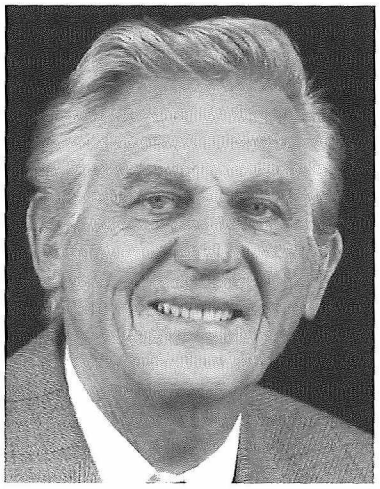
At its April 1999 meeting in Gent, the URSI Board of Officers decided to give the 1999 Awards to the following distinguished scientists...

Dr. Shlomo Shamai

The Balthasar Van der Pol Gold Medal will be awarded to Dr. Shlomo Shamai (Israel Institute of Technology, Israel) The citation reads : "For contributions to the basic understanding of the potentials for and the limitations to information transfer through various communication channel models".

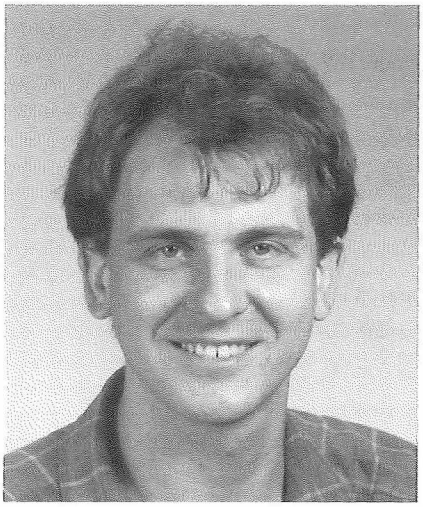
Prof. Akira Ishimaru

The John Howard Dellinger Gold Medal will be awarded to Prof. Akira Ishimaru (University of Washington, USA) : "For contributions to the theories and applications of wave propagation and scattering in random media and backscattering enhancement".



Prof. Ronald F. Woodman

After considering the views submitted by the Awards Advisory Panel, the Board of Officers submitted a short list of candidates in order of preference, with reasons for the order, to the Royal Society. The Council of the Royal Society approved the recommendation of the URSI Board to award the 1999 Appleton Prize to Prof. Ronald F. Woodman (Jicamarca Radio Observatory, Peru) : "For major contributions and leadership in radar studies of the ionosphere and neutral atmosphere".



Prof. Eric Michielssen

The Issac Koga Gold Medal will be awarded to Prof. Eric Michielssen (University of Illinois, USA) : "For contributions to computational electromagnetics, in particular the development of fast frequency and time domain integral equation analysis techniques and nature-driven synthesis methods".

The Awards will be presented at the Opening Ceremony of the XXVI General Assembly in Toronto on Sunday 15 August 1999 at 4.30 p.m.

News from ITU-R

This chapter, introduced to the Bulletin by the collaboration of URSI and the ITU-R, will be dedicated to reports on the ITU-R issues that are of interest to the URSI community, and reports and reflections from URSI scientists - of interest to the ITU-R community.

The birth of URSI is linked to the international collaboration in the research and usage of the Electromagnetic propagation medium for communications. URSI scientific activities in international research were related to the usage of the spectrum ever since, and a bond of mutual interest solidified between URSI with the ITU-R (The RadioCommunications branch of the International Telecommunications Union). The previous director of ITU-R, Richard Kirby, was at home in the URSI General Assembly and other activities, and the present director, Robert W. Jones, continues this tradition, together with his staff.

The last decade has seen enormous changes in the applications of radio Sciences and their role in the economy, education and personal welfare. Mobility, accessibility and global connectivity are being fuelled by the technological advancements in digital communications, inter networking, cellular and satellite communications, and by the global environment of privatization and global economy. These are blessings, but carry along the danger of short-sighted competition and misuse of the spectral resources.

ITU is a platform for negotiation and resolutions for its national members. It has been overwhelmed by the rate of growth of telecommunications and by the commercial pressures. Its needs for a scientific basis for its resolutions is stronger than ever before, but its structure and procedures dictate negotiative trade-offs between technical, political and commercial reasoning.

The collaboration between ITU-R and URSI has taken many forms along the years. URSI-associated scientists that participate in ITU-R study groups provide scientific rationale and impartial reasoning to these discussions. However, there are only few of these, an most of them active in the propagation-related groups. Structured liaisons have been tried along the years, with only a limited success that can be explained by the gap in the professional culture between the academic and the formal negotiative styles.

In the formal sense URSI has a very little influence in the ITU. It is a sector member, in the same position as many non governmental organizations, including huge commercial ones. The only way for us to affect this organization is by reasoning, marketing our ideas and a dialogue. We have started this route by creating COMMSPHERE, the dialogue forum, that convened successfully 5 times during this decade. This chapter in the RSB is still another avenue for this dialogue. I would like to encourage the ITU-R scientists, engineers and administrators to use this bulletin to express their technical issues in an informal language that attracts the attention of the scientific community. The scientific community is called to attend to these relevant problems and try to respond. I hope that this new communication vehicle will help bridging the gap between these two communities, that do have a common interest and need each other. Dr. Kevin Hughes from ITU-R has taken upon himself the difficult task to organize this chapter. I wish him our support and encouragement.

Dr. Joseph Shapira

Introductory remarks on URSI and ITU (and the link between them)

It is always highly appropriate for ITU, and in particular the radiocommunication side of ITU, to participate in events of URSI (such as this one) and cooperation between the two organisations has many precedents. Since the 1920's, both URSI and the ITU (through the CCIR) have enjoyed close links. URSI's role has been to promote radio science - something that it has successfully done since those early days of radio experiments through to today's wireless access systems of the so-called global information infrastructure. URSI involves itself more and more with spectrum usage. On the one hand, URSI is a user of the spectrum with involvement in active experiments undertaken within Commissions F, G and H; on the other hand, it is increasingly concerned with the passive use of the spectrum which is threatened by spectrum congestion and unwanted radiation. Here, the work of Commission J is far reaching and the benefits of its efforts are evident. ITU, however, is concerned with the overall use of radio and with finding the most efficient means of utilizing the spectrum; and this in the face of many, varied and growing applications of radio, requiring higher and higher data-rates and greater bandwidth. ITU does not involve itself in research *per se*, but makes use of the radio science and spectrum engineering undertaken by its members and discussed within ITU meetings such as those of its Study Groups.

With this background, therefore, the activities of URSI could well be viewed as complementary to those of ITU.

So, whilst liaison between ITU and URSI exists, it can doubtless be improved. How can this be achieved?

First, it is worthwhile to look at some examples where liaison is successfully carried out today. The last World Radiocommunication Conference responded to the need for spectrum and regulatory provisions to allow the introduction of new systems, in particular those associated with personal communications and wideband applications in the fixed, fixed-satellite and mobile-satellite services. At the same time, the Conference recognised the need for increased allocations to the science services and reacted accordingly. The overall result is that several new frequency bands were allocated, but because of spectrum congestion, none is exclusive. This results in new sharing situations which in turn require appropriate technical provisions if services are to coexist within the same band. Such sharing situations concern a significant proportion of the studies undertaken within the ITU Radiocommunication Sector (ITU-R), where methods and criteria are developed as tools to be used in the planning of shared services. It is in these studies, particularly with regard to the science services, that URSI, through IUCAF, is instrumental in providing expertise and information in ITU-R Study Group 7. Many of the Resolutions adopted by WRC-97 concern protection of these services, probably the most sensitive being that of radio-astronomy. Here, sharing issues involve newly developing systems such as high density fixed systems above 30 GHz and high altitude platform stations at around 47 GHz - these new systems having allocations coinciding with or adjacent to those of the RAS. A further concern of radio-astronomy is the establishment of limits on out-of-band emissions where again IUCAF has been active in studies undertaken in ITU-R Study Group 1. Another important Resolution concerning passive services relates to the future allocation of frequency bands above 71 GHz. In all these examples, radio science issues are prominent and fall into areas in which URSI scientists can play, or are playing, a role in the decision making process of future spectrum usage.

A second example of strong liaison between URSI and ITU is that found in the area of radiowave propagation. There has always been a close affinity between Commissions F and G and the propagation Study Groups of ITU-R (and formerly of the CCIR). The cooperation is healthy and active, with each organisation tending to drive the other. Last autumn was held the 8th Commission F Open Symposium - one of a series of symposia that stretches back over 20 years and which, with increasing success, brings together both the science and engineering aspects of the subject. At the symposium, the frequent reference to ITU-R Recommendations was most striking, with many of the presentations using propagation material developed in ITU-R Study Group 3 as the basis of their studies. Moreover, the thrust of the work was usually towards development and improvement of the material. Here is example, therefore, where ITU-R Study Group 3 can look forward to reaping the fruits of URSI-related work that will be reflected in contributions submitted to ITU meetings.

So, taking these two examples of existing association between the activities of URSI and ITU, what suggestions could be made to ensure that URSI continues and even strengthens its involvement with ITU activities to the benefit of both parties?

Perhaps an immediate response to this question is to promote conferences such as the one we are attending here in Toulouse this week. Past COMMSPHEREs have aimed to bring together experts from the field of radio science and engineering with a view to discussing together current issues of concern in telecommunications. Some of the sessions at General Assemblies of URSI have done likewise. It is clear that the programme of this COMMSPHERE is no exception and will touch on some of today's key issues in radiocommunications - issues which are subject to agenda items at WRC-2000 and issues which are major areas of study in ITU.

In the field of personal communications for example, IMT-2000 (the third generation International Mobile Telecommunication system) is a strategic priority at ITU and is the main activity of ITU-R Study Group 8. But the year 2000 is almost upon us and studies are already looking to the future IMT system that will incorporate increasingly elaborate features, e.g. wideband applications, at faster data rates, all with emphasis on mobile access. There is little doubt that this mobility, or portability, will be in increasing demand - both for classic telephony and also as part of the global information network - and features such as portable, high data rate Internet access are perhaps not far away. At the same time, the implementation of non-GSO satellite systems will enable the "anytime, anywhere" feature of IMT to become a reality.

You also have a session on broadcasting. ITU-R Study Groups 10 and 11 have active programmes for developing specifications for digital TV and digital radio systems, both terrestrial and satellite. The aim is for a single world-wide system in each case but whether this will be realised, is uncertain. At the same time, work is continuing from the previous WRC on the planning of the 12 GHz BSS bands in response to the request for investigating the possibility of increasing the number of channels allotted to a country. Digital radio broadcasting, both terrestrial and by satellite, is now at a trial stage; but digital radio technologies are not confined to the "higher" frequencies since very active studies are also underway to bring digital modulation techniques to HF, MF and LF broadcasting as well.

A reoccurring theme in this week's programme is that of spectrum usage. I have already mentioned sharing studies within ITU-R in relation to new frequency allocations arising from WRC-97 and the possible impact on certain science services. Many other Resolutions from that Conference call for studies to investigate the feasibility of sharing and to establish criteria and coordination procedures to facilitate sharing. For example, one major agenda item of the next Conference involves a revision of the long-standing procedure, contained in Appendix S7 (formerly Appendix 28) of the Radio Regulations, for earth station coordination.

Many such sharing and coordination studies call for considerations of radiowave propagation where the propagation effects of both the wanted signal and the potentially interfering signals must be identified and quantified. An accurate propagation prediction method, appropriate for the frequencies, geometries and systems characteristics of interest, represents an essential component of the overall spectrum management process for assessing the sharing possibility between services. ITU-R Study Group 3 spends much of its time working on such issues in liaison with the other Study Groups representing the various services.

I have mentioned three example topics of ongoing studies in ITU-R - examples which will be the subject of discussions in COMMSPHERE this week. The common theme, encompassing spectrum usage, spectrum efficiency and avoidance of interference in shared situations, represents a significant challenge for the spectrum manager and, with the expected growth in radiocommunications, such problems can only increase, both in number and complexity. To meet the challenge, therefore, it becomes more and more important for all interested parties who can contribute experience and expertise to be involved in the associated technical studies in order to facilitate satisfactory compromise solutions.
In this respect, it is clear that the interests of URSI, and of IUCAF, are already evident in the activities of ITU-R Study Groups 1, 3 and 7, and in the Conferences themselves on issues concerning science services. Perhaps URSI could look to widening its scope of involvement to include other Study Groups and Conference-related activities? It is appreciated that there may be logistic and economic difficulties for URSI to represent itself as a independent Sector Member at ITU meetings. A more practical approach might be for URSI members to be even more involved in national and regional preparations for ITU meetings and, if possible, be part of a Member State's delegation. For such an approach to be effective, URSI representatives should be encouraged to work closely with their national administration in order to gain support for their work. With strong endorsement at the national level, URSI's impact in the international arena will be all the stronger. However, with such an mechanism, the question might arise as to how views expressed in the name of URSI could be coordinated on an international scale.

Another very important consideration towards successful ITU/URSI liaison is the ease of availability of information and in particular documentation. In order for URSI members to contribute to ITU studies, there is a need for them to know of the areas of interest and concern. For example, what ITU Questions exist which define the work programmes of the various Study Groups? What Recommendations correspond to which subject? We at ITU are conscious of the problems encountered by our members in trying to find relevant publications and to understand the documentation system. Our web-site is vast and rich in content but is a bit of a minefield, although if you understand the system, everything can be found there! In the past, there have been attempts to strengthen the information link between the two organisations by way of liaison committees. These identified the topics of concern to the ITU-R Study Groups for which it was felt URSI could make a contribution. This initiative stemmed from the increasing difficulty found by Study Groups in being able to pursue scientific aspects of a topic - aspects which often represented the fundamental basis of an engineering procedure. Unfortunately, these committees met with limited success although they did serve as a focal point of liaison at grass roots level, which is perhaps lacking today. Perhaps the re-establishment of some sort of liaison committee should be reconsidered for the primary purpose of keeping both parties informed on topics of mutual interest.

Summary

Therefore, ITU continues to see URSI as having its major role in supporting and promoting radio science. It is clear that continuing liaison between the two organisations is highly desirable for the well-being of telecommunications in the future. This can be achieved in a number of ways, including the holding of conferences such as COMMSPHERE or the organisation of symposia like those of Commission F, all of which aim to bring together experts from both disciplines. URSI's participation in ITU activities is to be welcomed and can only strengthen the technical fora and help the development of compromise solutions. I use the word "compromise" here on purpose. Although URSI is a scientific body, when dealing with ITU it must be remembered that major international agreements do not always represent the best technical solution, but the best international compromise that can be reached within the framework of existing technology and financial and competitive pressures.

Kevin A. Hughes

ISES Annual Report for 1998

Introduction

The International Space Environment Service (formerly named the International Ursigram and World Days Service IUWDS) is a joint service of URSI, IAU and IUGG and a permanent service of the Federation of Astronomical and Geophysical Data Services (FAGS), provides rapid information to the world community to assist in the planning, coordination and conduct of scientific and other work affected by the sun-earth environment.

Three basic mechanisms have been selected to accomplish this program. Firstly, ISES prepares the International Geophysical Calendar each year. This calendar gives a list of "World Days" which scientists are encouraged to use for carrying out their experiments. The calendar is prepared for ISES by the World Data Center-A for Solar Terrestrial Physics in Boulder, USA. The calendar is distributed widely to the scientific community and is also published in a number of journals.

Secondly, there is the International Ursigram Service for assisting those who need a specific state of solar activity, earth atmosphere or magnetosphere at the time of their experiment. Both programs are very flexible and can be easily adjusted to fit the needs of the scientific community.

Thirdly, ISES arranges Solar Terrestrial Prediction Workshops bringing together scientists, solar terrestrial forecasters, and users of forecasts to advance the science of forecasting. Such workshops were held in Boulder (1979), Meudon near Paris (1984), Leura near Sydney (1989), and Ottawa (1992). Each workshop resulted in a collection of papers - the Workshop Proceedings - being published and becoming important reference material for the field.

In addition, on behalf of COSPAR, each month ISES summarises the status of satellite orbits around the earth and of space probes in the interplanetary medium in the Spacewarn Bulletin.

Future launches are announced, actual launches are reported, new satellites receive an international designation, decays in the earth atmosphere are predicted and announced, and finally series of satellites useful for international participation are listed. This bulletin is produced by the World Data Center-A for Rockets and Satellites at the Goddard Space Flight Center in Greenbelt, USA.

Indications are that the new solar cycle - Cycle Number 23 - will be of large amplitude, comparable to recent near record cycles. This level of activity, combined with the increasing sensitivity of modern technology, emphasises the relevance and importance of the services co-ordinated by ISES.

