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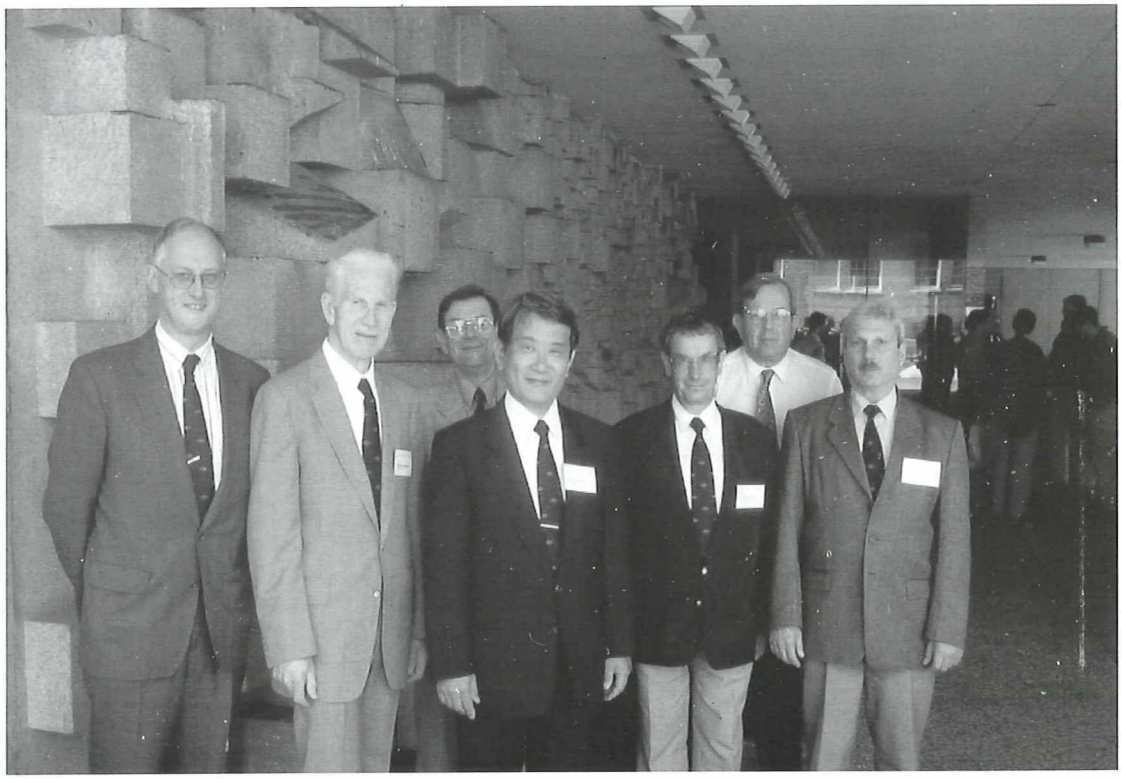

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# Contents



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**Front cover :** *The new URSI Board of Officers : From left to right : P. Lagasse, T.B.A. Senior, A.W. Wernik, H. Matsumoto, K. Schlegel, P.H. Wittke, J. Shapira. This picture was taken after the Closing Ceremony of the XXVIth URSI General Assembly in Toronto (Canada) last August.*

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# URSI Needs YOUR Help!

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ach triennium, URSI publishes *The Review of Radio Science* and *Modern Radio Science* through Oxford niversity Press. Both are made up of original, peer-reviewed papers. These books are an important part of RSI's efforts to share the latest in radio science with scientists and engineers around the world. One of the best ays to make this happen is for libraries and organizations to purchase the hardbound copies of these books to be ailable for their users. For this triennium, URSI has arranged with the IEEE Press to take over world-wide arketing of the books, making them available at *very* attractive prices. Information on the two books is given low. **Please give this page to your librarian or other appropriate person with a recommendation to order copy of each.** URSI isn't making money off of this: we simply want the broadest audience possible to learn of RSI and radio science through these books. Thank you!

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Edited by Dr. W. Ross Stone

onsisting of 37 original, peer-reviewed papers, ***Review of Radio Science 1996–1999*** brings together critical, in-epth reviews and tutorials on the advances and research in radio science that have been of significant nportance over the last three to four years. Highlights include:

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erfect for scientists, engineers, students, and researchers, the book is accompanied by a "Collected References" D-ROM that permits installation of a bibliographic database on a personal computer or workstation for easy earching. The CD-ROM contains the key references on the topics covered by each Commission of URSI that ne Commission has deemed to be the most significant during the triennium. August 1999/Hardcover/1044 pp; ist Price: US$ 89.95; IEEE Member Price: US$ 81.00. IEEE Product No. PC5838 ISBN 0-7803-6003-6.

## *Modern Radio Science 1999*

Edited by Prof. Maria A. Stuchly

his volume contains the peer-reviewed papers based on the Tutorial Lectures from each of the 10 URSI ommissions, plus the three General Lectures, presented at the XXVI General Assembly. Titles include: ◆ Future enerations of Mobile Communications, The Scientific Aspect ◆ Space-to-Ground Interferometry for Radio stronomy ◆ Engineering Issues in Space Weather ◆ EM Metrology in Wireless Communications ◆ lectromagnetic System Design Using Genetic Algorithms ◆ Intelligent Antennas for Future Wireless ommunications ◆ High-Impedance Electromagnetics ◆ ELF Sferics and Lightning Effects on the Middle and pper Atmosphere ◆ Remote Characterization of Geophysical Phenomena Using EM Waves ◆ Radar Systems r Ionospheric Research ◆ Wave Distribution Functions in Magnetospheric Physics ◆ Radio Stars: The High-nsitivity Frontier ◆ An Assessment of the Bioeffects Induced by Power-Line Frequency Electromagnetic ields. August 1999/Hardcover/350 pp; List Price: US$ 49.95; IEEE Member Price: US$ 45.00; IEEE Product o. PC5837 ISBN 0-7803-6002-8.

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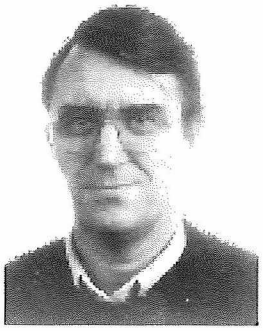
# Editorial

Dear URSI Correspondent,



It was a pleasure for us from URSI Headquarters to meet so many of you during the URSI General Assembly in Toronto last August. It was a successful event for us, and we hope for you too.

This issue of our Bulletin summarises a major part of the scientific work done within URSI during the past triennium. In particular you will find the scientific activity reports of the ten scientific commissions from September 1996 to July 1999. The Union Resolutions that were adopted during our General Assembly, as well as the data about the newly elected officers in Toronto are highlighted too. We also publish the speeches from the awards ceremony.

In the scientific part of this issue you will find three scientific contributions about mobile communications, by Bach Andersen, Johan Evans and Josef Huber. These papers concern respectively antenna arrays problems including an analysis of gain diversity and channel capacity, personal communication satellite systems and a prospective vision about the future UMTS systems.

