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Contents

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

Editorial

Dear URSI Correspondent,

Welcome to the last issue of our Bulletin this year.

After our meeting in Toronto during summer you have found in the previous issue several of the outcomes of our work during the last three years. This time we share with you reports concerning the business transacted by several of the URSI Commissions during the General Assembly.

The scientific part is devoted to radio astronomy. Two contributions by C. Rosolen et al. and K. Ruf are proposed. The first one concerns questions related to digital receivers used in this field. The other one presents several current projects and challenges.

In a letter to the editor R. Struzak points some aspects of spectrum congestion. His note is likely to rise interesting reactions in forthcoming issues. You will also find reviews of books published by URSI Correspondents.

In the administrative part of our Bulletin, announcements about future conferences sponsored or supported by URSI are given and, as usual before winter, an updated address list of URSI Officials is included. Please feel free to use it at your best convenience.

I wish you a merry Xmas and a pleasant reading.

Piotr Sobieski, Editor

Subscribe now!

If you were not able to attend the URSI General Assembly in Toronto last month, please fill in the form on the back cover of this issue and pay your Correspondent fee as soon as possible with VISA or MASTERCARD, so that you will receive the Radio Science Bulletin in the next triennium also. Please note that we do not accept cheques.

Letter to the Editor

Spectrum Congestion - a Voice in Discussion

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This note refers to discussions on spectrum congestion at the URSI General Assembly, Toronto 1999, and extends considerations presented in tutorial lecture [1]. Starting with Shannon's formula, it proposes quantitative measures to deal with congestion issues and wireless systems design.

Shannon's Limit

Delogne and Baan [1] quote Shannon's limit on the maximum amount of information (C_0) that communication channel can transport in unit time and unit bandwidth

$$C_0 = \log_2(1 + q) \qquad (1)$$

Here q is the power ratio (q = S/N) of wanted signal (S) to the additive noise (N) at the receiver end of the link. However, two comments have to be made at this point:

- The Shannon's theorem holds for an isolated communication link
- No radio link can be isolated from its environment.

Environmental Influence

Radio waves in open space cannot be confined to any specific volume due to basic laws of physics. Consequently, when a number of radio links operate at the same time and frequency, a part of power transported by radio waves penetrates from one link to another. Such unwanted power does not convey useful information and adds to the link's noise power. The process involves the receiving end of the victim link and the radiating end of the other links (and/or other radiating equipment). As a result, the channel capacity drops.

Congestion effects

The growing number of radio equipment leads to spectrum congestion, which in turn means the increase of the unwanted power penetrating from the environment into radio links, with consequential deterioration of their capacity. The results are:

- Smaller volume of information can be transmitted in a given time and bandwidth
- Longer time (or additional communication links) is required to transmit a given amount of information within a given bandwidth
- Wider bandwidth (or additional communication links) is needed to transmit a given amount of information in a given time
- Smaller number of users can employ a given bandwidth during a given time period

All this implies increased costs that are to be born by the communication services providers and by consumers, i.e. by the whole society. Moreover, in some applications such as radio astronomical observations, a part of scientific information contained in the natural signal received is irrevocably lost.

Congestion Index

To discuss spectrum congestion issues in an unambiguous way, we need an objective, quantitative measure. For that purpose, we propose "congestion index" (a*), defined as the power ratio of environment noise component (I) to the total noise (N + I) at the receiver end of the link:

$$a^* = I / (N + I) \qquad (2)$$

Its numerical value is confined between one and zero. When the environmental noise component (I) is zero, the congestion index equals zero. When the environmental noise I increases, the congestion index a* increases too, reaching 1/2 when the environmental and "internal" noise components are equal.

Isolation Index

A complementary measure, "Isolation index" (a) is defined as

$$a = (1 - a^*) = N / (N + I) \qquad (3)$$

When the link operates in perfect isolation (I = 0), its value is one, and when the environmental noise (I) is much greater than the link noise (N), it approaches zero.

Link Capacity

The maximum capacity of a link suffering from the environmental noise is

$$C = \log_2[1 + S/(N+I)] = \log_2(1 + aq) \qquad (4)$$

Note that C is always smaller than the potential link capacity C_o.

Capacity Loss

The absolute loss of link capacity due to the environmental noise is

$$(C_0 - C) = \log_2(1 + q) - \log_2(1 + aq)$$
$$= \log_2[(1 + q) / (1 + aq)] \qquad (5)$$

The relative loss

$$[(C_0 - C) / C_0] = 1 - C/C_0,$$
$$\text{where } C/C_0 = [\log_2(1 + aq)] / [\log_2(1 + q)] \qquad (6)$$

Example 1: Single Radiator

Assume that the environment of the link at hand consists of only one other radio link. For simplicity, we assume that it uses the same frequency, operates at the same time, and that the spatial deployment of all elements does not change with time. We assume (d^{-n})-type propagation model and we disregard shadowing and other radio propagation effects. The signal power (S), noise power (N) and environmental-noise power (I) at the receiver end of the link are

$$S = P_W G_{RW} G_{WR} (D_{WR})^{-n}$$
$$N = S/q$$
$$I = P_U G_{RU} G_{UR} (D_{UR})^{-n} \qquad (7)$$

Here, P_W is the power radiated by the (wanted) transmitter end of the link; G_{WR} and G_{RW} are the link transmitting- and receiving-antenna maximum gains. D_{WR} is the span of the link, and n is the propagation index. The link noise N derives from the signal power S at the receiver input and from the assumed signal-to-noise ratio (q). P_U is the power radiated from the unwanted radiator (environmental transmitter), G_{RU} is the receiving antenna gain in direction of that radiator, G_{UR} is the transmitting antenna gain of unwanted radiator in direction of the victim receiver, D_{UR} is the distance from the victim receiver to the unwanted radiator. After summation of the noise components (N) and (I), we obtain the isolation index of the link

$$a = 1/(1 + I/N) = 1/[1 + Rat\, q\, (D_{WR}/D_{UR})^n],$$
$$\text{where } Rat = (P_U/P_W)\,(G_{UR}/G_{WR})\,(G_{RU}/G_{RW}) \quad (8)$$

Isolation index a tends to one, and link capacity C approaches its potential maximum (C_0) when the following variables tend to zero:

- The distance ratio (D_{WR}/D_{UR})
- The power ratio (P_U/P_W)
- The radiating antenna gain ratio (G_{UR}/G_{WR})
- The receiving antenna gain ratio (G_{UR}/G_{WR}).

Congested Environment

In congested environment, the neighbourhood of the link may involve a large number of radio links (and/or other equipment) that may introduce additional noise component to the communication channel. If I_i, denotes the noise power due to *i-th* radio link, and K denotes the total number of the neighbouring links (radiators), the resultant noise power ($I = I_1 + I_2 + I_3 + ... + I_K$) and the isolation coefficient is (under the assumption that all radio links are operating at the same time and at the same frequency)

$$a = 1 / [1 + S_j(I_j / N)],\ j = 1, 2, \ldots, K \qquad (9)$$

When all components are identical, $S_j(I_j / N) = K\,(I/N)$ and $a = 1 / [1 + K\,(I/N)]$.

Global Losses

In a set of K mutually interacting radio links (not necessarily belonging to any common network or system), performances of each link are degraded due to the operation of neighbouring links. The degree of degradation depends on a number of variables such as the operating frequency, power radiated, spatial deployment, antenna directive gain etc. Let P_i be the i-*th* link's transmitter power, and t_{ij} be the transmission power gain (loss) from the transmitter of the j-*th* link to the receiver of the i-*th* link. It involves the antenna gains signal processing gain, and radio wave propagation effects, such as spread loss, shadowing etc. The I/N ratio at i-*th* receiver is

$$(I/N)_i = t_{ij} P_i / \{S_{j,\, j^1 i} (t_{ij}P_j) + N_i)\},\ i, j$$
$$= 1,2,3, K,\ i\ ^1 j. \qquad (10)$$

The isolation index, the capacity of i-*th* link, and the total capacity of all links (CS)are

$$a_i = 1 + 1/(I/N)_i$$
$$C_i = \log_2(1+ a_i q_i)$$
$$CS = SC_i = \log_2\{P(1+ a_i q_i)\},\ i$$
$$= 1, 2, \ldots, K \qquad (11)$$

Complex Cases

We assumed above for simplicity that all radio links involved are stationary and operating at the same time and frequency. We also assumed that out-of-band radiations, spurious emissions as well as out-of-band and spurious receiver responses are negligible. The real-life systems may require more sophisticated models and statistical approach may be needed.

Optimisation

The capacity loss due to environmental effects should be kept as low as possible for the reasons indicated in an earlier section. The approach can be formulated as follows. There is a set of K mutually interacting radio links each being degraded due to the interaction with the other links. The links do not necessarily belong to any common system or network. The task is to select the values of control variables in such a way as to minimize the total capacity losses due to the mutual interactions. An alternative formulation involves maximization of the total amount of information transmitted by all the links, as defined by formula (11). There may be some restriction imposed on the variables involved.

Concluding remarks

- Spectrum congestion limits the development of all applications of radio and involves costs to be paid by the whole society. Scientific community should continue investing efforts to lower that price.
- The original Shannon's formula (1) for an isolated channel neglects the environmental noise and consequently does not apply to radio communication systems that by their nature cannot be isolated from the environment. The maximum potential capacity of a radio link is given by modified Shannon's formula (4) that involves the isolation index of the link.
- The isolation index may serve as indicator of capacity loss due to environmental noise.
- The capacity loss of radio link can be minimized by rational design.

Reference

1. Delogne P, Baan W: Spectrum Congestion; in Modern Radio Science 1999, ed. by M A Stuchly, Oxford University Press 1999, p. 309-327

High Dynamic Range, Interferences Tolerant, Digital Receivers for Radio Astronomy

C. Rosolen, V. Clerc and A. Lecacheux

Radio astronomy in the decameter to centimeter wavelength range is facing new challenge because of man made interferences due to increasing needs in telecommunications. Different approaches are under studies to minimise or avoid the effects of these electromagnetic interferences on radiotelescopes and on very sensitive wide band receivers.

At the Radio astronomy department of Paris Meudon Observatory, we are working since four years on high dynamic range digital receivers based on Digital Signal Processors (DSP). The first realization is a digital spectropolarimeter devoted to spectroscopy of astrophysical radiation in decameter range, built in collaboration with the Space Research Institute (Graz Austria) and now in operation at the Nançay Decameter array. The bloc diagram of the receiver includes a high dynamic range analog session followed by a 12 bits analog to digital converter. The digital part is based on the utilization of high power, programmable digital circuits for signal processing, arranged in a dedicated parallel architecture, able to compute in real time the power spectrum and the correlation of the input signals.

We are presently working on a new digital receiver in order to increase the bandwidth. The objective is 60 MHz (or 2 x 30 MHz band) with at least 60 dB dynamic range. This new receiver will use additional computation power in order to be able to recognize and avoid man made interferences compared to radio astronomical signal. We think that this direct spectrum computation technique is really powerful and offers new capabilities for real time excision of the interferences.

1. Introduction

This paper describes a new type of spectrum analyzer for radio waves developed at the Radioastronomy department of Paris-Meudon (France) in collaboration with the Space Research Institute of the Austrian Academy of Sciences in Graz (Austria). Unlike almost every existing analyzers, this machine, performs real-time digital spectral analysis using signal processing dedicated chips. Both theoretical study and practical experience have shown that such an approach offers significant advantages over conventional analyzers, that will be discussed in the following pages.

The device is primarily intended for studying polarized decametric radio emissions (DAM) from Jupiter and the Sun in the 5 to 60 MHz frequency range. Considering the life time of the electro-magnetic phenomena (varying between 1 ms and several seconds) and their very low relative power, a suitable device must provide at least 1 ms time resolution and 70 dB dynamic range in order to manage man-made interference problems in ground-based low frequency radio astronomy. We will particularly focus on this last consideration.

2. Dealing with interferences : approaches and "solutions"

The following figure shows an example of spectrum in decametric bands.

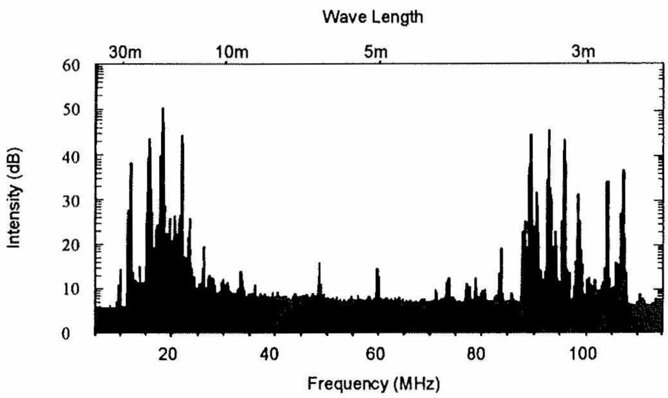

Fig. 1: Monitoring of the decametric band observed with the Nançay Decameter Array (France). We can clearly see the parasites from 10 to 22 MHz (AM broadcast) and from 88 to 108 MHz (FM broadcast). Those artificial radio sources are about 55 dB above the average sky noise level. With this 4000m2 effective area telescope radiations from natural radio sources, like Super Novae Remnants (SNR) or Pulsars, are often 25 dB lower than the sky level whereas Jupiter or the Sun radiations can reach 30 dB above the sky level. Artificial interferences are the most powerful that have to be treated by both the reception and conversion units. The required dynamic range can be characterized by means of the ratio of the strongest expected interference to the weakest natural source. Since the strongest interferences are usually narrow-banded, they can be approximated by, a sinusoid and a minimum signal-to-noise ratio can be determined which the ADC has to provide. In this case 80 dB would be necessary.

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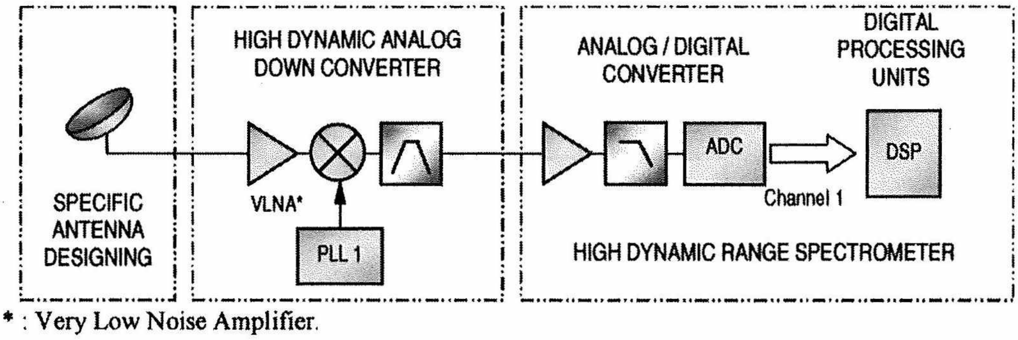

Fig. 2 : General synoptic of a digital receiver

With the ever-increasing usage of the radio spectrum and the recent explosion in global communication systems, spectrum management is becoming both complex and multisided.

Nowadays, due to obvious commercial stakes and new scientifical concerns, the classical approach that consists in protecting a given band becomes obsolete. On one hand global communications are putting the spectrum under pressure, on the other hand user-reserved limited band, is no more in accordance with the actual scientific wish to observe wider bandwidth. Then, the various tasks should be divided in two main options :

1) Administration and control of the current radio spectrum, which involves :

a) develop regulatory actions by the various national and international authorities.
b) Spectrum monitoring of the radio environment

2) Constant and regular instrumental adaptation to the growing spectrum pollution in order to facilitate an active and passive cohabitation for users. For the time being, significant progress has been made in a number of the above areas. These are:

a) On-Site Interference Monitoring and identification.
b) New concepts for less sensitive antennas to reduce the sensitivity to R.F.I.
c) Development of interferences tolerant receiver.
d) Interference Excision by hardware and /or software methods (Both on-line (real time) and off-line (post processing) RFI-excision).

Users of the spectrum must come to some coexistence since, even now, in some frequency bands, observations and utilization of the spectrum can only be carried out via RFI-excision techniques and interference tolerant receivers.

3. Radio astronomy receivers

Radio astronomy receivers are very sensitive and sophisticated systems, but they were generally not designed to deal with interferences.

- At the input they use very low noise cooled amplifiers with high gain and wide band. The dynamic range of the theses amplifiers is very poor and not well known. New studies and different designs must be carried out.
- Up and/or down conversions have also to be redesigned with improved dynamic range efficient filtering and with respect to in and out of band intermodulations products.
- Most of the time Digital Auto-Correlators (DAC) are used as spectrometers for decimeter to millimeter bands. They offer a great reconfiguration flexibility but with very poor dynamic range since digitizer's resolutions are 1 or 2 bits.
- Filter Banks (FB) and Acousto Optical Spectrometers (AOS) are also used providing 20 to 30 dB of dynamic range but with fixed resolution.

Future solutions have to take in account high dynamic range analog amplification and down conversion associated to wide band digital spectrometers.

4. High dynamic range spectrometers

4.1. Analog / digital converters (ADC)

Broad band architecture, as used in radioastronomy, requires generally several IF chains followed by an A/D converter. Channel selection, filtering and additional processing are, then, carried out numerically. This solution seems particularly attractive since it eliminates most of the redundancy from the preceding version. The essential drawback of this concept is the drastic performances requested from the components, and particularly from the ADC.

Consequently, to specify the converters in SFDR (Spurious Free Dynamic Range), SNR (Signal to Noise Ratio) is not sufficient any longer. SINAD (Signal to Noise And Distortion) must then be considered. Because of linearity errors, thermal noise, amplification noise, and harmonics generated by the digitization, the effective resolution of a given ADC is much lower than the raw dynamic that we could afford. The ideal maximum value that can be obtain with a n bits

ADC is mathematically 2^n . The dynamic is then equal to 6.02n dB ($20\log 2^n$). Since the different sources of error are depending on the use of the converter, the effective number of bits (ENOB) will be closely related with the SINAD(which can be considered as a function of the frequency).

Today, a few companies introduce 12 bits monolithic ADC at moderate cost able to digitize at 65 MSample/s. But for the use of instantaneous bands greater than 20MHz, lot of progress have to be done.

4.2. Processing unit

The main purpose of this stage is mainly to perform fast

$$\text{ENOB} = (\text{SINAD}_{dB} - 1.76) / 6.02 \qquad (4.1)$$

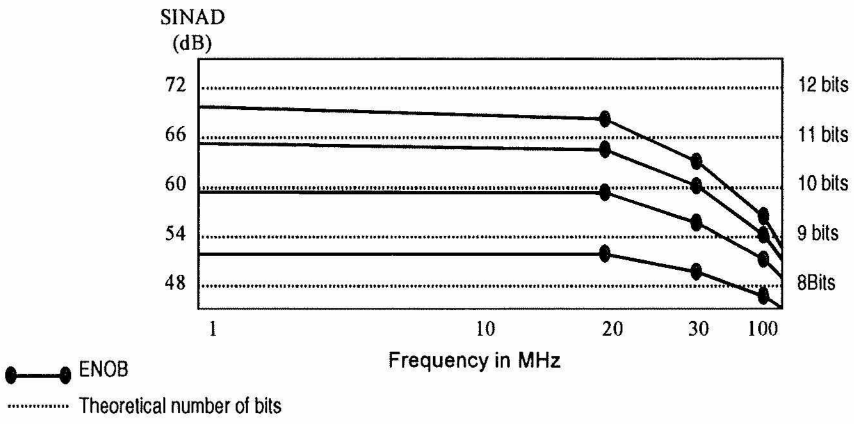

Fig. 3 : Evolution of the SINAD as a function of the frequency for 12, 11, 10, 9 and 8 bits A/D converters.

Fourier transform in real time in order to get an instantaneous analysis of the different phenomenons. Obviously the execution of the FFT will cause computational noise due to the round-off errors. If we perform a spectral analysis over N frequency channels, we obtain a noise power which is N-times lower than the one over the total instantaneous bandwidth. In a very simple manner and knowing that each additional bit yields a reduction in noise by a factor of 4 (or 6.02dB) one can estimate the required wordlength L for an FFT-processor:

$$L = WL + 1/2 \log_2 N \qquad (4.2.1)$$

For WL = 12bits and N =1024, we obtain L = 18. It is also assumed that the computation of the FFT is carried out noiseless, that is, rounding to L only occurs at the FFT-output. Since this is not the case the wordlength L may have to be increased. The additional noise due to intermediate rounding depends on N and the radix-order. A convenient value for L may be about 20. DSP-processors with a 32bit floating point format like the ADSP-21060™ and the brand new TMS320C67 ™ do not pose any problem in this respect. Consequently, FFT-computations on such processors can be considered noiseless.

5. 2 x 12 MHz Spectro-polarimeter

5.1. Device description

The analog preprocessor is made of three sections: radio frequency (RF), intermediate frequency (IF), and base band section. The RF-signal in the 5 to 60 MHz band is up converted to the IF, centered at 70 MHz, in the first mixer stage and is filtered through a bandpass-saw-filter of 11 MHz bandwidth. The second mixer down converts the 11MHz band to base band. The 11 MHz band to be processed can be placed anywhere between RF-frequencies from 5 to 60 MHz by means of the first mixer stage which contains a tunable synthesized local oscillator (PLL1).

Two 12bits A/D converters (Analog device AD9042™) are implemented on a dedicated board specifically designed to reach a very low level of spurious signals. Digital outputs are transferred to the computation boards though a synchronous fast dedicated 25 MHz bus. Computational units in which input/output are bufferized, are made of four ADSP21062 ™ SHARC ™ processors (Analog Device Super Harvard ARChitechture). Communication with the host system is ensured trough a VME interface.

The main idea when designing the machine was to sample the preprocessed, down-converted RF-signal using an analog-to-digital converter (ADC) and to perform spectral analysis entirely in the digital domain [Klee 97].

The employed method for estimating power spectral density (PSD) was originally proposed by P. D. Welch in 1967 [Welc 67]. This method based on the discrete Fourier transform (DFT), is computationally efficient and requires a relatively small amount of memory on the hardware platform. The spectrum estimate is computed by averaging so-called 'modified periodograms' 'Periodograms are the magnitude-squared short-time Fourier transforms of the signal to be analyzed). The device continuously samples the analog input signal, computes periodograms from this data stream and calculates the average of a number of these to obtain the final spectrum estimate.

The process can be outlined as follows:

- Windowing data vectors:

$$w(t)\, x_k(t) \qquad (5.1.1)$$

where x_k (t) denotes the data vector in the time domain, and w(t) the weighting function.

- Computation of FFT on each vector:

$$W(f) * X_K(f) = FFT\{ w(t).\, x_k(t) \} \qquad (5.1.2)$$

where X_k(t) denotes the Fourier transform of x_k(t), W(f) the Fourier transform of w(t), and star (*) the convolution operator.

- Computation of periodogram P_k(f):

$$P_k(f) = [W(f) * X_k(f)]\,[W(f) * X_k(f)]^* \qquad (5.1.3)$$

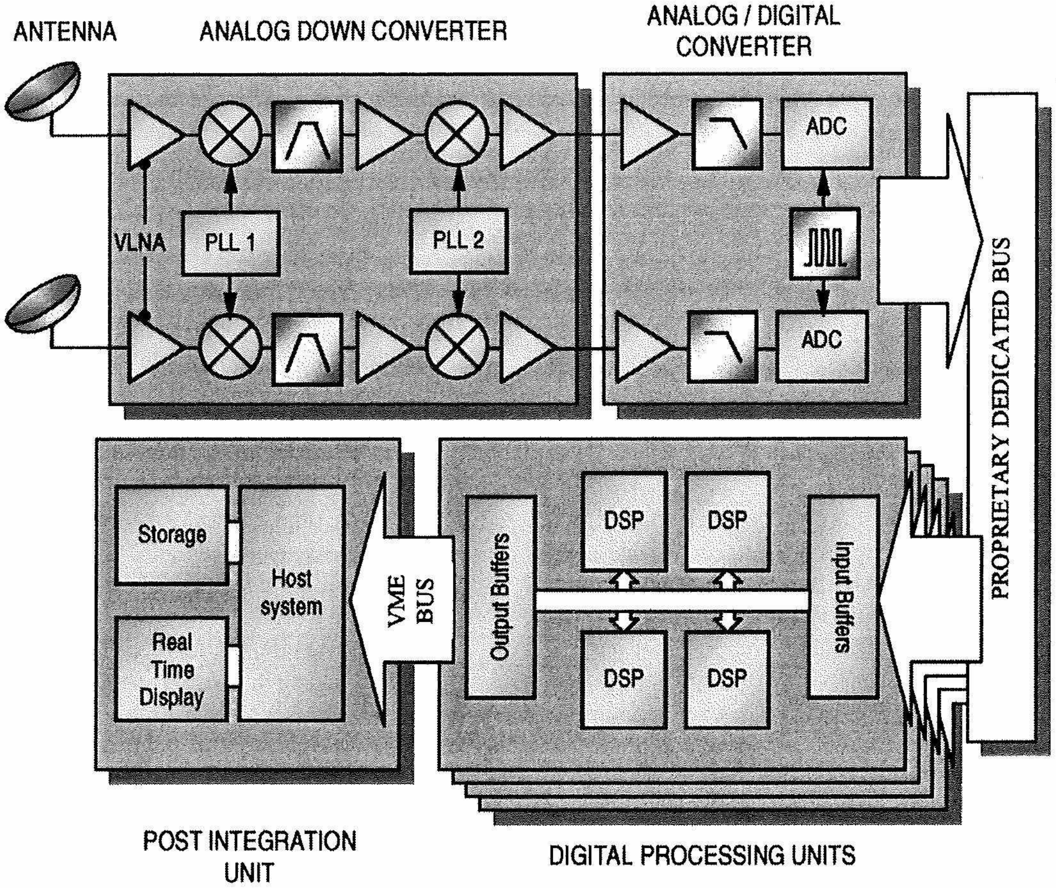

Fig. 4 : Synoptic of the Digital Spectro-Polarimeter. The first module (top left) contains the analog preprocessor performing amplification, filtering, and up/down conversion of the RF signal. An 12 bits A/D converter module (top right) samples and quantisizes the preprocessed signal, while several digital processing modules (down right), each containing a cluster of digital signal processors (DSP), perform spectral analysis in real time. Finally, a workstation (down left) serves as host.

where ([]*) denotes the complex conjugate of ([]).