The International Ursigram Service

The International Ursigram Service operates through a number of Regional Warning Centres (RWC) scattered all around the world. Warning Centres are located in : Beijing (China), Boulder (USA), Moscow (Russia), Paris (France), New Delhi (India), Ottawa (Canada), Prague (Czech Republic), Tokyo (Japan), Sydney (Australia) and Warsaw (Poland).

In its own geographic area, each Regional Warning Centre collects data available concerning the state of the sun-earth environment. In some cases, these come from observatories operated directly by the Regional Warning Centre. In many cases, they are gathered from regional scientific institutes and universities.

These data and reports are coded according to the ISES code book and distributed daily, on request to users and to other Regional Warning Centres. Data exchange is generally via a daily, or more frequent, message sent either by electronic mail or by facsimile transmission. Electronic transfer of data is also used to relay larger image files.

Information transmitted through the ISES network is analysed by Regional Warning Centres which produce a number of "summary" reports and forecasts. The "Geoalert", a forecast of solar-geophysical conditions for the next few days, is a particularly important one of these reports. Each RWC prepares its own forecast ("Geoalert") and sends it to the World Warning Agency (WWA) in Boulder each day. The World Warning Agency then issues a Geoalert which is distributed worldwide each day at 0300 UT through the ISES network.

Publications

The International Geophysical Calendar is distributed free of charge throughout the world. The present distribution is approximately 2000 copies produced at a nominal cost.

The Spacewarn Bulletin is also distributed free of charge throughout the world and the information is now available through an electronic bulletin board system.

The Geoalerts and the abbreviated Calendar records are published monthly in "Solar and Geophysical Data" produced and distributed by World Data Center-A for Solar Terrestrial Physics in Boulder, USA.

The daily Geoalerts and Ursigram messages are "real-time" information and only a summary is printed as the "ISES Alert Periods" in the Solar-Geophysical Data Books published by World Data Center-A. However, the production and distribution of Ursigrams is a very important part of the current expenses of the RWCs. This expense is borne by the host institutions.

The ISES Code Book has been updated and reprinted in a loose leaf format. Further updates occur on a regular basis as new codes are introduced or existing ones are changed. The updates are supplied to the Regional Warning Centres for distribution as required.

Recent ISES Activities

Proceedings of the 1996 Solar Terrestrial Predictions Workshop ISES has sponsored five predictions workshops - Boulder in 1979; Paris in 1984; Sydney in 1989; Ottawa in 1992; and Hitachi Japan in 1996. The purpose of the meetings has been to bring together scientists who study the solar terrestrial environment, forecasters who predict conditions, and the users of forecasts. By getting these people together ISES expects to improve the quality of forecasts and their value to the user community.

The Workshop Proceedings from the last Workshop (Japan 1996) were completed in early 1998 and were distributed to the scientific and user community.

ISES Steering Committee Meeting

A meeting of the ISES Steering Committee was held in conjunction with COSPAR held in Japan during July 1998. A major topic discussed was the future direction that ISES should take. In recent years there have been major changes which increasingly affect its role. Firstly, the dramatic changes in communications, particularly in the use of the Internet and the World Wide Web, has meant that ISES no longer needs to collect solar-terrestrial data to the extent it did in the past - these data are now readily available on the Web for all interested people. Secondly, there has been an equally dramatic increase in the interest of the scientific community in space weather and this has resulted in many more scientific meetings devoted to the topic. This means that, to some extent, there is less need for the the ISES Solar Terrestrial Predictions meetings which were once the only such meetings in the field.

ISES still sees an important role for itself. Being the only organisation linking agencies which are directly involved in space weather forecasting ISES has a unique and important perspective. Experience has shown that scientific understanding does not necessarily bring with it the ability to forecast. ISES can provide advice and feedback on this final and very difficult stage of turning scientific research into support for operational forecasting.

New ISES Chair and Secretary

The two main ISES office bearers are the Chairperson and the Secretary and it was decided to hold an election for these positions. This ballot was concluded by e-mail and the new office holders are:

ISES Chairperson : Katsuhide Marubashi, Communication Research Laboratory, Ministry of Posts and Telecommunications, 2-1, Nukui-Litamachi 4-chome, Koganei-shi, Tokyo 184, JAPAN, kmaru@crl.go.jp

ISES Secretary : Joe Hirman, Space Environment Center, 325 Broadway, Boulder Co 80303 USA, jhirman@sec.noaa.gov

The Next ISES Predictions Meeting

Because of the number of scientific meetings on space weather, ISES will hold a more restricted predictions meetings in 2000. This will be held in Boulder in conjunction with the Space Environment Centre space weather week. Attendance will be mostly limited to those directly involved in space weather forecasting and the meeting will attempt to provide a guide to the scientific community about the needs of forecasters for data and analytical tools.

ISES Home Page on the Web

More information about ISES and its Warning Centres, copies of the ISES code book, and references to the home pages of ISES centres can be found on the Web at: http://www.sec.noaa.gov/ises/

IUCAF Annual Report for 1998

1. Introduction

The Scientific Committee on Frequency Allocations for Radio Astronomy and Space Science, IUCAF, has been formed in 1960 by URSI, IAU and COSPAR. Its brief is to study the requirements of radio frequency allocations for radio astronomy, space science, and remote sensing in order to make these requirements known to the national and international bodies that allocate frequencies. IUCAF operates as a standing committee under the auspices of ICSU, the International Council for Science and is strongly supported by IAU, URSI and COSPAR. ICSU works under the umbrella of the United Nations organisation UNESCO.

As a result of the changes in the statutes of ICSU made during a Special General Assembly in 1998, IUCAF has changed its name in 1998 from Inter-Union Commission to Scientific Committee, while retaining its original acronym. The name of ICSU itself has also changed from International Council for Scientific Unions to International Council for Science.

2. Membership

At the end of 1998 the composition of membership for IUCAF was:

URSI	W.A. Baan, The Netherlands
	R.J. Cohen, United Kingdom
	A. van Eyken, Norway
	W. Keydel, Germany
	P. Poiares Baptista, The Netherlands

	K. Ruf, Germany
	J.B. Whiteoak, Australia
IAU	S. Ananthkrishnan, India
	A.R. Thompson, USA
	M. Ohishi, Japan
	B.A. Doubinsky, Russia
COSPAR	D. Breton, France
	A. Gasiewski USA

Ex Officio Advisers:
Director ITU Radio Bureau : Robert Jones, Canada
Chairman ITU Radio Board : M. Miura, Japan

At the request of Dr. Kentarou Kawaguchi from Nobeyama Radio Observatory, Dr. Masatoshi Ohishi from the National Observatory in Tokyo, Japan, has taken over the responsibilities of IUCAF membership. Dr Ohishi is very active in millimetre-wave molecular line astronomy and has been Co-Chair of the MM Working Group that has been instrumental in preparing the scientific basis for the radio astronomy proposals on the bands above 71 GHz for the WRC-2000. We thank Ken for his contributions to IUCAF in the last years and we wish him well with his work.

IUCAF continues to maintain its network of Correspondents in 35 countries in order to interact with national authorities responsible for radio frequency management.

At the end of 1998, the membership of IUCAF has decided to appoint Dr. Klaus Ruf from the Max Planck Institut for Radioastronomy in Bonn, Germany, as chairman after Dr. Willem Baan had expressed the desire to step down. During 1998 Dr. Baan has taken up the new function as Director of Westerbork Observatory in The Netherlands. Dr. Ruf had already served as secretary for IUCAF during most of 1998 and has extensively participated in national and international activities relating to spectrum management on behalf of the science services. The transition of Chairmanship will take place in the next meeting of IUCAF in Grenoble in January 1999. The secretariat and the Homepage location of IUCAF will move to the MPIfR in early 1999.

3. International meetings

During the period of January to December 1998, IUCAF Members and Correspondents took part in the following meetings:

January :	ITU-R Task Group 1-5 on Unwanted Emissions in Geneva
February :	IUCAF Pre-Meeting at IRAM in Grenoble, France
	ITU-R Working Party 7D in Geneva, Switzerland
April :	Meeting of CRAF, the Committee on Radio Astronomy
	Frequencies of the ESF in Bonn, Germany
July :	ITU-R Task Group 1-5 on Unwanted Emissions in Munich, Germany
	Commsphere Africa in Dakar, Senegal
September :	CEPT Consultation on European Spectrum Policy in Brussels, Belgium
	IUCAF Pre-Meeting at IRAM in Grenoble, France
September/October :	ITU-R Working Party 7D in Geneva, Switzerland
October :	Meeting of CRAF, the Committee on Radio Astronomy Frequencies of the ESF in Strasbourg, France

3.1 IUCAF Meetings

During the year 1998 IUCAF has met two times as a committee with invited guests at Institute Radio Astronomie Millimetric (IRAM) in Grenoble, France. These pre-WP7D meetings were held with the purpose of discussing and focussing on important issues without the interference of other (non-science) interest groups. IUCAF is thankful for the hospitality given by IRAM and its Director, Dr. Michael Grewing.

During international meetings attended by radio scientists in the last few years, caucus meetings under flag of IUCAF have served well to bring together the radio scientists to determine common positions regarding issues in these meetings.

4. Contact with the Unions

IUCAF has kept regular contact with the secretariats of the supporting unions and with the ICSU secretariat. The Unions plays a strong supporting role for IUCAF and the membership is greatly encouraged by their support.

4.1 Relations with IAU

In collaboration with members of IAU Commission 50, IUCAF members assisted in the preparations of IAU Colloquium 196 in Vienna, Austria in July 1999. This conference on "Preserving the Astronomical Skies" will address all issues of pollution related to astronomy including light pollution and the issue of space debris. The topical meeting will be held the week preceding the UNISPACE III conference organised by UNESCO on the "Peaceful Use of Space". Regular contact has been maintained between the General Secretary and the Chairman.

4.2 Relations with URSI – The Commsphere Conferences

Commsphere Africa was held 20-22 July in Dakar, Senegal. At this meeting the IUCAF Chairman presented a general overview of the various scientific uses of the radio spectrum and some of the applications relevant for the continent of Africa. The need for protection of the science bands was clearly relayed. In addition, the talks by Joe Shapira (URSI VP, Israel) and R. Struzak (ITU, Geneva) also re-emphasised the needs for the scientific services.

The meeting was attended by 50 representatives from African telecoms, African government regulators (and some from France), educators, and some satellite operators operating in Africa. The purpose of this meeting was to address the development of telecom infrastructure in Africa, multi-national co-ordination in regional and ITU related

spectrum management issues. In particular, the need for collaboration was addressed extensively and great progress was made in local networking efforts. It has become clear that this Commsphere meeting contributed significantly in this African effort and it is hoped that the African nations can produce a strong common position in the upcoming WRC-2000.

IUCAF members actively participated in the organisation of the next Commsphere meeting to be held from 25 to 28 January, 1999, in Toulouse, France. This URSI meeting will again provide a discussion forum between passive (scientific) spectrum users, government regulators, telecom operators, and manufacturers. It is important that passive spectrum users actively participate in these forums and also contribute papers.

5. Affairs of the International Telecommunication Union

5.1 The ITU-R World Radiocommunication Conference 2000

The World Radiocommunication Conference planned for October November of 1999 has been postponed to the period of 8 May – 2 June 2000 and will be in Istanbul, Turkey. The Agenda Items that relate to Passive Scientific use of the spectrum can be found at the IUCAF Web site. An IUCAF-CRAF-CORF position paper is being produced addressing all these relevant issues. The Agenda of WRC-2000 also sets a large fraction of the agendas for Working Parties 7C, 7D, and Task Group 1/5 as much of the preparatory work for the Conference is done in the ITU-R Study Groups.

5.2 The WRC-2000 Agenda Items Related to Radio Science

- 1.2 Finalise the remaining issues on spurious emission in Appendix S3 for space services,
- 1.4 Consider issues relating to allocations and regulatory aspects related to Res. COM5-16 (40.5 - 42.5 GHz FSS (space-Earth) and others,
- 1.5 Consider regulatory provisions and possible additional frequency allocations for services using High Altitude Platforms taking into account the results of COM5-7,
- 1.6.1 Review the spectrum requirements for the operation of terrestrial IMT-2000 with the view to identify future expansion bands and adjustments to the Table of Allocations,
- 1.9 Take into account the results of ITU-R studies in evaluating the feasibility of an allocation in the space-to-Earth direction to the MSS in a portion of the 1559 - 1567 MHz frequency range, in response to Resolutions 213 and COM5-31,
- 1.10 To consider the results of ITU-R studies in accordance with Resolution COM5-24 (Use of the bands 1525 - 1559 MHz and 1626.5 - 1660.5 MHz by the MSS),
- 1.11 Consider constraints on existing allocations and to consider additional allocations on a worldwide basis for the non-GSO/MSS below 1 GHz, taking into account Res. 214 (Rev WRC-97) and COM5-25 (406 MHz),
- 1.13 On the basis of the results of the studies in accordance with Resolution COM5-18 on the "Use of NGSO (non-geo-stationary-orbit) systems in the FSS in certain frequency bands",
- 1.14 Review the results of the studies on the feasibility of implementing NGSO MSS feeder links in the 15.43 - 15.63 GHz range in accordance with Res. COM5-8,
- 1.15. To consider new allocations to the radio-navigation-satellite service required to support developments in the range from 1 to 6 GHz,
- 1.16 To consider allocation of frequency bands above 71 GHz to the EES (passive) and RAS, taking into account Res. COM5-1,
- 1.17 To consider possible world-wide allocations for the EES (passive) and SR (passive) services in the band 18.6 - 1.8 GHz taking into account the results of the ITU-R studies.

5.3 IUCAF Activities Related to the Agenda Item 1.16 of WRC-2000

The IUCAF MMWave Working Group under chairmen Drs. Phil Jewell (NRAO, USA) and Masatoshi Ohishi (NAO, Japan) has finished its epic evaluation of the needs of radio astronomy at frequencies above 71 GHz and presented this report to WP 7D during its October Meeting (ITU-R WP7D/xxx). This effort was aimed at providing the scientific basis for the request for astronomy allocations of frequency bands as addressed in this crucial WRC-2000 Agenda Item 1.16. This conference will provide the last opportunity for the radio science community to make significant changes in the frequency allocation table above 71 GHz. Such changes are needed in order to reflect the changes in scientific insights that were gained since the current table was adopted at WARC-79. The guiding principles for re-allocation of the RAS bands have been the following: 1) the RAS can share some spectrum with terrestrial services by means of protection zones around the few mmwave observatories, 2) satellite downlinks and aeronautical operations need to be located adjacent to each other at the edges of atmospheric spectral windows, 3) any potentially damaging active operations need to be located in places where they do least damage to passive spectrum use, and 4) all services need to have continued access to the spectrum.

Based on the spectrum requirements in this MMWG document and similar requirements from the remote sensing community a proposal has been produced for the allocation table above 71 GHz. Within Europe, the CEPT Project Team 33 (Chairman Chris van Diepenbeek, The Netherlands) has been very essential in addressing this issue, which resulted in a proposal plan for re-organisation of the bands from 71 GHz to about 300 GHz. This plan has been submitted to WP7D and WP7C for discussion in the Fall meetings nad to the SFCG, the Space Frequency Co-ordination Group, in their September meeting in Kyoto. In addition, co-ordination between WP7C (EES) and WP7D (RAS) participants from the USA, Japan, Australia, and Europe has resulted in further modifications of the proposal.

This issue will be addressed further in the upcoming SG7 meetings and in various personal contacts in order to finalise these proposals in time for the Conference Preparatory Meeting in the Fall of 1999. The current proposals would give the remote sensing community access to bands that are of crucial importance for the studies of the Earth atmosphere and the surface. Similar the RAS will obtain dramatically increases in spectrum shared with terrestrial telecommunication services.

5.4 ITU-R Task Group 1-5 on Unwanted Emissions

The "Spurious Emission" standards contained in Recommendation ITU-R SM.329 have been incorporated into Appendix S3 of the Radio Regulations at WRC-97. The international community will have to wait six years before these "Category A" limits (mostly from the USA and Canada regulations) will be first enforced. It should be noted that these new standards will do very little to help the radio science community in protection from interference. On the other hand, the CEPT countries have put in place standards, which are typically 20-30 dB more stringent than the ITU-R standards.

At WRC-97 the Recommendation 66 was also modified to allow the new Task Group 1-5 to do its work on "Unwanted Emissions", which includes the unsolved issues on spurious emissions as well as the out-of-band emissions. IUCAF members have been playing a leading role in the ongoing work of Task Group 1-5, providing many input papers and the chairmen of large and critical drafting groups. IUCAF has considered TG 1-5 and its work very important for radio science and both TG 1-5 meetings in 1999 had some six radio astronomy participants from various countries. The important issues for the first two meetings of TG1-5 have been 1) setting the Space Service Limits that have only been "design limits" since WRC-97 and the preparation of CPM text, 2) revising Recommendation ITU-R SM.329 in order to also include limits for out-of-band emission, 3) revising the SM.328 on out-of-band emissions and better define the boundary conditions between spurious and OOB, and 4) defining protection procedures for the safety and passive services.