As usual, news from member committees is presented, this time from our colleagues in Egypt and Ireland. Also in the administrative part of our Bulletin you will find announcements about future conferences sponsored or supported by URSI.

I wish you a pleasant reading.

Piotr Sobieski, Editor

# Antenna Arrays in Mobile Communications-Gain, Diversity, and Channel Capacity

J. Bach Andersen

## 1. Introduction[1]

Are antenna arrays in mobile communications different from arrays in other applications? Yes, sometimes, and it is the purpose of this paper to explain in a tutorial fashion when this is the case, and what it means for path loss in link calculations. One thing is the classical gain of an antenna, which we have to understand in a new way, another thing is the possibility for two arrays in a scattering environment to create parallel channels and thus in effect act as many independent antennas at the same time, carrying much more traffic over the same bandwidth (Winters, Foschini, Raleigh).

Let us review the well known free space situation first. Consider two linear arrays of $M$ and $N$ elements with the assumption that $M>N$. For convenience it is assumed that the left array of $M$ elements is the transmitting array. The path loss equation is given by the classical Friis' formula

$$P_r = P_t \frac{G_1 G_2}{(4\pi R)^2} \lambda^2 \qquad (1)$$

where the two gains under some simplifying assumptions-like neglect of mutual coupling and element patterns - are $M$ and $N$, respectively. A standard spacing of half a wavelength is also assumed. The underlying assumption here is that the other antenna looks like a point source seen from one antenna, and thus a plane wave from one specific direction is radiated (and received). If instead of direct line-of-sight (LOS) there was just one path, like scattering from a dominant scatterer, then the equation would still be valid as far as the antenna gains are concerned. The more usual situation in mobile radio is a wide angular scattering (Fig. 1), where the angular spread seen from the mobile often is large, and where the scattering seen from the base station depends on the height and the general environment. We have highlighted one path out of many going from one element at the transmitter to one element in the receiver. The distance dependence in (1) is of course also changed by the scatterers, but this is not our concern here. The point of view is that the information carrying signal is scattered in many directions, and the general question is, how should we organize the combining of elements to maximize the power transfer. At each antenna we assume that we can apply different complex weights at each element, so there is complete freedom at both ends to combine the antenna signals.

The notation is $\mathbf{U} = (U_1, U_2, .., U_N)^T$ for the receiver weights, and $\mathbf{V} = (V_1, V_2, ..., V_M)^T$ for the transmitter, where $T$ means transpose. Both vectors are normalized to unit length. The narrowband channel connecting all elements may then be described by an $M$ by $N$ complex matrix $\mathbf{H}$, where $H_{ij}$ is the complex transmission coefficient from element $j$ on the left side to element $i$ on the right side.

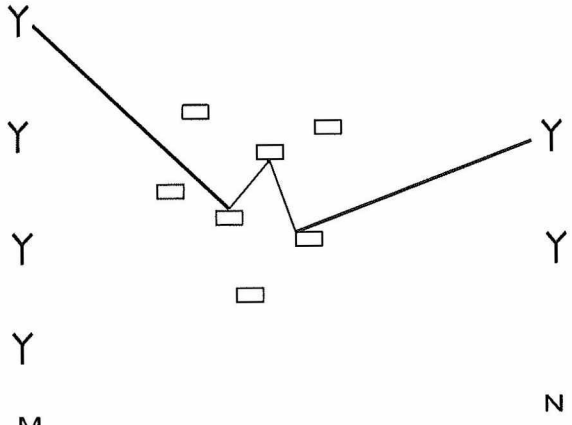



*Figure 1. Two linear arrays of M and N elements in a scattering environment*

## 2. Antenna Gain and Diversity

### *2.1 Transmitter weights fixed*

For simplicity assume that the transmitter weights are fixed, like in a beam mode where all the elements of $\mathbf{V}_0$ are identical in magnitude with a uniform phase difference. This would be an obvious choice when the transmitter does not 'know' the channel. On the receive side the incident signal is $\mathbf{S} = \mathbf{H} \cdot \mathbf{V}_0$. As is well known, the receiver maximum gain weights are

$$\mathbf{U} = \mathbf{S}^* / |\mathbf{S}| = (\mathbf{H} \cdot \mathbf{V}_0)^* / |\mathbf{S}| \qquad (2)$$

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[1] This paper is a modified version of one presented at Commsphere 99.

and the received power is the sum of the powers from the $N$ elements

$$P_r = |S_1|^2 + |S_2^2| + \cdots + |S_N|^2 \qquad (3)$$

For many scatterers and non-LOS the power at one element will be exponentially distributed (each transmission coefficient is Rayleigh fading), and the distribution of the sum of the powers will depend on the correlation. If the scatterers in Fig.1 shrink to an angularly narrow range then they will appear as a point source and the fading will be spatially flat. In this case the signals will be highly correlated

$$E\{P_r\} = N\, E\{|S_1|^2\} \qquad (4)$$

If we define the array gain as the mean value of the received power relative to one element at each end, then the array gain in this case is clearly $N$.

In the other extreme, where the scatterers are spread out in all directions, the signals will be uncorrelated but (4) will still be valid, so the array gain is $N$ also in this case. On top of this we get $N$-th order diversity gain for the uncorrelated case, where all transmission coefficients are fading independently.

If instead of the maximum gain combining of (1) we had chosen the beam mode for the receiver as well, i.e.

$$\mathbf{U}^T = (1,1,\cdots,1)/\sqrt{N} \qquad (5)$$

then it can be shown that the mean receiver array gain is 1. This is natural, since a narrow beam does not help when the energy is spread out in all directions. The above may be summarized in the following three tables for the mean link gain and diversity order

| | Rec. Low spread | Rec. High spread |
|---|---|---|
| Tr. Low spread | M N | M |
| Tr. High spread | N | 1 |

*Table 1a. Mean link gain for beam mode for both arrays*

| | Rec. Low spread | Rec. High spread |
|---|---|---|
| Tr. Low spread | M N | M N |
| Tr. High spread | M N | $(\sqrt{M}+\sqrt{N})^2$ |

*Table 1b. Mean link gain for maximum gain combining for both arrays.*

| | Rec. Low spread | Rec. High spread |
|---|---|---|
| Tr. Low spread | 1 | N |
| Tr. High spread | M | MN |

*Table 1c. Diversity order of the link for maximum gain combining*

As an example let us discuss the upper right corners with low angular spread (high correlation) at the transmitter and high angular spread (low correlation) at the receiver. In the beam mode the transmitter array sees a point source and has gain $M$, the receiver has gain 1, and the joint link has a gain of $M$. In the combining mode at the receiver the mean gain is $N$ (as is the diversity order), so the total gain is $MN$. The lower right corners refer to the joint optimization of the two arrays, which is the subject of the following section.

### *2.2 Transmit-receive gain for wide angular spreads*

The SVD (Singular Value Decomposition) (Scharf) is an attractive technique for solving the joint optimization of the two sides, the transmit side and the receive side. In the following it is assumed that the complex matrix (the channel matrix) is known both at the transmitter and receiver. This is not so strange as it sounds, i.e. in a TDD (time-division-duplex) where the channel is reciprocal because the frequency is the same in both directions, the channel will be known at the transmitter as well, unless the channel changes too rapidly.