- Average over K individual periodograms:

$$P(f) = < P_k(f) > \qquad (5.1.4)$$

For polarization measurements, the cross spectrum can be calculated from the Fourier transforms of the two associated antenna signals:

$$P_{cross}(f) = < [W(f) * X_{1k}(f)] \,.\, [W(f) * X_{2k}(f)]^* > \qquad (5.1.5)$$

From this complex spectrum and the (real) power spectra of the two antenna signals, the Stokes parameters can be calculated.

5.2. Practical Realization

Although published in 1967, Welch's method is still uncommon in the field of radio astronomy. This may be due to problems concerning analog-to-digital conversion on the one hand and computation power requirements on the other. According to theory, a continuous signal of a bandwidth B must be sampled at least at a frequency :

$$F_s > 2B \qquad (5.2.1)$$

to be represented unambiguously in the discrete-time domain, while the signal-to-noise ratio (SNR) of an AD-converter can be estimated [Oppe 75] from its number of bits b :

$$SNR\ [dB] \approx 6.b \qquad (5.2.2)$$

Thus, high dynamic range and wide bandwidth require a fast ADC with high resolution; for example, a 12-bit-ADC running at 25 MHz theoretically yields a bandwidth of 12.5 MHz and a signal-to-noise ratio of 72 dB. Such converters became available only recently.

Numerous fast Fourier transform algorithms have been published since 1965 [Cool 65].In general, they require a number of operations (OPS, meaning multiplications and additions in this context) which can roughly be calculated as :

$$OPS_{FFT} = k_{FFT} \,.\, N \log_2 N, \qquad (5.2.3)$$

while the direct computation of the discrete Fourier transform requires

$$OPS_{DFT} = 4.N^2 - 2.N \qquad (5.2.4)$$

operations. N is the number of frequency bins and k_{FFT} usually lies between 4 and 5 (depending on the algorithm). Using the formula for K from the previous chapter, assuming a sampling frequency of 25 MHz, a fractional overlap of 50%, and 1024 frequency channels, we obtain a computational load of more than one billion operations per second for a real-time spectral analysis; this number does not include any computation other than the FFT, such as windowing, squaring and averaging.

This high amount of computation power implies the use of a multiprocessor architecture. Furthermore, using the method of Welch, the process of spectral analysis can be easily decomposed into several identified tasks which can be executed in parallel.

The architecture we finally designed was a homogenous multiprocessing system with a symmetrical implementation of Welch's method. Twenty SHARC TM, each providing a computation power of about 100 MFLOPS (million floating point operations per second), are needed for a machine with 12.5 MHz bandwidth, 1024 frequency channels, and good sensitivity (50% fractional overlap). Those processors are distributed on 5 VME-bus card, allowing to build a homogeneous, symmetric multiprocessor platform around a host computer. The cards are designed for two antenna inputs. Additionally, several optimized software modules have been written for this platform.

5.3. Laboratory Results

The working version of the system has been tested in laboratory and is now operating on radio telescope (Decameter Radio Telescope of Nançay, France) since 1997. Laboratory tests were carried out in order to measure the response of the device to sinusoidal signals and to broadband noise. They show that the digital analyzer yields a spurious-free dynamic range of 75 dB and a linear response to white noise greater than 50 dB.

5.4. Astronomical results

First tests on radio telescope made in Nançay, also include polarization measurements. These preliminary results proved that the new real-time digital signal processing device is a valid alternative to existing analog analyzers. Its performance regarding time resolution (in the order of several milliseconds), frequency resolution (about 20 kHz equivalent noise bandwidth) and dynamic range is equal or superior to the one obtained with current machines. Polarization measurement (operation not allowed by AOS, SFA or FB) can be made at very high time resolution as well.

6. - 2 x 30 MHz Digital receiver

This new receiver is based on Signatec(tm) cards. Even if the general philosophy has been used, improvements on bandwidth are being made since a 60 MHz band has been reached and internal architecture is being reworking allowing multi-task processing and PCI interfaces.

Data acquisition is done at 62.5 MHz per channel, with a 12bits depth by a Signatec(tm) PDA12(tm) board. For the first time, analog RF pre-processor is no longer needed since we can access the 0 to 30 MHz band directly. Datas are sent to the processor nodes through a dedicated bus. PCI bus offers a significant improvement in data transfer rates as compared to VME, but relying on it for data movement in such a time critical application is still problematic.

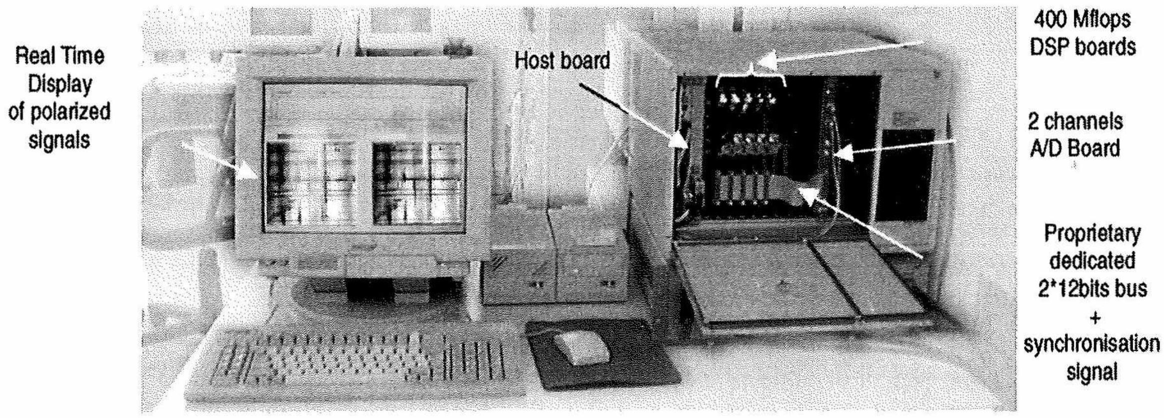

Fig. 5 : Global view of the system currently used in Graz and in Nançay. Each system can perform 2 Giga floating point operations per second.

One solution to get high performances is the Signatec(tm) Auxiliary Bus (SAB(tm)). By placing a 64 bit data bus on standard ISA/PCI boards, data can be moved between boards independently of the host bus. Using a maximum data clock rate of 25 MHz, data transfer rates of 200 megabytes per second can be sustained indefinitely. This eliminates all previous bottlenecks in moving of the data from A/D acquisition boards, signal processing boards. Additionally, multiple SABs(tm) can be implemented in a single computer which further increases the available bandwidth. Our application uses the SAB(tm) for time critical data movements and the host bus for less critical operations. Since both buses are in simultaneous operation, system throughput is maximized.

The computation of the FFTs is done by two Signatec(tm) PMP8(tm) parallel processing DSP boards which features a huge processing power. The internal mechanization of the boards utilizes multiple high speed busses combined with cross point port switching. Their

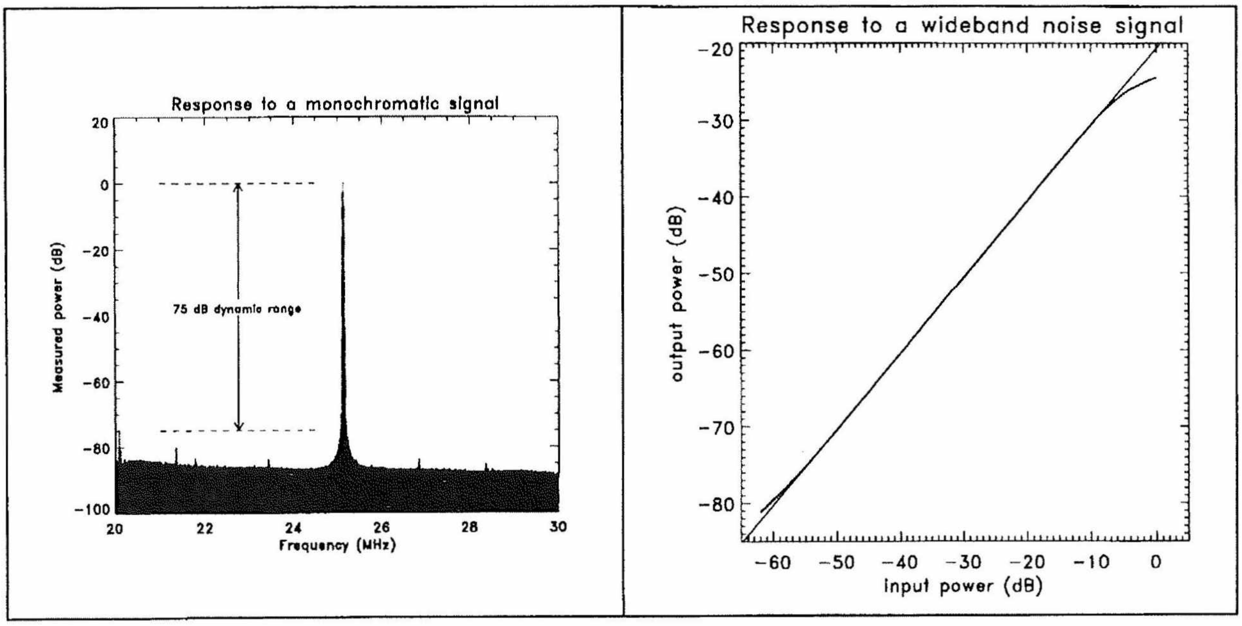

Fig. 6 : Dynamic range measurements show a 75 dB spurious free dynamic range.

architecture incorporates a master DSP called the Program Execution Processor (PEP) and up to 8 slave DSP's. All DSP's are Texas Instruments(tm) new TMS320C6701(tm) which are capable of 1 Gflops of peak floating point operations performance. One PMP8(tm) is used per Channel. Since the Cross polarization computation needs the processors to be aware of both channels, informations about spectra are exchanged between PEPs through another dedicated bus : the 32 bits Signatec(tm) External Bus (SEB).

In our case, the use of software programmable processors instead of hardwired chips offers greater flexibility since the device can be adapted to any new needs and open new fields for signal processing in radio astronomy and in RFI excision:

- One may use other transforms than the DFT for signal analysis (like Wigner-Ville or Wavelet transforms, for example).
- The great adaptability of digital processing methods authorizes real time interference excision. Such a study

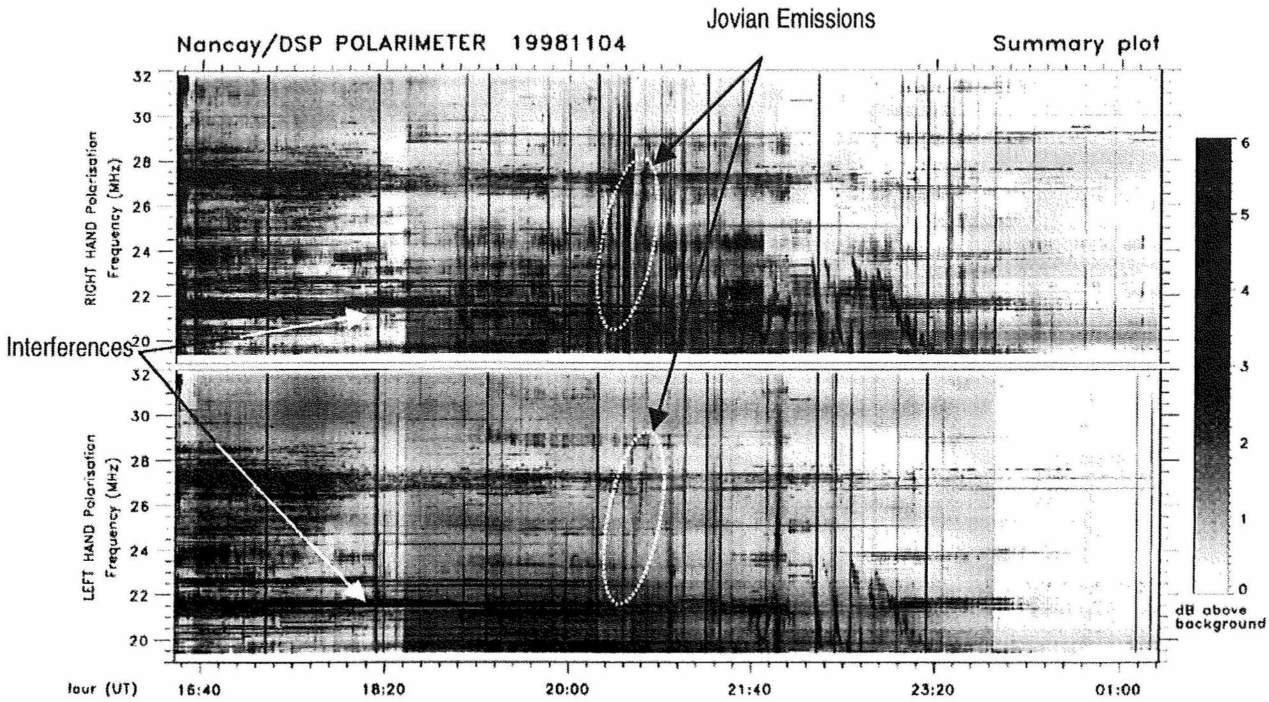

Fig. 7: Observations of Jupiter at 1 second time resolution and 26 MHz central frequency. Interferences are 30 to 60 dB stronger than natural radio-sources.

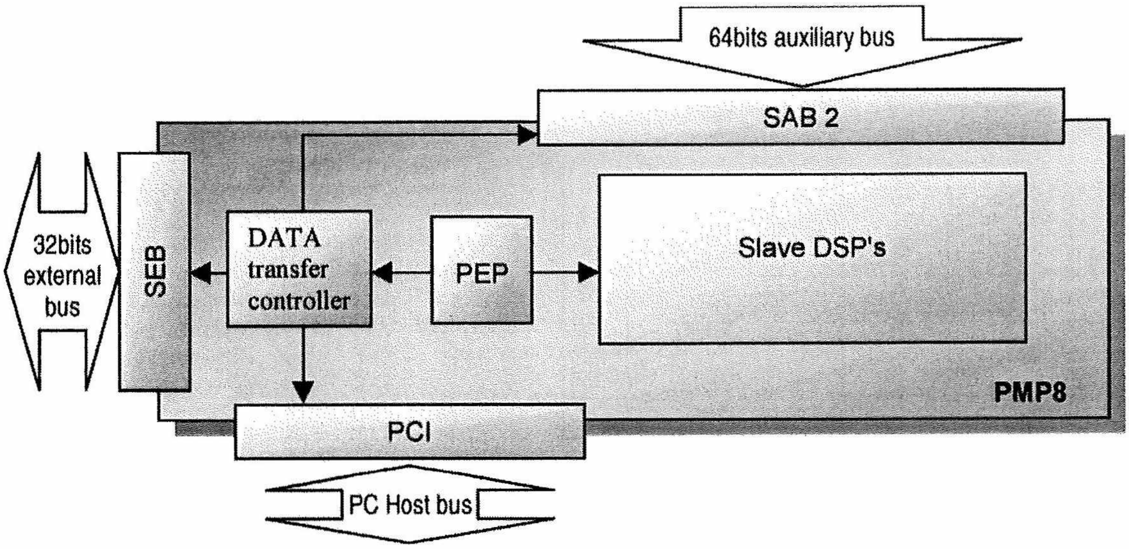

Figure 8 : Architecture of the PMP8 boards. Two 9 DSP 's PMP8(tm) are used : one per channel. The total computational power can reach up to 16 Gflops peak.

is currently being carried out at the Meudon Observatory. Both Frequency-time transforms and neural network based algorithms could be used to categorize the interferences in order to substract them from the signal.

- Event Automatic recognition by neural network processing is also possible. A recent study on this topic clearly showed the efficiency of neural network techniques allowing sorting and extracting Jovian patterns [deLa 97].
- Real time data compression techniques are also possible in such environment.

Conclusion

It should be stated that the approach that has been presented and evaluated within the scope of this project in the decameter wavelength range, shows the ability to observe very weak signals in between very strong interferences.

The increasing bandwidth analysis capabilities open new fields of investigation in the other wavelength of radio astronomy. Whereas, the quick progress in digital signal processing technology promises an interesting future in this domain of scientific research.

Working on interferences tolerant receiver is part of the solution but the stress must be applied on interferences removal. Many group are currently conducting research on algorithms and/or devices to realize intelligent interferences excision.

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Technical and Engineering Challenges for the Future of Radio Astronomy

Klaus Ruf

1. Introduction

Radio astronomy is part of the science of astronomy and can in fact be considered as a science of its own. Throughout the development of astronomy, steps in the enlargement of knowledge have always followed technical improvement in the instrumentation used. This is especially true for radio astronomy, which has, in the comparably few years of its existence, contributed enormously to our understanding of the universe, partly through confirmation of postulates made earlier, e.g. the 21 cm Hydrogen line, interstellar chemistry, and the cosmic background radiation, but to major part also through unexpected detections like the pulsars and the quasars. These detections and the ones we expect to make in the future, require highly sophisticated instrumentation and signal processing.

Different observing programs may have different requirements with respect to the spectral, spatial, or time resolution, but of central importance to almost all radio astronomical observations is the sensitivity. The celestial sources, which radio astronomy does not only want to observe but to analyse quantitatively, are in almost all cases weaker than the artificial sources of telecommunication transmitters by orders of magnitude.

2. Radio astronomy sensitivity and protection requirements

Other than most radiocommunication services radio astronomy needs to detect and analyse signals, which can be several tens of dB weaker than the noise contributed by the receiving equipment. This is achieved by determining the noise power increase (or system temperature increase) introduced into the system by the source under observation. Therefore the sensitivity, which can ultimately be achieved, is determined by the fluctuations of the noise power. This noise power fluctuation is a random variable and its statistical average can be found with a precision which is dependant on the number of independent samples. In radio astronomical terms the sensitivity limit depends on the bandwidth and the integration time in the following way:

$$\Delta P = \alpha P / \sqrt{Bt}$$

ΔP is the increase in noise power, α is a proportionality factor, which relates to details of the equipment and observing technique and can be set to 1 here for simplicity. P is the total noise power, which contains contributions from the equipment and from the source. B is the bandwidth and t is the integration time used. (A complete treatment can be found in the literature, e.g. Wilson and Rohlfs, Tools of Radioastronomy [1].) Through the Boltzman constant k the noise power P is related to the noise temperature T, $P = kT$, and the power fluctuation can be transformed into noise temperature fluctuation

$$\Delta T = T / \sqrt{Bt}$$

where the system temperature T is the sum of the antenna temperature T_A and the receiver noise temperature T_R. TA contains the noise contribution from the source, T_S, together with contributions like the cosmic background, T_{BG}, the atmosphere, T_{Atm}, and interference, T_{Int}. To detect a cosmic source of temperature T_S the system noise fluctuation ΔT must be accordingly smaller than T_S.

Radio astronomy is increasingly threatened that the limiting factor of sensitivity will be interference from active services. Being a science, radio astronomy shares the radio spectrum with other applications of radio and therefore shares the benefit of being a recognised service within the ITU-R. Being a service with a large variety of scientific questions to be answered, requiring experiments with a large variety of technical and operational set up, radio astronomy has very early tried to present interference criteria to the fellow radio services, based on the sensitivity considerations as sketched above, but at the same time not asking for the unreachable. The interference threshold level are derived and tabled in Recommendation ITU-R RA.769. (See also the Handbook on Radio Astronomy [2].) The criterion used is that the interfering noise temperature should not exceed $0.1 \times \Delta T$. Representative values for T_R and T_A are given in the table of recommendation ITU-R RA.769, the bandwidth B is either the bandwidth of the allocation or the bandwidth of a spectrometer channel, if the frequency band is used for spectroscopy; the integration time t is taken to be 2000 sec. The system noise fluctuations

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reached under these assumptions range from $\Delta T = 0.003$ mK to 0.15 mK for continuum bands above 1 GHz, and are in the range of 2 to 3 mK for narrow band spectroscopic observations. To convert these figures into spectral power flux densities, an isotropic antenna is assumed with an effective antenna area of $\lambda^2/4\pi$, which corresponds to an interfering sigal entering the antenna from a direction, towards which the antenna gain is 0 dBi. The resulting interference threshold values, expressed as spectral power flux density, vary from -213 to -259 dB(W/m^2 Hz) for continuum bands and from -195 to - 244dB(W/m^2 Hz) for spectral line bands.

Radio astronomy has defined, for its own purpose, a flux density unit named after one its pioneers, Carl Jansky, and 1 Jy = - 260 dB(W/m^2 Hz). Astronomical sources of a flux density of 1 Jy are nowadays considered strong sources. mJy sources are observed regularly with existing radio telescopes. This is made possible by the use of large collecting areas. It is interesting to compare the source strength with the permissible interference level developed for co-ordination purposes: an interfering transmitter, emitting into a radio astronomy band at the interference threshold level and seen by the radio telescope through a far side lobe of 0 dBi gain, adds to the system a noise power comparable to noise power introduced by the observed source in the main beam of the telescope with an assumed gain of 70 dBi. While radio astronomy has developed the skill to discriminate the observed weak source from a very noisy environment, there is empirical evidence that it cannot work with much higher levels of interference, and radio astronomy is right now preparing to increase sensitivity from the mJy to the μJy level.

3. Existing instruments and their achievements

Radiotelescopes are all unique, built for a certain range of observations, and they are all living instruments, which are constantly improved, sometimes in large upgrade programs. The examples presented here are not meant to be a complete description of radio astronomical instrumentation, they are not even meant to be representative, but just examples. Starting at low frequencies, the Nancay Radio Observatory in central France is a very unique instrument, which combines a large unblocked aperture with a very low geometrical profile. Due to the geometry the sky coverage is restricted and it operates at decametre wavelengths only, but it currently undergoes a major upgrade and will be among the most sensitive instruments at 18 and 21cm wavelengths, where it is heavily used for observations of the HI and the OH lines.

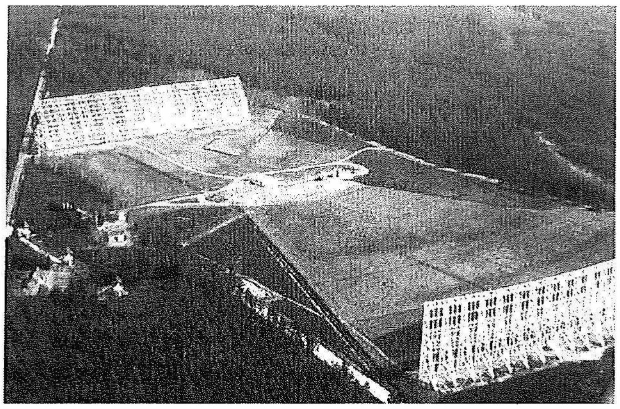

Figure 1: The Nancay Radioobservatory in France [3]

Going up in frequency to 8 GHz, the Westerbork Radio Telescope is an Array Telescope of 14 antennas of 25m diameter each. This telescope has been in operation already for more than 30 years, and it is also in the middle of an upgrade, which will lead to frequency agility as well as much improved data processing. Among its most important contributions to radio astronomy are high resolution maps of galactic and extragalactic HI line emission.

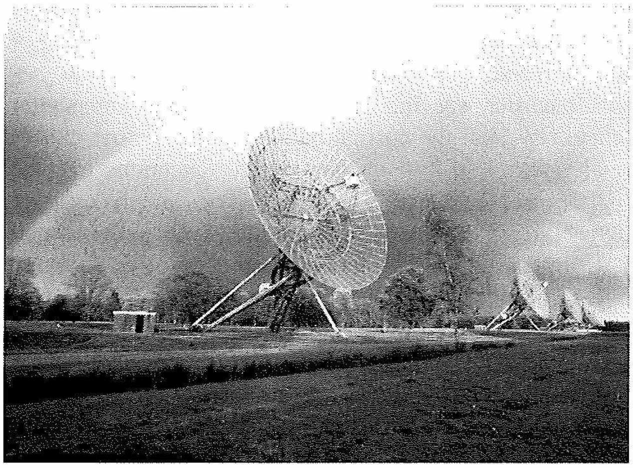

Figure 2: The Westerbork Synthesis Radio telescope in the Netherlands [4]

Spanning a large frequency range from 400 MHz to 86 GHz, the 100m Radio Telescope at Effelsberg is still the world's largest fully steerable single dish radio telescope. Designed in the 1960s to be useful at frequencies up to 10 GHz, the precision of the instrument turned out to be good enough for regular observations up to 50 GHz and interferometric observations at 86 GHz. There are even plans to widen the use in the 3mm wavelength range.