Although Recommendation 66 was initially meant to promote the study of new standards for unwanted emissions in order to protect the passive services, this part of the objective has been pushed back further and further into the background. It became clear already in the proceedings of TG 1-3, that the tighter standards would be burdensome for the Space Services and would cost much money to implement. Since then the Space Service operators, particularly from the USA and Canada, have led the effort to resist any tighter emission standards in Task Group 1-5. The CEPT countries in collaboration with the European space operators and equipment manufacturers have been very willing to establish standards for terrestrial and space operations that are meaningful. The effort of the USA has been to establish very lenient "safety net" standards as general standards and consider other state-of-the-art standards (as from CEPT) as special cases. This USA position has severely limited the viability of the TG 1-5 effort and is degrading the eventual outcome.

As a result of this Space Services effort the protection of the passive services and of the safety services have been relegated to a special case as well. In particular, the radio astronomy protection levels are very difficult to meet for the space operations. A Canadian proposal in tune with the wishes of the space services community has suggested that radio astronomy bands be considered on a "band-by-band" basis. Rather than having general limits that would benefit all spectrum users by reducing unwanted emissions as intended by Rec. 66, this proposal will only protect the radio science bands to a level that is practical for the interfering service. Such protection may not even meet the required criteria of the radio science bands.

Despite the goodwill of the IUCAF and RAS participants, the protection of the radio science bands will remain in jeopardy because of the burden it presents particularly for the space operators. In the meantime, the terminology of the discussions has changed as well. In general, spectrum sharing has been used to describe the situation where two equal spectrum occupants share the spectrum. Now the word sharing is also used to describe the situation, where a primary user needs to share the spectrum with a neighbour that is polluting its spectrum because of unwanted emissions. This would imply that bad engineering has turned into a right to invade a neighbour's spectrum.

5.5 ITU-R Working Parties 7D and 7C

Working Party 7D meets twice a year and deals with ongoing radio astronomy spectrum studies within the ITU-R. The radio astronomers working in WP7D maintain the liaison with other Study Groups such as those of the Space Services in SG 4 and 8. WP7D provides a forum to put forth ideas and standards on protection for the radio astronomy service, while WP7C addresses the issues of the remote sensing community. Some twelve to fourteen radio scientists participated in both WP7D meetings of which six were IUCAF members.

A major effort for Study Group 7 has been the preparation of the guidance text on all relevant issue to be included in the Report for the Conference Preparatory Meeting for WRC-2000. CPM text has been produced on the following major issues:

a) the use by the Fixed Satellite Service of the 42.5-43.5 GHz band, which is adjacent to an important RAS band (Item 1.4 & Resolution 128),
b) the use of the 48 GHz band by High Altitude Platforms above major metro areas for high density (broad band) applications (Item 1.5 & Resolution 122),
c) the use of the 1626.5-1660.5 MHz band usage by the Mobile Satellite Service (Item 1.10 & Res. 218). This concerns a revision of text and application of Recommendation ITU-R M.1316 "Principles and methodology for frequency sharing in the 1610.6-1613.8 and 1660-1660.5 MHz bands between the MSS (Earth-to-Space) and the RA service",
d) the re-allocation of bands below 1 GHz Item 1.11 (Res. 214 and 219),

e) the creation of a global allocation for the Earth Exploration Satellite Service in the 18 GHz band as contained in Item 1.17,
f) the mmwave radio spectrum for the EES and the RAS above 71 GHz (Item 1.16 & Res. 723), and
g) Item 1.2 relating to Recommendation 66 and Unwanted Emissions as part of the work of Task Group 1-5 (see section 4.5.1 above).

Other important issues within WP7D during 1999 have been:

a) the "10 percent issue", relating to the amount of time that can be lost to man-made interference,
b) the use of Monte Carlo methods for the determination of co-ordination distances between mobile spectrum users and radio astronomy observatories, and
c) the use of the bands 1390-1400 MHz and 1427-1432 MHz by the Mobile Satellite Service and the interference to the RAS in the 1400-1427 MHz band, which may become a WRC item in the future.

5.6 Specific Spectrum Issues

5.6.1 The Particular Case of the RAS 15.4-15.6 GHz Band

Resolution 123 of WRC97 asks for studies of the feasibility of feeder links for NGSO satellites in the Mobile Satellite Service (Space to Earth) in the frequency band 15.43 - 15.63 GHz taking account of the protection requirements of radio astronomy in the band 15.35 - 15.4 GHz, and of the interference potential of these feeder links to radio astronomy in the 15GHz band.

A satellite down link band, FSS (space-to-Earth) 15.4 - 15.7 GHz has been inserted into the table of frequency allocations by the WRC95. In order to protect the passive RAS band 15.35 - 15.4 GHz the footnote S5.511A has been inserted which limits the power flux density of the satellite transmissions and requests the interference threshold levels of Recommendation ITU-R RA.769 to be obeyed in the neighbouring band. Later studies within the ITU-R have concluded that an Fixed Satellite Service allocation would not be useful under these constraints. Therefore WRC97 introduced guard bands, but relaxed the pfd-limits. Additionally the uplink direction FSS (Earth-to-space) was introduced into the band 15.43 - 15.63 GHz and Resolution 123 was adopted.

In July 1998 a joint expert group of working parties 4A and 7C met at Toulouse, France, to discuss Res.123. Only one input document, from IUCAF, had been submitted. Additionally the UK presented a preliminary calculation during the discussion. The conclusions of both written and verbal inputs was that it would be very difficult for the FSS to include enough filtering to suppress the out-of-band emissions sufficiently to protect radio astronomy. In addition, it would be also very difficult for radio astronomy stations to include enough filtering to prevent overload by the satellite transmissions in the nearby band, when a satellite comes close to the main beam of a radio telescope. The meeting therefore followed, unanimously, the view of the IUCAF paper that the problem be best avoided by removing the FSS (space-to-Earth) allocation from the Radio Regulations. This conclusion has been brought to the attention of ITU-R Working Parties 4A and 7D, which met in Fall 1998. The latter is tasked by the CPM to co-ordinate the studies and to provide text for the CPM report.

5.6.2 Mobile Satellite Services

IRIDIUM has kept radio astronomy frequency protectors busy since 1992. Shortly before IRIDIUM's delayed initiation of commercial operation on November 1, 1998, a stable situation had developed that the IRIDIUM system had been issued licenses in most countries, subject to the requirement to protect radio astronomy in the nearby frequency band.

IRIDIUM offers to provide world-wide telephone (and fax and data transmission) service via a fleet of 66 low-Earth-orbit satellites. Unfortunately, these satellites use frequencies in the band 1621.35 - 1626.5 MHz to connect to the mobile Earth stations with both uplinks and downlinks. However, the current generation of satellites has been designed such that unwanted emissions spill over into the nearby Hydroxyl OH frequency band 1610.6 - 1613.8 MHz, which will reach unacceptable levels at already moderate traffic loads on the system.

A major effort has been ongoing in Europe order to come to a mutually agreeable solution for the radio astronomy community. Given the geographical fragmentation in Europe, it was felt that co-ordinating satellite downlink transmissions can only be done in a Europe-wide manner. For this purpose the Milestone Review Committee (MRC) was set up by the European Radio Committee ERC to evaluate the progress of the applying systems against commercial, technical, and compatibility criteria. Earlier work in Project Team 28 of the ERC spectrum engineering working group had not lead to generally accepted conclusions. The co-ordination process culminated in MRC Recommendation No. 04 giving surprisingly clear guidelines to the European administrations. MRC Recommendation No. 04 asks for a co-ordination agreement between IRIDIUM and Committee on Radio Astronomy Frequencies (sponsored by the European Science Foundation) has been very difficult to reach and at the end of 1998 it only covers the short-term and the long-term perspective. This agreement stipulates that until March 1, 1999 and after January 1, 2006, the IRIDIUM satellites will have to limit their out-of-band emissions into the radio astronomy band to below the threshold levels of ITU-R Recommendation RA.769-1. Discussions about time sharing parameters for the interim period from March 1, 1999 until December 31, 2005 are underway between IRIDIUM and CRAF. IUCAF has played a supporting role in all these negotiations

Other mobile satellite systems making use of this same MSS frequency allocation have avoided the complication of satellite downlink transmissions adjacent to the RAS band by putting the uplink at another frequency. GLOBALSTAR, which is planning to launch its service shortly, will use frequencies in the 2483.5 - 2500 MHz band for its satellite downlink. In this case the radio astronomy operations and the mobile uplink operations need to be co-ordinated geographically. Discussions about co-ordination zones around radio telescopes have started in some countries

but have not yet been directed to IUCAF or CRAF. It is expected that the necessary co-ordination radius for uplink systems co-sharing with the RAS will be much larger than the exclusion zones for IRIDIUM mobile Earth stations.

5.6.3 The Earth Exploration Satellite Band at 18.6-18.8 GHz

The 18.6-18.8 GHz band is used by Earth Exploration satellites to measure with scanning microwave radiometers a number of geophysical parameters: precipitation over ocean and land, ice concentration, type and temperature, liquid water content, snow extent, land surface temperature, etc. These parameters are derived by combining and interpolating the measurements done at 18.6-18.8 GHz with those done at other key frequencies (around 6.8 GHz, 10.6 GHz, 23.8 GHz, 36.5 GHz and 89 GHz) from the same instruments. The use of this type of sensor is extremely important to meteorology and climatology activities. These microwave instruments present the important characteristic of not being affected by cloud cover, as is the case for the instruments working in the infrared range.

The current ITU allocations in the band 18.6-18.8 are primary allocations to Fixed Satellite Service (FSS) and Fixed Service (terrestrial; FS) systems world-wide and, in region 2 (The Americas) only, a primary allocation to EESS (passive). Two footnotes invite all administrations to take into account the need for passive EESS measurements in the band by limiting radiated and output power (for FS) and power flux density (for FSS).

At the moment only a limited amount of FS systems are active, leading to limited and acceptable interference to the EESS, but the situation will degrade rapidly in the near future when more FS systems will become active and new high power Ka-band geostationary FSS systems will start to operate. While one may count on power and pfd limits imposed by FCC for the US, nothing similar has happened in Europe, with total disregard of the ITU footnotes. An attempt to extend the US limits to the other ITU regions failed at WRC-97 because of the strong European and Japanese opposition. The item will now be reported to WRC 2000. Compromise values have now been proposed, but, despite ad-hoc meeting by ITU in July this year, the solution seems to be still very far.

6. Publications and reports

IUCAF has contributed a number of documents to the proceedings of Task Group 1-5 and Study Group 7. These documents have all appeared on the ITU-R Home Page and have not all been distributed by email. As a result there was less need to post these documents on the IUCAF Home Page. Information about IUCAF documents and meeting reports is generally available on the IUCAF Home Page and has been distributed by email to the general IUCAF electronic mailing list.

7. Organisational matters

The need to be present at critical spectral meetings remains very strong for the radio science community, because not all parties look out for the well-being of scientific use of the spectrum when decisions are made. The radio scientists are often outnumbered by other participants with strongly opposing views. With only two professional spectrum managers, the radio astronomy community is particularly vulnerable and a global division of tasks among IUCAF members and correspondents has been instituted. Since co-ordination problems are becoming more global, IUCAF has an important role to play in unifying the efforts to protect the bands allocated for passive and active scientific use. Such global efforts require an increased travel budget and the continued support of ICSU, URSI, IAU, and COSPAR is essential.

Generous support from URSI, IAU, and COSPAR has enabled IUCAF to provide travel support to its Members and Correspondents to ensure adequate participation at important conferences. During 1998 IUCAF has been able to participate actively in meetings of the ITU Radiocommunication Sector, the meetings of ITU-R Task Group 1-5, and SFCG-18 of the Space Frequency Co-ordination Group. IUCAF Members and Correspondents have obtained considerable financial support for travel from their home institutions. ICSU has also awarded IUCAF with a grant for support of travel. The purpose of this grant was to stimulate the participation of scientists from developing countries in international spectrum meetings and for addressing issues related to preserving bands used by radio scientists in those countries.

During 1998 the business of the IUCAF Secretariat has been conducted from the Arecibo Observatory at Arecibo, Puerto Rico (USA), which is part of the National Astronomy and Ionosphere Centre (NAIC) and is based at Cornell University in Ithaca, New York (USA), and from the Westerbork Observatory, which is part of the Netherlands Foundation for Research in Astronomy (NFRA), based in Dwingeloo (The Netherlands). IUCAF thanks NAIC and NFRA for providing secretarial support and access to all means of electronic communication for partial travel support for the Chairman.

Starting February 1999, the IUCAF secretariat will be hosted by the Max Planck Institut fur Radioastronomie in Bonn, Germany.

8. Conclusion

The pressure for commercial spectrum applications has remained steady and intense during recent years. In order to obtain access to large bandwidths the commercial applications are now calling for spectrum up to the edge of the atmospheric window at 60 GHz. These applications mostly relate to high density (and wide band) applications such as Internet from the sky or from stratospheric (aerostat) platforms located above major cities, and as terrestrial wide-area distribution systems. This drive for spectrum results in part from the desire to be first in the targeted market. In addition, the technology for operating at these high frequencies is now becoming commercially available, in part as a result of the pioneering work of the radio astronomers and Earth exploration scientists. In this regard it is of extreme importance that the band allocations above 71 GHz are being considered at WRC-2000. This will indeed be the last chance for the radio science community to change things in that part of the spectrum. It is good to

see that IUCAF has been able to take up a central role in the preparations for this Agenda Item at WRC-2000.

In recent years it has also become clear that the commercial markets will not be able to support so many system. For instance, close to one hundred satellite systems have been announced at the ITU to provide broad band (Internet-like) services. In the space application sector, there is also the concept of "paper satellites". These systems have been announced at the ITU to operate in certain spectrum bands but they exist only on paper to reserve a place for the future and have no adequate funding. In particular for the geo-stationary orbits, there are many more satellites than orbital slots. Although this situation appears grim for the radio scientists, it is likely that most of these applications and that many ventures will fail. It could very well be that systems, that raise concerns for the radio astronomers at this time, may not become commercial successes at all.

The protection levels for harmful interference continue to be difficult to meet by active spectrum users. Task Group 1-5 has continued its efforts to set sensible thresholds for unwanted but has not been able to convince certain administrations that this would be in the benefit of all spectrum users. Special interest groups, such as the USA space community, have lobbied strongly against any global standards that are any tighter than the current standards. Rather than alleviating some of the interference problems of the passive services and of the safety services through general standards, TG 1-5 has been forced to choose for non-state-of-the-art standards and for making the needs of the vulnerable services into a special case. A growing number of administrations has recognised the needs of the science services and is committed to help their cause. On the other hand, many consider the radio scientist and their needs a great nuisance. IUCAF remains committed to the work of Task Group 1-5 and is thankful for the support that is received from many sympathetic administrations.

Members and correspondents of IUCAF have continued to support and initiate efforts to bring the radio spectrum pollution issue to the highest governmental offices. Recently the OECD Mega-Science Forum on Radio Astronomy has also addressed these issues and appears successful to bring them to the attention of government officials of OECD countries and leaders of the telecommunication industry. IUCAF continues to supports this effort and hopes that this will lead to increased recognition of the global issues facing the scientific community.

IUCAF members and correspondents clearly have their plate full of spectrum issues relevant to radio science. Many existing spectrum issues have remained and the interference problems continue to expand to higher frequencies. IUCAF will continue to emphasise the message of protecting the radio science for future generations. In particular, the need for expounding on the relevance of such efforts in developing countries and for expanding personal contacts there remain urgent for the coming years. Also the satellite down-link issues will continue to draw attention.

IUCAF is thankful for the moral and financial support that has been given for these continuing efforts by ICSU, IAU, URSI, and COSPAR during the recent years. IUCAF also recognises the clear support that has been given by radio astronomy observatories and universities to individual members in order to participate in the work of IUCAF.

On a personal note, the former chairman would like to praise the members and correspondents of IUCAF for their help and support. It has been very rewarding and an honour to work with this group.