An SVD expansion is a description of $\boldsymbol{H}$ as

$$\mathbf{H} = \mathbf{U} \cdot \mathbf{D} \cdot \mathbf{V}' \qquad (6)$$

where $\mathbf{D}$ is a diagonal matrix of real, non-negative singular values, the square roots of the eigenvalues of $\mathbf{G} = \mathbf{H}'\mathbf{H}$, a Hermitian matrix. The columns of the orthogonal matrices $\mathbf{U}$ and $\mathbf{V}$ are the corresponding singular vectors. Since $\mathbf{G}$ may be written as follows

$$\mathbf{G} = \mathbf{H}' \cdot \mathbf{H} = \mathbf{V} \cdot \mathbf{D}' \cdot \mathbf{D} \cdot \mathbf{V}' \qquad (7)$$

it follows that the columns of $\mathbf{V}$ are eigenvectors of $\mathbf{G}$. The SVD is particularly useful for interpretation in the antenna context. Writing (6) differently

$$\mathbf{H} \cdot \mathbf{V}_1 = \sqrt{\lambda_1}\, \mathbf{U}_1 \qquad (8)$$

for one particular eigenvalue, it is noted that $\mathbf{V}_1$ is the transmit weight factor for excitation of the singular value $\sqrt{\lambda_1}$. A receive weight factor of $\mathbf{U}'_1$, a conjugate match, gives the receive voltage and the square of that the received power

$$V'_1 = \mathbf{U}'_1 \cdot \mathbf{U}_1 \sqrt{\lambda_1}$$

$$P_r = |V_1|^2 = \lambda_1 \qquad (9)$$

so the eigenvalues correspond to the power gains and all we need to do is to extract the largest eigenvalue with corresponding $\mathbf{V}$ and $\mathbf{U}$ vectors, and maximum gain is achieved for that particular channel matrix.

Recent results (Haagerup) concerning the distribution of the eigenvalues of a random Hermitian matrix can give some insight into the maximum gain and how it varies with $M$ and $N$. In the asymptotic limit when $M$ and $N$ are large it may be shown that the largest eigenvalue is bounded above by

$$G_{\text{joint}} = \lambda_{\max} < \left(\sqrt{M} + \sqrt{N}\right)^2 \qquad (10)$$

This indicates that the joint link gain can no longer be separated in a transmitter antenna gain and a receiver antenna gain. For $M=N$ the gain equals $4N$, which is much less than the $N^2$ available when the spreading is small. As an explanation compare the $(M,N)$ case with the $(1,N)$ case. In the latter case we have $N$ degrees of freedom (elements of the weight vector) and $N$ different signals, which matches. In the former case we have $M+N$ degrees of freedom but $MN$ different signals, a clear mismatch for large $M$ and $N$, and we must accept a reduced gain. Although the gain is reduced it is still greater than $M$ and $N$, and the diversity order is truly large, namely $MN$. This follows from the fact that there are $MN$ different signals, and the probability of having all paths fading at the same time is vanishing small. Thus the fading has practically disappeared for reasonable values of $M$ and $N$.

The mean gains for $\rho = 0$ (uncorrelated signals) are shown in Figure 2 together with the upper bound and the gain for the correlated, free space case, $N^2$. For $N = 10$ the true mean gain is just 1 dB below the upper bound. Thus the price to pay for the random scattering is a diminishment of the gain from $N^2$ to $4N$ for N large. For a partly correlated case we can expect the gain to lie between the $\rho = 0$ and the $\rho=1$ cases.

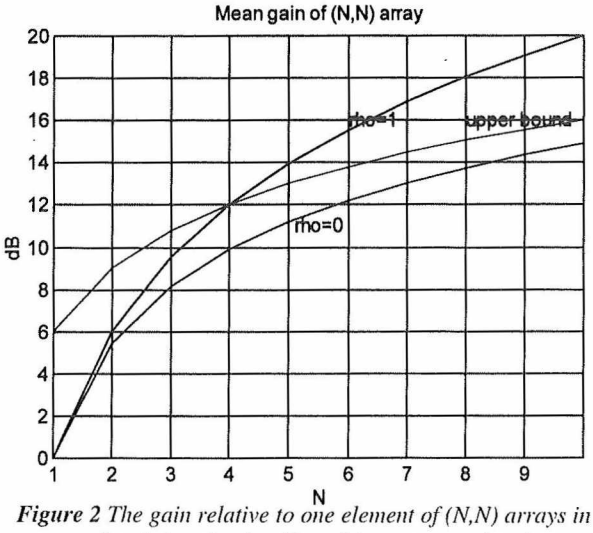


*Figure 2 The gain relative to one element of (N,N) arrays in a correlated situation (ρ=1), and in an uncorrelated case (ρ=0). The upper bound equals 4N and is the asymptotic upper bound for the gain for N tending to infinity.*

### *2.3 Implications for path loss*

Equation (1) implies that received power decreases as the square of the carrier frequency for frequency independent gains like dipole, or other small handset antennas. If instead the antenna apertures are introduced in the free space case (or in the case of small angular spreads) the situation reverses, as is well known. Let $A_1 = M\frac{\lambda^2}{4\pi}$, $A_2 = N\frac{\lambda^2}{4\pi}$ then the path loss equation for the correlated case reads

$$P_r = P_t \frac{A_1 A_2}{\lambda^2 R^2} \qquad (11)$$

and for the uncorrelated case

$$P_r = P_t \frac{\left(\sqrt{A_1} + \sqrt{A_2}\right)^2}{4\pi R^2} \qquad (12)$$

with the interesting result that the frequency dependence has disappeared for the uncorrelated case. The assumptions behind equation (12) are the same as in equation (10).

The equations imply that we can only gain from going to higher carrier frequencies for given areas of antenna arrays, when atmospheric absorption and diffraction is ignored. When the spreading is small the joint gain may be very high, and when the spreading is large the worst situation is a constant power, it does not decrease as in eq. (1). The true benefit would be that there is more bandwidth available at the higher microwave frequencies

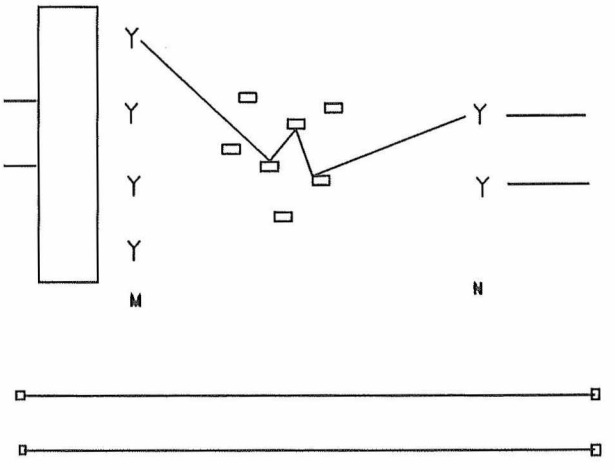


*Fig. 3 N different signals are distributed over the M antennas with the resulting N parallel channels*

## 3. Spectral Efficiency of Parallel Channels

The joint gain of the link corresponded to the largest eigenvalue of $\mathbf{G}$. The first question is, how many eigenvalues are there? For the completely correlated case there is only one, but for the uncorrelated case there are $\min(M,N)$ distinct eigenvalues with corresponding pairs of $\mathbf{V}$ and $\mathbf{U}$ vectors. Since we have been assuming $M>N$ we have $N$ eigenvalues. This tells us that it is possible to send multiple

sets of data over the same physical channel for the same bandwidth since the weight vectors corresponding to separate eigenvalues are orthogonal [1,4,6-8]. In this way the spectral efficiency can be greatly increased. Physically, the many different paths in the environment create the possibility of multiple channels as illustrated in Figure 3, all we have to do is to diagonalize the channel matrix as was done in the previous section.