Effelsberg is a multi-purpose instrument, which achieved good results in galactic and extragalactic spectroscopy as well as high sensitivity continuum and polarisation observations. All receivers used at Effelsberg are developed at the electronic labs of the Max-Planck-Institut für Radioastronomie and normally are cryogenically cooled HEMT amplifier receivers.

As an example one module of a 32 GHz multi-channel receiver is shown. A second module has recently been added and a third module is under construction to form a 3 x 3 horn 18 channel receiver.

Effelsberg is normally run with a split schedule. When the weather is good enough for high frequency observations ($\geq \sim 10$ GHz), the high frequency program is run, if not, the back-up program at lower frequency is observed.

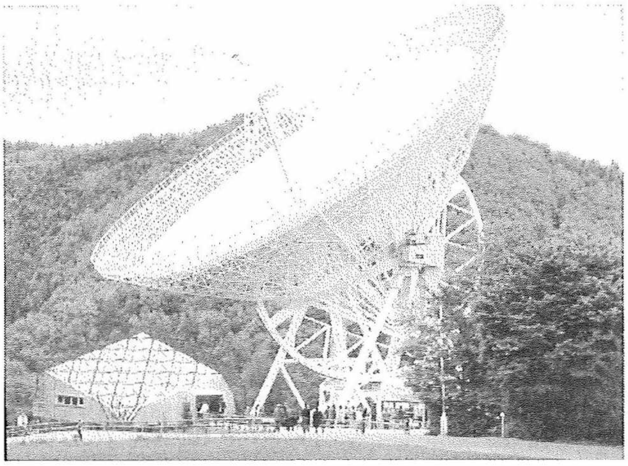

Figure 3: The 100m Radiotelescope at Effelsberg, Germany [5]

For dedicated mm or sub-mm wave telescopes this option is not valid, they are built onto high mountains in order to leave as big a part as possible of the water vapour in the atmosphere behind. Apart from some ozone absorption bands, water vapour is mostly responsible for atmospheric absorption. Fortunately the water vapour is more strongly concentrated at lower altitudes, so above a few thousand meters altitude, where it is still possible to live and to work, one can find excellent observing conditions for frequencies up to ≈400 GHz. One such telescope is the 30m mm-wave telescope of IRAM in the Sierra Nevada in Southern Spain. It is also used for spectroscopy as well as continuum. For mm-wave spectroscopy observations, the standard receiver now in use is the SIS-mixer receiver. Continuum observations at mm and sub-mm wave frequencies are also performed using bolometers.

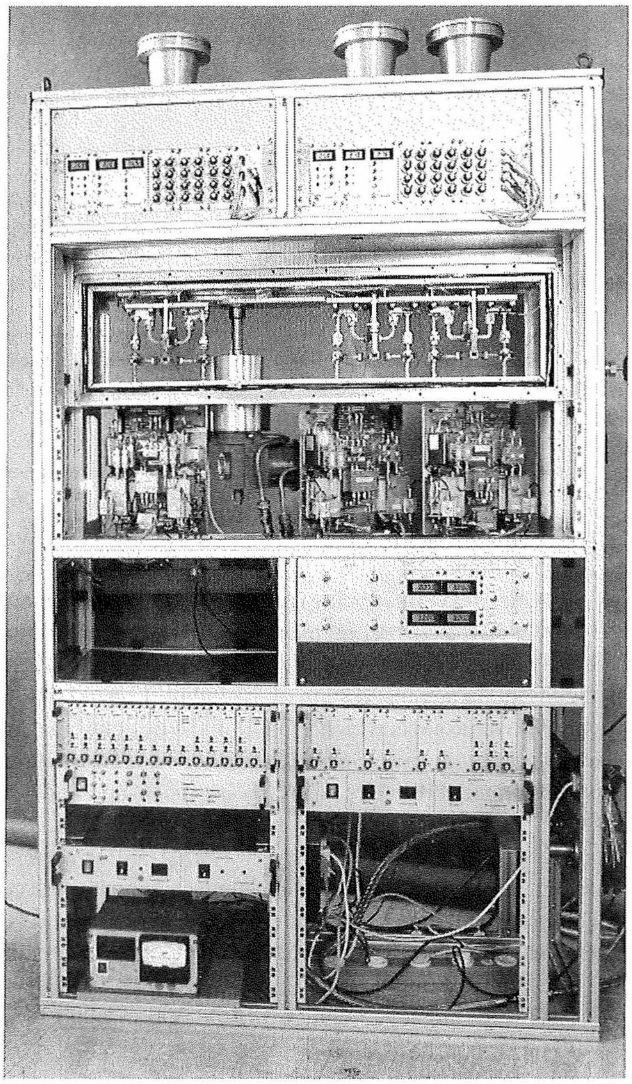

Figure 4: A 32 GHz Receiver Front end, here still during testing in the lab

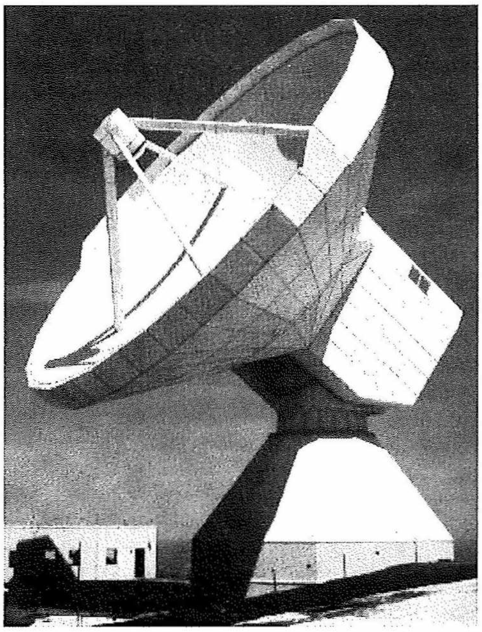

Figure 5: The IRAM 30m mm-Wave Telescope on Pico Veleta, Spain [6]

As an example a 37-channel bolometer array front-end for 250 GHz is shown in figure 6. Its bandwidth is 80 GHz and it enables us to map extended sources very fast, yet very sensitive. The map of NGC 4631 (figure 7) was taken with the bolometer array on the 30m IRAM telescope and is overlayed with an optical image (Hα) of the same galaxy. The power flux density of this source is 2 mJy per beam with a beamwidth of 13 arc seconds.

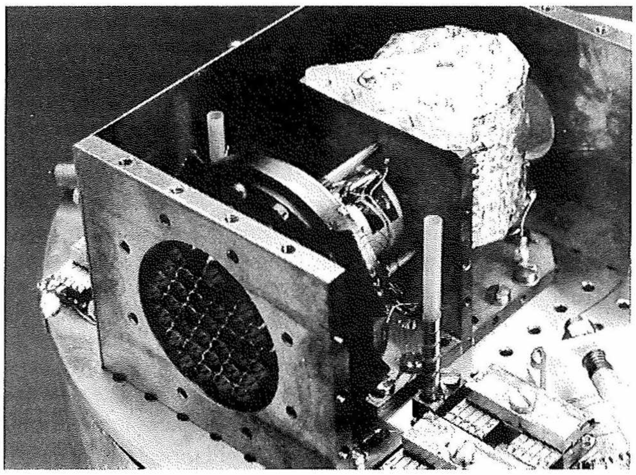

Figure 6: 37-Channel Bolometer, built at MPIfR, Germany [7]

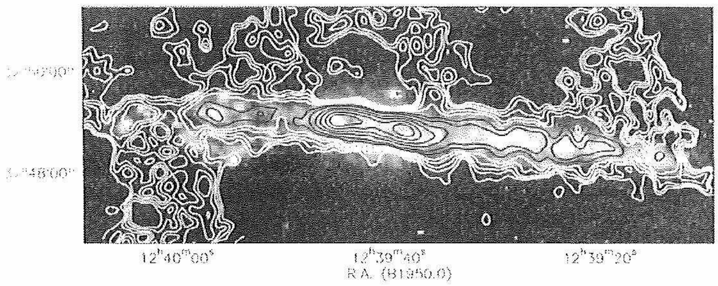

Figure 7: Composite Map of NGC4631 [8]

In the same mm-wave frequency range, also interferometers are operated, like the 5 element array on Plateau de Bure in the French Alps. In this case the antennas are on tracks and can be positioned in several configurations.

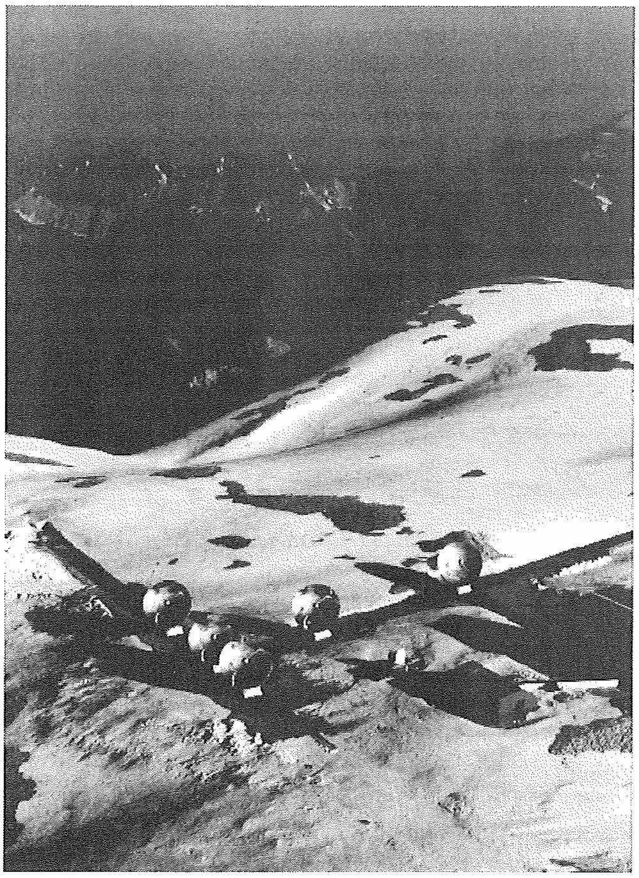

Figure 8: mm-Wave Interferometer operated by IRAM on Plateau de Bure [9]

To observe at frequencies as high as 800 GHz, the atmospheric transparency requires even higher sites, such as Mount Graham near Tucson, Arizona, or Mauna Kea, Hawaii.

The results obtained with these existing instruments are astonishing and have advanced the science of radio astronomy in particular and astronomy in general quite a lot. The other branches of astronomy have also made enormous progress, technically and scientifically. A well known example is the Hubble Space Telescope. It produces images with a formerly unresolvable richness and variety of objects, galaxies of the most different morphologies and other objects. If we compare such an image with a radio map of the same sky region, taken with e.g. the VLA, which is an array of 30 telescopes of 25m diameter each, located near Socorro, New Mexico, the radio sky looks like it was empty. Radio astronomers are certain, that emission from many of these galaxies and from other sources is present and measurable, we just have not yet reached the sensitivity. This is the motivation for designing radio telescopes, which are an order of magnitude more sensitive than present day instrumentation.

4. Future Radio Telescopes

This development is pushed forward both at low and at very high frequencies. Receiver development is already so advanced that an order of magnitude sensitivity increase cannot be achieved by lowering the receiver noise temperature, because the system noise temperature is already mainly determined by the antenna temperature. Improved receiver stability to enable longer integration times is also not considered helpful. The only option is another quantum step in collecting area.

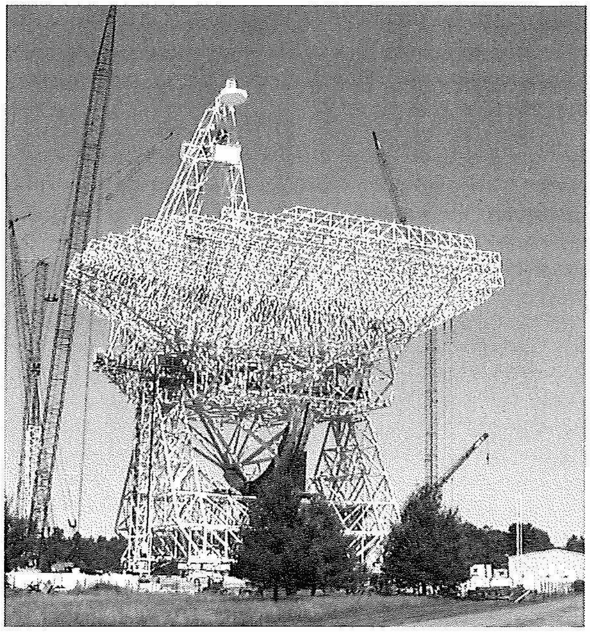

Figure 9: The Green Bank Telescope in the US, which is under construction [10]

One very interesting project is the Green Bank Telescope, which will increase sensitivity by improving the efficiency with an adaptive surface. This project is already in an advanced state of assembly. I would like to present two projects which are still in the design stage and will work at low and at very high frequencies. The first one is the square kilometre array, SKA, a co-operation of several institutes to achieve 1 square kilometre of effective collecting area distributed in a way that an aperture of several hundred kilometre diameter can be synthesised. This project will not be built on parabolic dish antennas, but use flat panels of efficient radiating elements to collect the weak signals.

The frequency coverage will be 300 to 2000 MHz with an option to extend up to 10 GHz. Very low noise amplification can be achieved at all these frequencies, but integrating LNA´s of this bandwidth into the antenna array

Figure 10: Artists Impression of the Future Square Kilometer Array [11]

is still under development. One thing can, however, be safely assumed: radioastronomers will have to break with the tradition of cryogenically cooling the first stage amplifier.

Signal processing will certainly be the biggest challenge in this project, and the correlators needed to form beams from the myriad's of bits will have to be of yet unachieved complexity. In fact there will have to be a hierarchy of beam forming networks, following the hierarchical structure of the antenna. But signal processing also offers the greatest advantage in rapid, sensitive imaging as well as interference excision. The same field of the sky, which looks almost empty in maps taken with the best existing radio telescopes, is expected to show the same complexity as a Hubble Space Telescope image. This is illustrated in figure 11, where a real image of a certain region of the sky is compared with the envisaged view of the same region seen with the Square Kilometer Array.

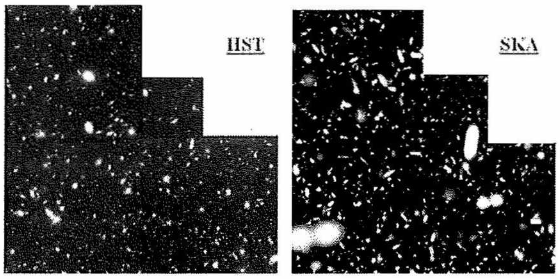

Figure 11: Radio-Optical comparison

In the range of sub-mm wavelength other techniques need to be applied to come to collecting areas required for the order of magnitude step in sensitivity increase. A project is in the planning stage to achieve mJy instantaneous sensitivities at frequencies up to 850 GHz. This again is an international project, called ALMA, the Atacama Large Millimetre Array. As explained already, a very high altitude site is needed for sub-mm astronomy, and it has to be flat and extended for a large antenna array. A site has already been chosen in the Chilean Andes at an elevation of 5000m and extensively tested for atmospheric conditions. The planned instrumentation is based on the need to provide as much collecting surface as required at the lowest achievable price. It will be an array of at least 50 telescopes of 12 m diameter, arranged in a circle of 3 km diameter. Design goals are single source instantaneous sensitivity of mJy per beam, as well as fast sensitive imaging.

5. Interference suppression

While the sub-mm wave telescopes do not really have to fear interference from other radiocommunication services at their observing frequency, for the low frequency projects a high degree of RFI immunity has to be designed into the instruments. This is particularly true for the SKA project, which shall observe large bandwidths in a region of the radio spectrum already heavily used by a number of different transmitting services. SKA will be an array interferometer, consisting of a large number of individual antenna elements.

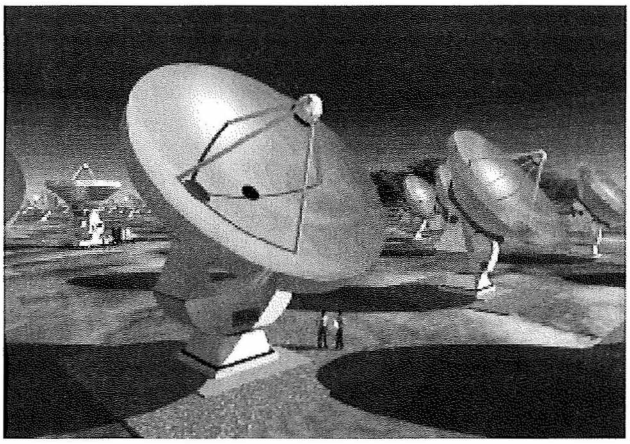

Figure 12: Model of ALMA, the Atacama Large Millimeter Array [12]

The same technique, which produces a beam in the observing direction, can of course be used to point a null towards a known source of interference, and the direction of the null may even move relative to the observing direction. This technique has already been tested and confirmed in the lab. The test set-up consisted of eight dipole antennas and two sources, one representing the wanted signal with broadband noise and weak spectral features on top, the other source producing a spike like the carrier of a radio signal. The eight antenna outputs were digitised and adaptive beam forming was applied. The result was displayed on a spectrum analyser. Clearly the adaptive beamforming is very efficient

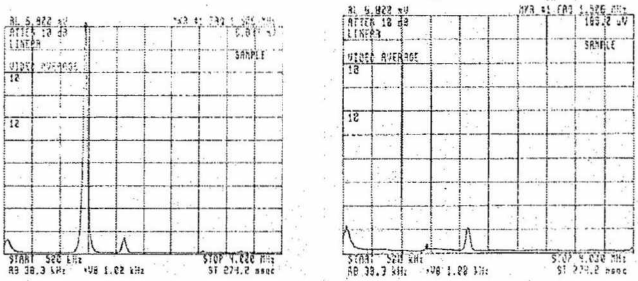

Figure 13: Suppression of a strong interfering signal, using Adaptive Beamforming

to suppress the RFI signal. Suppression of signals from satellite transmitters, geostationary as well as orbiting, is now among the goals of this research.

This technique is not applicable to the large single dish telescopes, unless they use an additional reference antenna to form a combined beam pattern, which then can present a null towards an interfering transmitter. Once the interfering signal has entered the receiver through an antenna sidelobe, other techniques may be applied. Filtering, including notch filtering at RF have been employed for many years, as well as blanking to avoid interference from pulsed signals. The progress made in digital signal processing, which causes a number of new radio services to pop up, this same progress offers the potential to detect and

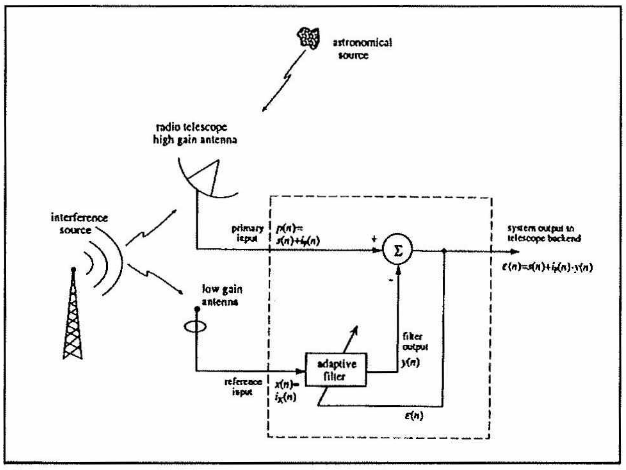

Figure 14: The principle of Adaptive Filtering

consequently excise unwanted signals in real time from the data stream. This technique, known for many years as adaptive filtering, has long been useful in narrow band applications. The much increased speed in modern DSPs (digital signal processors) makes adaptive filtering appear applicable to the bandwidths required for sensitive radioastronomical observations.

The basic principle is the following [13]: Again a reference signal from a low gain antenna is needed. This reference signal, which is assumed not to contain the wanted signal from the radioastronomical source, is subtracted from the main antenna signal, which contains both wanted and unwanted signal. An adaptive filter is used to correct the spectrum of the reference signal, and the filter is controlled by an algorithm, which constantly minimises the signal noise power of the difference signal, because the output is minimum when the unwanted signals from the main beam and from the reference antenna are equal and hence cancel. By this technique also interfering signals variable in time and location may be detected and taken out of the data. More detailed considerations show that one reference antenna can be used to excise one interfering signal only and that for several interfering signals at least the same number of reference antennae is required. Also this procedure works best, when the signal-to-interference ratio S/I is greatest in the main beam signal and the interference-to-noise ratio I/N good enough in the reference signal. Therefore this technique cannot be considered an already available and satisfactory solution of interference problems in radio astronomy. However, both beam steering and adaptive filtering techniques can in principle be advantageously combined.

Various groups in the US as well as in Europe and elsewhere are now working on such methods. The NRAO of the US has quite a tradition of work dedicated to interference excision, with published results [14]. Also in Europe most of the major radio observatories have recently found together, triggered by the SKA development and, of course, by the increasing spectrum congestion, to combine their efforts in spectrum monitoring and developing methods to observe through interference. This project even received partial funding by the European Union and a workplan has now been established.

Let me, however, conclude with a word of caution. Very much work has to be done to enable suppression of unwanted signals to the extend needed to allow very high sensitivity radioastronomical observations. It has been possible to demonstrate suppression of strong signals by many tens of dB, but it may be much more difficult to achieve the still necessary suppression of the remaining few dB.

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XXVIth General Assembly

BUSINESS TRANSACTED BY COMMISSION A

Commission A Electromagnetic Metrology
Chair: Dr. M. Kanda
Vice-Chair Prof. E. Bava

The Commission held three Open Commission Meetings, respectively on 16, 18 and 20 August 1999. At the beginning of each meeting there has been the introduction of the Chair, followed by the Vice-Chair and by all the other participants, both Officers and just audience. Then the Chair proposed the agenda, requested suggestions for new items or modifications, before the approval. The minutes of the three Meetings have been taken by the Vice-Chair, who, as usual, is responsible to report on the activity of Commission A at the XXVI General Assembly (GA).

First Open Commission Meeting (16 August 1999)

1. According to a recent request of the URSI Board the elections of the new Vice-Chair have to be carried out in the first Business Meeting. The Chair proposes as a candidate Dr. Quirino Balzano, Corporate Vice-President and Director, Florida Corporate Electromagnetics Research Laboratory, Motorola, USA. During the organisation of the XXVI GA, Dr. Balzano has operated as a Convenor of session A1 (New RF-to-Submillimeter wave standards and measurements) and is also the speaker of the Commission A Tutorial "Electromagnetic Metrology Issues in Wireless Communications". His research has been concerned mainly with electromagnetic field measurements and with the interactions of the field strength with the human body. Dr. Kanda points out also the complementarity in research between the Vice-Chair and Dr. Balzano, which is in agreement with the tradition of Commission A. Because there is no other proposal for candidates, the election starts with eleven Officers present; meanwhile Dr. Kanda shows a viewgraph with the indications of the Commissions Chairs and Vice-Chairs as established in the Lille GA and with the proposals of the new Vice-Chairs.
2. There are at the moment no proposals for variations in the Commission A list of the terms of reference. It is agreed that new terms or variations, if any, will be discussed in the next meeting before being submitted to the Council for approval.
3. The preliminary data available on the program of the XXVI GA are summarised in general, and in particular as far as Commission A is concerned. Compared with the total of 1764 communications (oral+posters) the 105 presentations in Commission A appear a reasonable number. Although metrologists are not so many as the scientists of other URSI Commissions in the world, however it is stressed that the participation of people active in the measurement area to the URSI-GA must be increased. This shall be an important goal charged to the incoming Chair and Vice-Chair, to the Officers and to all the scientists working in this area. Summarising the Commission A program in this GA there are 1 Tutorial, 9 Commission A sessions, 4 joint sessions and 5 sessions where Commission a is involved (18 oral sessions in the overall) and 1 poster. Dealing with the Young Scientist Program, there were in the overall 224 applications and 121 were accepted; as regards Commission A the applications were 11, 9 accepted.
4. The triennial report of Commission A is available on INTERNET at the site (also reported on the Bulletin) http://www.intec.rug.ac.be/ursi. In particular Dr Kanda summarised in this occasion how the money for sponsorships has been used. The total amount of 360 000 BEF was distributed as B sponsorship to ISEM 97 (96 000 BEF), EMC Wroclaw Conference 98 (87 000 BEF), CPEM 98 (35 000 BEF), EMC 98-Rome (71 000 BEF), EMC 99-Zurich (71 000 BEF), whereas A sponsorship (no financial support) was given to Telecom 97, EFTF 98, PIERS 98. Explanations have been given by Dr. Kanda about his choice. According to the URSI indications, one and the most important guidelines is that a financial support can be given to the young scientist program, if exists, in the sponsored meeting. Although CPEM is to be considered a wealthy conference, there was in that occasion a well defined young scientist program. As far the other sponsored meetings, these were in agreement with indications expressed in the Lille GA. For the next triennium there are at the moment two requests: EUROEM 2000 (A) and International School of Physics (B). There is the agreement among the Officers present that the incoming Chair will report on the use of the money for sponsorships in the next GA.
5. The Chair informs that in the next business meeting the Commission A must choose its own Editor for the Review of Radio Science, the Editor of the Disk of References and the Assistant Editor for the Radio Science Bulletin. The attendees are invited to submit proposals for these charges.
6. Prof. Leschiutta gives to the audience a copy of a recommendation concerned with the proposal to discontinue the practice of the Leap Second in UTC. The discussion and decision on this topic are postponed to the next meeting.