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SCOSTEP 1996-1998

This report on the activities of SCOSTEP (Scientific Committee for Solar-Terrestrial Physics) is based on information distributed among the SCOSTEP Bureau members by J. H. Allen, the Scientific Secretary of SCOSTEP, and results of the two Bureau Meetings held in 1997 in Uppsala, Sweden and in 1998 in Chung-Li, Taiwan. My participation in those meetings was made possible thanks to the financial support of URSI, SCOSTEP and my parent institution, Space Research Center, PAS. Details of meetings have been already reported to the URSI Secretariat. SCOSTEP is the scientific committee of ICSU since 1978 with the following principal tasks: 1. to promote international interdisciplinary programs in solar-terrestrial physics, and to organize and coordinate such programs of interest to and approved by at least two of the Participating Bodies, 2. to coordinate and sponsor of symposia in solar-terrestrial physics. The Participating Bodies are COSPAR, IAMAP, IAGA, IAU, IUPAP, and URSI, which have their representatives on the SCOSTEP's Bureau. The General Council consists of representatives from 29 subscribing Adherents. To provide the expertise in various disciplines SCOSTEP chooses Scientific Discipline Representatives, currently 41 scientists from 21 countries.

In 1997 the major SCOSTEP Solar-Terrestrial Energy Program (STEP) ended. Originally planned for 1990-1995, it has been extended until 1997. Its history is marked with numerous satellite, rocket and ground-based experiments and observations conducted all over the world. It has resulted in a substantial improvement of our understanding of energy production, transfer, storage, and dissipation through the solar-terrestrial environment. STEP results have been summarized at the 9th Quadrennial Solar-Terrestrial Physics (STP) Symposium held in August 1997 in Uppsala, Sweden. This week-long meeting attracted over 300 participants. Tutorials and review talks have been published in a special issue of the Journal of Atmospheric and Solar-Terrestrial Physics (volume 61, No. 1-2, January 1999).

The 10th Quadrennial STP Symposium will be held in 2001. At present the location, host for the meeting, and organizer(s) are not identified.

In order to make efficient use of data collected during STEP, and of new data supplied by STEP-related satellites and ground-based instruments, as well as to pursue interdisciplinary activity, SCOSTEP has launched four new post-STEP programs. All programs started in 1998 and will continue until 2002.

A. STEP Results, Applications and Modeling Phase (SRAMP) which will emphasize use of data taken from 1990 through 1997, by STEP projects. The main scientific objective of SRAMP is to study, by data analysis and modeling, the coupling mechanisms between the various regions of the sun-geospace system. SRAMP should be of particular interest to the URSI Commissions E, F, G, H, and J.
B. Planetary Scale Mesopause Observing System (PSMOS) will concentrate on determination of the large-scale dynamics of the mesopause region, determination of the zonally average temperature trend, and study of the gravity waves characteristics. It has a strong connection to the objectives of the URSI Joint Working Group GF.1 "Middle Atmosphere".
C. Equatorial Processes Including Coupling (EPIC) will address the crucial problems of the dynamical, electrodynamical and chemical coupling in the equatorial atmosphere and ionosphere. The program should be of interest to Commissions F, G and H.
D. International Solar Cycle Studies (ISCS) will conduct research toward understanding the underlying and resulting processes associated with the rising and maximum phase of a solar cycle. This program is probably least related to the URSI objectives, although its results should be of interest to Commissions F, G and H.

Each of the programs has one or more websites on WWW. SCOSTEP, through the Working Group of SRAMP, is coordinating international efforts in the Space Weather area. The interest and activity in this area is rapidly increasing. The Working Group established Space Weather website which serves as a self-contained site and also provides an efficient access to other sites devoted to the topic. The Space Weather is of interest to the URSI Commissions E, F, G, H and J.

SCOSTEP pays a lot of attention to properly and competently inform the science administrators, agencies, and general public about its activities. The STEP International Coordinator has done an excellent job in promoting solar-terrestrial physics in the developed and developing countries. SCOSTEP actively encourages participation of the developing countries in its international programs and is involved in the ICSU program Capacity Building in Science.

With the financial aid from several participating countries SCOSTEP Secretariat issues a quarterly "International SCOSTEP Newsletter" (until December 1997 "International STEP Newsletter") which is mailed to some 4 000 persons worldwide. STEP Handbooks series become popular reference works among the solar-terrestrial physics community. SCOSTEP Secretariat maintains an extensive website at the address: http://www.ngdc.noaa.gov/stp/SCOSTEP/ with links to related homepages.

SCOSTEP organizes and co-sponsors a great number of international scientific meetings each year. In 1996-1999 SCOSTEP has financially supported the following meetings co-sponsored by URSI:

School on Atmospheric Radar and 8th MST Radar Workshop, 10-20 December 1997, Tirupati/Gadanki/ Bangalore, India.

International Workshop on Radio Methods for Studying Turbulence, 9-12 August 1999, Urbana, IL, USA.

With the adoption of post-STEP Programs for 1998-2002, SCOSTEP is actively moving into the new millennium. When these programs are ended, it will be very important to have a well-defined long-term program. The SCOSTEP Bureau has formed a special sub-group which will look into its long-term future. It will consider SCOSTEP future goals, its unique role as the only international body solely devoted to the solar-terrestrial physics, as the initiator and co-ordinator of interdisciplinary, international scientific programs, as the promoter of science in general, and solar-terrestrial relationship studies in particular. The sub-group will present a report at the next Bureau meeting in UK, July 1999. At the same time, at the General Meeting of SCOSTEP, a new President and Vice-President will be elected.

Andrzej W. Wernik
URSI Representative on
SCOSTEP Bureau

S-RAMP 1996-1998

The Scientific Committee for Solar-Terrestrial Physics (SCOSTEP) is the parent body which helped to organize the Solar Terrestrial Energy Program (STEP), a seven-year program which ended in December 1997. SCOSTEP, during its 9th Quadrennial Symposium at Uppsala in August 1997, organized review sessions in the discipline areas of the six Working Groups of the STEP Program to document the progress achieved during the time period covering this multidisciplinary program. A special issue of the Journal of Atmospheric and Solar-Terrestrial Physics was published in January 1999 containing a selection of the reviews presented at that meeting.

At this Uppsala Meeting, SCOSTEP launched four post-STEP programs for the period 1998-2002. These programs are the following: S-RAMP (STEP-Results, Applications, and Modeling Phase), PSMOS (Planetary Scale Mesopause Observing System), EPIC (Equatorial Processes Including Coupling), and ISCS (International Solar Cycle Studies). The symbiotic connections between them have led to the establishment of both formal and informal links. For instance, S-RAMP considered the main "heir" to the STEP program has the Chairs of the other three programs represented on its Steering Committee (SC).

Dan Baker (baker@lynx.colorado.edu) chairs the S-RAMP SC whose membership includes the author of this report. The broadest S-RAMP program objective is to facilitate and enable the detailed study and understanding of the coupling mechanisms between regions of the Sun-Earth system via effective transfer of data and information and feedback between the experimental, theoretical, and computer modeling communities. Notably, S-RAMP plans to lead the International Space Weather effort. STEP projects, which are as yet incomplete, will be finalized under the auspices of S-RAMP. The S-RAMP web page is currently under preparation.

PSMOS is intended to extend our understanding of dynamical processes in the atmosphere, particularly as they relate to atmospheric variability, to long-term trends, and to the improvement of models. PSMOS SC co-chairs Gordon Shepherd (gordon@windii.yorku.ca) and Maura Hagan (hagan@ncar.ucar.edu) provide details about the project via the PSMOS home page (http://www.cress.yorku.ca/~gordon/psmosweb.htm).

The broad scientific objective of EPIC is to understand equatorial processes occurring in the middle atmosphere and upper atmosphere/ionosphere on all spatial and temporal scales. The EPIC purview also includes studies of vertical coupling with regions above and below the middle and upper atmosphere as well as horizontal coupling with the atmosphere/ionosphere at extratropical latitudes. The EPIC SC is chaired by Shoichiro Fukao (fukao@kurasc.kyoto-u.ac.jp).

ISCS aims at understanding of the solar processes during the rising and maximum phases of the upcoming 23rd solar cycle and their effects on the interplanetary environment. Working groups for studies of Solar Energy Flux, Solar Magnetic Field Variability, and Solar Emissions have been established. Anyone interested in participating in these studies should contact S. T. Wu (wus@cspar.uah.edu).

An important part of the S-RAMP activity is to coordinate the international space weather effort as mentioned above. At the Uppsala meeting, a Space Weather Working Group of S-RAMP was set-up with H. Koskinen of Finland as Chair. A meeting of this Space Weather Working Group was convened at the COSPAR General Assembly in Nagoya, Japan in July 1998 to discuss future activities. J. Kozyra, a member of that Working Group reported on the new International Space Weather Clearninghouse web site established at the University of Michigan (URL: http://aoss.engin.umich.edu/intl_space_weather/sramp/).

The American Geophysical Union's fifth Western Pacific Geophysics Meeting was held in Taipei, Taiwan, in July 1998 after the COSPAR Meeting. A special session there involved presentations on space weather programs in

the US, Japan, Taiwan, Korea, Canada and Australia by scientists representing those countries. The S-RAMP Steering Committee met in Taipei and identified the especially active solar period of April-May 1998 as a "Special Study Interval". The Committee encourages scientists involved in all aspects of solar physics, interplanetary and magnetosphere physics, upper atmosphere and middle atmosphere physics, and Space Weather topics to concentrate on phenomena recorded by the extensive array of satellites and ground-based facilities operating at this time.

The Committee also approved the idea of organizing the First S-RAMP Space Weather Campaign for the fall of 1999 (now set for September 1999). The period 6-24 September 1999 is listed as an alert interval in the 1999 Incoherent Scatter Radar World Day Calendar (http://www.eiscat.no/URSI_ISWG/) with a three-day floating period to be chosen based on magnetic activity. The objective of this campaign is to study the effects of space weather disturbances on the coupled magnetosphere-ionosphere-thermosphere system on a global scale including the impacts on technological systems such as electric power grids, satellites, and ground or space based communication and navigation systems. In order to better understand the physical processes, as well as to provide a quantitative assessment of the effects on technological systems, the campaign will also include observations from other global arrays of radio, optical and magnetic instruments. The coordinators of these activities are P. Wilkinson of Australia and D. Boteler of Canada. An effort will be made to have efficient communications of activity alerts, information about observations, and electronic transfer of data and images worldwide. Special effort will be made to see that scientists in developing countries have good access to data in a timely manner.

Further plans for the 1999 Fall Campaign will be discussed at an S-RAMP Steering Committee Meeting to be held in conjunction with the Spring AGU Meeting in Boston in June 1999 and at International meetings such as IUGG and URSI in July and August 1999 respectively. The First S-RAMP Conference will be organized in Sapporo, Japan during 2-6 October 2000.

Dr. Sunanda Basu
URSI Representative on S-RAMP

The Impact of Signal Processing on an Efficient Use of the Spectrum

P. Delogne
M. Bellanger

The radio spectrum is a limited resource shared by various types of services, for some of which the allocation of frequencies was decided several decades ago. Since then, a lot of progress has been accomplished in electronics and, with the processing power offered by present technology and the advances in algorithms, more and more sophisticated functions can be efficiently and accurately performed. As a consequence, a much more efficient use of the spectrum can be contemplated. A typical example to illustrate the impact of signal processing is the OFDM technique, which permits the broadcasting of more programs in radio and television terrestrial channels, allows for a better reuse of the spectrum and has the potential to exploit poor quality frequency bands to transmit high data rates.

1 - Introduction

The radio spectrum is exploited for communications, television and audio broadcasting, localisation and navigation. In the total usable bandwidth, which stretches from a few Hertz to a 100 GHz, the most useful part is located below a few GHz and it is poorly exploited, particularly by television services. In fact, the allocations of bandwidths to a number of services were agreed at a time, when the technology was essentially analog and very limited processing was possible.

For example, the analog television signal is highly redundant and it can be efficiently compressed. Moreover, in the terrestrial broadcasting process, in order to make sure that the programs could reach all the viewers with minor interferences, different channels have been allocated to neighbouring geographical areas. The result is a highly unefficient use of the best part of the radio spectrum.

During the last three decades, the digital revolution took place. Digital techniques have progressively replaced analog techniques in many areas, among which consumer electronics, communications and defence systems. The driving force is the economy due to the progress of integrated circuits, the improved flexibility and adaptivity, and the potential to optimize the exploitation of the available resources, among which the radio spectrum.

Globally, the advances in digital signal processing follow the general Moore's law for microelectronics. The processing capacity doubles every two years. At present, single chip processors are able to support sampling rates up to 200 MHz and perform over one billion arithmetic operations per second. This processing power has been applied to the digital compression of the most familiar signals, speech, sound and images, and a wide range of standards are now available. Roughly, speech and sound can be compressed by a factor 10, while television signals can be compressed by factors up to 100 [1].

As concerns transmission and broadcasting, frequency bandwidths can be split, the channels can be accurately separated and equalised, jammers can be rejected and interferences can be cancelled. Moreover, optimal detection can be performed, in connection with powerful error detection and correction methods. The consequence is that, in any given bandwidth, the theoretical transmission capacity limit can be closely approached and single-frequency networks can be implemented for broadcasting.

In this paper, the technique retained for digital terrestrial television broadcasting, namely OFDM, is presented in section 4 [2]. We will also devote some attention to the effect of multipath propagation. But, before, two fundamental aspects are discussed. The analog-digital interface is essential, because it controls the frequency domain in which digital techniques can be applied and programmable receivers can be designed. In fact, software programmable and configurable receivers and emitters are a key to a flexible, adaptive and optimal use of the spectrum. Another fundamental concept is the information capacity of a channel, discussed in section 3, which is the reference to assess the performance of transmission techniques [3].

2 - The digital - Analog Interface

An emitter or a receiver is connected to the communication channel through an analog front end, which performs the analog-to-digital conversion or digital-to-analog conversion, the frequency shift between the baseband and the frequency band occupied in the radio spectrum, and the necessary filtering and amplification. The block diagram of a receiver is shown in figure 1.

The performance of the analog front end, in terms of distortion, noise and resolution, is limited by the technology.

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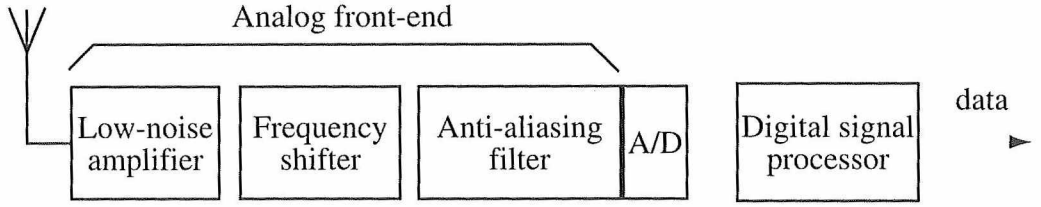

Figure 1 : Analog front end in a conventional receiver

Moreover, it has very limited flexibility and no adaptivity. Therefore it is desirable to place the A/D and D/A conversions as close as possible to the antenna, which implies that the highest possible sampling frequency must be sought.

For real signals, the useful bandwidth, where digital signal processing can be applied, is less than half the sampling frequency. However, when the analog front end delivers a complex signal, with in-phase and quadrature components, the useful band equals the sampling frequency f_S. The second most important parameter in the interface is the accuracy of the A/D conversion, expressed in bits. The number of bits controls the quantisation distorsion introduced by the converter, which is also depending on the probability distribution of the signal magnitudes. For a Gaussian signal, the maximum value of the signal-to-quantisation distortion is

$$SNR = 6.02 \quad N - 8.24 \qquad \text{(dB)} \qquad (1)$$

where N is the number of bits and the signal is assumed to have a peak factor of 13 dB. Another useful parameter for receivers is the so-called spurious free dynamic range, *SFDR*, associated with sinusoidal inputs. It satisfies the following inequality

$$SFDR < 6N \qquad \text{(dB)} \qquad (2)$$

With the present state of technology, typical nominal values for A/D converters are the following:

$$f_S = 60 \text{ MHz} \qquad N = 14 \text{ bits}$$
$$f_S = 1000 \text{ MHz} \qquad N = 8 \text{ bits}$$

As a consequence, digital signal processing can be performed with high accuracy on signal bandwidths up to 60 MHz and with moderate accuracy up to 1 GHz.

It is worth pointing out that the actual performance may be well below the nominal figures, due to the distortion and noise introduced by the analog section of the A/D converter. The loss in *SNR* generally increases with the frequency of the input signal and it can reach several decibels at the high end of the spectrum. The D/A converter is simpler to implement and it exhibits higher performance, in both speed and accuracy.

3 - Channel capacity

A transmission channel is characterised by its bandwidth B and noise power N. Assuming the noise is white and Gaussian, the capacity of the channel, defined as the maximum number of bits of information it can transmit per second, is expressed by

$$C = B \log_2 \left[1 + \frac{S}{N} \right] \qquad (3)$$

For practical use of this theoretical result, a number of considerations have to be taken into account. First, equation (3) assumes perfect coding and infinite delay. In practice, the coding power as well as the delay are limited and a bit error rate must be specified. A number of coding techniques are now available: convolutional codes, block codes and the recently proposed turbo codes.