The situation is easily described by Shannon's information measure

$$C = \log_2 (1 + P/\sigma) \qquad \text{b/s/Hz} \qquad (13)$$

where $P/\sigma$ is the signal-to-noise ratio, *SNR*, for one channel. For $N$ parallel channels the capacities add

$$C = \sum_1^N \log_2 (1 + \lambda_i P_i / \sigma) \qquad (14)$$

where $P_i$ is the power put into channel $i$, and $\lambda_i$ is the gain of that channel. The total power $P$ as the sum of all the separate powers is assumed constant to make comparisons fair. The problem of assigning powers to the individual channels may be solved by the 'water filling scheme' (Gallager), which makes sure that the channels with the highest gains get most of the power. If $P$ is very small, only the largest gain gets any power, and we are in the situation of the one-eigenvalue-case of the previous section. In accordance with the simplifying assumptions of large $N$ and $M$ it may be shown that all the eigenvalues are bound by

$$(\sqrt{M} - \sqrt{N})^2 < \lambda_i < (\sqrt{M} + \sqrt{N})^2 \qquad (15)$$

so if $M$ is larger than $N$ the eigenvalues tend to cluster around $M$, they will approximately be allocated the same power, and eq. (14) reduces to

$$C = N \log_2 (1 + MP / N\sigma) \qquad (16)$$

An illustrative case is shown in Figure 4 for a basic mean SNR of 10 dB for one antenna. The spectral efficiency has increased in the mean from 2.9 to 18.8 b/s/Hz when using 12 transmit antennas and 4 receive antennas compared with one antenna at each end - an impressive improvement. Also in this case the diversity effect is important, the (12,4) case shows an almost constant capacity. The approximate upper bound of eq. (15) gives a value of 19.6 b/s/Hz.

## 4. Discussion

The seemingly complicated, random environment in mobile and personal communications gives rise to some new possibilities in the antenna area. The received fields come from many different directions and for a noise limited system it is important to absorb all the energy. For those situations where the channel transfer from all elements to all elements are known it is possible to maximise the total transfer power by adjusting the antenna weights in the arrays jointly. The resulting joint antenna gain depends on

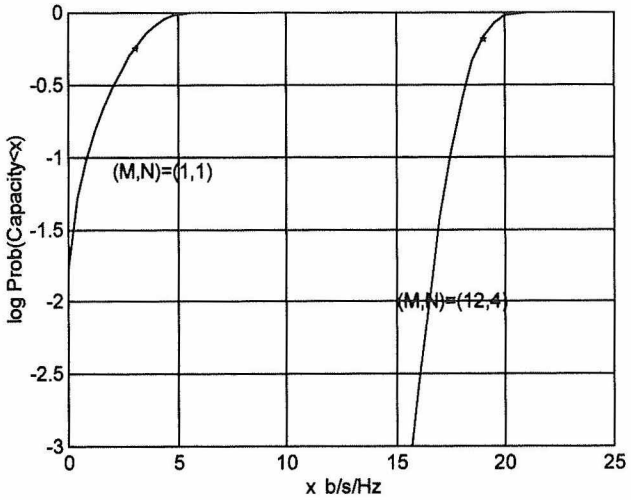


*Figure 4 Cumulative distribution of capacity for a single channel with SNR=10 dB and for an optimised 4 channel case with 12 transmit antennas. Mean values are indicated with a *.*

the angular spread of the environment as seen from the two antennas, where in one extreme of high correlation we get the usual free space gain, while in the other extreme we get a smaller gain due to the lack of degrees of freedom. If we introduce antenna apertures in the link budget instead of directivities, it is interesting to observe that we obtain a link gain which is independent of carrier frequency. This seems to indicate that it should be worthwhile to go to higher frequencies to get the higher bandwidths available.

The other possibility in a wide scattering situation is to apply different information signals to the various antennas and utilize the inherently high spectral efficiencies of the channel. This may be done by effectively creating a number of parallel orthogonal channels, which all have high gain and high order diversity, especially when the number of transmit antennas are higher than the number of receive antennas.

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# Personal Satellite Communications Systems

John V. Evans

*ABSTRACT - Commercial communications satellite systems were originally developed to provide long-distance communications (e.g. between countries), and later for broadcasting television to domestic cable head ends. Recently, new systems have been proposed and/or are being constructed to provide services to individual customers. These systems fall into two classes: those that will provide voice (and fax or low-rate data) communications to mobile users via small handsets, and those that will to provide multimedia (i.e., high-rate data such as Internet services) via small fixed terminals. The former systems operate at L- or S-band, while the latter are planned for Ku- or Ka-band (although systems have also been proposed for Q/V-band).*

*The paper describes briefly the systems now being developed and their prospects for commercial success.*

## 1. Introduction

Recent trends in satellite technology are increasingly directed toward providing services to individual customers. The earliest evidence of this new direction were satellite systems designed to deliver television direct to the home (DTH). These systems have benefited from the increased prime power (currently 10 kW or more) that can now be generated onboard satellites, which allows the operation of a sizeable number ($\geq 16$) high-power ($\geq$100-watt) Ku-band transponders. Another contributor to the success of these systems (at least in the U.S.) has been the development of powerful digital compression schemes which permit as many as 10 television channels to be transmitted via a single transponder and the picture to be recovered in a settop box containing special-purpose, very-large-scale digital integrated (VLSI) circuits manufactured at low cost.

Next to be conceived and developed were satellite systems designed to provide cellular-like voice service to mobile users equipped with small hand-held terminals. Three such systems providing global or nearly global coverage are under construction, and two more are seeking financing. In addition, a number of regional systems are being constructed. These systems are discussed in Section 2. Section 3 reviews a class of satellites recently proposed for the delivery of multimedia services (e.g., tele-education, tele-medicine, and Internet access) to individual consumers and small offices. With one notable exception, all of these systems would operate at Ka-band (or even higher frequencies). While the first of the mobile systems commenced operation on November 1, 1998 proponents of the multimedia satellite system are still attempting to secure financing. Thus, it is unlikely that any of the multimedia systems will be in operation before 2002.