At the end of this first business meeting the election results of the new Vice-Chair are communicated. On 11 votes there were 9 in favour of Dr. Balzano (USA) and 2 against.

Second Open Commission Meeting (18 August 1999)

1. The Chairman introduces Dr. Quirino Balzano, the new elected Vice-Chairman, who could not attend the previous business meeting. Dr. Balzano took the "Laurea" degree in Electronic Engineering in 1975 at the University of Rome "La Sapienza", Italy. His main research interests have been in microwave radars, specifically in antennas and propagation, and in interactions of the electromagnetic energy on the human body, dealing in particular with dosimetry, field measurements and sensor development.
2. Prof. Leschiutta introduces his proposal of recommendation as distributed in the preceding meeting. It is concerned with the Leap Second practice in UTC to keep the difference between UTC and UT1 at a level lower than .7 s. The adoption of UTC was made by ITU after a consultation with BIH, URSI Comm A, UAI, UGGI, IMO, IAMA, ICAO and other bodies. The widespread use of satellite navigation systems has questioned this practice and the problem has been discussed at CCTF in Paris in April 99 and an inquiry has been promoted among the already consulted bodies and other bodies interested in the use of UTC. At the discussion participate Prof. Leschiutta (Chairman of CCTF and IEN President), Dr. Banerjee (NPL, India) and Dr. Petit (BIPM, Paris). The proposed recommendation is approved after some amendments as an expression of opinions. The amended version shall be delivered to the URSI Board.
3. Dr. Kanda informs the audience about some important modifications in the Review of Radio Science (R.R.S.) discussed by the Standing Committee on Publications. The book is highly appreciated in general and its publication will continue. However, to cope with the problems that URSI participants usually have with its weigh and volume, in the next GA the book will be provided to the attendees as a CD-ROM. The hardbound book will be available and sold to individuals and institutions after order. To fulfil the requirements of the Standing Committee, the Chairman proposes Prof. S. Celozzi, University of Rome "La Sapienza", as Commission A Editor for the R.R.S.. Prof. Celozzi (Tel +3906 44585 520, fax +3906 488 3235, e-mail: celozzi@elettrica.ing.uniroma1.it, Italy) acted as the Commission A Editor for the Disk of References in the last triennium. The proposal is approved and Dr. Kanda requests scientists and officers, who can provide useful suggestions for the R.R.S., to contact Prof. Celozzi,
4. The Standing Committee on Publications has proposed to discontinue the Disk of references because it requires too much effort if compared to the use, since many ways to have access to references are now available. For this last GA only a few Commissions (6) prepared the Disk. The Editor for Commission A was Prof. Celozzi, he collected 238 references. There is a general agreement on this point.
5. No proposal has been presented for modifications of the list of Terms of References. Dr. Kanda suggests that, if proposals arise, they can be submitted with the proper motivations to the incoming Chairman. He can make known the proposals and organise a ballot by mail.
6. Dr. Kanda proposes Dr. Banerjee (NPL, India) as the new Associate Editor for the Radio Science Bulletin. The attendees agree on that and Dr. Banerjee accepts.
7. Concerning the organisation of the XXVI GA the opinion is in general accepted that the concentration of the scientific sessions and of the business meetings in one week period shows advantages and disadvantages. On the one hand there is the gain in time and as a consequence in lodging expenses as well, on the other it turned out a too crowded list of scientific sessions and of business meetings. To allow an easier movement between sessions of different commissions it is suggested that not only time is to be squeezed, but space as well. From this point of view a Convention Centre is a better solution than a University. It has been remarked the problem of no-shows as well, in someway linked to the level of presentations: no-show is typical of contributed papers or posters, not of invited. It has been agreed that it is responsibility of the convenors to accept or reject a contribution, considering that there are people who can not attend a meeting if their work is not accepted. The poster sessions, which are not to be considered as collections of low-level works, but on the contrary the proper site where to discuss problems too specialised and unsuitable for an oral presentation, could help to cope with the requests that papers be accepted to allow participation without imposing a heavy oral preparation. However there is no way to avoid no-shows linked to financial difficulties. It is stressed, moreover, the use of equal time slots in presentations to allow easier movements from one session to another.

Third Open Commission Meeting (20 August 1999)

1. The expression of opinion discussed in the previous meeting is presented in the final form as passed to the URSI Board with the amendments requested .
2. Dr. Kanda informs the attendees on the results of the Council elections of the new Board (President, Vice-Presidents). Moreover the Council has decided that the XXVII GA shall be held in Maastricht (The Netherlands) in 2002, 17-24 August.
3. Dr. Kanda introduces the incoming Chairman, Prof. Elio Bava, Italy. Prof. Bava warmly thanks Dr. Kanda, also on behalf of the Commission A members, for his work in the organisation of the GA, keeping the main responsibility in accomplishing this task. The number of Commission A sessions and joint sessions has exceeded that of the previous GA, in spite of the squeezed time.
4. The incoming Chairman introduces the last part of the Business Meeting. The first item is the list of the

requests of URSI Sponsorship for the next triennium already received and those supposed to arrive in next future according to the previous experience and the information available. As soon as the amount of money is established by the URSI Secretariat decisions shall be taken and, as agreed in the first Business Meeting, he will report at the next GA on the distribution adopted. The list shall be sent to the URSI Board as a preliminary list, as it has been requested.

5. Representatives of Commission A in other bodies give their report. Prof. Stumper, Dr. Kanda and Dr. McSteele gave detailed reports on the triennial report available in INTERNET. Prof. Leschiutta, who had to leave suddenly, informed the incoming Chairman that he did not attend either IMEKO conferences or the Assembly (Tampere, Finland) and is not interested to be the representative in IMEKO any longer. Dr. Lundén gives his report on IEC and ISO. In the last triennium there has been a lot of publications by IEC and ISO, however the activity relevant with URSI Commission A is limited. IEC publications are available in the web site catalogue http://www.iec.ch/catlg-e.htm . On CD-ROM a multilingual dictionary is available, as well as the EMC International Standards. Of interest for URSI should be the IEC61983 "Measurement and Evaluation of High-Frequency Electromagnetic Fields with regard to Human Exposure". The representatives in the next triennium are then proposed. It should be remembered that the Chair is the representative in CPEM and in CIPM and the related committees. However, as occurred in the past, the incoming Chairman would like that scientists, who are very active in these bodies, be charged as representatives as follows: Prof. Leschiutta (CCTF, of which he is the Chair), Dr. Helmcke (CCL), Dr. Erard (CCE), Prof. Stumper (RF-WG of CCE) and Dr. Kanda (CPEM). Moreover Dr. Lundén accepts to continue as the representative in IEC and ISO.
6. As far as the program for the next GA, the incoming Chair shows the following proposal, which takes into account the well established sessions and joint sessions of Commission A, including suggestions received in the preceding days.

A1	New RF-to-Submm Wave Standards and Measurements
A2	Material Measurements
A3	Time and Frequency Standards
A4	Optical Frequency Standards (Laser Stabilisation)
A5	Time Keeping and Time Transfer
A6	Optical and Fiber Measurements
A7	Quantum Metrology
A8	Metrology for Interconnects and Packaging in High-Speed Electronics
A9	Measurements on Tissues

AB1	Antenna and Electromagnetic Field Measurements
AB2	Time-Domain Measurements and Analysis
AC	Clock Synchronisation in Telecommunications
AD	Characterisation of Semiconductor Devices for Wireless Communications
AE	EMC Measurements
EA	Electromagnetic Compatibility and EM Pollution
FAB	Techniques and Applications (for Sub-Surface) Remote Sensing
KA	Exposure Assessment for Cellular and Personal Telecommunications

Tutorials (to be chosen among)
- New Techniques in Atomic Frequency Standards
- New Techniques in Two-Ways Time Comparison
- Advances in Quantum Electronics Devices

According to the elected Vice-Chairman there is a lot of work and funds at the moment in the area indicated in A9, therefore it is likely that many new results be available for the next GA. It was also suggested to make some inquiry on few traditional sessions where very few contributions were presented, with large no-shows as well, in areas where CPEMs receive many papers of value.

It was suggested to include in A1 also dc and low-frequency standards. At the proper time this inclusion will be evaluated considering also the possibility of a new session.

A few of the joint sessions received a confirmation of interest from the relevant incoming Chairmen, a deeper analysis will be carried out as soon as possible.

7. The Board suggestion on a different way to prepare the election of the Vice-Chairman is discussed. The proposal concerns the establishment of a small committee, composed by Past-Chairmen, Vice-Chairman and/or scientists involved for a long time in the works of a commission, aimed at soliciting, generating and then selecting two/three candidates for the election, in order to offer both choice and not excessive number of candidates. After a debate the present Officers and Members decide to keep the traditional way to elect the Vice-Chairman.
8. On behalf of Prof. Leschiutta, Prof. Bava announces that in 2000 (25 July 4 August) at the International School of Physics (Varenna, Italy) a Course will be held on "Recent advances in metrology and fundamental constants", organised by IEN. The Directors are Prof. S. Leschiutta (IEN) and Dr. T.J. Quinn (BIPM), the secretary is Dr. P. Tavella (IEN) (tel. +39 011 3919235, fax +39 011 3919259, E-mail tavella@tf.ien.it). This Course is the third of a series (1976, Varenna, Italy and 1989, Lerici, Italy) organised by the same school; teachers are chosen among leading scientists to assure a high-level course useful for Ph.D. students or post-docs who want to be acquainted with the latest methodologies and results in the field. 50 hours of lessons are foreseen and applications from young scientists for support are possible.
9. Just to remind Officers and members the structure of Commission A for the next triennium, the incoming Chair recalls the following :

   Chair: Prof. E. Bava (Italy)

Vice-Chair: Dr. Q. Balzano (USA)
RRS Editor: Prof. S. Celozzi (Italy)
Bulletin Associate Editor: Dr. Banerjee (India)

10. The last issue of the meeting is how to increase URSI attendance of scientists active in Commission A. The discussion resumes the claims already exposed for heavy no-shows which upset some sessions. Attention should be paid by convenors in accepting contributions when there are suspects on the willing to attend the GA, however efforts should be done by the Chair, Vice-Chair, Officers and members to generate interest in participating to the GA. The proposal from the Standing Committee on Publications to substitute the book of abstracts (heavy and of little use to select papers and to document author's scientific work) with Proceedings of summaries up to 3-4 pages each, distributed both as CD-ROM and as a book in a form yet to be defined, should help in yielding more enthusiasm in attending URSI GA.

BUSINESS TRANSACTED BY COMMISSION B

Commission B - Fields and Waves
Chair: Prof. C.M. Butler
Vice-Chair Prof. S.E.G. Ström

The intensity of the scientific activity in the area represented by Commission B, i.e. "Fields and Waves", remains on a very high level and this is particularly true concerning areas which border on and overlap with other Commissions. As a consequence, in spite of the reduced time available, Commission B had a scientific program that was in essence as comprehensive as during previous General Assemblies. Thus, Commission B organised by itself 10 half-day scientific sessions (B1-B10) consisting of oral contributions and in addition there was a poster session organised around the same theme as each of the oral sessions. Two convenors had been appointed for each of the 10 session topic areas and the convenors were also responsible for the related poster sessions. Commission B also organised two comprehensive poster sessions which had no oral counterparts and which were subdivided into 5 and 4 subsessions respectively , with two convenors for each of these subsessions. In total, approximately 250 poster presentations were scheduled at poster sessions organised by Commission B.

The breadth of the Commission B interests are further illustrated by the fact that Commission B was involved in organising 9 sessions jointly with other Commissions, viz. A, C, D, E, F, J, and K (sessions AB 1, AB 2, BD 1, BD 2, DB, EB, FAB, JBC, and KB).

Commission B also contributed in an essential way to Modern Radio Science and Review of Radio Science, 1996-1999. The Commission B contributions to the latter was edited by Prof. Y. Rahmat-Samii., UCLA. As decided at the previous General Assembly in Lille, Commission B contributed to the contents of the CD-ROM with "Collected References" from 1996-1999, distributed together with "Review of Radio Science,1996-1999". The Editor for the Commission B part of this disk was Prof. M. Ando, Tokyo Institute of Technology. In this task he was assisted by 8 topic area editors.

The Commission B Tutorial Lecture, "Electromagnetic System Design Using Genetic Algorithms", authored by E. Michielssen, Y. Rahmat-Samii and D.S. Weile and presented by E. Michielssen was followed by a session (B2) on the same topic and both enjoyed a very high attendance. Other sessions with a high attendance were B3 "Scattering and Diffraction", B4 "Electromagnetic Theory", and B5 "Time-domain Electromagnetics". In general, the attendance at all Commission B sessions was good.

In total there were some 350 (oral and poster) papers presented at Commission B sessions, out of a total of 1750. Therefore, Commission B has, as before, a strong interest in getting a share of the time and space available for the scientific program that is commensurate with the scientific contributions of the Commission B community.

The following views and sentiments concerning the arrangements during the Toronto General Assembly were often heard among the Commission B community:

1. The fact that the times for the individual talks were not listed in the final program was very much regretted. As a consequence it was difficult or impossible to plan how to switch between sessions
2. The "one week plus weekends" format for the General Assembly should be kept, but the Council meetings, various committee meetings, and Commission business meetings should be held as much as possible during the weekends at the beginning and the end of the General Assembly
3. Additional efforts should be made to avoid collisions between sessions dealing with closely related topics. Do not schedule all the poster sessions belonging to one Commission for the same time, as was done for Commission B. The posters should be allowed to stay up some time beyond the time of the poster session.

Commission B business meeting

During the General Assembly, Commission B held one business meeting. The Chair, Prof. Chalmers Butler, gave an exposé over the preparations for the General Assembly and thanked all involved: convenors, editors and others, who had contributed so generously with their time and professional experience. The contributions of all those who were involved in the organisation of the 1998 EM Theory Symposium in Thessaloniki were also recognised and thanked. In addition the Chair gave some statistics concerning the General Assembly, with focus on the Commission B participation.

An important point on the agenda was the completion of the vote concerning incoming vice-chair. The result was that Prof. M. Ando was elected, with Prof. K. Langenberg as alternate (the URSI Council subsequently appointed Prof. Ando as Commission B vice-chair for the triennium 1999-2002).

Taking into consideration that a fairly large number of proposals concerning the venue for the 2004 EM Theory Symposium can be expected, the Chair proposed that, in order to avoid having a succession of votes (which is time-consuming when conducted by mail), a committee should be set up with the task of selecting the 2 (or at most 3) most attractive proposals. The national representatives would then be asked to vote, in one ballot, on these proposals. An invitation to Commission B national representatives to submit a proposal will be sent out during the fall of 1999. The vote can then take place well in advance of the 2001 EM Theory Symposium in Victoria, thus giving the organisers of the 2004 Symposium more than three years for their preparations.

Prof. Jens Bornemann, Chair of the Local Organising Committee for the 2001 EM Theory Symposium in Victoria gave a brief presentation of the present status of the preparations for that event.

During the meeting of the Coordinating Committee on August 14, it was suggested that the Commissions should become more active in making sure that a sufficient number of qualified candidates were persuaded to stand for election. Thus it was suggested that the Commissions form a small committee consisting of the vice-chair plus a few experienced scientists which is then charged with the task of vitalising the elections. This pros and cons of this proposal were discussed and it was noted that, even if it is not formalised, Commission B usually operates in a way that is similar to what is now proposed.

Conclusion

The scientific program of a Commission is the responsibility of its Chair, who invites the convenors and editors and coaches them through the arduous process of creating a program that properly reviews and highlights the scientific status of the field. Therefore, on behalf of the Commission B community, I want to express our gratitude and appreciation to Prof. Chalmers Butler, past Chair of Commission B, for his dedicated and successful work in creating the excellent Commission B program at this General Assembly. The same gratitude and appreciation goes to all the convenors and editors for their very professional work.

BUSINESS TRANSACTED BY COMMISSION F

Commission F-Wave Propagation and Remote Sensing
Chair: Mr. M. P. M. Hall (UK)
Vice-Chair: Dr. Yoji Furuhama (Japan)

The Commission held three Open Business Meetings, respectively on 16, 18, and 20 August 1999. Copies of the agenda and of the Commission F report to Council for 1996-99 (previously published, in the September issue of the Radio Science Bulletin) were made available. The following items were discussed at the meetings:

1. Election of Vice-Chair

Member Committee Representatives had had the opportunity to vote for Vice-Chair by mail, but were again given the opportunity to vote (or to change their vote) at the GA. Credentials of those voting were checked. The following names were proposed to the Council, in order of preference:
1. M. T. Hallikainen (Finland)
2. G. O. Ajayi (Nigeria)
The Commission confirmed its wish that Dr. Furuhama would become Chair at the conclusion of the General Assembly. The Council subsequently confirmed the appointment of Dr Furuhama and Prof. Hallikainen.

2. 1999 General Assembly Program

Commission F organized 10 scientific oral sessions of invited papers and one large poster session. Session names and convenors were as follows;

F1: Mobile terrestrial and satellite propagation modelling, F. Perez-Fontan (Spain) and Y. Karasawa (Japan)
F2: Climatic parameters in radiowave propagation, J. P. V. Poiares Baptista (The Netherlands) and T. Tjelta (Norway)
F3: Millimetric, sub-millimetric and optical wave propagation prediction, K. H. Craig (UK) and S. Ito (Japan)
F4: Remote and in-situ sensing of clouds and their effects on radiowave propagation, P. A. Watson and A. J. Illingworth (UK)
F5: Atmospheric dynamics in the lower atmosphere: measurement, modelling and effects, D. T. Gjessing (Norway)
F6: Spaceborne remote sensing of precipitation-TRMM, C. Kummerow (USA) and K. Okamoto (Japan)
F7: Remote sensing of Earth surfaces, M. T. Hallikainen (Finland) and B. Arbesser-Rastburg (The Netherlands)
F8: Interferometric techniques in remote sensing, J. Fr. Hjelmstad (Norway) and J. van Zyl (USA)
F9: Polarimetric techniques in remote sensing, W-M, Boerner (USA) and S. R. Cloude (UK)
F10: Synergetic use of remote sensing instruments, H. Oettl (Germany) and A. J. Bedard (USA)
FP: Wave propagation and remote sensing, Y. Furuhama (Japan)

Having all invited papers distinguishes Commission F sessions at General Assemblies (GAs) from those at the Triennial Open Symposia held the year before the General Assemblies.

Joint sessions were:

FAB: Techniques and applications for sub-surface remote sensing, D. Noon (Australia) and G. S. Smith (USA)

CF: Mobile and personal communications, E. Bonek (Austria) and H. Bertoni (USA)

EF: Interference in communication, E. J. Gavan (Israel) and B. Arbesser-Rastburg (The Netherlands)

GF: Ionosphere and troposphere parameters retrieved from GPS/GLONASS measurements, P. Hoeg (Denmark) and J. P. V. Poiares Baptista (The Netherlands)

JF: Tropospheric path delay correction, D. Woody (USA) and J. P. V. Poiares Baptista (The Netherlands)

Commission F tutorial lecture was:

Remote characterization of geophysical phenomena using EM waves, D. T. Gjessing (Norway)

Before the regular scientific sessions of the GA, Commission F had organized three Workshops:

WSF1: Interfacing propagation with transmission and antenna system studies for mobile/personal communications, F. Perez-Fontan (Spain) and Y. Karasawa (Japan)

WSF2: Synergy of active and passive remote sensing instruments, B. Arbesser-Rastburg (The Netherlands) and M. T. Hallikainen (Finland)

WSF3: WISP-Wideband (ULF to UV) Interferometric sensing and imaging polarimetry-theory and applications, W-M. Boerner (USA) and S. R. Cloude (UK)

The regular sessions had a well balanced technical content and also were geographically well balanced. However there was concern that the quality level was not so high for some papers and that the whole meeting had been too busy.

3. Matters relating to Council and Coordinating Committee

3.1. Commission Assistant Editors for the Radio Science Bulletin

Mr. Hall informed that Dr. W. R. Stone (USA) sought from each commission an Associate Editor to solicit two papers per year (e.g. radiowave propagation and remote sensing for Commission F), and to arrange full refereeing. Certain papers at conferences might be a starting point. Dr. K. Andersen (USA) volunteered to do this. People were urged to get their libraries to subscribe.

3.2. Duration of future General Assembly

In this Toronto GA, 7 days duration was introduced. All Commissions had been invited to give their opinion and Commission F confirmed its preference by a show of hands as to whether the format of the next GA should be 7 days as this time or 10 days as the previous one. Answers of Commission F representatives were slightly in favor of the present duration of 7 days.

3.3 Formation of Nomination Committee for a Vice Chair

Mr. Hall said there had been a strong recommendation for commissions to have Ad Hoc Nominating Committees to solicit and generate nominations, and to then select a slate of three candidates who would agree to serve if elected. However, all Commission F representatives, including several ex-Commission F chairs, expressed the wish to keep the present selection procedure in Commission F and not to change as proposed. This was later accepted in Council.

3.4. Terms of Reference

It was agreed to keep them as they were.

3.5. Relations between URSI and ITU-R

Mr. Hall said there had been a lot of discussion on this in Council and that Commission F was noted for its good interaction with ITU-R Study Group 3 and its Working Parties. However, there was now some activity in trying to promote contacts between other Commissions and Study Groups. It was important to recognize the major work of IUCAF in relation to protecting radio frequency interests of those in remote sensing and radioastronomy, as had been reported in the Radio Science Bulletin. (See Section 7.4.)

3.6 Other proposals

Mr. Baptista (The Netherlands) said that there was need for a statement about the frequency bands for Earth exploration. Prof. Boerner (USA) spoke on the importance of reserving several frequency bands below 10GHz for SAR. Commission F made two recommendations: F.1 "Support for EES (Earth Exploration Services) spectrum management" and F.2 "Allocation and sharing of frequencies within the MF/HF/VHF/UHF bands".

4. Inter-assembly meetings

4.1 Commission F meetings in last triennium

Commission F was sponsor or co-sponsor of 21 meetings between the 1996 and 1999 URSI GAs. Below are shown meetings, locations, dates and Modes (where Mode A has the name of URSI and logo, but no URSI money; Mode B has a grant (typically 2000 US$) from Commission F, but only for participation of individual scientists, mainly from developing countries or the New Independent States; Mode C is a major conference with direct involvement of URSI headquarters in management and budget with significant support (typically 5000 US$), and share in any profits).

The main Commission F meeting between URSI General Assemblies is the Commission F Open Symposium, held this time in Aveiro, Portugal on September 22-25, 1998 (Mode B).

Commission F, as usual, co-sponsored with the IEEE Geoscience and Remote Sensing Society three International Geoscience Remote Sensing Symposia (IGARSSs), all as Mode A; these, the largest remote sensing meetings, continue to draw nearly 1000 papers. IGARSS'97 was held in Singapore on August 3-8, 1997, IGARSS'98 was held in Seattle, Washington, USA on July 6-10, 1998, IGARSS'99 was held in Hamburg, Germany on June 28-July 2, 1999. CLIMPARA'98, the third in the series, was held in Ottawa, Canada in April 27-29, 1998 (Mode B). Again it was followed immediately by ITU-R Working Party meetings and was a focus of relations with ITU-R Study Group 3.

In addition, the International Symposium on Radiowave Propagation (ISRP) was held in Qiangdao, China on August 12-16, 1997 (Mode B), the Eighth International Workshop on Technical and Scientific Aspects of MST Radar (MST8) was held in Bangalore, India on December 15-20, 1997 (Mode B), the Physics and Engineering of MM and SubMM EM Waves meeting was held in Kharkov, Ukraine on September 15-17, 1998 (Mode B), and the Workshop on Radio Methods for Studying Turbulence was held in Urbana, Illinois, USA on August 9-12, 1999 (Mode B). A meeting on Microwave Signatures in Remote Sensing was initially planned to be held in Moscow, Russia on March 11-13, 1998, but this Symposium was cancelled at short notice and the grant returned in full.