Second, the channel is assumed to be distortion free. If it is not the case, an equaliser must be introduced in the receiver to correct the frequency response. Digital processing techniques are very good at performing this task and different structures and algorithms have been worked out to cope with all sorts of situations. It must be emphasized that the introduction of equalisers is not without penalty, because it generally increases the noise power and degrades the performance in that respect. Great care must be exercised in the design of these devices.

In equation (3), it is the signal to noise ratio which is involved, which implies that the signal amplitude can take on the maximum value the channel and the signal processing algorithms can bear, without introducing non linear distortion. In fact, it is the dynamic range of the signal which counts, particularly regarding the number of bits required in the implementation of algorithms. At the input, the data often are complex numbers which form the so-called constellations, when represented in the complex plane. From an information transmission perspective, all the input numbers are considered to have the same probability of occurrence and, therefore, the signal power is the average of the powers generated by the points in the constellation. A peak factor has to be introduced on top of the dynamic range of the channel and the shape of the constellation must be chosen to minimise its value.

If the signal bandwidth is large, the assumption of either flat channel frequency response or white additive noise is likely not to be valid any more, and an alternative form of the channel capacity formula has to be considered. The following equation is frequently proposed

$$C = \int_{f_1}^{f_2} \log_2 \left[1 + \frac{\gamma_s(f)}{\gamma_N(f)} \right] df \qquad (4)$$

where $\gamma_S(f)$ and $\gamma_N(f)$ are the power spectrum densities of the signal and noise, respectively.

In order to cope with this situation of a varying signal-to-noise ratio across the usable bandwidth, the equation above suggests that the channel be split into a large number of independent sub-channels and, in each subchannel, the bit rate be adjusted to the relevant signal to noise ratio. From a signal processing view point, this approach is very appealing, since the dynamic ranges in the subchannels are hereby considerably reduced, and simple equalisers might be sufficient. This principle is achieved by multicarrier techniques, as shown in figure 2.

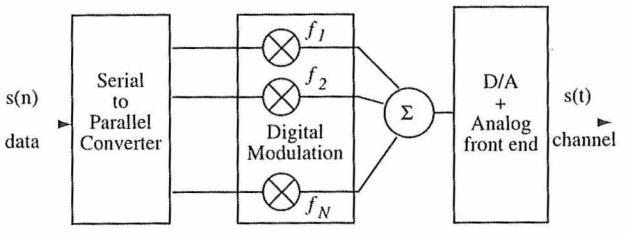

Figure 2 : Principle of multicarrier transmission

Among the multicarrier techniques, Orthogonal Frequency Division Multiplexing (OFDM) offers a good compromise between complexity and performance, and it has been retained for several broadcasting applications.

4 - The OFDM Technique

The OFDM technique is based on the Discrete Fourier Transform (DFT) and on its inverse (IDFT), both being implemented with the Fast Fourier Transform (FFT) algorithm.

The modulator principle is illustrated on figure 3. The input binary data are arranged into blocks, which are furthermore organised into binary words holding on m_1, m_2, ... bits. The k-th binary word, with length m_k, is further converted into a complex symbol X_k belonging to the discrete set of complex amplitudes defining the so-called "modulation grid" of a quadrature amplitude modulation scheme. The IDFT operator computes the N elements of a sequence

$$x(n) = \sum_{k=0}^{N-1} X(k) \exp(2\pi jkn/N) \qquad (5)$$

It actually performs the function of a set of modulators uniformly distributed in frequency and combined with a low-pass filtering function. The elements $x(n)$ are indeed the N temporal samples, over the period of a block, of a signal $x(t)$ which is the sum of N carriers, each of these being QAM modulated by a complex amplitude $X(k)$. The

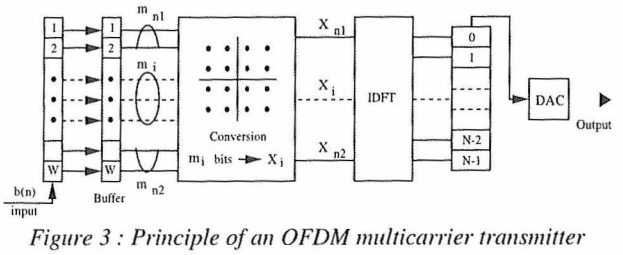

Figure 3 : Principle of an OFDM multicarrier transmitter

receiver structure is shown on figure 4. The DFT operator implements the inverse of equation (5), i.e.

$$X(k) = \frac{1}{N} \sum_{n=0}^{N-1} x(n) \exp(-2\pi jkn/N) \qquad (6)$$

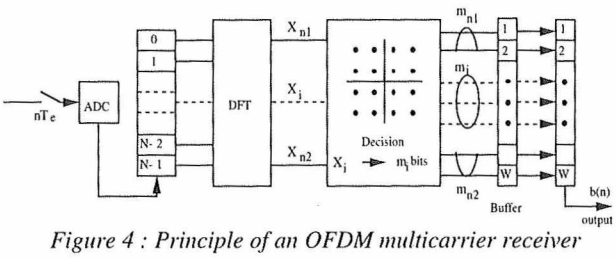

Figure 4 : Principle of an OFDM multicarrier receiver

If the samples $X(k)$are the data to be transmitted, equation (5) amounts to a set of N modulations of N carriers, with frequency spacing $1/N$. In the process, the symbol $X(k)$ is kept constant for N sampling intervals, which amounts to a filtering function and the subchannel filter response is

$$H(f) = \frac{\sin(\pi fN)}{\pi fN} \qquad (7)$$

Therefore, the responses of the subchannels overlap as shown in Figure 5. However, in their centers, the subchannels are orthogonal and the data can be perfectly recovered through equation (5), provided synchronisation is achieved in the time and frequency domains.

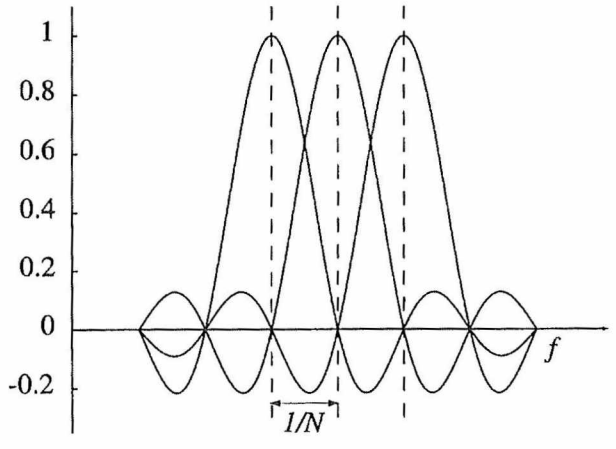

Figure 5 : Spectrum overlapping of the subchannels

In order to make that simple scheme work, some constraints have to be introduced, to maintain the orthogonality under practical circumstances. Since the channel has an impulse response which, generally spans several sampling periods, overlaps between consecutive symbols can occur, leading to intersymbol interference. This is avoided through the introduction of a guard time T_g between symbols, which must exceed the duration of the channels impulse response [4]. The scheme has the following advantages:

- in each subchannel, the bit rate can be adjusted to the signal-to-noise ratio. If a narrow-band jammer is present in the channel, the subcarriers in its vicinity are not used.
- equalisation in simple form is sufficient. In particular, multipath propagation has no impact as long as the delay

between the paths remains smaller than the guard time.
- the scheme is robust to impulse noise due to the integration effect in the receiver, represented by equation (5).

Worth mentioning is the fact that the spectrum of the OFDM output signal is flat and, provided the data are random or randomised, the time samples have a Gaussian distribution, with a 12 dB peak factor. It is a crucial point for the adjustment of the output level to the dynamic range of the transmission channel.

In one of the modes of the digital terrestrial television broadcasting (DTTB) standard adopted in Europe, N = 8192, and 6817 carriers are used, occupying a 7.61 MHz frequency band. The guard time can take up to 20 per cent of the symbol duration. The sampling frequency of the A/D and D/A converters is 18.284 MHz. With a 16-QAM modulation scheme in each subchannel, a total raw bit rate of 20 Mbit/s can be expected, which, for example, can be used to broadcast 4 programs in a regular television channel with 8 MHz spacing.

Furthermore, since the system is designed to equalise very large multipath delays (up to 180 μs), wide area single-frequency networks can be implemented. Signals received from two transmitters operating on the same carrier frequency can indeed be seen as delayed versions of the same signal. The technique of single-frequency networks will provide considerable spectrum savings.

5 - The Potential of Wideband Techniques

It is interesting to come back on equation (4). This suggests that, for selective fading, it is possible to take benefit from the fact that some frequencies inside the bandwidth are not unfavourably weakened by multipath propagation.

In order to evaluate this, we consider the model of a two-path channel. The channel transfer function is given by

$$H(f) = K\left[1 + a\exp\left\{-j\left[2\pi(f - f_0)\tau - \theta\right]\right\}\right] \qquad (8)$$

where a is the relative amplitude of the secondary path, τ the delay, and θ the phase at the center frequency f_0. We denote by P_t the transmitter power and assume that the power spectrum density of the emitted signal is flat over the band B. We also suppose that the received signal is perturbed by additive white Gaussian noise with one-sided power spectrum density N_0.

According to equation (4) the maximum spectrum efficiency is given by

$$E = \frac{C}{B} = \frac{1}{B}\int_{f0-B/2}^{f0+B/2} \log_2\left[1 + \frac{P_t|H(f)|^2}{N_0 B}\right] df \qquad (9)$$

in bit/s/Hz. In the absence of the secondary path, i.e. for

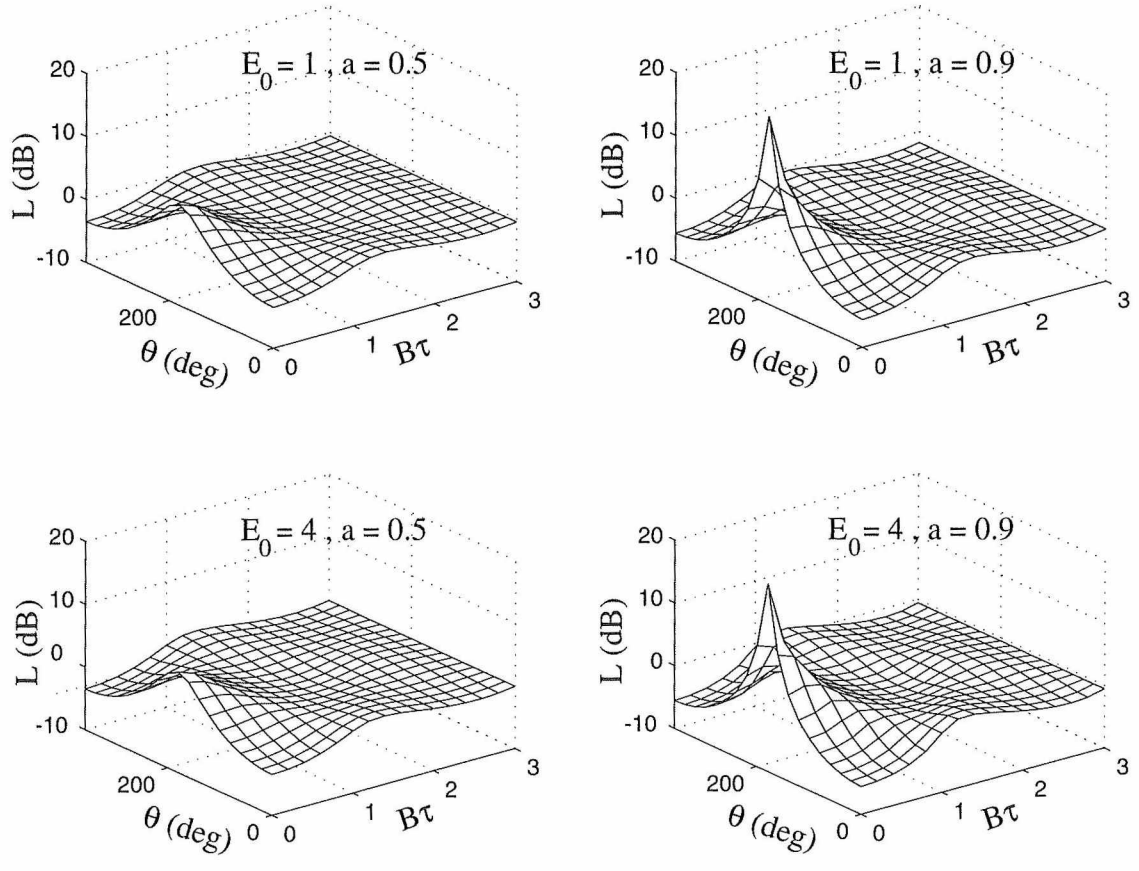

Figure 6 : The equivalent loss L in function of the parameters (Bτ,θ) for four combinations of a and E_0 for the broadcasting scenario

$a = 0$, the efficiency would take the value

$$E_0 = \log_2\left[1+\frac{P_t|K|^2}{N_0 B}\right] \qquad (10)$$

It is possible to write equation (9) as

$$E = \log_2\left[1+\frac{P_t|K|^2}{N_0 BL}\right] = \log_2\left[1+\frac{2^{E_0}-1}{L}\right] \qquad (11)$$

which actually defines a quantity L. This equation expresses that the effect of fading is equivalent, regarding the channel capacity, to a loss L in terms of signal-to-noise ratio.
The fading loss L depends on the parameters $(a, B\tau, \theta, E_0)$. It is shown on figure 6 in function of $(B\tau, \theta)$ for four combinations of a and E_0. These results are very interesting. The surface $L(B\tau, \theta)$ exhibits a different behaviour in two regions:

- For $Bt << 1$, the fading is flat, non selective. Whereas it is true that a favourable phase of the secondary path can reinforce the received signal, the contrary can also happen, possibly leading to a deep fading event.
- For $Bt > 1$, fading is selective. It is seen that the loss L due to multipath is very low (max. 2 dB) in any conditions.

The reasoning held above is valid for a broadcasting environment. By assuming that the power spectral density of the transmit signal is flat, we have indeed implicitely assumed that the transmitter does not attempt to adapt to the transmission channel characteristics. This is the right assumption when a transmitter has to serve several receivers with different multipath transfer functions.

The scenario is different for point-to-point communications. In this single-transmitter, single receiver scenario, the channel transfer function is perfectly defined and a realistic assumption is that the channel equalisation function can be shared between the transmitter and the receiver. Theory tells us that the optimum solution is to share the equalisation filtering in equal parts between the tranmitter and the receiver, so as to have two so-called half-Nyquist filters upstream and downstream the white noise addition point [6]. The reasoning can be repeated for this case and leads to the results shown on figure 7. The main difference with figure 6 is that the multipath loss is practially zero in the selective fading case.