## 2. Global Personal Communications Systems

### *2.1 – Introduction*

Several companies (most of them in the United States) have announced plans to construct and operate satellite communications systems to provide personal communications services (PCS) around the globe. Much of this activity was spurred by Motorola's bold plan to create a global personal satellite communications system called Iridium, employing 77 (later changed to 66) satellites in low earth orbit (LEO). Other proposals for LEO systems followed, causing Inmarsat to consider what type of PCS it might launch. Guided to some extent by design studies performed by TRW, Inmarsat adopted a system with satellites placed in 6-hr orbits at 10,000-km altitude (i.e., above the Van Allen radiation belts). This system is now being built by an affiliate company called ICO-Global.

Studies conducted by the proponents of PCS systems have identified four potential markets:

i) international business travelers: primarily from the developed world traveling to less-developed countries;
ii) national roamers: primarily business travelers who need mobile communications in their own countries, but who travel beyond the reach of terrestrial cellular systems;
iii) national rural fixed service: an extension of the national fixed services to regions where they are presently unobtainable; and
iv) government agencies: law enforcement, fire, public safety, and other services.

The designs of the global PCS systems discussed here represent different assumptions concerning the business to be attracted from these four segments.

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[1] This paper is a modified version of one presented at Commsphere 99.

| Parameter | Iridium | Globalstar | ICO-Global | Ellipso | Aires (ECCO) |
|---|---|---|---|---|---|
| Company | Motorola | Loral/ Qualcomm | ICO-Global | Mobile Comm. Holdings, Inc. | Constellation Comm., Inc. |
| No of Active Satellites | 66 | 48 | 10 | 17 | 46 |
| Orbit Planes | 6 circular polar (86.5°) | 6 circular inclined (52°) | 2 circular inclined (45°) | 2 elliptical inclined (116.6°) | 7 circular inclined |
| | | | | 1 circular equatorial | 1 circular equatorial |
| Orbit Altitude (km) | 780 | 1,414 | 10,355 | N.A.<br>8,060 equatorial | ?<br>2,000 equatorial |
| Satellites per Orbit Plane | 11 | 8 | 5 | 5 in each elliptical orbit | 5 in each inclined orbit |
| | | | | 7 in equatorial orbit | 11 in equatorial orbit |
| Beams per Satellite | 48 | 16 | 163 | 61 | 1 |
| Reported Cost ($B) | 4.7 | 2.5 | 4.6 | 0.56 | 1.15 |

***Table 1.*** *Proposed new global satellite PCS systems.*

*2.2 – Proposed Systems*

Five of the proposed global PCS systems appear to be proceeding. Of these, the Iridium, Globalstar, and ICO systems appear to have the best chance of being fielded, while the financing of the others remains to be completed. Table 1 summarizes the parameters of these systems.

*2.2.1 – Iridium*

From a technical standpoint, the Iridium system—proposed by Motorola and constructed by that company in conjunction with Lockheed Martin, Raytheon, and other contractors—is the most ambitious of the five systems to be discussed. The system has been purchased and is being operated by a separate company (Iridium, Inc.), which has secured investment from many parts of the world. The design employs 66 active satellites placed in circular polar orbits at 780-km altitude. The satellites are deployed into six equispaced orbital planes, with 11 satellites (and 1 spare) equally separated around each orbit. Satellites in adjacent planes are staggered with respect to each other to maximize their coverage at the equator, where a user may be required to access a satellite that is as low as 10° above the horizon.

Users employ small handsets operating in frequency-division-multiplexed/time-division multiple access (FDM/TDMA) fashion to access the satellite at L-band. Eight users will share 45-ms transmit and 45-ms receive frames in channels with 31.5-kHz bandwidth, spaced at 41.67-kHz. Because the three phased-array antennas on the satellite (Figure 1a) are used for both transmitting and receiving, users are synchronized so that they transmit and receive in the same time windows alternately.

The Iridium system is unique in that it is designed to achieve essentially global coverage with a small number of gateway earth stations that connect to the public switched network. (In all, 11 will be built). The satellites are designed to route traffic from satellite to satellite. Each satellite employs onboard processing to demodulate each arriving TDMA burst, determine how to route it, and retransmit it to its next destination. This can be to the ground if a gateway earth station is in view or, failing that, to one of the four nearest satellites: the one ahead or behind in the same orbital plane, or the nearest in either orbital plane to the east or west. These satellite cross-links operate at 23 GHz, while the links to the gateway earth stations are at 20 GHz. Figure 1b shows these pathways schematically.

The Iridium satellites are station-kept using onboard propulsion in order to overcome atmospheric drag and

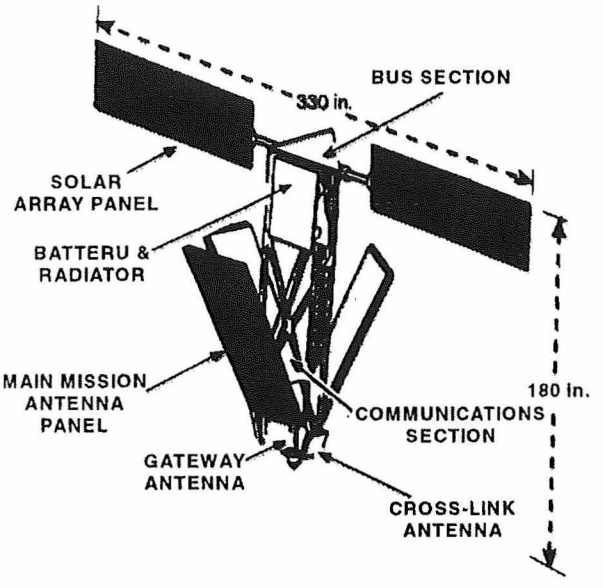


*Figure 1a: Service (L-band) spot beams formed by an Iridium satellite over the equator.*

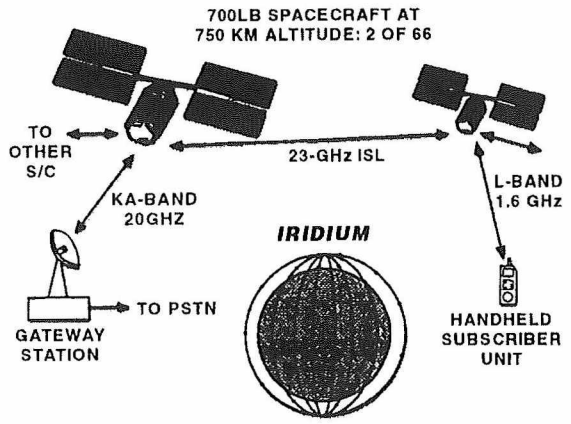


*Figure 1b: Connections possible in the Iridium system between users, the satellite, and the ground.*

have sufficient fuel for an 8-year life. Four telemetry, tracking, and control facilities (in Hawaii, at Yellowknife and Iqualvit in Canada, and at Eider in Iceland) manage satellite operations. A separate engineering facility exists to diagnose problems that may arise (such as the failure of a cross-link). This Master Control Facility is located in Lansdowne, Virginia, USA, with a backup in Rome, Italy.