Other Mode A meetings co-sponsored with other groups, including other URSI commissions, were the International Symposium on Antennas and Propagation (ISAP'96), held in Chiba, Japan, on September 24-27, 1996, the International Conference on Antennas and Propagation (ICAP'97), held in Edinburgh, UK, on April 14-17, 1996, Radio Africa'97, held in Nairobi, Kenya, on August 4-8, 1997, the Urban Radiowave Propagation Symposium (URPS'97), held in Tomsk, Russia, on September 2-4, 1997, the 1998 International Wireless and Telecommunications Symposium/Exhibition (IWTS'97), held in Kuala Lumpur, Malaysia, on May 11-15, 1998, the European Conference on Synthetic Aperture Radar (EUSAR'98), held in Friedrichshafen, Germany, on May 25-27, 1998, the International Workshop "Day on Diffraction'98", held in St. Petersburg, Russia, on June 2-4, 1998, the COSPAR Scientific Assembly, held in Nagoya, Japan, on July 12-19, 1998, PIERS'98, held in Nantes, France, on July 13-17, 1998, the 10th Microcoll, held in Budapest, Hungary, on March 21-25, 1999, and the International Workshop "Day on Diffraction'99", held in St. Petersburg, Russia, on June 1-44, 1999.

4.2 Proposed Commission F meetings for next triennium
Most of the following meetings were mentioned during Commission F business meetings, but a few have been added since.

Mode A – seeks no funds:

AP2000 – Davos, Switzerland, April 9-14, 2000
EUSAR 2000– Munich, Germany, May 23-25, 2000
GPR 2000 – Gold Coast, Queensland, Australia, May 23-26, 2000
IGARSS 2000 – Honolulu, Hawaii, USA, July 24-28, 2000
ISAP 2000 – Fukuoka, Japan, August 22-25, 2000
Antennas and Propagation for Wireless Communications – Waltham, MA, USA, November 6-8, 2000
ICAP 2001– Manchester, UK, April 2001
IGARSS 2001 – Sydney, Australia, July 9-13, 2001

Mode B – seeks funds:

Radio Africa'99 – Gaborone, Botswana, October 25-29,1999
MST9-COST79 Workshop – Toulouse, France, March 13-17, 2000
33rd COSPAR Scientific Assembly – Warsaw, Poland, July 23-26, 2000
Commission F Triennial Open Symposium– 2001
AP-RASC'01 (2001Asia-Pacific Radio Science Conference) –Tokyo, Japan, August 1-4, 2001
CLIMPARA'01– 2001

There were several opinions about the venue for Commission F Triennium Meeting and Climpara'01. We would like to continue these discussions by e-mail.

4.3 Responsibilities of URSI Representatives at meetings sponsored by Commission F
Mr. Hall emphasized the importance of the role of Commission F representative in organizing meetings, namely:

For all Mode: ensure URSI involvement clearly, logo etc., especially in Call for Papers, etc.: participate in organizing committee, especially for technical program; provide call-for-papers and report on the meeting for URSI's Radio Science Bulletin: and keep Commission F Chair fully informed of developments.

For Mode B: organize invitation and funding of URSI-supported scientists; possibly speak in opening session, banquet, etc; report to URSI Bulletin and Secretariat, copied to Commission F Chair.

For Mode C and for major Mode B events being organized exclusively by URSI: arrange for registration frees to be reduced by 30 US$ for all URSI correspondents, the 30 US$ paid by non-URSI correspondents to be remitted to URSI headquarters with a list of those who paid it. Those paying then become URSI correspondents and receive the Radio Science Bulletin, etc.

5. 2002 General Assembly

5.1 Proposals for sessions and organizers
Many proposals for sessions have been put forward by Dr. J. P. V. Poiares Baptista (The Netherlands), Prof. W-M. Boerner (USA), Dr. T. Tjelta (Norway), Dr. R. L. Olsen (Canada), Dr. J. Lemorton (France), Dr. D. Noon (Australia), Dr. D. T. Gjessing (Norway), Dr. B. Arbesser-Rastburg (The Netherlands), Prof. M. T. Hallikainen (Finland), and Dr. J. Fr. Hjelmstad (Norway). These proposals will need rationalization and grouping together.

In the business meetings, it was felt that, in view of the Triennial Open Symposia (covering all Commission F topics areas), it was appropriate to maintain the Commission F tradition of having compact invited-paper sessions on specific subjects and allow a broader allocation of contributed papers as posters. There should be 8 oral sessions, each with two less papers per session followed by discussion, having 4 sessions for propagation and 4 sessions for remote sensing. It was agreed that it had been well worth using the opportunity to hold Workshops in 1999, but that they were too separated from the sessions held in the following week. Any such workshops in future would be part of the main program.

5.2 Proposals for joint sessions with other commissions
Up to now, several people expressed their interest in joint sessions with Commissions of B, C and D. However, it was felt that time would allow only one session on this.

5.3 Proposals for tutorial topics, general lectures and their speakers
None were proposed in the business meetings, but Mr. Hall requested proposals be sent to Dr. Furuhama. The tutorials were felt to be of general interest and good for young scientists.

6. Intercommission Working Groups

Mr. Hall mentioned that these automatically end at a General Assembly unless renewed by Resolution to Council. It was felt that results from Working Groups should be made known through the Radio Science Bulletin, as well as in reports to the Council.
It was agreed to continue **WG GF.1** (Middle atmosphere) with Prof. J. Röttger (Germany) as coordinator and Prof. C-H Liu (China, SRS) as the Commission F representative.
It was also agreed to continue WG GFA1, but with the designation and title slightly changed to "**WG FG.1**: Atmospheric and Ionospheric Remote Sensing using Global Positioning Systems (GPS/GLONASS)" with Mr. J. P. V. Poires Baptista (The Netherlands) as coordinator and Dr. P. Hoeg (Denmark) as Commission G representative.

7. Representatives to other organizations

7.1 SCOR (Scientific Committee on Oceanic Research)
Commission F interests are looked after by Prof. M. T. Hallikainen.

7.2 IUCAF (Inter-Union Committee on Frequency Allocations for Radioastronomy and Space Research)
Commission F to be represented by Mr. J. P. V. Poires Baptista and Dr. G. Rochard (France).

7.3 COSPAR (Committee on Space Research)
Mr. J. P. V. Poires Baptista to be the formal member, with the representation at a meeting depending on where that meeting is to be held.

7.4 SCT (Scientific Committee for Telecommunications)
Mr. Hall mentioned the progress of chairs meeting about relations between URSI and ITU. The outcome was that the Scientific Committee for Communications (SCT) was to be reactivated. However there was no time to enter into details. In general, the currently retiring Commission Chairs were being proposed to serve on the STC in its early stages and it was agreed that Mr. Hall represent Commission F on this basis.

8. Publications and publicity

8.1 Review of Radio Science
It was agreed to continue the policy of having review chapters corresponding to most General Assembly session topics and for the session convenors to write the chapters; it was also agreed that the new Vice Chair be the editor for Commission F.

The Council had decided that future publication of the RRS be on CD-ROM for distribution to the attendees at the General Assembly, with hardbound books produced for sale to libraries, institutions, and those who specifically want a paper book.

8.2 Disk
Mr. Hall expressed appreciation for the work undertaken by Dr. R. L. Olsen (Canada) and by the national representatives in preparing material for the disk of references for Commission F. Dr. Olsen mentioned the big task of preparing the disk and felt it was not realistic to retain the present method anymore. Considering that the perceived value from the disk is not commensurate with the very substantial amount of time required on the part of the Commission Disk Editor and others involved in preparing it, the Council subsequently concluded that preparation and publication of the Disk should not be undertaken for the next triennium.

8.3 Modern Radio Science
The equivalence of MRS (Modern Radio Science) will in future be published in RSB (Radio Science Bulletin).

8.4 General Assembly book of abstracts
There had been much paperwork for Commission Chairs and Session Convenors that should be avoided in future. The Standing Committee on Publications had recommended that the current book of one-page abstracts be replaced by three-to-four page summaries, made available by electronic media and distributed at the GA on CD-ROM.

8.5 Publicity
Mr. Hall commented on the difficulty of contacting some Member Committee Representatives and the fact that certain Member Committees did not even have Representatives for Commission F (as was also the case for other Commissions). He also commented on the need to make known the activities of Commission F within the various countries, some of whom had national meetings and some of whom did not.

9. Any other business

It was noted that Mr. Hall had been appointed as Coordinator for the Scientific Program for the next General Assembly. He would welcome comments sent to him directly.
Dr Furuhama introduced a proposal for publication in "Radio Science" (RS). He had been invited to serve as a guest editor for setting up a special section for publication in "Radio Science" on the most important areas of research in the area of URSI Commission F as we enter the 21st Century. He proposed that several authors of Commission F chapters for "Review of Radio Science" in Toronto General Assembly and some appropriate members, perhaps session convenors, should revise the contents by adding new information which appeared in this General Assembly and prepare manuscripts for "Radio Science". He would prepare an introductory note for the special section.

Commission G - Ionospheric Radio ans Propagation
Chair: Prof. Bodo W. Reinisch
Vice-Chair Dr. Phil Wilkinson

The Commission held three Open Commission Meetings, respectively on 16, 18 and 20 August 1999.

1. Business Meeting 1: Monday, 16 August 1999

1.1. In Memoriam

The Business Meeting commenced with a brief moment remembering past friends of Commission G.

Lucien Bossy

Prof. Lucien Bossy died two weeks after the Lille URSI General Assembly at the age of 78. He was a mathematician and physicist who has dedicated his outstanding talents to the understanding of the earth's environment, especially the ionosphere. For long years he represented the ionospheric research community at URSI and other international organizations and has been an inspiration and friend to many of us. Josef Lemaire has reported on his life in The Radio Science Bulletin (Dec 96).

Edward J. Weber

Dr. Ed Weber died on 1 December 1998 at the age of 50 years. He was an ionospheric research scientist at the AF Research Laboratories at Hanscom AFB in Massachusetts, USA. At the time of his death he was the Chief of the Ionospheric Interactions Branch. From his early years as a graduate student in Antarctica to his very last day he was dedicated to the exploration and understanding of the earth's ionosphere using optical and radio techniques. With his observations from the ground and aboard the KC135 research plane he discovered and described the development and dynamics of the polar cap patches, and he gave one of the early descriptions of the ionospheric depletions associated with plumes, spread F and scintillations. In his last years he developed satellite programs for the study of ionospheric dynamics and structure.

Harvey Cummack

Dr. Harvey Cummack, who died December 1 1996, was born March 3rd, 1929 in Auckland, New Zealand. He was educated at the University of Canterbury as a mathematician and subsequently devoted his scientific life to the terrestrial ionosphere, first in the New Zealand Geophysical Observatory and then, on retirement in 1987, at the Physics and Astronomy Department of the University of Canterbury. His early work covered modelling the ionosphere at middle and low latitudes; his later work aimed at understanding the returns observed on ionograms. Harvey traveled little outside New Zealand, but for those who met him he will always be remembered as a person willing to discuss new ideas and impart the benefit of his experience to co-workers, and to people entering atmospheric and ionospheric physics. In his retirement, he was very proud of his work with several younger scientists as they set out on their careers.

1.2. Commission G Triennial Report

The Chair, B. Reinisch, noted that the past triennium had been a busy and productive time for Commission G. The complete URSI Commission Report was published prior to the General Assembly in Toronto and can be found on the Commission G Web site, currently at http://ulcar.uml.edu/ursi/.

1.3. Terms of Reference

In discussions, P. Cannon, J. Matthews and Sa. Basu suggested the Commission G terms of reference should be broadened to encompass topics that are currently either dealt with in the commission or could be. The new terms of reference expand Commission G interests beyond communications and emphasise both ground-based and space-based operations. These changes were adopted by the meeting and proposed to the URSI Council where they were subsequently accepted. The general terms of reference remain the same with the minor changes shown below, underlined.

Commission G: IONOSPHERIC RADIO AND PROPAGATION

The Commission deals with the study of the ionosphere in order to provide the broad understanding necessary to support space and ground-based radio systems. *Specifically, the study includes the following areas:*

(a) Global morphology and modelling of the ionosphere;
(b) Ionospheric space-time variations;
(c) Development of tools and networks needed to measure ionospheric properties and trends;
(d) Theory and practice of radio propagation via the ionosphere;
(e) Application of ionospheric information to radio systems.

To achieve these objectives, the Commission co-operates with other URSI Commissions, corresponding bodies of the ICSU family (IUGG, IAU, COSPAR, SCOSTEP, etc.) and other organisations (ITU, IEEE, etc.).

1.4. Election of Commission G Vice-Chair for 1999-2002

Following a decision by the URSI Board, a maximum of three candidates may nominate for the Vice-Chair position per General Assembly. This Assembly the three candidates were: P. Bencze, C. Hanuise and S. Pulinets. Votes were distributed to 40 Commission G national delegates and, including votes cast during the Assembly, 27 countries voted with C. Hanuise being the successful candidate and S. Pulinets second.

Subsequently, the URSI Council endorsed C. Hanuise as the Vice Chair of Commission G for 1999-2002.

1.5. Commission G Working Groups and Joint Working Groups, 1996-99

All Working Group Triennium reports are included in the Commission Triennium Report that is available on the

Commission G web site. Groups that did not supply a triennium report are indicated below. These reports are the responsibility of the lead Commission representative. In some cases these reports did not state that the working groups were to continue or not, this being settled during Working Group Business meetings held as part of the URSI General Assembly. Below the current Commission G working Groups, and Joint Working groups, are summarised together with brief reports and recommendations for future activity.

G.1. Ionosonde Network Advisory Group (INAG)
Chair: R. Conkright (USA); Vice-Chairs: P. Wilkinson (Australia) and J-C. Jodogne (Belgium). The principal objectives for the next three years is to extend the INAG Web page (http://www.ips.gov.au/INAG) and promote ionosonde data exchange using the World Data Center A Space Physics Interactive Data Resource (SPIDR). Recommend continuing with same officers.

G.2. Studies of the Ionosphere Using Beacon Satellites
Chair: R. Leitinger (Austria); Vice-Chairs: J.A. Klobuchar (USA) and P.V.S. Rama Rao (India). Tomography and occultation are new techniques encompassed by the Working Group now. Recommend continuing with same officers.

G.3 Incoherent Scatter
Chair : A.P. van Eyken (Norway); Vice-Chair: W. Swartz (USA). The main objective is to schedule the Incoherent Scatter World Day program. Recommend continuing with same officers.

G.4 Ionospheric Informatics
Chair : S.M. Radicella (Argentina); Vice-Chair: R. Hanbaba (France). Work on developing mean electron density profiles will be extended further to encompass the globe. Recommend continuing with same officers.

GF.1. Middle Atmosphere
Co-Chair for Comm. G : J. Röttger (Germany); Co-Chair for Comm. F: C.H. Liu (China, SRS). The group will continue to conduct workshops. Recommend continuing with same officers.

GFA.1. Ionosphere and Atmosphere Remote Sensing using Global Positioning Systems (GPS/GLONASS)
Co-Chair for Commission G: P. Høeg (Denmark); Co-Chair for Commission F: F. Solheim (USA); Co-Chair for Commission A: P. Banerjee (India). No report was supplied. Further action was deferred until the second Business Meeting.

GH.1. Active Experiments in Plasmas
Co-Chair for Commission G: Sa. Basu (USA); Co-Chair for Commission H: T. Leyser (Sweden). Recommend continuing with same officers.

GH.2. Computer Experiments, Simulation and Analysis of Wave Plasma Processes
Co-Chair for Commission G: H. Thiemann (Germany); Co-Chair for Commission H: H. Matsumoto (Japan) No report was supplied. Recommend continuing with same officers.

CGH.1. Wave and Turbulence Analysis
Co-Chair for Commission G: A.W. Wernik (Poland); Co-Chair for Commission H: F. Lefeuvre (France). No Commission C person was identified to participate in this group. A very successful workshop was held Aug 9-12, 1999, at University of Illinios at Urbana-Champaign, hosted by Prof. K. C. Yeh and Commissions E, F, G, H and J assisted with finance, in addition to SCOSTEP, and NSF helped fund students to attend.

EGH.1. EM Effects Associated with Seismic Activity
Co-Chair for Commission E : T. Yoshino (Japan); Co-Chair for Commission G: O.A. Pokhotelov (Russia); Co-Chair for Commission H: M. Parrot (France) No report was supplied. Further action was deferred until the second Business Meeting.

1.6. Inter-Union Working Groups, 1996-1999
There are two inter-Union Working Groups sponsored by Commission G.

URSI/IAGA VLF/ELF Remote Sensing of the Ionospheric and Magnetosphere (VERSIM)
Co-Chair for IAGA Commission 2 and 3: A.J. Smith (UK); Co-Chair for URSI Commission G and H: M. Parrot (France). Recommend continuing with same officers.

URSI-COSPAR on International Reference Ionosphere (IRI)
Chair: D. Bilitza (USA); Vice Chair for COSPAR: K.I. Oyama (Japan); Vice Chair for URSI: B.W. Reinisch (USA). Recommend continuing with same officers. A Commission G resolution was also proposed by this group.

1.7. Report on Contributions to Reviews of Radio Science
The Chair, B. Reinisch, on behalf of the Commission, thanked the Commission G Editor, C. Hanuise, for his excellent work preparing the Commission contributions to Reviews of Radio Science. Hanuise commented that the task had been straightforward thanks to the reminders from Ross Stone, and the good work and rapid responses received from the referees.

1.8. Proposal for Sessions in 2002
Several proposals for sessions were discussed. Some attempt was made to emphasise sessions that would include issues known to be important to the International Telecommunications Union (ITU). Subsequent discussions raised topics that could not be readily accommodated in the first set of sessions proposed. Using this information a set of potential sessions was prepared and discussed in the second Business Meeting.

1.9. Commission G Resolutions Committee
At the previous Assembly Commission G received a flood of resolutions diluting the tenuous value of Commission resolutions. Consequently, to act as a filter for the Commission a Committee to handle resolutions was formed. The committee comprised the past Chair, current Chair, current Vice-Chair and Vice-Chair elect. This Committee would have greater responsibilities than the Resolution Committees from precious Assemblies. B. Reinisch stressed that resolutions must be directed to somebody so it is apparent what action ought to occur.

1.10. Session Review Forms
A review form was proposed by URSI to be filled out by Convenors, continuing the session assessments made at

previous Assemblies. In addition, Commission G decided to introduce a further level of assessment by distributing assessment forms to a few members of the audience for each session Commission G headed. This information would be held by the Commission Chair and used to assist Convenors prepare sessions.

1.11 Joint Business Meeting with Commission H

No joint meeting was held with Commission H as the main tasks for the meeting were identified and dealt with by the Commission Chairs. While this was suitable at the time, Commission H has now requested that a Joint Meeting be scheduled for future Assemblies. This will be done.

2. Business Meeting 2: Friday, 20 August 1999

The meeting opened with a brief summary of the results of the Council Elections that took place on the previous evening. The meeting congratulated K. Schlegel and A. Wernik on being elected as Vice-Presidents of URSI.

2.1. Publications

Commission G editor for Reviews of Radio Science: J. Sahr (USA) has been appointed.
Proposed Commission G topics for Reviews of Radio Science
a) Ionospheric effects on HF propagation – P. Cannon
b) Space weather effects on the ionosphere.
c) To be decided
Commission G associate editor for Radio Science Bulletin: D. Hysell (USA) has been appointed.
Commission G tutorial lecture for 2002: Proposed: Radio Occultation Observations.

2.2. Commission G Web Site

During the triennium 1996-1999, URSI Commission G has been active through its Working Groups, sponsored symposia and workshops. Early in the triennium a Commission G web site was established (http://ulcar.uml.edu/ursi/) to ease communication between the Chair and the Commission. The triennium report is available at this site.

During the next triennium this Website will be moved to the URSI Web site and updated there. Future Commission Newsletters and Reports will be found on the Commission Web site.

2.3. Resolutions

There were four resolutions, below, proposed by Commission G and endorsed by the meeting.

The meeting endorsed the first resolution, noting that it ought to be a URSI resolution, rather than a Commission resolution but the new rules for URSI resolutions prevent this. URSI Resolutions must now be proposed well in advance of the Assembly so that the National Delegates have time to consider them prior to the Assembly.

The second resolution discussion noted there are many models of the ionosphere, but the meeting accepted it was important to acknowledge one model as a baseline.

The third resolution acknowledged recent work on the International Reference Ionosphere (IRI) has shown there are significant defects in our synoptic knowledge of the topside ionosphere that cannot be redressed globally without a topside ionosonde program. Some felt the resolution should be framed in stronger words.

The fourth resolution acknowledged that a good start has been made to protect Jicamarca Observatory, but this resolution will reinforce the efforts already made and confirm the International value of the work carried out there.

All resolutions were passed by the meeting and later accepted by the URSI Council.

2.3.1 Resolution 1: The IGY plus 50 years: New Perspectives for the Next Millenium

Recognizing that the years 2007-2008 will be exactly 50 years after the highly successful International Geophysical Year, and
Whereas the science agencies of the various adherent nations are engaged in, or have planned, aggressive science programs, and
Whereas these science programs are directed toward understanding the solid bodies, the oceans, the atmospheres, and the plasma environments of the Earth, the planets, the minor bodies, and the sun itself along with their physical and biological interaction, and
Whereas the science programs hold great promise for the education of the younger citizens of the whole world and the enthusiastic engagement of people everywhere, and
Whereas the further comprehensive understanding of the sun, the Earth system, and indeed all the planetary systems, will give us a practical ability to protect human technological systems, and
Whereas radio science contributed and will continue to contribute crucially in all aspects of the above-mentioned science programs,
URSI Commission G resolves
To support the SCOSTEP initiative to declare the period 2007 to 2008 "The IGY plus 50 years: New Perspective for the next Millenium" and urges all URSI Commissions to join the opportunity to share in the exploration, the excitement, and the adventure as humankind pushes forward in the next Millenium to a consolidated view of our entire solar system, just as humans did in the Earth's case in the decades following the IGY.

2.3.2 Resolution 2: The IRI as a standard for the ionosphere

Recognizing the need for an international standard for the specification of the ionospheric environment, and
Recognizing that the Presidents of URSI and COSPAR have written to international organizations in support of the International Reference Ionosphere as an ionospheric standard,
URSI Commission G resolves
That the International Reference Ionosphere (IRI), as developed by the URSI/COSPAR Inter-Union IRI Working Group, be internationally recognized as the standard for the ionosphere.

2.3.3 Resolution 3: Encouragement for topside sounder programs

Considering the large uncertainties in the specification of the F layer peak densities and heights over large parts of the globe, specifically the oceans and the southern hemisphere, and

Considering the large uncertainties in the specification of the topside ionospheric and plasmaspheric densities, and

Considering the need for the real-time specification of the ionosphere for operational use,

URSI Commission G resolves

That National Space Agencies be encouraged to launch a series of topside sounders that can specify the topside ionosphere in real time up to an altitude of about 1000 km.

2.3.4 Resolution 4: Protection for Jicamarca Observatory

Whereas the Jicamarca observatory is a unique facility for international atmosphere and ionosphere research at the magnetic equator, and

Whereas the location was selected for its isolation from radio interference and its clear environment, and

Whereas encroaching urban and demographic growth threaten these special characteristics of the site, and

Whereas we have been informed by the Peruvian delegation of legal initiatives that have been taken to protect the unique environment of the Jicamarca Observatory,

Therefore Commission G applauds the initial steps taken by the Peruvian Government, and

URSI Commission G resolves

To urge the Peruvian Authorities to take the additional necessary steps to complete the protection of this valuable facility.

2.4. Scientific Committee on Telecommunication, SCT

Over the last triennium there has been much effort in URSI to increase ITU/URSI interactions. This effort commenced in Prague (1990) with the creation of the Scientific Committee on Telecommunications (SCT), lead by L. Barclay. While the SCT did some good work, there was also a good deal of impatience and criticism of its output. Consequently, the SCT was dissolved in Lille and replaced by an ad hoc group chaired by J. Shapira. Commsphere was formed, but the link to the URSI Commissions was not evident. Nor did the Commission Chairs support an expansion of Commsphere into the General Assembly, proposed at this Assembly. The Commissions are therefore encouraged to increase their connections with ITU. In particular, while Commissions B, C and F have close relationships, Commission G used to be very active through the initiative of L. Barclay and P. Bradley. The meeting noted this information.

The past Commission G Chair, B. Reinisch, has proposed P. Bradley becomes the Commission G member on the reconstituted SCT.

2.5. Working Groups 1999-2002

The meeting approved the following Working Groups and Joint Working Groups for the next triennium.

G.1. Ionosonde Network Advisory Group (INAG)

Chair: R. Conkright (USA); Vice-Chairs: P. Wilkinson (Australia) and J-C. Jodogne (Belgium).

G.2. Studies of the Ionosphere Using Beacon Satellites

Chair: R. Leitinger (Austria); Vice-Chairs: J.A. Klobuchar (USA) and P.V.S. Rama Rao (India).

G.3 Incoherent Scatter

Chair: A.P. van Eyken (Norway); Vice-Chair: W. Swartz (USA).

G.4 Ionospheric Informatics

Chair: S.M. Radicella (Argentina); Vice-Chair: R. Hanbaba (France).