This analysis leads to extremely interesting conclusions regarding an efficient use of the spectrum. Narrow-band systems, in the sense of $Bt < 1$, suffer from deep flat fading. Eventually there is no alternative torestaure the channel capacity than increasing the signal power. This has

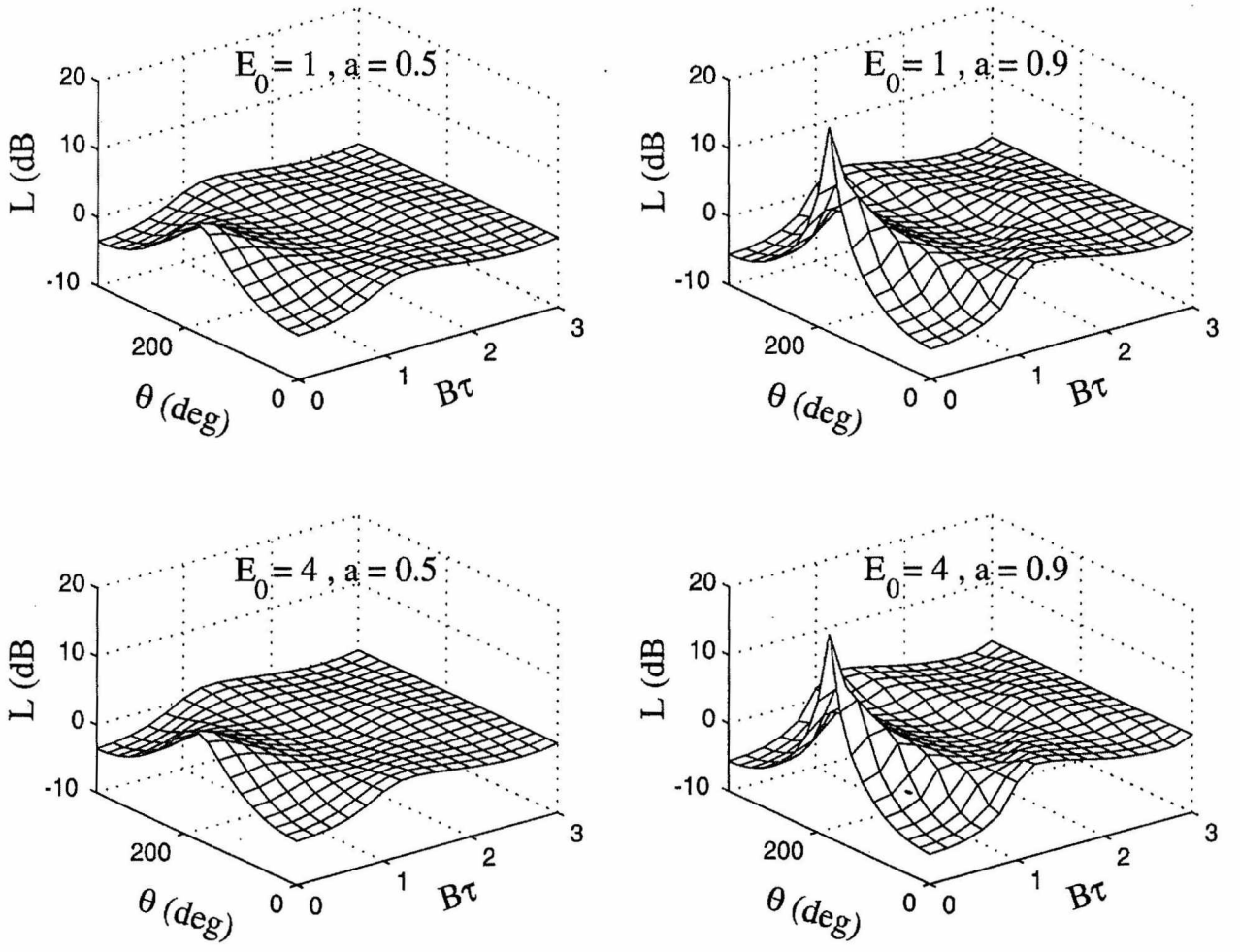

Figure 7 : The equivalent loss L in function of the parameters (Bτ,θ) for four combinations of a and E_0 for the point-to-point scenario

catastrophic consequences from the spectrum efficiency view point, because it causes a degradation of the interference environment, even when adaptive power control is used.

This does not happen when fading is selective. This suggests a more systematic use of wideband systems. The OFDM technique for digital terrestrial television broadcasting discussed above is a nice application of this principle. By packing several TV programmes in a single signal, thereby using a wideband channel with selective fading, a more efficient use of the spectrum is made than by transmitting one programme per carrier, because the flat fading situation is avoided.

In other application areas, where the bit rates are not as high, spread spectrum techniques such as well-designed CDMA and TDMA provide a similar advantage. Of course, in any case, it is necessary to use powerful equalising techniques which are now available. Here again, signal processing contributes to a more efficient use of the spectrum.

6 - Conclusion

Digital signal processing already contributes much to a more efficient use of the radio spectrum in many aspects. Source coding and compression allows a larger number of signals to share the same bandwidth. Powerful modern signal processing are now also available to equalise the channels and adapt the modulations, in order to achieve, in combination with optimal detection and error correction, bit rates close to the theoretical limits. With the capability to counter or cancel interferences, it can considerably expand the geographical area in which a frequency channel can be used for broadcasting.

In communications, software programmable and configurable emitters and receivers can be designed, in order to occupy just the frequency bandwidth which is needed and when it is needed. Through the implementation of multiple standards in a single piece of equipment, a smooth transition can be provided between existing and future services [5].

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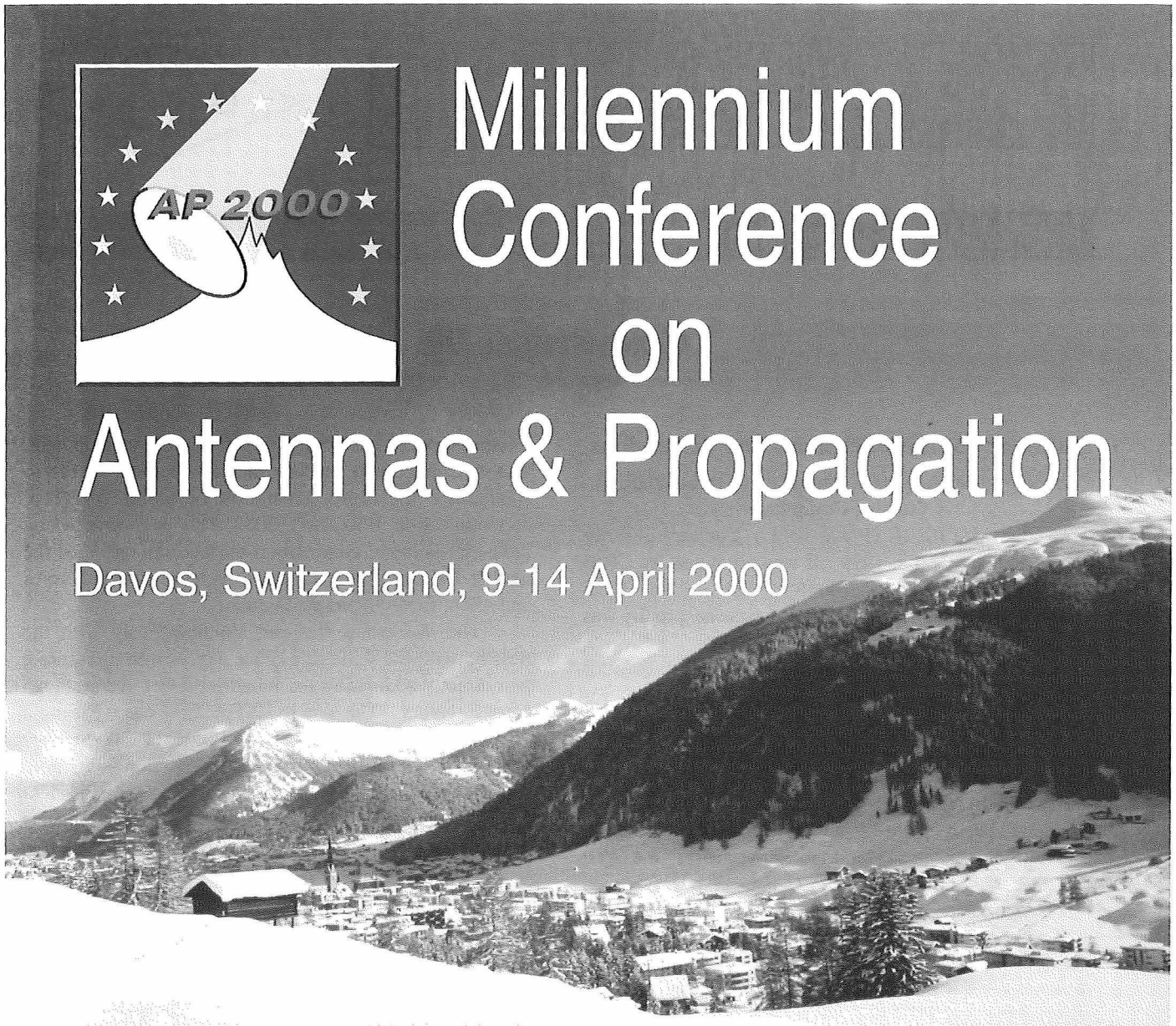

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Conferences

CONFERENCE REPORT

COMMSPHERE 99

Toulouse, France, 25 - 28 January 1999

Summary of the workshops and discussions

Edited by Joseph Shapira Chairman, COMMSPHERE Steering Committee

COMMSPHERE 99 was held in Toulouse, France during January 25-28, 1999 . It was organised by URSI and CNES, in collaboration with ITU-R. The local arrangements were made by CNES, whose hospitality was warm and gracious.

COMMSPHERE is an international forum of concerned scientists, experts and administrators, for interdisciplinary discussions of the challenges facing the future of telecommunications and other uses of the electromagnetic radiation. The participation was relatively low (about 70 registered). However, the participation was characterised by senior scientists and key people from relevant organisations and administrations, all well informed. Commissions B, C, D, E, F, G, H, J, K were well represented.

The session topics were: 1. Science services: radioastronomy, passive and active remote sensing 2. The third generation of cellular/personal communications 3. Satellite Personal Communications 4. Spectrum efficiency and enabling technologies for efficient spectrum usage 5. Future spectrum efficient sound and television broadcasting The workshop topics were: 1. The electromagnetic environment 2. Satellite personal communications, including interference problems with radioastronomy 3. The UMTS - IMT-2000 debate 4. Future spectrum efficient sound and television broadcasting 5. Wireless and radiation effects (an added discussion, not reported)

The presentation at the opening session - The impact of signal processing on an efficient use of the spectrum (Bellanger, Delogne) set up a neat ground to the discussions to follow.

Workshop 1 : Third Generation of Cellular/ Personal Communications

Reporter: J. Bach Andersen

The wireless mobile communications is one of the fastest growing services, capturing an average of over 15% of the population in developed countries and penetrating fast to developing countries. A much broader range of data and multimedia services is envisioned to be provided by the third generation of this service. The explosive growth of the Internet service gives further impetus to this development. The ITU has been leading an international effort to standardise this third generation of mobile personal communication, titled IMT 2000. This is confronted by industrial-political competition on the dominance of the market. URSI interest in this arena involves spectral issues and scientific-technological issues.

The Workshop was run simultaneously with the Session with the same title. Four papers were presented, two directly addressing the broad issues of 3rd systems: Josef F. Huber, "The way to UMTS: how can we bring a vision to reality?" E. Bonek, "UMTS and IMT2000-Science or business & Politics?", while two were addressing more specific technical issues D. Li, "A Highly Spectrum Efficient Multiple Access Code" J. Bach Andersen, "New Aspects of Multiple Antennas for Spectral Efficiency". The two latter talks are not addressed here.

Mr Huber gave an overview of the present situation globally from a spectrum perspective, where the present allocations are a 230 MHz allocation, of which 170 MHz are for terrestrial services. Since this was made in 1992 the explosive use of the Internet seems to indicate that there is a market for mobile broad (or broader) band services, the Internet growth and the mobile area growth following parallel growth curves.

It was emphasised that although a number of system specifications have been made there is still a lot of scientific work to be done to realise the ITU vision, such as for example the role of adaptive antennas.

Mr. Bonek emphasised the present trade-war-like situation with the disagreement between various versions of CDMA proposals. These differences were partly of a technical character and partly relating to intellectual property rights, and it was discussed whether and how science could play a role.

It was proposed that due to the complexity of the systems, only real tests with a high number of users would be able to highlight pros and cons of various proposals before standardisation. Such a test should be managed by independent scientists. It was felt however, that time and cost might not allow such a realistic field trial.

The cost and availability of base stations for 3rd generation systems was another issue, and for that reason it was felt that an evolutionary, migratory approach from 2nd generation systems might be foreseen. This again points to

the backwards compatibility, which is also an important factor in the present disputes.

Although the mobile terrestrial area had obtained additional spectrum, the spectrum available to TV and satellite were much higher, with rather low spectrum efficiency for the satellite part.

Workshop 2 : The Electromagnetic Environment

Reporter: J. Hamelin

Ten participants attended this workshop. The discussions were held in French, as there were 7 participants from France and 3 from Germany, but with a good knowledge of this language.

The debates concluded to some doubts about the adequacy of existing standards as well as to deep concerns about the intrusion of political factors in the definition of standards (application of the precaution principle). This is an indication of some lack of scientific knowledge.

The electromagnetic environment has been the subject of numerous research works, but the latter were most frequently carried out to serve specific needs of some communities, such as the aeronautical defence, etc. This knowledge has not resulted in an updating of the reference documents used by bodies such as ITU and IEC for the environmental characterisation of consumer systems. Furthermore criteria in use may be obsolete when they are based on requirements valid some decades ago for the interaction of the electromagnetic environment with narrow-band analogue systems. There is an urgent need to start a dialog between the communities of "signal processing and digital transmission" on the one hand, and "electromagnetic environment" on the other hand, whereby the former would help the latter in specifying system requirements.

This is particularly necessary because the proliferation of digital transmission systems using high-immunity coding techniques lead, for instance, to the use of channels which were not designed for this purpose, such as power lines including in-house circuits, or with the widespread use of radio links in the 20, 40 or 70 GHz bands without enough consideration for their consequences for the electromagnetic environment.

The inadequacy of existing electromagnetic environment standards as well as the existing tendency to a posteriori control (cf. e.g. the European Union RTE Directive) can lead to irrational reactions from the public and from political decision makers. This could have a strong impact on industry activity, for instance as the result of a systematic application of the "precaution principle".

The scientific community, and in particular URSI, should not ignore the related risks.

Workshop 3 : Personal Satellite communications, including interference problems with radio astronomy

Reporter: J. Evans

This workshop together with Session 3 of the program (entitled "Satellite Personal Communications") examined the explosive interest in new satellite systems-many of which are designed to provide services globally by employing constellations of satellites.

Communication satellites were initially conceived for spanning intercontinental distances and achieving improved global telephony. With the advent of fiber optic cables, that role is declining, yet satellites are of increasing interest for new applications, where they are economically superior to the alternatives. The first of these is for delivering the same information to a widely dispersed set of receiving sites (e.g. distributing television to cable head ends). The advent of high power satellites together with powerful digital compression schemes has made it possible to deliver upwards of 100 television channels directly to the home, i.e., to individual consumers. Direct audio broadcasting seems likely to see widespread introduction shortly.

Communication satellites are also unbeatable for providing access to mobile platforms such as shops and aircraft. The present thrust, however, is to launching systems that permit individuals employing small hand held terminals to gain access to the public switched network usually from areas where cellular service is not available. The 66-satellite Iridium system is already in service, and will be followed by Globalstar, ICO and possibly other global systems, as well as several regional ones (ACeS, Agrani, Thuraya, etc.) The jury is still out on the likely economic success of these systems, but already the Iridium system has the dubious distinction of generating unwanted interference in the OH radio astronomy band.

A third application for new proposed satellite systems is for so-called "last mile" connections i.e., connecting users to the digital backbone at high data rates thereby enabling multimedia dissemination between offices, and high-access to the Internet by individual consumers. Non-geostationary (NGSO) systems have been proposed for this service operating at Ku-band, while GEO and NGSO systems have been proposed for both Ka- and Q/V-bands. Rain attenuation makes it difficult to deliver reliable service at Ka- or Q/V-bands and the problem of avoiding interference with existing geostationary satellites will likely hamper the introduction of the Ku-band systems. Besides technical difficulties are uncertainties about the size of the market (which depends upon an assumed continued growth of the Internet and its use for commerce), and the high cost of any of the global systems. Terrestrial alternatives (ADSL or cable modems) are expected to be less expensive and even high flying aircraft are being proposed for this service. Nevertheless, it seems likely that several of the large projects now proposed will go forward.

With respect to radio astronomy it is clear that these global systems make it impossible for radio astronomers to find "radio quiet" sites. Indeed interference is being caused by Glonass and Iridium in the OH band. The situation threatens to be made worse by the actions of certain countries (e.g. the United States) where the economic value of radio frequency licenses has caused attempts to raise revenue by auctioning them. That is, there is a growing tendency to place commercial interest above all else.

The radio astronomers present at the meeting deplored these developments, and the loss of scientific opportunity that they represent. They continue to believe that their best hope lies in the agreements reached internationally within the ITU framework, but consider that opening up that body to industrial participation will make it much harder for their voices to be heard. We did not hear a pro-satellite point-of-view as we were not able to secure appropriate participation at the meeting.

Workshop 4: Future spectrum efficient sound and television broadcasting

Reporter: J.-J. Delmas

Broadcasting has been, and is bound to stay, a basic service. Its importance to the public has led in the past to vast allocations of spectrum in frequencies most suitable for other emerging services, and mainly mobile communications. New technologies have emerged that offer better service and much higher spectral efficiency.

A discussion took place for television as well as for radio in continuity with the papers presented in session 5 on future spectrum efficiency sound and television broadcasting systems. Two papers were presented: The first one dealt with Digital Sound Broadcasting by satellite (S-DSB). S-DSB has started in Africa by Worldspace, with a proprietary standard system and is reported to be expensive. A S-DSB project for Europe, Mediastar, based on the Eureka 147 system, has been delayed due to the lack of commercial interest. S-DSB systems are sensitive to jamming and reception in urban areas and in-door is poor. This can be solved by terrestrial fill-in transmitters if a license from local authorities can be achieved. In Europe only 12.5 MHz in the 1.5 GHz range is available. The use of this band is severely restricted by the need to protect mobile aeronautical telemetry (MAT) services. If S-DSB is required on a large scale in Europe a larger frequency band with less restriction is needed.