### *2.2.2 – Globalstar*

The Globalstar system is being purchased by a limited partnership in which Loral and Qualcomm of the United States are principal partners. The satellites are being assembled in Italy (by Alenia Spazio), while Qualcomm has developed much of the ground segment.

Unlike the Iridium system which offers a true global service, Globalstar's business plan calls for launching the space segment and franchising its use to partners in different countries. More than 90 such relationships have already been established.

The Globalstar system will employ 48 satellites in 8 planes of 6 satellites each (Figure 2a). The orbits are circular, at 1,414 km and 52° inclination. An inclined orbit concentrates available satellite capacityat lower latitudes where the largest populations exist; little or no coverage is provided beyond ± 70° latitude (Figure 2b). As can be seen in Figure 2b, two or more satellites are visible (above 10°

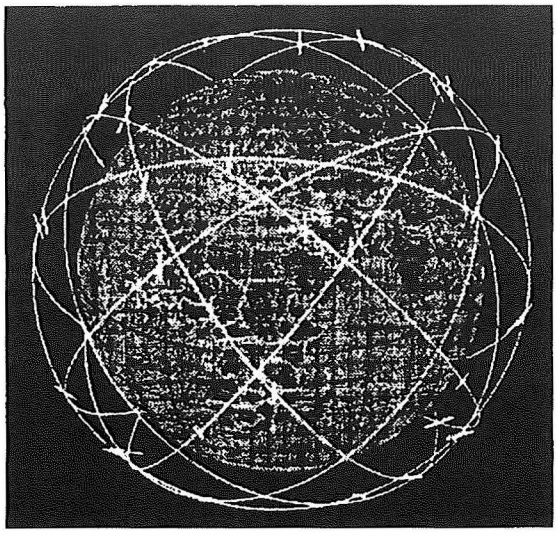

*Figure 2a: The Globalstar constellation.*

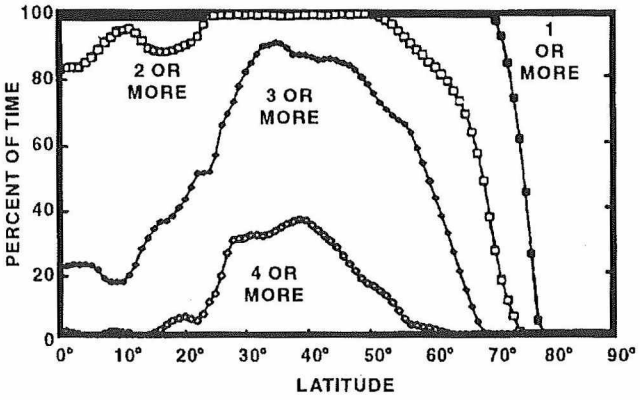


*Figure 2b: Multiple-satellite coverage provided to users (at elevations above 10°) by Globalstar.*

elevation) between 25° and 50° latitude at all times, and from the equator to 60° latitude 80% of the time. The Globalstar spacecraft are three-axis-stabilized, with a mission life of 7.5 years (minimum).

Because the Globalstar system does not employ satellite cross-links, a subscriber can gain access to the system only when a satellite in view can also be seen by a gateway earth station. Typically, this means that service areas are within 1,000 miles of each gateway earth station. To achieve truly global coverage would require the construction of more than 200 earth stations, which seems unlikely to happen. Thus, Globalstar is more likely to serve national roamers than international business travelers.

In contrast to Iridium, each Globalstar satellite covers a comparable area of the earth's surface with 16 spot beams. This, together with many more users sharing the satellite's receive channels, reduces the available link margins to about 3 to 6 dB. (For a small number of users, this can be increased to 11 dB.) Access to and from the satellite is at L- and S-bands, respectively, utilizing code-division multiple access (CDMA) in channels that are 1.25 MHz in bandwidth. Voice is encoded at 1 to 9 kb/s, depending on speaker activity. Simple "bent pipe" transponders are employed, with the feeder links at C-band.

Since all 16 beams of all of the 48 satellites are always active, each satellite that is in view of a subscriber will pick up the subscriber's signal and retransmit it in its feeder link. Thus, by tracking the several satellites that are in view of a given gateway earth station, two channels can be kept open to the subscriber. The channel providing the stronger signal can then be selected for connection to the public switched network. This feature should mitigate blocking by buildings and provides an automatic "soft" handoff from satellite to satellite. Sixteen of the 48 satellites have been launched so far, and Globalstar hopes to have its system in operation by late 1999.

### *2.2.3 – ICO*

ICO-Global is a spinoff from Inmarsat, which owns 15 percent of the corporation. The remainder is currently owned by Inmarsat signatories, and by Hughes (the builder of the spacecraft) and TRW.

ICO-Global has chosen an intermediate circular orbit (at 10,355-km altitude) for its system, with 10 satellites divided evenly between two circular orbits inclined at 45°.

This reduces the coverage at high latitudes, but allows for the smallest number of satellites. (Actually, 12 satellites are to be launched in order to provide a spare in each orbital plane.)

To improve the link margins on the ICO satellites, Inmarsat chose a design that employs 163 spot beams. Routing the signals to the correct spot beam becomes extraordinarily difficult to accomplish with analog [e.g., surface acoustic wave (SAW)] filters, and instead will be performed using a digital filter bank [which performs a fast Fourier transform (FFT) on the signals arriving from the gateway earth station]. Therefore, to access a given spot beam, the gateway earth station must transmit at a particular frequency.

ICO has adopted a true TDMA scheme for the service links, with six subscribers multiplexed into channels 25.2 kHz in width at a 36-kb/s bit rate. A disadvantage of this access scheme is that a soft handoff (e.g., from beam to beam) is not automatic, and it is more difficult to exploit dual-satellite visibility.

The ICO satellites are being built by Hughes Space and Communications Division, and the ground segment by a team consisting of NEC, Eriksson, and Hughes Network Systems Division. ICO hopes to have its system in operation by the year 2000.

*2.2.4 - Ellipso*

The Ellipso system differs from all the others in that satellites will be deployed into elliptical orbits (refer to Table 1). This design takes advantage of the fact that most of the world's population lies in the northern hemisphere. The system is to be built by Mobile Communications Holdings, Inc. (MCHI) of Washington, D.C., and claims to be a very- low-cost approach to the market.

The Ellipso system's space segment contains 16 satellites in three orbital planes. Each plane remains approximately edge-on to the sun, thereby simplifying control of the solar panels. Six satellites are placed in a circular orbit above the earth's equator at 8,060 km altitude (4.8-hr period). This constellation can serve users between 40°S and 40°N latitudes. Higher northerly latitudes will be served by two inclined elliptical orbits separated by 180° in which there are five satellites, each with a 3-hr period. Figure 3 shows this arrangement. The apogee of these elliptic orbit satellites will be near 7,800 km.