GF Middle Atmosphere *(this is the former AFG.1)*

Co-Chair for Comm. G: J. Röttger (Germany); Co-Chair for Comm. F: C.H. Liu (China, SRS).

GH.1. Active Experiments in Plasmas

Co-Chair for Commission G: Sa. Basu (USA); Co-Chair for Commission H: T. Leyser (Sweden).

GH.2. Computer Experiments, Simulation and Analysis of Wave Plasma Processes

Co-Chair for Commission G: H. Thiemann (Germany); Co-Chair for Commission H: H. Matsumoto (Japan).

GH.3. Wave and Turbulence Analysis

Co-Chair for Commission G: A.W. Wernik (Poland), Co-Chair for Commission H: F. Lefeuvre (France). The group will continue, but as a joint GH Working group. After a successful workshop in Urbana, a similar meeting is planned within the next 2 – 3 years. A school on methods of data analysis in turbulence has also been considered.

EGH Lithosphere-Atmosphere-Ionosphere coupling

Co-Chair for Commission E: Hayakawa (Japan); Co-Chair for Commission G: S. Pulinets (Russia); Co-Chair for Commission H: M. Parrot (France) This group replaces the Working Group EGH.1 "EM Effects Associated with Seismic Activity".

FG. Atmospheric and Ionospheric Remote Sensing using Global Positioning Systems (GPS/GLONASS)

Co-Chair for Commission F: P. Baptista (Netherlands); Co-Chair for Commission G: P. Høeg (Denmark). This working group is a continuation of Working Group GFA.1 with a minor change of name and Commission F is now the lead commission as this better reflects the interests of the group.

2.6. Inter-Union Working Groups, 1999-2002

The meeting approved the following two inter-Union Working Groups for the next triennium.

URSI/IAGA VLF/ELF Remote Sensing of the Ionospheric and Magnetosphere (VERSIM)

Co-Chair for IAGA Commission 2 and 3: A. J. Smith (UK); Co-Chair for URSI Commission G and H: M. Parrot (France). Recommend continuing with same officers.

URSI-COSPAR on International Reference Ionosphere (IRI)

Chair: D. Bilitza (USA); Vice Chair for COSPAR: K. I. Oyama (Japan); Vice Chair for URSI: B. W. Reinisch (USA). Recommend continuing with same officers. A Commission G resolution was also proposed by this group.

2.7. Commission G Sessions Proposed for the URSI General Assembly, 2002

Several sessions were suggested for the 2002 General Assembly. The sessions and convenors will be confirmed in the lead up to commencing preparations for the next Assembly. The final format for the next Assembly is not yet defined, but the Scientific Organizer, M. Hall, has suggested there should be fewer sessions than was the case this Assembly. Suggestions and problems with the present Assembly format identified by the meeting will be brought to the attention of the URSI Council in the final Commission report.

The sessions suggested are shown below.

G1 Ionospheric effects on HF propagation(P. Cannon - UK, P. Lassudrie - France). A specific problem of interest to ITU is a requirement for a model of delay spread caused by ionospheric features on HF wideband (say 100 kHz) transmissions. This is one of the propagation topics that should be dealt with in this session.

G2 Transionospheric signal degradation (R. Leitinger - Austria, to be decided). ITU is still seeking a suitable model, or models, for amplitude and phase scintillation, their frequency dependence and cumulative statistics, and characteristics and low and high latitudes. Topics likely to be of interest in this session will include: scintillation, Satellite-to-satellite propagation

G3 Operational ionospheric models including data ingestion (D. Bilitza - USA, K. Igarashi - Japan). In a variety of situations, ionospheric models are used to assist in system planning and, more recently, real time operation. This session will draw on the more novel uses of ionospheric models, among other aspects of ionospheric modeling.

G4 New approaches to radio sensing of the ionosphere(C. Hanuise - France, J. Röttger - Germany). A wide variety of new applications including lower ionosphere results and meteor radio science will feature in this session.

G5 Open session and latest results (B. Reinisch - USA, to be decided). During the last two Assemblies this session, intended to catch late breaking new scientific results, has become a selection of papers from a diverse range of radio science topics. An effort will be made to distribute some of these papers into other sessions for the next Assembly, hopefully returning the emphasis to the latest results. An alternate suggestion is to increase the time allowed for the session, but this is unlikely to be possible. A later submission date may be explored, but then some evidence may be required to show the paper could not have been submitted earlier.

GH1 High power radio wave ionospheric interaction: coupling of plasma processes. (G: Sa. Basu - USA; H. T. Leyser - Sweden).

GH2 Topside ionosphere and plasmasphere (G – J. Foster - USA, H – I. Kimura - Japan). This session is expected to encourage papers exploring this part of the ionosphere recently identified as poorly modelled.

GHE Space Weather effects on systems (G – P. Wilkinson - Australia; H – A. Hilgers - ; E to be decided.) This session will focus on space weather related system effects, especially failures and fault mitigation. It anticipates that before the next Assembly there will be at least one major solar storm and results from this storm are likely to form the core of this session. It will also seek input from the analysis stage of the SRAMP Space Weather Month, September 1999.

EGH1 Lightning effects in the ionosphere and the radiation belts (H – S. Cummer - USA, C. Rodgers - UK, G - to be decided, E - to be decided)

EGH2 Lithosphere-Atmosphere-Ionosphere coupling (E – M. Hayakawa - Japan, G – S. Pulinets - Russia, H – M. Parrot - France)

FG1 Atmospheric and ionospheric parameter retrieval using GNSS (F - P. Baptista - Netherlands, G - P. Hoeg - Denmark)

HG1 Space and ground observations of stimulated and natural space-plasma waves (H – M. Hashimoto - Japan, R. Anderson - USA, G - to be decided)

HG2 Active experiments in space and laboratory plasmas (W. Amatucci - USA, R. Hatakeyama - , J. Raitt - USA)

HGE Dynamics of dusty plasmas in space and laboratory (H – G. Ganguli - USA; G – S. Avery - USA; E – R. Merlino - USA)

HGJC Analysis methods for plasma waves and turbulence (H - T. Dudok de Wit - France; G - A. Wernik - Poland; J – B. J. Rickett – USA, C – to be decided). This may be accompanied by a Workshop to be held before the next Assembly.

2.8 Close of Business

At the conclusion of the meeting the outgoing Chair, B. Reinisch, thanked the Commission for the support they had given him during his tenure. Dr Wilkinson then acknowledged the work put in by Prof. Reinisch and thanked him for his efforts as well as and expressing his pleasure at being the incoming Chair.

3. Sessions held this Assembly

Sessions Commission G held

P / O** Convenors

G1 Recent Radar Systems and Scientific Highlights In Polar Ionosphere and Atmosphere Research 17 / 11 J. Röttger (Germany) and W. Hocking (Canada)

G2 Ionospheric Storms And Substorms : Radio Observations And Modeling 14 / 8 A. Shirochkov (Russia) and J. Hargreaves (UK)

G3 Low Latitude Ionosphere Effects On Systems And Radio Propagation 9 / 15 S. Basu (USA), Su. Basu (USA) and B. M. Reddy (India)

G4 Open Session And Latest Results 55 / 14K . Schlegel (Germany)

G5 Internet Session : Ionospheric Data And Models On The WWW 11 / 11D. Bilitza (USA) and T. Araki (Japan)

General Lecture

Engineering Issues in Space Weather

L. J. Lanzerotti, D. J. Thompson and C. G. Maclennan (USA)

G Tutorial Radar Systems For Ionospheric Research

J. Roettger (Germany)

Sessions Commission G lead in co-operation with other Commissions
*GC Digital Techniques In Ionospheric Radio Propagation, Control And Communication. 4 / 11 D. M. Haines (USA) and P. Cannon (UK)
GF Ionosphere And Troposphere Parameters Retrieved From GPS/GLONASS Measurements. 8 / 11 P. Hoeg (Denmark) and J. P. V. Poiares-Baptista (Netherlands)
GH1 Electromagnetic Coupling Including Seismic Activity Between The Ground And The Upper Ionosphere & Magnetosphere 11 / 16S. Pulinets (Russia), M. Parrot (France), S. Uyeda & M. Hayakama (Japan)
GH2 Lightning Ionosphere Interaction 5 / 10 U. Inan (USA) and D. Nunn (UK)

Sessions Commission G participated in.
HG1 Theory & Simulation Of Nonlinear Kinetic Processes In Space Plasmas 7 / 11 Y. Omura, (Japan), M. Ashour-Abdalla, (USA) and S. Ossakow (USA)
HG2 Radio-Frequency Sounders In Space, New And Old 13 / 11G. James (Canada), R. Benson, (USA) and B. Reinisch (USA)
HG3 Wave Propagation : Observation And Data Analysis 13 / 18F. Lefeuvre (France) and Y. Hashimoto (Japan) and K. Mahajan (India)
HG4 Comparative Studies Of Space & Laboratory Plasmas - / 10 W. Gekelman (USA) and C. Hanuise (France)
HG5 Ionospheric Modification With High Power Radio Waves: Coupling Of Plasma Processes 22 / 15T. B. Leyser (Sweden) and S. Basu (USA)
*JCEG Interference Protection Measures 3 / 7 R. Fisher (USA)
* Contribution to the spectrum congestion theme
** Number of (P) poster and (O) oral papers presented for each session.

BUSINESS TRANSACTED BY COMMISSION H

Commission H - Waves in Plasmas
Chair: Dr. V. Fiala (Czech Republic)
Vice-Chair: Dr. H.G. James (Canada)

First Business Meeting, 16 August 1999

The Chairman proposed a first meeting agenda which corresponds to the main numbered headings below.

1. Election of the Vice-Chair
In 1999, there were six nominations. Since the URSI Secretariat wants final elections with two or three candidates, there were preliminary and final votes, both by mail-in ballot before the General Assembly (GA). After the addition of one national vote (France) from the floor, the Chairman declared Dr. U.S. Inan (USA) to be the Vice-Chair designate for the new triennium. The vote tallies are available upon request from the outgoing Chairman.

2. Working Group activities and proposals for the next triennium
Five working groups involving Commission H will continue to operate:

VLF/ELF remote sensing of the ionosphere and magnetosphere (VERSIM), an URSI/IAGA inter-union WG. A report was submitted by M. Parrot. See also the VERSIM web site at http://www.nerc- bas.ac.uk/public/uasd/versim.html

Computer experiments, simulations and analysis of wave plasma processes (GH.2). This WG was involved in the 5th International School/Symposium of Space Simulations (ISSS-5). It was held during 13-19 March 1997 in Kyoto, Japan and attracted 182 participants. Y. Omura is the H co-chair, and submitted a report. More information can be obtained at http://www.kurasc.kyoto-u.ac.jp/isss/program.html

Wave and turbulence Analysis (CGH.1). 47 participants attended a workshop on radio Methods of Studying Turbulence at Urbana, Illinois, USA during 9-12 August 1999. T. Dudok de Wit was the H representative.

Active Experiments in Space Plasmas (GH.1). J. Raitt was the H co-chair, and helped to organize a session with this name at the COSPAR 32nd Scientific Assembly in Nagoya in 1998.

Electromagnetic effects associated with seismic activity (EGH.1). M. Parrot was the H representative.

3. Past and future sponsorship of conferences and meetings
A report is available from the Secretariat listing the meetings and other activities that were supported by H in 1996-1999. Five meetings of various sorts were sponsored under mode B at a total cost of $US 5100. Four other meetings were endorsed under mode A (no financial support). Another $US 4025 went to supporting individuals' costs associated with the Toronto GA. For more details, the 1996-1999 H Triennial Report also can be examined.

The meeting was reminded that URSI has established guidelines for meetings that it sponsors. These guidelines include application, approval and preparation cycles before the meeting and reporting afterward. A communication from the Secretary General indicated that the Commission budget sum in the new triennium will be about 9,000 Euro.

4. Review of Radio Science (RRS) and Reference Disk
It was reported that RRS Editor Ross Stone will plan to allocate about the same space for each commission in the next RRS. It will distributed largely on CD-ROM, with hard copies going to institutional libraries.

The URSI publications committee reportedly will recommend cessation of the Disk to Council. The meeting agreed with this recommendation.

5. Commission H and joint HG sessions, propositions for the next GA

Upon invitation from the Chair, various delegates contributed verbal descriptions of proposed sessions for the next General Assembly. Some speakers urged more joint sessions than in GA99. The final GA business meeting report below gives the list of session titles.

6. Commission resolutions, recommendations and opinions

It was proposed by J.F. Lemaire that Commission H submit a Recommendation for URSI approval, entitled "Survey of the spatial distributions of VLF and ELF waves in the magnetosphere". The Commission supported the action after it was confirmed that it represented similar interests of the VERSIM (A.J. Smith) and NASA/GSFC (S. Boardsen) groups.

7. Next business meeting

A joint G-H business meeting was planned for 18 August, subject to G interest therein.8. Any other business
R. Horne and R. Anderson took an action to draft, for the Chairman's signature, a letter of tribute to the late Alan Johnstone.

Second Business Meeting, 18 August 1999

1. H-only and H-leading sessions for the next GA

It was reported that Commission G did not require a joint meeting with H. No G representatives were present. Nevertheless the interests of Commission G in joint sessions were clarified. Since URSI leaders encouraged greater interdisciplinary contact, more joint Commissions were discussed. H decided to plan one Union session.

Third Business Meeting, 20 August 1999

1. Sessions for the next GA

A list of 11 H-only sessions and H-led joint sessions and convenors was approved, as follows:

H-only:

H1 Kinetic Effects in Boundary Layers (B. Lembege, M. Hoshino, B. Daughton)
H2 Wave and Coherent Structures in Space Plasmas (Y. Omura, M. Ashour-Abdalla)
H3 Antennas and RF Probes in Plasmas (E. Mareev, V. Fiala, I. Nagano)
H4 Plasmaspheric Structure and Phenomena (B. Fraser, G, Ganguli, R. Anderson)
H5 Open Session on Latest Results (G. James)

H-led joint sessions:

HG1 Spacecraft and Ground Observations of Stimulated and Natural Space-Plasma Waves (H - K. Hashimoto, R. Anderson; G - tbd)
HG2 Active Experiments in Space and Laboratory Plasmas (H - W. Amatucci, R. Hatakeyama, J. Raitt; G - tbd)
HGE1 Lightning Effects in the Ionosphere and the Radiation Belts (H - S. Cummer; G - C.J. Rodger; E - Y. Hobara)
HGE2 Dynamics of Dusty Plasmas in Space and Laboratory (H - G. Ganguli; G - S. Avery; E - R. Merlino)
HGJC Analysis Methods for Plasma Waves and Turbulence (H - T. Dudok de Wit; G - A. Wernik; J - B. Rickett; C - tbd)
Union Power Transmission from Solar Power Stations, Technological, Environmental and Biological Aspects (H - K. Hashimoto, others - tbd)

In addition other joint sessions led by other Commissions were submitted:
GH1 High-Power Radio Wave-Ionosphere Interactions: Coupling of Plasma Processes (G - Sa. Basu; H - T. Leyser)
GH2 Topside Ionosphere and Plasmasphere (G - J. Foster; H - I. Kimura)
EGH Lithosphere-Atmosphere-Ionosphere Coupling (E - M. Hayakawa; G - S. Pulinets; H - M. Parrot)
GHE Space Weather Effects on Systems (G - P. Wilkinson; H - A. Hilgers; E - tbd)

2. Commission H meeting support

It was agreed to support the five following meetings:

- 33rd COSPAR Scientific Assembly, 16-23 July 2000, Warsaw, Mode A.
- First STEP-Results, Applications and Modeling Phase (S-RAMP) Conference, 2-6 October 2000, Sapporo, Japan, Mode A.
- School "Analysis techniques for plasma data as obtained by satellites", February 2001 Marseille, Mode B.
- Sixth International School for Space Simulations (ISSS-6), June 2001, Germany, Mode B.
- 2001 Asia-Pacific Radio Science Conference (AP-RASC '01), 1-4 August 2001, Tokyo, Mode B.

It was noted that formal applications for support have been received so far only for the first two of the above five events.

Some delegates reported that the H Workshop at GA99, organized by J. Lemaire and O. Storey, was a very successful event, and said that another workshop should be considered for GA02. A suggestion from the first business meeting for a workshop celebrating the work of an esteemed colleague had to be withdrawn. Given the uncertainty about the length of GA02, a tentative theme for an H workshop was subsumed under the proposed regular session on the plasmasphere.

3. H chapters in the RRS99-02

A number of topics and author names were suggested to incoming Vice Chair Inan:

- Wave-Particle Interactions (Horne et al.)
- Boundaries in Space Identified by Plasma Waves (tbd)
- Auroral Acceleration Processes and AKR (Strangeway, Kintner)
- Dusty Plasmas (Verheest, Merlino, Mendis, Ganguli)
- State of the art sensors, instrumentation and techniques (Beghin)

- Solar System Radio Emissions (Bougeret, Kaiser, Mann, Reiner)
- Lightning Effects in the Ionosphere (Hiroshi Fukunishi)
- Active Experiments (Raitt, Bernhardt)
- Waves in strongly inhomogeneous media (G. Ganguli)

4. Radio Science Bulletin

F. Lefeuvre agreed to serve as H-Commission Associate Editor in 1999-2002.

5. H tutorial lecture for GA02

The names of a number of well known scientists and proposed topics were given to the incoming Chair James, who will enter into contact with prospective speakers.

6. Commission Vice Chair Nominations

The meeting was apprised of a proposal from the Secretariat that each commission set up a nominating committee. The delegates were of the opinion that the present system, wherein the Chairman gathers nominations from national committees, has worked satisfactorily in the past and should be retained in Commission H. Hope was expressed for a higher percentage of national votes in the next triennium.

7. Concerns about the GA technical program

Abstract Length and Oral Sessions:

The meeting was informed that URSI leaders are considering extending abstract length to four pages for the next GA. The meeting voted to inform the URSI Board that H wishes to retain the present one-page abstract.

The abstract form should ask the submitter to indicate whether special audio-visual facilities will be used or needed. It should ask the submitter to say whether only oral or only poster presentation is acceptable.

The discussion of abstract length per se also evoked concern about the quality of communications in the GA sessions. The problems encountered in oral papers at GA99 were usually in the area of presentation, not in content. The call for papers should urge presenters to practice their presentations in front of colleagues prior to the GA and to limit their visual displays to several, clear examples.

Participants asked the URSI GA organizers to print the starting time (hr:min) with each paper title entry in the Program book. Also, session chairs should be equipped with timing devices to help them better enforce presentation time lengths.

Facilities at GA99:

Participants found insufficient time to visit all posters of interest to them at GA99. It would be more desirable to have all GA posters in one large hall and to budget more time for poster sessions. The H-session meeting room was uncomfortably cold, and there was no way to correct this. Participants found the computer access good.

Combined G-H business meeting

The delegates felt that the combined meeting should be retained at the next GA.8. Thanks to outgoing Chair.

F. Lefeuvre expressed thanks to V. Fiala for his leadership and for the profitable technical sessions that were enjoyed at GA99; this was unanimously approved by the meeting.

BUSINESS TRANSACTED BY COMMISSION K

Commission K – Electromagnetics in Biology and Medicine

Chair: Professor James C. Lin (USA)
Vice-Chair: Professor Shoogo Ueno (Japan)

Commission K held a business meeting on August 16, 1999.

1. Election of a Vice-Chair

Three candidates were nominated for the position of Vice-Chair for the next triennium: Bernard Veyret (France), Niels Kuster (Switzerland) and Jitendra Behari (India). Of the 54 votes that were cast in the election, Bernard Veyret received the majority vote. Niels Kuster and Jitendra Behari followed respectively.

2. Resolution of Commission K

A resolution of Commission K, which calls for an increase in national support for research on the beneficial applications of electromagnetic fields in diagnostic and therapeutic medicine, was passed unanimously.

3. Resolution of the French National Committee

A resolution of the French National Committee, which proposes to create a network of research centres to distribute and to co-ordinate information distribution in relation to the bioeffects and hazards associated with electric and magnetic fields, was discussed. Also, the relationship with WHO and its large database were discussed. No action was taken in either case.

4. 2001 International Scientific Meeting on Electromagnetic Fields in Medicine

The next meeting of the International Scientific Meeting on Electromagnetic Fields in Medicine will be held in Tokyo, Japan in the spring of 2001.

5. Review of Radio Science and Disk of Reference

Five chapters were contributed to the Review of Radio Science 1996-1999, which was edited by Professor Shoogo Ueno, the editor of Commission K. Chapters included the biological effects and RF dosimetry of mobile communications, bioelectric and biomagnetic measurements, and biomedical applications.

About 800 references were collected for the Disk of collected references of Commission K, which was edited by Professor Masao Taki (Japan).

6. Expression of Gratitude

The vice-Chair, Professor Shoogo Ueno, congratulated and expressed his sincerest gratitude to the outgoing chair, Professor James C. Lin, for his tremendous efforts and accomplishments in organising and promoting the Commission in the last triennium.

7. Scientific Programme

7a. Commission K organised four sessions and four joint sessions with Commissions A, B, C and E.

K1 Mechanisms and modelling of electromagnetic interaction with biological systems
Conveners: C. Polk (USA) and G. D'Inzeo (Italy)

K2 Biological effects of electromagnetic fields
Conveners: L. Kheifets (USA) and R. Korenstein (Israel)

K3 Hazard assessment for wireless communications
Conveners: P. Bernardi (Italy) and B. Veyret (France)

K4 Biomedical applications of electromagnetic fields and waves
Conveners: C. Gabriel (UK) and S. Ueno (Japan)

KA Exposure assessment for cellular and personal telecommunications
Conveners: C. Chou (USA) and M. Taki (Japan)

KB Computation of EM fields in the human body
Conveners: O. Gandhi (USA) and Y. Rahmat-Samii (USA)

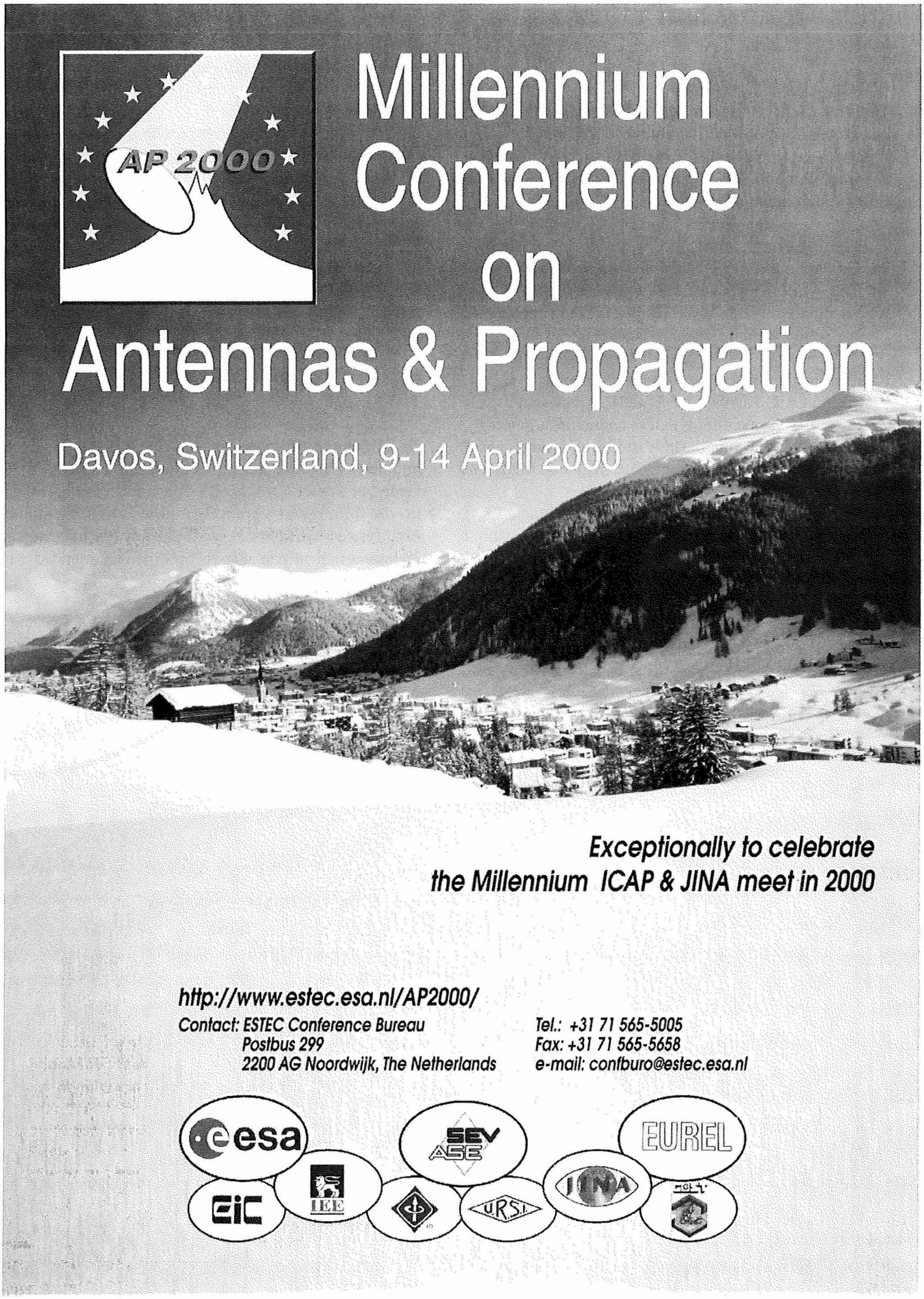
KC Health effects of mobile telephones
Conveners: R. Adey (USA), N. Kuster (Switzerland) and E. Bonek (Austria)

KE Electromagnetic interference with medical devices
Conveners: D. Witters (USA) and O. Fujiwara (Japan)

Session	Oral	No-Shows	Poster	No-Shows	Participants
K1	8	1	9	4	65
K2	10	0	9	7	80
K3	10	2	0	0	100
K4	11	0	25	12	160
KA	11	1	4	1	80
KB	11	0	11	2	80
KC	8	0	0	0	160
KE	8	0	0	0	40
TOTAL	77	4	58	26	765

7b. K-Tutorial: An Assessment of the Bioeffects Induced by Power-Line Frequency Electromagnetic Fields

Professor Russel J. Reiter (USA) reviewed studies related to the biological effects of power-line frequency electromagnetic fields as well as possible mechanisms including radical pair models. 160 people attended with great interest.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Davos, Switzerland, 9-14 April 2000
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Conferences

CONFERENCE REPORTS

CLIMPARA'98

Ottawa, Canada, 27-29 April 1998

CLIMPARA'98 was a special interest URSI Commission F Open Symposium hosted in Ottawa by the Communications Research Centre from 27-29 April 1998. Its subject matter was 'Climatic Parameters in Radiowave Propagation Prediction'.