The second one dealt with a simulator for HF transmissions characteristics. In a previous paper presented in session 5, on signal processing for HF Modems (skywave channel) SACET has shown that blind timing algorithms can be applied to OFDM timing recovery without relying on the cyclic prefix with a very good accuracy. It was also shown that channel interpolation with the EM algorithm provides more than 0.5 - 0.7 dB over the Wiener interpolation. Finally it was shown that multidimensional rotated constellations provide a diversity scheme that can give up to 5 dB improvement at BER of with a 19 QAM and with no loss in spectral efficiency. In the second paper presented in workshop 5, a solution for an HF skywave simulation based on the scattering function and block processing was described. The method allows long term simulation of virtually any kind of channel. One of its advantages is that non-stationary channels (dusk and dawn events for example) can be simulated. An hardware DSP version of the simulator is under study.

At the end of the workshop, a debate took place on the development of digital terrestrial television in comparison to the existing system already use in cable and satellite. A more efficient use of the spectrum can justify the introduction of digital terrestrial broadcasting but also the development of new services based on the portability of the TV-set or which require TV and multimedia reception in mobiles such as car, buses, train and so on.

Meeting of COMMSPHERE Steering Committee

Summarised by J. Shapira

- The importance of COMMSPHERE as a discussion forum was reaffirmed.
- The collaboration of ITU-R has been reassured
- The need for more industrial participation was pointed out.
- The small participation in the last two conferences indicates the focal interest of senior scientists and experts in this forum, and less - of the broader scientific/ engineering community.
- The rate of progress brings enough discussible issues to organise these events more frequently
- It has therefore been proposed to hold these meetings every 18 months: Once as a part of the General Assembly, which enables the broader community to be involved, and may bring more ITU and other experts to the GA Once in the mid-term, in conjunction with the URSI board and Coordinating Committee meeting. This brings together all commission chairs and board members. Chairmen of ITU study groups, and industry leaders will be invited, to form a very intense discussion group for 2-3 days.
- The unbalanced promotion of research related to competitive telecommunications programs, leaving behind major issues of spectral efficiency, frequency and service sharing - lead to non optimal planning and co-ordination of the spectrum. Research on spectral efficiency and sharing should be enhanced. It is proposed to form a fund for this research. The contributions should be raised from ICSU, institutions involved in telecommunications (e.g. CNES), ITU and industries. The steering committee will form a fund management committee that will propose the rules and procedures.

This article was reprinted, with some modifications, from a paper published in the Proceedings of the Commsphere'99 Symposium, held in Toulouse (France), 25-28 January 1999. Permission of CNES for reprinting this paper is gratefully acknowledged.

THE UNIVERSE AT LOW RADIO FREQUENCIES

Pune, India, 30 November - 4 December 1999

The IAU Symposium 199entitled "The Universe at Low Frequencies" will he held in Pune, India, from 30 November to 4 December 1999.

Scientific Organizing Committee : G. Swarup (India, Chair), S. Ananthakrishnan (India), G. de Bruyn (The Netherlands), P. Dewdney (Canada), R.D. Ekers (Australia, Chairperson), W. Erickson (Australia), Gopal Krishna (India), M. Goss (USA), N.S. Kardashev (Russia), A. Lyne (UK), L. Padrielli (Italy), N.Rendong (China).

Chair Local Organizing Committee : A. Pramesh Rao

Topics

- Extended extragalactic radio sources
- HI at high redshifts
- Radio source surveys at low frequencies
- Relic radio sources
- Low frequency variability of radio sources
- Galactic radio sources SNRs, HII regions, pulsars, Sun and radio stars
- Recombination lines and the interstellar medium
- Instruments and techniques for low frequency radio astronomy
- Interference rejection/cancellation

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MST9 - ISAR 3

Toulouse, France, 13-17 & 20-24 March 2000

The Ninth International Workshop on Technical and Scientific Aspects of MST Radar (MST9) combined with COST-76 Final Profiler Workshop (cost76) - and the Third International School on Atmospheric Radar (ISAR 3) will be held in Toulouse, France on March 13-17 and March 20-24, 2000.

The international workshop on MST radar, held about every two years, is a major event drawing together experts from all over the world, engaged in research and development of radar techniques to study the mesosphere, stratosphere, troposphere (MST) and the ionosphere. It offers also excellent opportunities to young scientists, research students and also new entrants to the field for close interactions with the experts on all technical and scientific aspects of MST radar. The latter applications will be highlighted in this workshop by the particular inclusion of wind profiler projects.

- mst9 -

The major topics of the ninth MST radar workshop - mst9 - deal as usual with radar scattering processes in the atmosphere and ionosphere, winds, waves and turbulence in the lower and middle atmosphere, meteorological phenomena and applications, such as, wind profilers, boundary layer radars and networks, as well as major scientific, technical and signal processing achievements and highlights from the MST radar facilities and wind profilers of the world. MF, meteor, boundary layer and coherent ionospheric scatter radars are included in mst9.

- cost76 -

Special sessions will be held dealing with wind profiler applications by the combination of mst9 with the COST-76 Final Profiler Conference - cost76 -. COST-76 is an action of the European Commission on the "Development of UHF/VHF wind profilers and vertical sounders for use in European observing systems". As for cost76, which is more focused on operational aspects and networking, special sessions will be held on the main topics: Operational experience with wind profilers, quality control and quality evaluation, technical and scientific development of wind profilers, development of other upper-air observing systems, user requirements, studies and demonstrations of usefulness of wind profilers.

Steering and Programme Committee The International Steering Group of mst9-cost76 (ISC), consists of J. Roettger (Chair, Germany), S. Fukao (Cochair, Japan), M.F. Larsen (USA), C.H. Liu (Taiwan R.O.C.), A.P. Mitra (India) and W. Monna (The Netherlands). The Programme Committee, besides members of ISC, includes L. Alonso (Spain), K.S. Gage (USA), W.K. Hocking (Canada), E. Legrand (France), G. Nastrom (USA), G. Peters (Germany),

P.B. Rao (India), R.A. Vincent (Australia) and R.F. Woodman (Peru). The local organization is under V. Klaus (France). At the invitation of the French ST radar community, the mst9-cost76 will be held 13-17 March 2000 at the Centre International de Conferences in Toulouse, France. Return the attached form to indicate your interest in mst9-cost76.

- isar3 -

Following mst9+cost76, the 3rd International School on Atmospheric Radar (isar3) is planned to be held at Ecole Nationale de la Meteorologie (ENM), Toulouse, during 20-24 March 2000. The syllabus of isar3 will include basic lectures on atmospheric radar, a few tutorials on scientific/technical highlights by eminent scientists, attending the mst9, and extensive group discussions with the participants. Interested young scientists and newcomers to the field should announce their interest in isar3 to the local organizers by returning the attached form..

Sponsoring Sponsorship of mst9-cost76 and isar3 by COST, SCOSTEP, URSI, CNRS and Meteo-France is anticipated.

Contact

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HF Radio Systems and Techniques

Surrey, United Kingdom, 10-13 July 2000

Eighth International Conference on HF Radio Systems and Techniques will be held at the University of Surrey, Guildford, United Kingdom on 10 - 13 July 2000

The Institution of Electrical Engineers has organised at approximately 3 year intervals seven highly successful Conferences on 'HF Radio Systems and Techniques'. You are invited to contribute to the Eighth International Conference to be held at the University of Surrey, Guildford, UK: 10 - 13 July 2000. The aims are to bring together those with interests in the area of HF Systems to present and discuss papers on recent advances in the relevant theory and practice. Any topics related to long-range terrestrial radio systems falling within the general scope of the Conference (including, for example, meteorburst, and VLF-MF systems) will be considered.

The Conference is being organised by the Electronics & Communications Division of the Institution of Electrical Engineers in association with EUREL, Institute of Electrical & Electronic Engineers (UKRI Section), Institute of Physics Institution of Mathematics and its Applications, Radio Society of Great Britain and URSI. The Conference Organising Committee is chaired by Mr J D Milsom, Marconi Research Centre.

Scope

1. System design, control and management, Adaptive Operation, including Automatic Channel Selection, Link Establishment and Link Maintenance, Networking, Frequency Management, Assignment and Associated Tools, System Architecture, Packet Radio Techniques, System Performance Modelling, Multiple Access, Interoperability and Standardisation
2. Signal design and processing, Digital Transmission, Speech Transmission Techniques, Digital Signal Processing, Coding, Modulation Recognition, Modem Design and Synchronisation, Waveform Evaluation and Performance Modelling
3. EW Systems and direction finding techniques, Spread Spectrum, Power Control, Null Steering and Cancellation Techniques, Equipment Aspects, Security Aspects, Electronic Protection Measures, Electronic Surveillance Measures, System Vulnerability, General DF Techniques
4. Propagation, noise and interference, Analysis, Modelling (especially Time and Frequency Dispersion), Measurement and Real Time Channel Evaluation), Channel Simulation (including Simulation for Spread Spectrum Techniques), Co-site EMC (including Digital Powerline Transmission Techniques), Propagation Decision Aids
5. Antennas and couplers, New Designs, Numerical Modelling, Combiners, Broadband and Frequency Agile Operation, Antenna Measurement and Assessment
6. Transmitters, Linear Amplifiers, Fast Tuning, Efficiency, Digital Drives, New Transmitter Techniques
7. Receivers, Digital Architectures, HF Software Radio Techniques, Analogue Components & Techniques, Performance Characterisation
8. Related Systems and techniques , VLF-MF Systems , Meteorburst, Amateur Radio 73/136 kHz Systems, Other Terrestrial beyond line-of-sight Communications up to 100 MHz
9. Future requirements , Unique Applications, Traffic Studies, System Simulation and Modelling, Multimedia Applications, Cost Effectiveness, Spectrum Administration, Internet Support for the HF Community
10. HF Radar, Performance Modelling, Sea State Sensing, Target Tracking, Equipment Aspects
11. HF Digital broadcasting, Waveforms, Modulation and Coding, Signal Processing Aspects, Equipment Aspects, Market and Applications, System Control, Spectrum Considerations and Frequency Allocation

This list is not intended to be exhaustive or exclusive.

Deadlines

Receipt of synopses : 17 September 1999
Notification of provisional acceptance of synopses : November 1999
Receipt of full typescripts for final review : 31 January 2000

Contact

HF Radio 2000 Secretariat
Conference & Exhibition Services
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2001 Asia-Pacific Radio Science Conference

Tokyo, Japan, 1-4 August 2001

2001 Asia-Pacific Radio Science Conference (AP-RASC'01) will be the first conference to treat all aspects of radio science in Asia-Pacific area. The aim of this conference is to promote the study of radio science in Asia-Pacific area by providing an opportunity to present and discuss recent advances in radio science.

AP-RASC'01 is sponsored by the Science Council of Japan, Liaison Committee for Radio Science and the Institute of Electronics, Information and Communication Engineers (IEICE) ; and co-sponsored by URSI.

Topics

- Electromagnetic Metrology
- Fields and Waves
- Signal and Systems
- Electronics and Photonics
- Electromagnetic Noise and Interference
- Wave Propagation and Remote Sensing
- Ionospheric Radio and Propagation
- Waves in Plasma
- Radio Astronomy
- Electromagnetics in Biology and Medicine

Everyone interested in radio science is welcome !

Deadlines

First Call for Papers : December, 1999
Final Call for Papers : August, 2000
Abstract Submission Deadline : January 31, 2001
Notification of Acceptance : March, 2001

For further information, please contact:
Japan National Committee of URSI
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URSI CONFERENCE CALENDAR

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July 1999

IGARSS'99
Hamburg, Germany, 28 June - 2 July 1999
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August 1999

Radio Methods for Studying Turbulence
Urbana, Illinois, USA, 9-12 August 1999
Contact : Prof. A. W. Wernik, Space Research Center, Polish Academy of Sciences, ul. Bartycka 18a, 00-716 Warsaw, Poland, Tel +48-22-403766 ext 379; fax +48-22-403131; email aww@cbk.waw.pl

International Reference Workshop 1999
Massachusetts, Lowell, USA, 9-12 August 1999
Contact : Prof. Bodo W. Reinisch, Center for Atmospheric Research, University of Massachusetts Lowell, 600 Suffolk Street, Lowell, MA 01854, USA, Phone : +1978-934 4903, Fax : +1 978-459 7915

XXVIth URSI General Assembly
Toronto, Canada, 13-21 August 1999
Contact : URSI GA '99 Secretariat, National Research Council Canada, Ottawa, Ontario K1A 0R6, Canada, Tel. +1 613-993 7271, Fax +1 613-993 7250, E-mail : ursi99@nrc.ca, http://www.nrc.ca/confserv/ursi99/welcome.html

Gamow Memorial International Conference(GMIC'99) Early Universe : Cosmological Problems & Instrumental Technologies
Sankt-Petersburg, Russia, 23-27 August 1999
Contact : Dr. V. Khaikin, The Special Astrophysical Observatory of RAS, St. Petersburg branch, Poly-technicheskaya 21, room 111, St.Petersburg 125220, Russia, Fax: 7-(901)4982931, E-mail: conf99@brown. nord.nw.ru

October 1999

RADIO AFRICA'99
Gaborone, Botswana, 25-29 October 1999
Contact : Dr. Thomas Afullo, Faculty of Engineering & Technology, University of Botswana, Private Bag 0061, Gaborone, Botswana. Tel: +267-3554342,Fax: +267-352309, E-mail: afullotj@noka.ub.bw

November 1999

ICCEA'99
International Conference on Computational Electromagnetics and its Applications
Beijing, China, 1-4 November 1999
Contact : Mr. Meng-Qi Zhou, P.O. Box 165, Beijing 10036 China, fax +8610 6828-3458, E-mail : mqzhou@public.bta.net.cn

The Universe at Low Radio Frequencies
Pune, India, 30 November - 4 December 1999
Contact : Prof. V.K. Kapahi, NCRA-TIFR, Pune 7, India, Tel. +91 212-35 5149, Fax +91 212-35 7257, E-mail vijay@ncra.tifr.res.in

March 2000

MST9-ISAR3
Toulouse, France, 13-17 & 20-24 March 2000
Contact : Centre International de Conferences, Attn. Sylvaine Balland, 42, avenue Gaspard Coriolis, F-31057 Toulouse Cedex, France, Fax +33 561-078059, E-mail : cic-toulouse@meteo.fr

April 2000

AP 2000
Davos, Switzerland, 9-14 April 2000
Contact : AP 2000, ESTEC Conference Bureau, Postbus 299, NL-2200 AG Noordwijk, The Netherlands, Tel: +31 71 565-5005, Fax: +31 71 565-5658, E-mail: confburo@estec.esa.nl

May 2000

EUSAR 2000
Munich, Germany, 23-25 May 2000
Contact: Dr. W. Keydel, German Aerospace Center (DLR), Postfach 1116, D-82230 Wessling, Germany, Tel. +49 8153-28 2305, fax +49 8153-28 1335, E-mail: eusar2000@dlr.de

EUROEM, EuroElectromagnetics
Edinburgh, Scotland, UK, 30 May - 2 June 2000
Contact : EUROEM 2000, Concorde Services Ltd., Suite 325, The Pentagon Centre, Washington Street, Glasgow G3 8AZ, Scotland, United Kingdom, Tel: +44-141-221-5411, Fax: +44-141-221-2411, E-mail: euroem@concorde-uk.com

July 2000

HF Radio Systems and Techniques
Surrey, United Kingdom, 10-13 July 2000
Contact : HF Radio 2000 Secretariat, Conference & Exhibition Services, Institution of Electrical Engineers, Savoy Place, London WC2R 0BL, United Kingdom, Tel. +44 171-344 5471, Fax +44 171-240-8830, E-mail hf2000@iee.org.uk, http/::www.iee.org.uk/Conf/

August 2000

ISAP 2000
Fukuoka, Japan, 22-25 August 2000
Contact : Dr. Yoshio Karasawa, ISAP 2000, KDD R&D Labs, Inc. 2-1-15 Ohara, Kamifukuoka-shi, Saitama 356-8502, Japan, Tel. +81 492-78 7327, Fax +81 492-78 7524, E-mail karasawa@lab.kdd.co.jp

August 2001

Asia-Pacific Radio Science Conference
Tokyo, Japan, 1-4 August 2001
Contact : AP-RASC Secretariat, c/o The Japanese URSI Committee, c/o Dr. Y. Furuhama, Communications Research Laboratory, Ministry of Posts and Telecommunications, 4-2-1 Nukuikita-machi, Koganei-shi, 184-8795 Tokyo, Japan, http://www.kurasc.kyoto-u.ac.jp/ursi/

News from the URSI Community

PROFILE OF A MEMBER COMMITTEE

CANADA

Canada joined URSI in 1952, relatively late compared to its sister commonwealth countries Australia (1922) and New Zealand (1931). Radio research in Canada had grown rapidly under the direction of a National Research Council (NRC) of Canada Associate Committee on Radio Research, during the 1939-45 war. By 1950, with many NRC radio researchers no longer in defence work, an Associate Committee on Radio Science was formed. In 1951, this became also the Canadian Committee for URSI under the chairmanship of D.W.R. McKinley, then Associate Director of the Radio and Electrical Engineering Division of NRC. The committee consisted of six senior scientists and engineers from government laboratories and departments concerned with radio science and its applications, and five radio physicists, an electrical engineer and a radioastonomer from the universities. By 1968 the size of the committee had grown to 23 members from government, universities and industry. In 1971 the size of the committee was cut in half, to consist of a Committee Chairman, a Past Chairman, a Secretary and a Chairman for each of the eight Commissions.