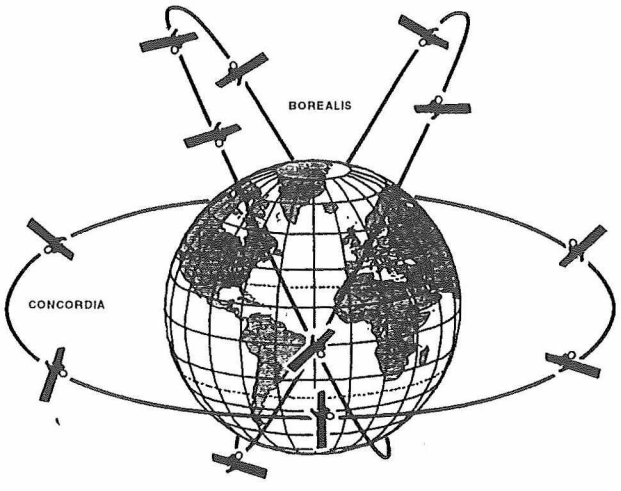


*Figure 3: Arrangement of orbits in the Ellipso system.*

The satellites will be similar to those used by Globalstar, with simple repeater transponders and employing CDMA transmission. Each subscriber's signal will occupy the full 16 MHz assigned at L-band.

The satellites are oriented to face the earth and provide coverage via 61 spot beams. They are expected to weigh 700 kg and have a lifetime of 5 to 7 years.

*2.2.5 - Aries*

The Aries system is a proposal put forth by Constellation Communications, Inc. (CCI), based in Reston, VA. As originally proposed, the system would employ 48 lightweight satellites arranged in four circumpolar orbit planes (12 satellites per plane) at an altitude of 1,020 km. Subsequent changes to the design of the Aries system have included a new constellation plan employing 46 satellites. Eleven satellites are placed in a circular equatorial orbit at 2,000-km altitude, and five are placed in each of seven inclined orbits. The equatorial portion, which is to be completed first, is known as ECCO. The ECCO system will be capable of providing service up to 23° north and south of the equator. The goal of the system is to provide rural telephony (at 2.4 kb/s) and fax (at 4.8 kb/s) using CDMA encoding.

## 3. Proposed New Multimedia Satellite Systems

*3.1 – Introduction*

Fixed-satellite services were first offered, by INTELSAT, at C-band using frequencies around 6 GHz (5-cm wavelength) in the earth-to-satellite direction and 4 GHz (7.5-cm wavelength) in the satellite-to-earth direction. The earth terminal antennas employed in the INTELSAT system were initially large, but have decreased in size as more powerful satellites have been launched. As other satellites providing domestic or regional fixed-satellite services were deployed, agreement had to be reached on their separation along the orbital arc lest there be mutual interference among systems (caused by an earth station with a small antenna illuminating satellites on either side of the intended one). Initially set at 3°, this spacing is now set at 2° around most parts of the orbital arc.

Absence of suitable C-band orbital slots drove constructors to build Ku-band satellites (14-GHz earth-to-satellite direction and 12-GHz satellite-to-earth direction), and most INTELSAT satellites are built with transponders operating in both bands. Powerful DTH TV broadcasting satellites operate at Ku-band. It is almost impossible to secure an orbital location where a satellite can operate at C- or Ku-bands without interfering with its neighbors. This has spurred interest in operating at Ka-band (roughly 29 GHz for earth-to-satellite links and 19 GHz for satellite-to-earth links.)

| Company | System | Orbit | Coverage | No of Satellites | Satellite Capacity (Gb/s) | Inter-satellite Link | Onboard Switching | Capital Investment ($B) |
|---|---|---|---|---|---|---|---|---|
| Lockheed-Martin | Astrolink | GEO | Global | 9 | 7.7 | 1 Gb/s | FPS | 4.0 |
| Loral | Cyberstar | GEO | Limited Global | 3 | 4.9 | 1 Gb/s | BBS | 1.05 |
| Hughes | Galaxy/ Spaceway | GEO | Global | 20 | 4.4 | 1Gb/s | BBS | 5.1 |
| GE Americom | GE*Star | GEO | Limited Global | 9 | 4.7 | None | BBS | 4.0 |
| Morning Star | Morning | GEO | Limited Global | 4 | 0.5 | None | None | 0.82 |
| Teledesic | Teledesic | LEO | Global | 840* | 13.3* | 1 Gb/s* | FPS* | 9.0* |

FPS: Fast Packet Switching, BBS: Baseband Switch
*Original design numbers

***Table 2.*** *Proposed U.S. Ka-band global satellite communications systems.*

Until recently, interest in this band has been confined to experimental satellites launched by Japan, the United States, and Italy. This is because, unlike at C-band, rain greatly attenuates Ka-band signals (and to some lesser extent, Ku-band signals), making this a difficult band in which to provide satellite services. A group of private U.S. investors proposed a Ka-band satellite system that would provide a global wideband data distribution capability known as the Calling[sm] Network, later renamed Teledesic. This system was to employ 840 low-altitude satellites, each of which could relay to its eight nearest neighbors and provide users (who had sufficiently large terminals) access at rates up to 1.2 Gb/s.

The Teledesic organization was successful in lobbying at the World Administration Radio Conference for Ka-band frequency assignments. This caused the FCC to proceed with a Notice of Inquiry that offered others the opportunity to seek Ka-band spectrum (and orbital locations). Thirteen applications were submitted (in addition to the one from Teledesic)—all for geostationary satellite systems. Subsequently, AT&T withdrew its filing for a 12-satellite global system, and in May 1997 the FCC approved the applications of all 12 remaining Ka-band geostationary fixed-satellite systems.

There are over 50 proposed Ka-band projects worldwide, requiring more than 170 geostationary orbit locations. These are mostly national or regional systems, and not a great deal has been published about them. Six of the 13 licensed U. S. systems propose to offer global (as distinct from domestic) service, and these are reviewed briefly below.

The growth of cellular telephone usage around the globe is the basis for the mobile PCS satellite systems. The market for broadband satellite communications services to individual customers and small offices is less well established. By far the largest market is believed to be access to the Internet.

### *3.2 – Proposed U.S. Ka-band Systems*

#### *3.2.1 – General*

As noted previously, a large number of Ka-band satellite system proposals have been filed with the ITU in Geneva. In the U.S., the FCC has opened two filing windows for systems operating in this band, and one for systems operating at still higher frequencies (40 and 50 GHz) known as Q and V-band. We will discuss only the global systems which received licenses from the FCC in May 1997. These are listed in Table 2.

It is known that many of these systems are undergoing major design changes. For example, Teledesic has announced that it plans to raise the orbit of its fleet of satellites to 1,400 km and reduce their number from 840 to 288. Further, a recent decision by Motorola not to pursue its own LEO system (called Celestri), and instead join Teledesic in building that system, is likely to generate further design changes. Also, it should be noted that some filers (e.g., Hughes) requested both Ka- and Ku-band capacity in their filings. The FCC has not acted on the request for the Ku-band capacity.

#### *3.2.2 – Astrolink*

The Astrolink system proposed by Lockheed Martin will employ nine geostationary satellites in five orbit locations (Figure 4a). The total capacity of each satellite is 4 Gb/s. By placing two satellites at the same orbit location and operating them with orthogonal polarizations, a total capacity of 8 Gb/s is achieved over the Americas, Europe, and Asia (Figure 4b). Cross-links between satellites operating at 60 GHz provide a means of routing traffic round the globe, and each link has a capacity of 1 Gb/s.