There were 57 participants from 25 countries on six continents, with 14 invited papers and 37 submitted papers on recent relevant activities. The proceedings contain 50 of these papers. There were five variously-structured scientific sessions on clear-air and precipitation modelling, mapping, and measurements, each initiated by invited papers. Each session was co-chaired by an expert from a temperate country and another from a tropical country. In addition, there was a session of three invited papers on ITU-R issues relevant to URSI Commission F, chaired by the Chairman of ITU-R Study Group 3. The symposium concluded with workshops on clear-air effects and on precipitation effects, each co-chaired by a propagation scientist and a meteorologist. There was lively discussion in the workshops and ITU-R session as well as after individual presentations in the scientific sessions.

CLIMPARA'98 was immediately followed by parallel meetings of ITU-R Working Parties 3J and 3M which gave emphasis to the same general topic area. A clear distinction was made between the radio science of CLIMPARA'98, and the radio engineering applications of the ITU-R WP meetings, but the mutual benefit of running the meetings in serial were widely commented on. Many people found it possible to participate in both areas where normally they would participate in only one.

The symposium began on the evening of 26 April with a reception at the symposium hotel, hosted by the Communications Research Centre. A short tour of the Canadian Museum of Civilization took place on 28 April, followed by a reception and banquet in two spectacularly attractive areas of the museum. Informal tours of accompanying persons were arranged during the symposium. Finally, two informally arranged social events for all participants occurred during the subsequent ITU-R meetings. Dr. Ben Segal chaired the local arrangements committee.

To some extent, CLIMPARA'98 built on the experience of CLIMPARA'96 in Oslo, and CLIMPARA'94 in Moscow, also dealing with both clear-air and precipitation climatic parameters. All meetings built on the URSI Commission F Open Symposium held in Rio de Janeiro in 1990 on 'Regional Factors in Predicting Radiowave Attenuation due to Rain', the first "CLIMPARA". In particular, CLIMPARA'98 followed the 1990 and 1996 pattern of immediately preceding meetings of ITU-R Working Parties 3J and 3M, the two ITU-R Study Group 3 Working Parties most closely associated with these issues. There is already interest in holding another CLIMPARA.

J.P.V. Poiares Baptista and Roderic L. Olsen

IRI'99 WORKSHOP

Ottawa, Canada, 27-29 April 1998

The annual workshops are the life blood of the international IRI (INTERNATIONAL REFERENCE IONOSPHERE) effort, since they provide an opportunity to review the status of various modelling efforts and to discuss improvements and additions to this widely used ionospheric model. IRI'99 was held at the Center for Atmospheric Research (CAR) of the University of Massachusetts Lowell (UML) from August 9 to 12. Excellent support was provided by the local host Bodo Reinisch (CAR Director) and his team. The meeting was supported through financial contributions from the International Union of Radio Science (URSI), the Committee on Space Research (COSPAR), the National Science Foundation (NSF) and the UML. The four day meeting was attended by 37 participants representing 14 different countries. 47 papers were divided into the following sessions: Ray Tracing, D Region, Measurements and Comparisons, Temperature and Ion composition, Topside and Plasmasphere, Total electron Content, Improvements and New Inputs, Drift Data and Modelling, Evaluation of IRI and Other Models, Applications, and Final Discussion (http://ulcar.uml.edu/ursi/iri_workshop.html). As a result of the presentations and discussions the IRI Working Group decided to include several improvements and additions in the next edition of the model, IRI-2000. It is also planned to publish an IRI-2000 report similar to the very popular IRI-1990 report.

Workshop Topics

The special focus of IRI'99 was on ray tracing and on variability. Different ray tracing methods and techniques were reviewed by Dyson and Benett (Australia). Huang and Reinisch (CAR) presented a multi quasi-parabolic description of IRI density profiles that allows for analytical ray tracing computations. The later is now under consideration for inclusion in IRI. A quantitative description of ionospheric variability (= the standard deviation from a monthly average) has long been a goal of the IRI group, since this parameter is of great interest for many Space Weather applications. Future ICTP Task Force Activities will deal with this important modelling aspect using the presentations from the Lowell meeting (e.g. Gulyaeva, Russia and Mahajan, India) as a starting point (Radicella, ICTP).

Electron Density – Bottomside and E and D regions

In the lowest (D) region, Friedrich (Austria) has now assembled all available and reliable rocket measurements (114 profiles) using the IRI selection criteria (in situ radio propagation experiments). He will provide the latest version of his model as a new option for the IRI D-region. Work continues on more realistic description of the night-time variation of the E peak density and height (Bibl, CAR; Mahajan, India). Recent work by Titheridge (New Zealand) should be also helpful in this context. Inclusion of a statistical model for the occurrence of Sporadic-E was suggested as a new work item and review talks will be invited for the next IRI meeting (Smith, Boulder). The new bottomside model developed by the ICTP Task Force Activity was accepted for IRI-2000 (Adeniyi, Nigeria; Radicella, ICTP; Reinisch, CAR; Bilitza, RITSS/GSFC; Mosert, Argentina; S. Zhang, China; et al.). This includes a new formula for the probability of F1 occurrence, a realistic representation of the bottomside thickness parameter B0 at low and equatorial latitudes and an analytical description of the intermediate region that is free of artificial valleys and discontinuities.

Electron Density – Topside, Plasmasphere and TEC

Bilitza (RITSS) gave a status report about his topside modelling project. Based on all electronically available electron density profiles deduced from Alouette and ISIS topside sounder measurements, his approach plans to use a number of fix points to describe the shape of the topside profile (e.g., the inversion point, the scale height transition point). Comparisons with Hinotori in situ measurements (Ezquer, Argentina), with ATS-6 TEC data (Ezquer, Argentina), with GPS data (Breed and Goodwin, Australia) and with Arecibo incoherent scatter results (Sethi, Pandey, Mahajan, India) all demonstrated the need for an improved IRI topside model. Gallagher (MSFC) presented the status of his plasmaspheric model and linkage to the IRI. Although fairly advanced the model is not yet ready for release. The IRI'2000 Workshop will have the topside and plasmasphere as its special topic and will have the inclusion of a plasmaspheric model as one of its most important goals.

Electron Density - F Peak Parameters

In general IRI describes the monthly average F peak densities (NmF2) reasonably well using either the CCIR (over land) or URSI (oceans) options. In the case of the peak height hmF2 there is, however, a clear need for improvement especially in the low latitude dusk sector. A prerequisite for a new modelling effort is an increased global data base for this parameter or as stated in a resolution submitted to URSI: more topside sounder measurements are needed for a better global representation of the F peak height. This resolution was adopted by Commission G during the 1999 URSI General Assembly (Toronto, Aug 13-21). Richards (U Alabama Huntsville) investigated large enhancements in the night-time NmF2 for magnetically quiet conditions at Millstone Hill. IRI provides a night-time enhancement much smaller than the observed values. Richards's FLIP model can reproduce about half the enhancement if it is adjusted with the measured electron temperatures. For stormtime conditions it is planned to include in IRI-2000 the updating algorithm proposed by Fuller-Rowell (NOAA) during the 1998 IRI Workshop.

Temperature, Ion Composition and Drift

Potekhin (Russia) found good agreement between IRI and plasma temperatures measured by the Irkutsk incoherent scatter radar during summer and discrepancies of several 100 degrees during winter. AKEBONO data could be a good source for modelling the plasma temperatures in the transition region from ionosphere to plasmasphere (Oyama, Japan). Data from several Russian satellites were used to establish global models of the electron temperature at several fixed heights. Comparisons with DE and Hinotori data show good agreement with the model values (Truhlik, Czech Republic). These models will be used to improve the topside electron temperature model for IRI. Mass spectrometer measurements from the Russian ACTIVE satellite and the AE-C,-E satellites have been used to study the global, seasonal, diurnal and solar cycle variations of the upper transition height in the ion composition (Triskova, Czech Republic). It is planned (although not for IRI-2000) to replace the current ion composition model in IRI with a model that is anchored by the transition heights (Bilitza, Grebowsky, GSFC). An important new addition to the parameters provided by IRI will be the vertical ion drift. For IRI-2000 it was decided to include the model for equatorial latitudes developed by Scherliess and Fejer (USU). Scherliess reported about the global model that he is working on now and that might become a good candidate for a later update of the IRI model. Drift data from the Japanese MU Radar were presented by S. Zhang (China).

Applications

Total Electron Content (TEC) is the ionospheric parameter that is most important for many applications. Reinisch (CAR) showed how TEC can be deduced from groundbased DIGISONDE measurements and Radicella (ICTP) used his DGR model to obtain TEC from IK19 topside sounder measurements. Bust et al. (U Texas Austin) and Cornely (UML) described how IRI and similar models can be of help in tomographic reconstruction of ionospheric contour maps. IRI-related applications and web systems were reviewed during a special half-day session including: telecommunications (Bradley, U.K.), evaluation of TEC computations (Wilkinson, Australia), ionospheric corrections for microwave remote sensing from space (Abraham and LeVine, GSFC), WWW interfaces for data/ model computations, retrieval and plotting (Conkright, NGDC; Bilitza, GSFC), an IRI Windows interface (Huang, UML), and the use of IRI for FMCW signal simulations (Potekhin et al., Russia). Bradley (UK) pointed out that the International Telecommunication Union (ITU) requires specific radio propagation parameters that are in general different from the standard IRI output parameters. He will co-ordinate an effort to use IRI for the computation of ITU parameters. The WDC C2 Kyoto maintains Web pages that let users compute ionospheric conductivities using the IRI and CIRA models. This service was recently discontinued. But because of several requests from users and from the IRI team they were put back online (Araki, Japan). A number of these IRI-related systems were also described during the URSI session G5 on Ionospheric Data and Models Available on the WWW; agenda and links are available at http://nssdc.gsfc.nasa.gov/space/model/ionos/ursi99_g5_links.html.

New Developments

A neural network approach to representing F peak and profile parameters from South Africa was presented by Poole and McKinnell (South Africa). Rawer and Eyfrig (Germany) studied long-term trends in M(3000)F2 data and found non-negligible secular changes. IK-19 topside sounder data were used to demonstrate the ionospheric effects induced by seismic activity and an attempt was made to explain the coupling mechanism (Pulinets, Russia). An evaluation of ionospheric models is being undertaken by Decker et al. (AFRL). First results for two TEC stations (Hamilton and a Taiwanese station) show that the three models perform equally well and that the predictions are about a STD away from the measured mean. Rich and Sultan (AFRL) investigated the shortcomings of the IRI, PIM, and RIBG topside models with DMSP in situ measurements at 840 km. The model predictions are again fairly close to each other and up to a factor 2 from the data. Results were also presented on a comparison of IRI with a station-specific model for Millstone Hill (Buonsanto, Millstone Hill). It showed small discrepancies in representing the solar cycle variation and indicated the importance of including in IRI the motion of the auroral trough.

Members, Meetings, Publications, ISO, URSI Resolution

A number of new members were elected into the IRI Working Group: J. O. Adeniyi (Nigeria), A. Poole (South Africa), S.P. Gupta (India), R. Ezquer (Argentina), S. Pulinets (Russia), X. Huang (UML, USA). Four members are no longer participating in the IRI effort: B.C. N. Rao (India), L. McNamara (Australia), W. Hoegy (USA), K. Champion (USA). The next IRI meeting will be held as session C4.1 during the COSPAR Scientific Assembly in Warsaw, Poland (July 16-23). Special emphasis will be given to topside and plasmasphere modeling. The editing process for the papers from the 1998 IRI Workshop was completed in July 1999 and the package of 32 papers on 226 pages was submitted to Advances in Space Research (Editors: K. Rawer, D. Bilitza, K. Oyama and W. Singer). Currently there are two proposals before the International Standardisation Organisation (ISO) for an international standard ionosphere involving the SMI and the IRI models, respectively. The Lowell Workshop provided a good opportunity to discuss the consolidation of these two efforts and resulted in plans for a joint project (Gulyaeva, Chasovitin, Russia; Bilitza, RITSS). During the URSI General Assembly in Toronto (Aug 99) Commission G adopted the following IRI-related resolution:

Recognising *the need for an international standard for the specification of the ionospheric environment, and*
Recognising that the Presidents of URSI and COSPAR have written to international organisations in support of the International Reference Ionosphere as an ionospheric standard,
URSI Commission G resolves
That the International Reference Ionosphere (IRI), as developed by the URSI / COSPAR Inter-Union IRI Working Group, be internationally recognised as the standard for the ionosphere.
The IRI Homepage is at http://nssdc.gsfc.nasa.gov/space/model/ionos/iri.html

Dieter Bilitza

33RD COSPAR SCIENTIFIC ASSEMBLY

Warsaw, Poland, 16 - 23 July 2000

The 33rd COSPAR Scientific Assembly and Associated Events will be held in Warsaw, Poland on 16 - 23 July 2000
Scientific Program Chair: Prof. K. Stepien, Warsaw University Observatory, Warsaw, Poland
Local Organizing Com. Chair: Prof. J.B. Zielinski, Space Research Center, Warsaw, Poland
Abstract Deadline : **10 January 2000**

Topics

Approximately 80 meetings and symposia covering the following areas: The Earth's Surface, Meteorology, and Climate; The Earth-Moon System, Planets, and Small Bodies of the Solar System; The Upper Atmospheres of the Earth and Planets incl. Reference Atmospheres; Space Plasmas in the Solar System, including Planetary Magnetospheres; Research in Astrophysics; Life Sciences as Related to Space; Materials Sciences in Space; Fundamental Physics in Space; Space Debris; Satellite Dynamics; Scientific Ballooning; Radiation Belts; Space Weather; Integrated Global Observation System ; Role and Benefits for Developing Countries; The Public Understanding of Space Science
Papers Published in: *Advances in Space Research*

Scientific program

A0.1 New Global Satellite Observations of the Earth's Surface, Atmosphere and Ocean A0.2 Calibration and Characterization of Satellite Sensors and Accuracy of Derived Physical Parameters A0.3 Panel Discussion: The Concept of an Integrated Global Observing Strategy and its Benefits for Earth Science A0.4 Improving the Assimilation of Spaceborne Observations for Atmospheric and Oceanic Modelling and Numerical Weather Prediction A0.5 Forty Years of Weather Satellites: Where Are We and Where Are We Going? A1.2 Remote Sensing of Trace Constituents in the Lower Stratosphere, Troposphere and the Earth's Surface: Global Observations, Air Pollution and the Atmospheric Correction A1.3/C2.8 Contribution of Remote Sensing of the Upper Troposphere and Stratosphere to Understanding Climate Change A2.1 Progress in Remote Sensing of Ocean Biological and Physical Processes A3.1 Monitoring and Assessment of Biogeochemical Cycles A3.2 Combined Interpretation of Multi-Sensor Data and Utility of Medium and Coarse Resolution Satellite Data for Land Surface Characterization B0.1/PEDAS1 Space Debris B0.2 Lunar Exploration 2000 B0.3 Near-Earth Objects and Impact Hazard B0.4/C3.5 Mars: Latest Results and International Program Status B0.5/D3.6 Io: the Volcanic "Heart" of the Jovian System B0.6/C3.4/D3.7/F3.0 Europa and Titan: Atmospheres, Oceans, Plasma Environments and Exobiology B0.7 Cratering of Icy Surfaces B1.1/D0.3 Exploration of Small Solar System Objects: Past, Present and Future B1.2/D0.4 Modelling and Laboratory Studies Supporting Space Missions to Small Bodies B2.1/PSD1 New Trends in Space Geodesy C1.1 Multi-instrument Studies of the Thermosphere and Ionosphere Using Combinations of Space-based and Ground-based Techniques C2.1 Ozone Variations of Solar Origin C2.2 Changes in Greenhouse Gases C2.3/A1.4 Middle Atmosphere Spatial Structures C2.4 Spatial and Temporal Variations in Gravity Waves C2.5 Aerosols, Dust and Layers in the Middle Atmosphere C2.6 Lightning Middle Atmosphere Interaction C2.7 Advances in Remote Sensing of the Middle and Upper Atmosphere and the Ionosphere C3.1 Planetary Atmospheres C3.2/D3.8 Planetary Ionospheres C4.1/D3.9 Modelling the Topside Ionosphere and Plasmasphere C4.2 CIRA Part III: Supplements: Additional Reference Atmospheres for Trace Constituents and Comparison with Latest Data D0.1/E3.1 Comparative Reconnection Studies at the Sun and in Planetary Magnetospheres D0.2 Alfvénic Structures: From the Sun to the Magnetosphere D1.1 Galactic and Anomalous Cosmic Rays in the Heliosphere: the Cycle 22 Solar Minimum and the Onset of Cycle 23 D2.1/E3.2 Solar Composition: New Perspectives from In-situ and Remote Sensing Studies D3.1/C3.3 Planetary Magnetospheres D3.2 Advances in Auroral Physics D3.3 Advances in Global Magnetospheric Structure, Dynamics, and Region Coupling D3.4 Validation of Magnetospheric Models D3.5 Multiscale Structure of the Dynamic Processes in the Critical Magnetospheric Regions D4.1/B1.3 Dusty Plasmas and Active Experiments E1.1 New Vistas from X-ray Observatories E1.2/H0.3 X-ray and Gamma-ray Signatures of Black Holes and Weakly Magnetized Neutron Stars E1.3 Origin and Acceleration of Cosmic Rays E1.4 New Results in Far IR and Sub-mm Astronomy E1.5/H0.2 The Copernican Principle and Homogeneity of the Universe E1.6 Small Satellites for Astrophysical Research E2.1/D2.3 Heating and Energetics of the Solar Corona and Solar Wind E2.2/D2.2 Structure, Energetics and Dynamics of the Corona and the Heliosphere during the Rising Phase of the 23rd Solar Cycle E2.3 Solar Variability from Helioseismology and Irradiance Observations E2.4 Current and Future High Resolution In-situ and Remote Sensing Solar Physics Missions F0.1 Life Sciences Issues in Connection with Human Missions to Mars F1.1 Gravity Perception and Transduction in Plants, Fungi and Unicellular Organisms F1.2 Gravity-related Research with Animals - Past, Present, Future F1.3/F2.3 The Nervous System: Space Flight Environmental Factors Effects -Present Results and New Perspectives F1.4 Planetary Environments and Living Organisms F2.1 Physical and Biological Basis of Radiation Risk Assessment F2.2 Investigating Space Radiation Effects at Particle Accelerators -Biology and Physics Experiments F2.4 Genetic and Oncogenic Damages of Space Radiation: Detection, Prediction and Mechanisms F2.5 Comparison & Analysis of Recently Obtained Space & Ground-based Results by Means of Space Radiation Instruments F2.6 Perspectives on Radiation Risks on Long Space Missions: Deterministic and Stochastic Effects F3.1 The Influence of UV Radiation on Biological Evolution F3.2/F3.3 The Limits of Life F3.4-1/B0.8 Extraterrestrial Organic Chemistry: From the Interstellar Medium to the Origins of Life - Part 1: Interstellar Medium, Comets, and Meteorites F3.4-2/B0.8 Extraterrestrial Organic Chemistry: From the Interstellar Medium to the Origins of Life - Part 2: Complex Organic Chemistry in the Environment of Planets and Satellites F3.4-3 Extraterrestrial Organic Chemistry: From the ISM to the Origins of Life - Part 3: Homochirality: Handedness of Organics in the Universe F3.5/PPP1 Planetary Protection: Policy and Implementation for the 21st Century F4.2 Food and Waste Processing for Advanced Life Support F4.3 Analysis and Integration of Life Support Systems F4.4 Closed Ecosystems: Space and Earth Applications F4.5 Influence of Different Natural Physical Fields on Biological Processes G0.1 The Impact of the Gravity Level on Materials Processing and Fluid Dynamics H0.1 Fundamental Physics in Space PSB1 Scientific Ballooning in the Next Century: Goals and Challenges PSRB1 Radiation Belt Models for the Solar Maximum PSRDC1 Integrated Global Observation System (IGOS) - Role and Benefits to the Developing Countries PSW1/C0.1/D0.5/E2.5/F2.0 Space Weather Special Symposium The Public Understanding of Space Science

Contact:

COSPAR Secretariat
51 bd de Montmorency
F-75016 Paris, France
Tel: +33 1 45 25 06 79
Fax: +33 1 40 50 98 27 /
COSPAR@paris7.jussieu.fr
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February 2000

Commsphere 2000
Chennai, India, 28 February - 2 March 2000
Contact : Prof. Ashok Jhunjhunwala, Convener, Commsphere 2000, Dept. of Electrical Engineering, Indian Institute of Technology, Chennai 600 036, India, Tel. +91 44-445 8414, Fax +91 44-235 2120, E-mail : commsphere@tenet.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

June 2000

EMC Wroclaw 2000
Wroclaw, Poland, 27-30 June 2000
Contact : EMC Symposium, Box 2141, 51-645 Wroclaw 12, Poland, fax +48 71-728 878, e-mail : emc@ita.pwr.wroc.pl

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/

33rd COSPAR Scientific Assembly
Warsaw, Poland, 16-23 July 2000
Contact : Prof. S. GRZEDZIELSKI, Executive Director, COSPAR, Committee on Space Research, 51, Boulevard de Montmorency, F-75016 PARIS, FRANCE, Phone : +33 1-4525 0679, Fax : +33 1-4050 9827

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

February 2001

EMC Zurich
Zurich, Switzerland, 20-22 February 2001
Contact : Dr. G. Meyer, ETHZ-IKT, ETH-Zentrum, CH-8092 ZÜRICH, SWITZERLAND, Phone : (41) 1-2562 793, Fax : (41) 1-2620 943

July 2001

ISSSE'01 - "Questing More Significant Harmony and Integration : Systems/Devices and Softwares/ Hardwares"
Tokyo, Japan, 24-27 July 2001
Contact : E-mail : issse01@ee.kagu.sut.ac.jp, http:// issse01.ee.kagu.sut.ac.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, E-mail : ap-rasc@kurasc.kyoto-u.ac.jp, http://www.kurasc.kyoto-u.ac.jp/ap-rasc/

News from the URSI Community

BOOK PUBLISHED BY AN URSI CORRESPONDENT

Science and Identification of Visually Obscured Targets

by Carl E. Baum, Air Force Phillips Laboratory, Albuquerque, NM

The first of its kind, this book addresses such topics as : electromagnetic singularity identification, acoustic singularity identification, magnetic singularity identification, synthetic aperture radar, and the use of static magnetic field from ferrous targets. Intended for the student and researcher in electromagnetics, this book also includes a CD-ROM, *Minefacts*, to familiarise the reader with real mines.
Ocober 1998, 456 pp, Cloth 1-56032-533-X, USD79.95

Electromagnetic Symmetry

by Carl E. Baum, Air Force Phillips Laboratory, Albuquerque, NM
and D.V. Giri, Pro-Tech, Lafayette, CA

With contributions from leading specialists, this resource systematically develops such concepts in the context of electromagnetic theory and applications as used in electrical engineering (antennas, propagation, and scattering). This pioneering work not only provides a comprehensive overview of the subject, but also new direction to future research and applications.
1995, 376 pp, Cloth 1-56032-321-3, USD69.95

NEWS FROM THE MEMBER COMMITTEES

BELGIUM
URSI Forum 1999

7[th] URSI Forum - 1999
Université Libre de Bruxelles, Friday 17[th] December 1999

The 7th URSI Forum is offering a meeting opportunity to all Belgian researchers working towards a Ph.D. in the different scientific fields covered by URSI. The meeting provides to the researchers and to the academic and scientific staff of the Belgian universities and institutes a unique opportunity to be informed about the different research programmes.
Following the evaluations of the previous editions of the URSI Forum, the structure of the Forum will be constituted of Posters Sessions, in which contributions from different research groups at the Belgian universities and institutes are grouped along the fields of interests of URSI.
The proceedings of the URSI Forum will consist of a collection of the submitted abstracts and summaries and will be distributed at the Forum to all participants.