Canadian radio scientists quickly became involved in URSI affairs. G.A.Woonton of McGill University in 1952 became Chairman of Commission VII on radio electronics and later (1957-63) a Vice President of URSI. Woonton also organized the 1952 McGill Symposium on Microwave Optics, the forerunner of the Triennial Commission B Symposia on Electromagnetic Wave Theory. The third such meeting was held in 1959, organized by G.Sinclair, of the University of Toronto. The next Commission B Symposium will be held in Victoria, British Columbia, in 2001. Two early committee members were B.G. Ballard and J.H. Chapman. Ballard was appointed President of the National Research Council of Canada and Chapman was the first winner of the John Howard Dellinger Gold Medal. Joint US/Canada URSI meetings were held in Ottawa in 1953, 1962 and 1967 and the 1969 URSI General Assembly was held in Ottawa.

In 1973 an NRC Bureau of International Relations was formed which became the administrative body for all Canadian member committees of the international scientific and technical unions. The Canadian committee ceased to have a dual role as a government advisory committee and an URSI committee. Since then, the committee has been comprised of a Chairman, a Past Chairman, a Secretary and a Chairman for each of the technical commissions. These are selected for three or six-year terms with due regard for geographical, institutional and linguistic representation. Meetings are held usually once a year in Ottawa, in late April or early May.

The 1980 North American Radio Science Meeting and IEEE Antennas and Propagation International Symposium was held at Laval University, Quebec, and organized by J.A.Cummins and G.Y.Delisle. This was the first of a series of successful regional meetings jointly arranged by US and Canadian URSI and the IEEE/AP-S. The second followed in 1985 at the University of British Columbia in Vancouver, organized by K.S.McCormick and E.V. Jull, a third in 1991 at the University of Western Ontario in London, Ontario, under the chairmanship of A.R.Webster, and the fourth in 1997, in Montreal, Quebec, under the joint chairmanship of G.Y. Delisle and S.J. Kubina. The splendid cooperation enjoyed at these meetings is an outcome of the close relations between US and Canadian radio scientists and IEEE Antennas and Propagation Society members.

The National Research Council of Canada, which was instrumental in the establishment of the Canadian National Committee and which is the adhering member for Canada in international scientific and technical organizations, reviews through its Committee on International Science, Engineering and Technology, these affiliations and their sponsoring organizations. Currently, the Canadian National Committee is supported jointly by the Herzberg Institute of Astrophysics of the National Research Council of Canada and NRC Corporate Services.

In the 1990's, the Canadian committee has seen its greatest participation in URSI at the international level, with the Presidency of E.V. Jull, 1993-96 and the Vice-presidency of M.A. Stuchly, 1996-99. Commission A was chaired by J. Vanier, 1990-93, Commission C by P. Wittke, 1993-96 and Commission K was chaired by M.A. Stuchly, 1991-93. The Vice-chair of Commission H is currently H.G. James. The climax of this ten-year period will be in August, this year, with the intense activity associated with the XXVIth General Assembly, which will be held at the University of Toronto, Toronto, Canada, under the organizing chairmanship of K.G. Balmain.

Canadian Committee for URSI

Chairmen		Secretaries	
D.W.R.McKinley	1951-57	J.C.W.Scott	1951-54
J.S.Marshal	1957-61	Ann Marshall	1955-58
J.T.Henderson	1961-65	D.W.R.McKinley	1958-61
R.S.Rettie	1965-68	P.M.Millman	1961-63
M.P.Bachynski	1968-71	J.H.Chapman	1966-68
R.E.Barrington	1971-74	J.L.Locke	1968-73
F.J.F.Osborne	1974-80	J.Y.Wong	1973-80
E.V.Jull	1980-86	L.H.Doherty	1980-86
P.H.Wittke	1986-93	R.F.Clark	1986-93
G.Y. Delisle	1993-99	R.H. Hayward	1993-96
		K. Tapping	1996-98
		J.P. Vallee	1998-

G. Y. Delisle, E.V. Jull and P.H. Wittke

NEWS FROM THE MEMBER COMMITTEES

POLAND
9th National Symposium of Radio Science

The 9th National Symposium of Radio Science "URSI'99" was held in Poznañ, Poland, on 16-17 March, 1999.

The symposium attracted more than 60 papers submitted by Polish and foreign authors. The papers were divided on 6 sections. The plenary session was devoted to the latest achievements in radio astronomy, digital modulations, and magnetotherapy. More than 110 participants attended the conference. The participants and the authors of the papers came from all major Polish academic centres.

During coffee breaks the participants were able to visit the exhibition of measurement equipment for radio communications made by the leading manufacturers in the world. The latest scientific books from the area of radio science were also available.

The symposium was organised by the Institute of Electronics and Telecommunications of Poznan University of Technology and sponsored by the biggest Polish communication operator Telekomunikacja Polska S.A.

Prof. Andrzej Dobrogowski
Chairman, Organising Committee

UKRAINE
Activity report of the Ukrainian Commission D

The Ukrainian Commission D on Electronics andPhotonics has participated in the foundation of the new specialised journal"Semiconductor Physics, Quantum- and Optoelectronics" (Editor-in Chief Prof. S.V. Svechnikov) which was issued under the general responsibility of the national Academy of Sciences of Ukraine (NASU) . The interest of our Commission to participate in the activity of the journal is due to electronic and optoelectronic devices in radio and high frequency region, communication equipment and elements, as well as in the research topics submitted to this issue. Our Commission has presented for the first issue of this Journal 6 articles:

The photosensitive porous Si-based structures with thin and thick porous layers was studied in article of S.V. Svechnikov with collaborators (Inst. of Semiconductor Physics (ISP) of NASU. The properties obtained were explained in the frame of isotope heterojunction band diagram with opposite band bending on the opposite sides.

Characteristics of the interface of the short-period quantum-well structures corrugation with aim to detect ultra-low geometry relief (up to some A) have been investigated by two groups - headed by K. Ploog (Inst. of Solid-State Electronics, Berlin) and by V.G. Litovchenko (ISP NASU, Kiev). The anomalous polarisation of the luminescence spectra at the normal incidence of the excitation light flux has proved such corrugation, formulae for the estimation of it were obtained. Dynamics of the switching in multi-QW structures with the bi-stable electro-optical absorption for the development of the new converter of an analogue optical signal to digital one have been calculated in presentation of the also joint group of V. Kochelap (ISP, NASU, Kiev) and L. Bonille (University of Carles, Madrid). Authors have shown that optical bistability for MQW with negligible intervalley transport appear only in limited intensity range. Other switching wave structures were asymmetric thyristor structures, its theory was developed by Z. Gribnikov (ISP NASU) and V. Mitin (Wayne State University, Detroit). They have shown, that high speed operation can be reached in structures with the long base-2 (having larger diffusion length) and with the small life-time of carriers in this base. Quantum-dots Si in Sio2 phase was analysed in thermodynamic quasi- lquid approach - by the other joint group - I. Blonski (Ist. Of Physics, NASU, Kiev) and M. Valakh (Isp, NASU, Kiev) Such structures are interesting for the development of the Si-based light-emitted devices.

The fundamental characteristics of the perspective green-GaN LEDs were studied by the new method-

differential spectroscopy method jointly by two groups- one headed by P. Oleksenko (ISP, NASU, Kiev) and another - headed by D. Shin (Dougguk University, Seoul). This very accurate method enabled to obtained such important parameters of the I(v) characteristics as slope, kinetics, etc.

For the second issue the commission also presented several articles. Among them the joint work concerned with the fabrication of the optoelectronic elements (gratings, etc.) on the base of chalcogenide inorganic resists by two groups : A. Stronski and M. Vlcek and others.

We intend to continue the collaboration of our D Commission with this new Journal through presentation of the addition materials on the respective topics of out Commission and of the Seminar of our Commission . We also invite our URSI colleagues to participate in journal < Semiconductor Physics, Quantum- and Optoelectronics> by submitting the original manuscripts.

Prof. Vladimir Litovchenko, Chair Com. D
Prof. Pavel Oleksenko, Deputy Chairman
Dr. Alexander Stronski, Secretary Com. D

IN MEMORIAM

GEORGES A. DESCHAMPS
1911 - 1998

Our friend Georges A. Deschamps passed away on June 20, 1998, at the age of 86 after a long illness.

Georges was a leader and innovator in the Antennas and Propagation communities. Georges was born in Vendome, France, on October 18, 1911, and studied mathematics at the Ecole Normale Supérieure in Paris, one of the famous French "grandes écoles." Always fascinated by theoretical physics, he received advanced degrees in mathematics and physics from the Sorbonne, also in Paris. Then he served in the French army as a lieutenant, before coming to the United States in 1937, where he spent a year at Princeton University. After that he taught mathematics and physics for about ten years at the Lycée Français de New York.

In 1947, Deschamps gave up teaching and became a Project Engineer with the Federal Telecommunication Laboratories, a division of I.T.T, where, among his many responsibilities, he worked on direction finding and radio navigation systems. It was at ITT that Georges invented a special-purpose quaternion computer for the solution of problems in inertial navigation. Geometric techniques always played a central role in his research. For example, he presented a unified description of a variety of transmission line, waveguide junction, and polarisation problems in terms of a simple geometrical model. Based on this model, he developed graphical solution methods that he implemented in his "hyperbolic protractor." In many of his studies, Georges was a true forerunner. He developed a graphical representation of dispersion surfaces of wave propagation in magnetoplasmas and computed Fourier transforms by the fast Fourier transform method long before their "official discovery." He suggested the early form of microstrip antennas before they became popular.

In 1958, Deschamps joined the University of Illinois at Urbana-Champaign as a Professor of Electrical Engineering and the Director of the Antenna Laboratory. Until his retirement in 1982, and even thereafter, Professor Deschamps made several highly original and significant contributions to electromagnetic theory. He developed scattering diagrams in electromagnetic theory, complex-source-point representations for a Gaussian beam, ray technique problems, techniques for analysing diffraction by wedges, and differential form-based methods for electromagnetics. He was especially fond of this last topic and always believed that Maxwell's equations ought to be taught using differential forms instead of vector analysis.

Professor Deschamps was an early participant and a very active member of URSI, he was also a Life Fellow of the IEEE. He was admitted to the National Academy of Engineering in 1978 with an Award Citation that reads "For highly original application of mathematical techniques to electromagnetic and antenna theory and for a lifetime dedicated to generously sharing his knowledge with colleagues and students." In 1984 he received the IEEE Centennial Medal, and in 1987, the Antennas and Propagation Society Distinguished Achievement Award.

Georges Deschamps was a man of great intellect, deeply insightful about electromagnetic theory, much sought after as a consultant by students and co-workers to whom he gave generously of his wisdom and expertise. Reserved, even shy, he was regarded with great affection by his many friends and colleagues. He indulged in his scientific endeavour and shared his knowledge with colleagues even long after his retirement.

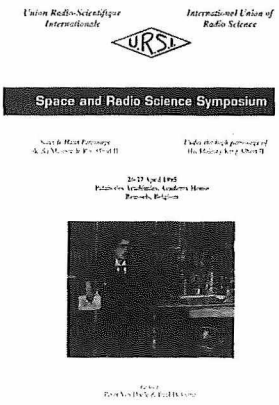
He is survived by his wife Bunty, his son François, two daughters, Georgianne Gregg and Christiane, and five grandchildren.

Weng Cho Chew, Shun-Lien Chuang,
Shung-Wu Lee, Yuen T. Lo, Paul E. Mayes,
George Swenson, Kung C. Yeh

URSI Publications

Proceedings of the "Space and Radio Science Symposium"

Editors: Peter Van Daele and Paul Delogne
ISBN 90-9008628-5



This "Space and Radio Science Symposium" was held on 26-27 April 1995, at the occasion of the 75th Anniversary of our Union.

Copies of these Proceedings are available at the URSI Secretariat for 12.39 Euro per copy (for countries outside Europe we charge an extra 3.47 Euro for mailing costs).

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  "The activities of URSI since its first General Assembly in 1922"
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  "Global Satellite Navigation Systems: Uses of Space-Time Fixe from Geodesy to Sailing"
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  "Antennas in Space : Modern Developments and Future Challenges"
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  "The future of Digital TV and HDTV by Satellite"
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  "Real-Aperture Radar (RAR) Imaging from Space"
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  "Measurements of Mesoscale Oceanic and Atmospheric Phenomena by ERS-1 SAR"
* Dr. D. Massonet (CNES, Toulouse, France)
  "SAR Interferometry and the Monitoring of the Earth Surface at Centimeter Level"
* Prof. R.T. Schilizzi (Joint Institute for VLBI in Europe)
  "Future Developments in VLBI Astronomy on the Ground and in Space"
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Modern Radio Science 1996

Editor: Joël Hamelin
ISBN 0-19-856530-5
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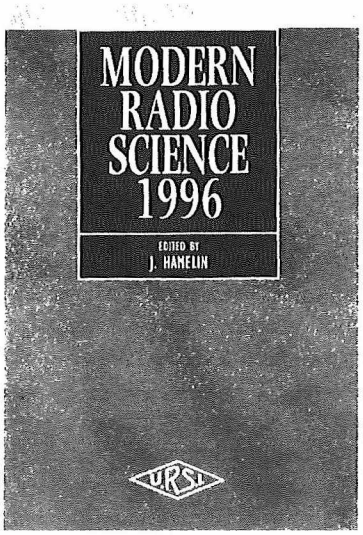

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Review of Radio Science 1993-1996

Editor: W. Ross Stone
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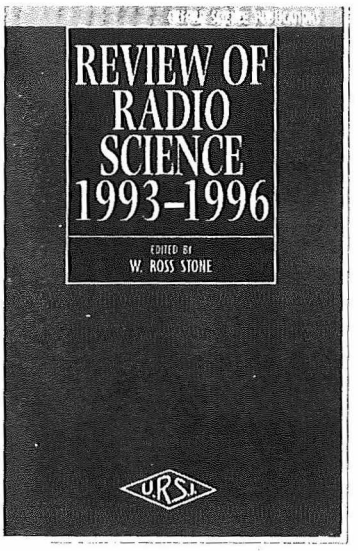

Handbook on Radiopropagation Related to Satellite Communications in Tropical and Subtropical Countries

Editor: G.O. Ajayi
with the collaboration of :
S. Feng
S.M. Radicella
B.M. Reddy

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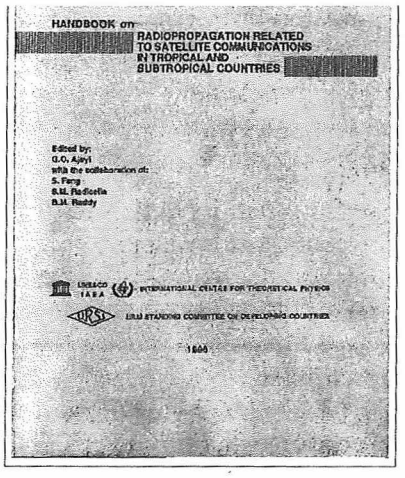

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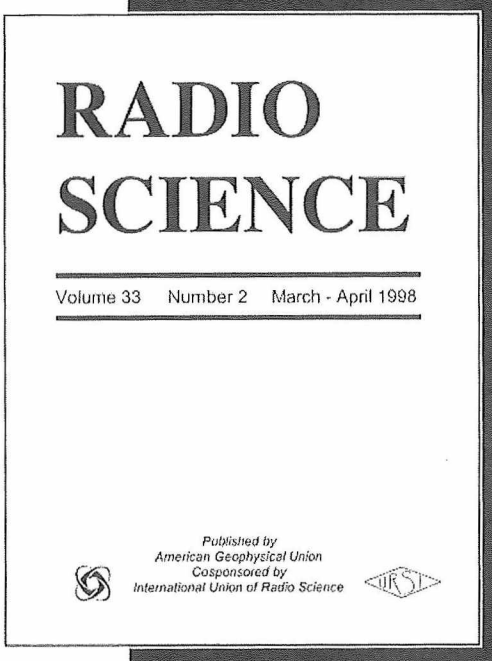

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