Organisation & Contact:
Prof. Serge PROHOROFF (Chair)
ULB - URPOEM
Ave. F.D. Roosevelt 50 CP165-51, B-1050 Bruxelles
Tel: +32-2-650.3086, Fax: +32-2-650.4206

GERMANY
Kleinheubacher Tagung 2000

The annual meeting of the German Committee 'Kleinheubacher Tagung 2000' will be held from 25 to 29 September 2000.

If you would like to propose a theme, please do so before 31 December 1999. More information can be obtained from Dr. Arne K. Richter, Copernicus Gesellschaft e.V., Max-Planck-Strasse 13, D-37191 Katlenburg-Lindau, Germany, Tel. +49 5556-91099, Fax : +49 5556-4709, cop@copernicus.org, http://www.copernicus.org/URSI/URSI.html

International Geophysical Calendar 2000

U.R.S.I.

	S	M	T	W	T	F	S
JANUARY							1
	2	3	4	5*	6*N+	7+	8
	9	10	11	12	13	14	15
	16	17	18	19	20	21F	22
	23	24	25	26	27	28	29
	30	31	1	2	3	4	5N
FEBRUARY	6	7	8*	9*	10	11	12
	13	14	15	16	17	18	19F
	20	21	22	23	24	25	26
	27	28	29	1	2	3	4
MARCH	5	6N	7*	8*	9	10	11
	12	13	14+	15+	16+	17+	18
	19	20F	21	22	23	24	25
	26	27	28	29	30	31	1
APRIL	2	3	4*N	5*	6	7	8
	9	10	11+	12+	13+	14	15
	16	17	18F	19	20	21	22
	23	24	25	26	27	28	29
	30	1	2	3*	4*N	5	6
MAY	7	8	9	10	11	12	13
	14	15	16	17	18F	19	20
	21	22	23	24	25	26	27
	28	29	30	31*	1*	2N	3
JUNE	4	5	6	7	8	9	10
	11	12	13+	14+	15	16F	17
	18	19	20	21	22	23	24
	25	26	27	28*	29*	30	
	S	M	T	W	T	F	S

S	M	T	W	T	F	S	
						1N	JULY
2	3	4	5+	6+	7+	8	
9	10	11	12	13	14	15	
16F	17	18	19	20	21	22	
23	24	25	26*	27*	28	29	
30	31N	1	2	3	4	5	AUGUST
6	7	8	9	10	11	12	
13	14	15F	16	17	18	19	
20	21	22	23*	24*	25	26	
27	28	29N	30	31	1	2	SEPTEMBER
3	4	5	6	7	8	9	
10	11	12	13F	14	15	16	
17	18	19	20	21+	22+	23+	
24+	25+	26+	27*N+	28*	29	30	
1	2	3	4	5	6	7	OCTOBER
8	9	10	11	12	13F	14	
15	16	17	18	19	20	21	
22	23	24+	25*+	26*+	27N+	28	
29	30	31	1	2	3	4	NOVEMBER
5	6	7	8	9	10	11F	
12	13	14	15	16	17	18	
19	20	21	22*	23*	24	25N	
26	27	28	29	30	1	2	DECEMBER
3	4	5	6	7	8	9	
10	11F+	12+	13+	14+	15+	16	
17	18	19*	20*	21	22	23	
24	25N	26	27	28	29	30	
31	1	2	3	4	5	6	2001
7	8	9F	10	11	12	13	JANUARY
14	15	16	17	18	19	20	
21	22	23*	24*N	25	26	27	
28	29	30	31				
S	M	T	W	T	F	S	

(11) Regular World Day (RWD)

(12) Priority Regular World Day (PRWD)

8 Quarterly World Day (QWD) also a PRWD and RWD

5 Regular Geophysical Day (RGD)

6 7 World Geophysical Interval (WGI)

7 + Incoherent Scatter Coordinated Observation Day

N New Moon F Full Moon

5 Day of Solar Eclipse: Feb 5, Jul 1 & 31, Dec 25

[5 6] Airglow and Aurora Period

5 * Dark Moon Geophysical Day (DMGD)

NOTES on other dates and programs of interest:

1. Days with **significant meteor shower activity** are: Northern Hemisphere 3-5 Jan; 21-23 Apr; 4-6 May; 6-11, 27-29 Jun; 11-14 Aug; 21-23 Oct; 16-19 Nov; 13-15, 21-23 Dec 2000; 3-5 Jan 2001. Southern Hemisphere 4-6 May; 6-11, 27-29 Jun; 27 Jul-2 Aug; 21-23 Oct; 16-19 Nov; 13-15 Dec 2000. These can be studied for their own geophysical effects or may be "geophysical noise" to other experiments. The Leonid shower is projected to be strong in 2000. Peak activity is expected at 04 UT and 08 UT on November 18, 2000.
2. **Global Atmosphere Watch (GAW)** — early warning system for changes in greenhouse gases, ozone layer, and long range transport of pollutants. (See Explanations.)
3. **ISCS (International Solar Cycle Studies)** Observing Program 1998-2002: SCOSTEP Study of processes associated with the rising and maximum phase of the solar cycle. (See Explanations.)
4. **S-RAMP — SCOSTEP Project.** Solar Terrestrial Energy Program (S) - Results, Applications, and Modeling Phase (RAMP). (See Explanations.)
5. **+ Incoherent Scatter Coordinated Observations Days** (see Explanations) starting at 1300 UT on the first day of the intervals indicated, and ending at 1600 UT on the last day of the intervals: 6-7 Jan POLITE; 14-17 Mar Global convection/Hi-TRAC; 4-26 Apr WLS month-long alert (11-13 Apr default)/SPARC; 13-14 Jun POLITE; 5-7 Jul Mid-July Baseline; 4-29 Sep LTCS month-long alert (21-27 Sep default)/TIMED; 24-27 Oct Global Ionosphere-thermosphere Coupling/WLS/SPARC; 4-22 Dec LTCS month-long alert (11-15 Dec default)/TIMED, where

HiTRAC = High Time Resolution Auroral Radar Convection (J. Holt – jmh@haystack.mit.edu);
LTCS = Lower-Thermosphere Coupling Study (C. Fesen - fesen@tides.utdallas.edu).
POLITE = Plasmaspheric Observations of Light Ions in the Topside Exosphere (P. Erickson — pje@hyperion.haystack.edu);
SPARC = Researchers in upper atmospheric and space physics (T. Killeen tkilleen@umich.edu)
TIMED = Thermosphere Ionosphere Mesosphere Energetics Dynamics satellite (J. Salah — jes@haystack.mit.edu);
WLS = Wide-Latitude Substorm Dynamics (J. Foster – jcf@hyperion.haystack.edu). See http://www.eiscat.uit.no/URSI_ISWG for complete definitions.

This Calendar continues the series begun for the IGY years 1957-58, and is issued annually to recommend dates for solar and geophysical observations, which cannot be carried out continuously. Thus, the amount of observational data in existence tends to be larger on Calendar days. The recommendations on data reduction and especially the flow of data to World Data Centers (WDCs) in many instances emphasize Calendar days. The Calendar is prepared by the International Space Environment Service (ISES) with the advice of spokesmen for the various scientific disciplines. For some programs, greater detail concerning recommendations appears from time to time published in IAGA News, IUGG Chronicle, URSI Information Bulletin or other scientific journals or newsletters. For on-line information, see *http://www.sec.noaa.gov/ises/ises.html.*

The definitions of the designated days remain as described on previous Calendars. Universal Time (UT) is the standard time for all world days. Regular Geophysical Days (RGD) are each Wednesday. Regular World Days (RWD) are three consecutive days each month (always Tuesday, Wednesday and Thursday near the middle of the month). Priority Regular World Days (PRWD) are the RWD which fall on Wednesdays. Quarterly World Days (QWD) are one day each quarter and are the PRWD which fall in the World Geophysical Intervals (WGI). The WGI are fourteen consecutive days in each season, beginning on Monday of the selected month, and normally shift from year to year. In 2000 the WGI will be March, June, September and December.

The **Solar Eclipses** are:

- **5 February 2000** (partial) visible in the South Pacific Ocean near Antarctica, crosses the Ross Sea, crosses Antarctica in parts of Victoria Land and Wilkes Land, and extends into the central southern Indian Ocean, with a magnitude of 59%.
- **1 July 2000** (partial) visible in the central southern Pacific Ocean just North of Antarctica, moves across the southern most part of Chile and Argentina, ends in the South Atlantic Ocean. The magnitude will be 48%.
- **31 July 2000** (partial) visible in the northern part of Greenland, the northwest of continental United States (from a line extending through the western parts of the Dakotas through Colorado, northwest Utah, mid-Nevada, and mid-California), western Canada, Alaska, northern Russia, and northern Scandinavia. The magnitude will be 60%.
- **25 December 2000** (partial) visible through all of North America (though only at sunrise in the NW U.S.) except Alaska, Central America as far south as Nicaragua, and the extreme northern tip of Columbia and Venezuela, including Aruba and many other Caribbean islands extending southeast from the U.S. to the Leeward Islands. It will extend as far east as the Azores. The magnitude will be 72%.

Web Sites: http://umbra.gsfc.nasa.gov/eclipse/predictions/eclipse-paths.html; International Astronomical Union Working Group on Eclipses: http://www.williams.edu/Astronomy/IAU_eclipses

References: Fred Espenak, Fifty Year Canon of Solar Eclipses: 1986-2035, NASA Reference Publication 1178 Revised, July 1987. Leon Golub and Jay M. Pasachoff, The Solar Corona, Cambridge University Press, 1998. http://www.williams.edu/Astronomy/corona

Jay M. Pasachoff, Astronomy: From the Earth to the Universe, 5th ed., Saunders College Publishing, 1998. http://www.williams.edu/Astronomy/jay

Provided by Jay M. Pasachoff, Williams College, Williamstown, MA 01267, USA, Chair, Working Group on Eclipses of the International Astronomical Union

Meteor Showers (selected by R. Hawkes, Mount Allison Univ, Canada, rhawkes@mta.ca) include the most prominent regular showers. The dates for Northern Hemisphere meteor showers are: Jan 3-5 (Quadrantid); Apr 21-23 (Lyrid); May 4-6 (Eta-Aquarid); Jun 6-11 (Arietid, Zeta-Perseid); Jun 27-29 (Beta-Taurid); Aug 11-14 (Perseid); Oct 21-23 (Orionid); Nov 16-19 (Leonid); Dec 13-15 (Geminid); Dec 21-23, 2000 (Ursid); and Jan 3-5, 2001 (Quadrantid). The dates for Southern Hemisphere meteor showers are: May 4-6 (Eta-Aquarid); Jun 6-11 (Arietid, Zeta-Perseid); Jun 27-29 (Beta-Taurid); Jul 27-Aug 2 (S. Delta-Aquarid, Alpha-Aurigid); Oct 21-23 (Orionid); Nov 16-19 (Leonid); and Dec 13-15, 2000 (Geminid). The Leonid shower is projected to be strong in 2000. Peak activity is expected at 04 UT and 08 UT on November 18, 2000.

The occurrence of **unusual solar or geophysical conditions** is announced or forecast by the ISES through various types of geophysical **"Alerts"** (which are widely distributed by telegram and radio broadcast on a current schedule). Stratospheric warmings (STRATWARM) are also designated. The meteorological telecommunications network coordinated by WMO carries these worldwide Alerts once daily soon after 0400 UT. For definitions of Alerts see ISES "Synoptic Codes for Solar and Geophysical Data", March 1990 and its amendments. Retrospective World Intervals are selected and announced by MONSEE and elsewhere to provide additional analyzed data for particular events studied in the ICSU Scientific Committee on Solar-Terrestrial Physics (SCOSTEP) programs.

RECOMMENDED SCIENTIFIC PROGRAMS OPERATIONAL EDITION (The following material was reviewed in 1999 by spokesmen of IAGA, WMO and URSI as suitable for coordinated geophysical programs in 2000.)

Airglow and Aurora Phenomena. Airglow and auroral observatories operate with their full capacity around the New Moon periods. However, for progress in understanding the mechanism of many phenomena, such as low latitude aurora, the coordinated use of all available techniques, optical and radio, from the ground and in space is required. Thus, for the airglow and aurora 7-day periods on the Calendar, ionosonde, incoherent scatter, special satellite or balloon observations, etc., are especially encouraged. Periods of approximately one weeks' duration centered on the New Moon are proposed for high resolution of ionospheric, auroral and magnetospheric observations at high latitudes during northern winter.

Atmospheric Electricity. Non-continuous measurements and data reduction for continuous measurements of atmospheric electric current density, field, conductivities, space charges, ion number densities, ionosphere potentials, condensation nuclei, etc.; both at ground as well as with radiosondes, aircraft, rockets; should be done with first priority on the RGD each Wednesday, beginning on 5 January 2000 at 0000 UT, 12 January at 0600 UT, 19 January at 1200 UT, 26 January at 1800 UT, etc. (beginning hour shifts six hours each week, but is always on Wednesday). Minimum program is at the same time on PRWD beginning with 12 January at 0600 UT. Data reduction for continuous measurements should be extended, if possible, to cover at least the full RGD including, in addition, at least 6 hours prior to indicated beginning time. Measurements prohibited by bad weather should be done 24 hours later. Results on sferics and ELF are wanted with first priority for the same hours, short-period measurements centered around the minutes 35-50 of the hours indicated. Priority Weeks are the weeks that contain a PRWD; minimum priority weeks are the ones with a QWD. The World Data Centre for Atmospheric Electricity, 7 Karbysheva, St. Petersburg 194018, USSR, is the collection point for data and information on measurements.

Geomagnetic Phenomena. It has always been a leading principle for geomagnetic observatories that operations should be as continuous as possible and the great majority of stations undertake the same program without regard to the Calendar. Stations equipped for making magnetic observations, but which cannot carry out such observations and reductions on a continuous schedule are encouraged to carry out such work at least on RWD (and during times of MAGSTORM Alert).

Ionospheric Phenomena. Special attention is continuing on particular events that cannot be forecast in advance with reasonable certainty. These will be identified by Retrospective World Intervals. The importance of obtaining full observational coverage is therefore stressed even if it is possible to analyze the detailed data only for the chosen events. In the case of vertical incidence sounding, the need to obtain quarter-hourly ionograms at as many stations as possible is particularly stressed and takes priority over recommendation (a) below when both are not practical.

For the **vertical incidence (VI) sounding program**, the summary recommendations are:

(a) All stations should make soundings on the hour and every quarter hour;

(b) On RWDs, ionogram soundings should be made at least every quarter hour and preferably every five minutes or more frequently, particularly at high latitudes;

(c) All stations are encouraged to make f-plots on RWDs; f-plots should be made for high latitude stations, and for so-called "representative" stations at lower latitudes for all days (i.e., including RWDs and WGIs) (Continuous records of ionospheric parameters are acceptable in place of f-plots at temperate and low latitude stations);

(d) Copies of all ionogram scaled parameters, in digital form if possible, be sent to WDCs;

(e) Stations in the eclipse zone and its conjugate area should take continuous observations on solar eclipse days and special observations on adjacent days. See also recommendations under Airglow and Aurora Phenomena.

For the **incoherent scatter observation program**, every effort should be made to obtain measurements at least on the Incoherent Scatter Coordinated Observation Days, and intensive series should be attempted whenever possible in WGIs, on Dark Moon Geophysical Days (DMGD) or the Airglow and Aurora Periods. The need for collateral VI observations with not more than quarter-hourly spacing at least during all observation periods is stressed.

Special programs include:

- DATABASE — Incoherent Scatter Database — emphasis on broad latitudinal coverage of the F region (Anthony van Eyken - tony@eiscat.no);
- Global ionospheric convection – time-dependent model fitting (M. Kosch – kosch@linax2.dnet.gwdg.de);
- Global Ionosphere-Thermosphere Coupling Study (M. Kosch – kosch@linax2.dnet.gwdg.de);
- Hi-TRAC — High Time Resolution Auroral Radar Convection (J. Holt – jmh@haystack.mit.edu);
- LTCS — Lower Thermosphere Coupling Study (C. Fesen - fesen@tides.utdallas.edu);
- Mid-July Baseline – to improve statistics of parameters measured by ISRs during summer. (M. Buonsanto – mjb@haystack.mit.edu);
- POLITE — Plasmaspheric Observations of Light Ions in the Topside Exosphere — global coordinated measurements of topside light ions. Simultaneous optical observations of neutral hydrogen and helium are highly desirable where possible (Phillip Erickson - pje@hyperion.haystack.edu);
- SPARC – brings together researchers in upper atmospheric and space physics from around the world, providing them a set of online collaboration tools and workspaces that link together scientific instruments, data, and models. (T. Killeen – tkilleen@umich.edu);
- TIMED – Thermosphere Ionosphere Mesosphere Energetics Dynamics satellite (Joint observations with CEDAR — J. Salah – jes@haystack.mit.edu);
- WLS — Wide-Latitude Substorm Dynamics (John Foster - jcf@hyperion.haystack.edu).

Special programs: Dr. Anthony P. van Eyken, EISCAT Scientific Association, Ramfjordmoen, N-9027 Ramfjordbotn, Norway. Tel. +47 77692166; Fax +47 77692380; e-mail: tony@eiscat.no; URSI Working Group G.5. See http://www.eiscat.uit.no/URSI_ISWG for complete definitions.

For the ionospheric drift or wind measurement by the various radio techniques, observations are recommended to be concentrated on the weeks including RWDs.

For traveling ionosphere disturbances, propose special periods for coordinated measurements of gravity waves induced by magnetospheric activity, probably on selected PRWD and RWD.

For the ionospheric absorption program half-hourly observations are made at least on all RWDs and half-hourly tabulations sent to WDCs. Observations should be continuous on solar eclipse days for stations in eclipse zone and in its conjugate area. Special efforts should be made to obtain daily absorption measurements at temperate latitude stations during the period of Absorption Winter Anomaly, particularly on days of abnormally high or abnormally low absorption (approximately October-March, Northern Hemisphere; April-September, Southern Hemisphere).

For back-scatter and forward scatter programs, observations should be made and analyzed at least on all RWDs.

For synoptic observations of mesospheric (D region) electron densities, several groups have agreed on using the RGD for the hours around noon.

For ELF noise measurements involving the earth-ionosphere cavity resonances any special effort should be concentrated during the WGIs.

It is recommended that more intensive observations in all programs be considered on days of unusual meteor activity.

Meteorology. Particular efforts should be made to carry out an intensified program on the RGD — each Wednesday, UT. A desirable goal would be the scheduling of meteorological rocketsondes, ozone sondes and radiometer sondes on these days, together with maximum-altitude rawinsonde ascents at both 0000 and 1200 UT.

During **WGI and STRATWARM Alert Intervals**, intensified programs are also desirable, preferably by the implementation of RGD-type programs (see above) on Mondays and Fridays, as well as on Wednesdays.

Global Atmosphere Watch (GAW) The World Meteorological Organizations (WMO) GAW integrates many monitoring and research activities involving measurement of atmospheric composition. Serves as an early warning system to detect further changes in atmospheric concentrations of greenhouse gases, changes in the ozone layer and in the long range transport of pollutants, including acidity and toxicity of rain as well as of atmospheric burden of aerosols (dirt and dust particles). Contact WMO, 41, avenue Giuseppe-Motta, P.O. Box 2300, 1211 Geneva 2, Switzerland.

Solar Phenomena. Observatories making specialized studies of solar phenomena, particularly using new or complex techniques, such that continuous observation or reporting is impractical, are requested to make special efforts to provide to WDCs data for solar eclipse days, RWDs and during PROTON/FLARE ALERTS. The attention of those recording solar noise spectra, solar magnetic fields and doing specialized optical studies is particularly drawn to this recommendation.

ISCS (International Solar Cycle Studies). Program within the SCOSTEP (Scientific Committee on Solar-Terrestrial Physics): 1998-2002. Its focus is on observations and basic research directed toward understanding the underlying and resulting processes associated with the rising and maximum phase of a solar cycle. Contacts are S.T. Wu, Univ of Alabama, Huntsville Dept. Mech. Eng. & Ctr. for Space Plasma & Aeron. Res., Huntsville, AL 35899 USA, (205)895-6413, Fax (205)895-6328, wu@cspar.uah.edu, and V. Obridko, IZMIRAN, Solar Physics Department, 142092 Troitsk, Moscow, Russia, 095-344-0926, Fax 095-334-0124, obridko@lars.izmiran.troitsk.su.

Solar Terrestrial Energy Program (STEP) Results, Applications, and Modeling Phase (RAMP) [S-RAMP]. Global coordinated ground-based and space-borne observations of space weather phenomena covering the entire space weather chain from the surface of the Sun to the effects on the near-Earth space and ground-based technological systems. Contacts: Dr. David Boteler (Boteler@Geolab.nrcan.gc.ca) and Dr. Phil Wilkinson, IPS Radio and Space Services, P.O. Box 1386, Haymarket, NSW 1240, Australia, +61 2 9213 8003, Fax +61 2 9213 8060 (Phil@ips.gov.au). See www.ngdc.noaa.gov/stp/SRAMP/sramp.html.

Space Research, Interplanetary Phenomena, Cosmic Rays, Aeronomy. Experimenters should take into account that observational effort in other disciplines tends to be intensified on the days marked on the Calendar, and schedule balloon and rocket experiments accordingly if there are no other geophysical reasons for choice. In particular it is desirable to make rocket measurements of ionospheric characteristics on the same day at as many locations as possible; where feasible, experimenters should endeavor to launch rockets to monitor at least normal conditions on the Quarterly World Days (QWD) or on RWDs, since these are also days when there will be maximum support from ground observations. Also, special efforts should be made to assure recording of telemetry on QWD and Airglow and Aurora Periods of experiments on satellites and of experiments on spacecraft in orbit around the Sun.

The **International Space Environment Service (ISES)** is a permanent scientific service of the International Union of Radio Science (URSI), with the participation of the International Astronomical Union and the International Union Geodesy and Geophysics. ISES adheres to the Federation of Astronomical and Geophysical Data Analysis Services (FAGS) of the International Council of Scientific Unions (ICSU). The ISES coordinates the international aspects of the world days program and rapid data interchange.

This Calendar for 2000 has been drawn up by H.E. Coffey, of the ISES Steering Committee, in association with spokesmen for the various scientific disciplines in SCOSTEP, IAGA and URSI and other ICSU organizations. Similar Calendars are issued annually beginning with the IGY, 1957-58, and are published in various widely available scientific publications.

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Additional copies are available upon request to ISES Chairman, Dr. Katsuhide Marubashi, Space Science Division, Communications Research Laboratory, 4-2-1 Nukui-kita, Koganei-shi, Tokyo 184-8795, Japan (FAX number +81-42-327-6677; e-mail kmaru@crl.go.jp), or ISES Secretary for World Days, Miss H.E. Coffey, WDC-A for Solar-Terrestrial Physics, NOAA E/GC2, 325 Broadway, Boulder, Colorado 80303, USA (FAX number (303)497-6513; e-mail hcoffey@ngdc.noaa.gov).

The calendar is available on-line at :

http://www.sec.noaa.gov/ises/ises.html

or via the URSI Homepage at

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

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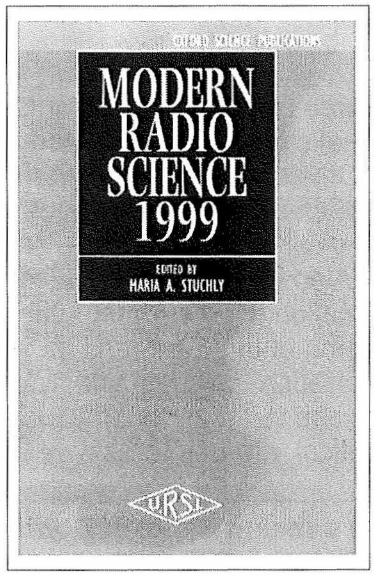

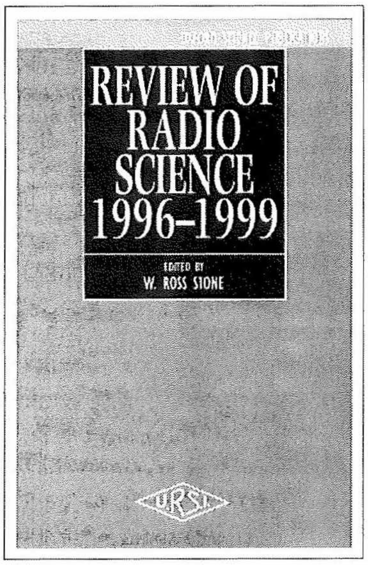

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