Astrolink proposes to equip users with terminals employing antennas of 65, 85, and 120 cm in diameter that can be operated at power levels in the range of 0.25 to 10.0 W, at rates in the range of 64 kb/s to 8.448 Mb/s (with larger antennas and higher powers being required for the higher rates.) These terminals would interconnect with the terrestrial switched network via gateway stations employing 2.4- or 4.5-m antennas with up to 200 W of power.

The system would presumably be built in stages, with only one satellite initially located in each orbital slot. Even so, each satellite will be large and expensive, representing a considerable financial investment.

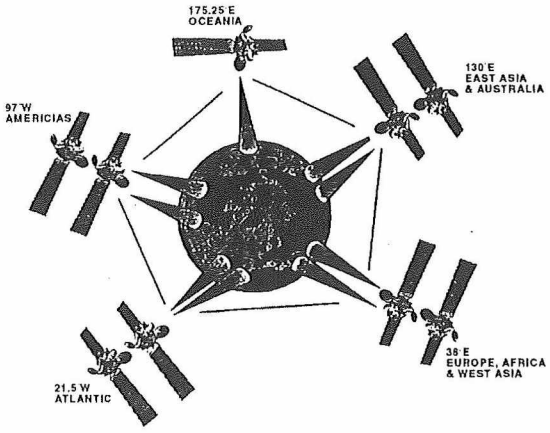


*Figure 4a: Astrolink system constellation.*

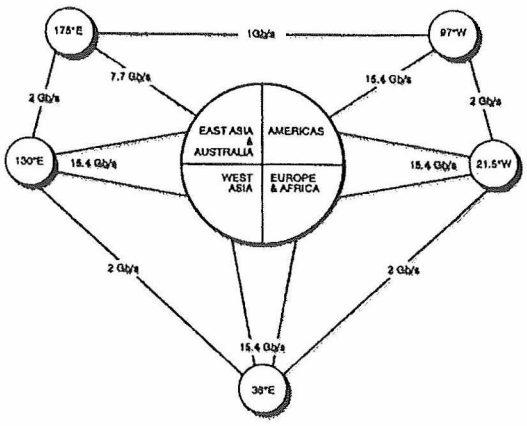


*Figure 4b: Allocation of capacity in the Astrolink system.*

*3.2.3 – Cyberstar*

In contrast to Astrolink, Loral's proposed Cyberstar system represents a lower cost, less risky approach to the market. Loral proposes to launch three geostationary satellites positioned to reach the world's largest population centers, and has been awarded slots at 28°E, 105.5°E, and 115°W. While Loral originally proposed satellites employing multiple spot beams interconnected by an on-board processor, its plans have undergone changes. For a time it pursued a simlified satellite design (Phase 1) with no on-board processor, allowing early entry to the market. These Phase 1 satellites could employ as many as 72 spot beams interconnected via an intermediate frequency (RF) switch. The total capacity of these satellites would be on the order of 5 Gb/s, and they were to be launched by the year 2000.

In Phase 2, three larger, more powerful satellites were to be launched, each with a total capacity of 10 Gb/s and capable of providing beam-to-beam connectivity via an onboard processor. At last report, Loral appeared to be reevaluating this plan in favor of going directly to the Phase 2 system. For the moment, however, Loral seems intent on developing an interim service capability (called Cyberlink) using the assets it obtained from AT&T and Orion.

*3.2.4 - Galaxy/Spaceway*

Hughes has proposed to construct a fleet of geostationary satellites for a system called Galaxy/Spaceway. The proposed constellation would have 21 satellites in 16 orbital locations. The Spaceway™ portion of this system resembles that proposed by Lockheed Martin for Astrolink (Figure 4a) in that it consists of nine satellites placed in five orbital locations with intersatellite links between four of the locations.

In the Spaceway portion of the system, two satellites are to be deployed in each of four orbit locations. By operating each satellite over the allowed 500 MHz of spectrum (but with different polarizations), Hughes obtains an equivalent 1,000 MHz of bandwidth. Each satellite can support 68 transponders, 64 of which occupy 125 MHz each (for the users), and two of which occupy 250 MHz (for gateways), thus achieving further frequency reuse. These transponders operate into narrow (59-dBW EIRP) and wide (52.3-dBW EIRP) spot beams arranged to cover the land masses visible to the satellites. The intersatellite links operate at 60 GHz and have a data rate of 1 Gb/s. Communications services will be provided at rates of 16 kb/s to 1.544 Mb/s via terminals with antennas in the range of 66 to 200 cm in diameter, and uplink transmitters of up to 2 W. On-board processing of arriving packets is employed, both to route traffic between beams and to merge the traffic in a given transponder into a single 92-Mb/s stream.

*3.2.5 - GE* Star*

Like Lockheed Martin and Hughes, GE American Communications, Inc. ("GE Americom") proposed a system (called GE* Star) of nine geostationary satellites occupying five orbit locations. GE Americom proposes to secure satellites which produce 44 spot beams each for transmitting and receiving and operate in a fourfold frequency reuse pattern. Signals received in these beams are separated by filters into six 24-MHz subbands for high-traffic regions (24 beams) and three 24-MHz subbands in low-traffic regions (20 beams). Each of the 204 subbands is then processed at baseband to recover the digital bit streams, which are routed to the appropriate downlink beam. The downlink beams would operate at 40 Mb/s, with an EIRP at beam center of 54 dBW or 51 dBW for the high- and low-traffic regions, respectively.

GE Americom does not intend to procure ground terminals, but will work with manufacturers to ensure that terminals are produced that are compatible with its system. Terminals with antenna sizes of 75 and 150 cm are proposed, operating at 1 W and achieving rates of 384 kb/s and 1.544 Mb/s, respectively.

GE Americom evidently does not wish potential competitors (Hughes, Lockheed Martin, or Loral) to manufacture its satellites and has announced a plan to have them built by the Harris Corporation.

*3.2.6 - Morning Star*

The Morning Star Satellite Company, L.L.C., of Washington, D.C., has proposed a system of four geostationary satellites designed to serve parts of North America, Europe, and Asia. Like the Hughes Galaxy proposal, Morning Star proposed using hybrid Ku/Ka-band satellites, but has been authorized to proceed only with the Ka-band portion. As

originally proposed, each satellite would utilize up to 10 receive spot beams operating at 30 GHz and combine its traffic into a single 20-GHz downlink beam to a gateway earth station. This station would uplink signals at 30 GHz that would be separated and transmitted via the spot beams at 12 GHz (Ku-band). Since the use of the Ku-band was not authorized, this arrangement will have to be modified.

The satellites employ simple frequency-translating transponders with no on-board processing. This, together with the absence of frequency reuse, limits their capacity to 0.7 Gb/s. The design is unique in that beam-to-beam connectivity can be provided, but requires two transmissions through the satellite (a so-called double-hop). This is wasteful of satellite resources, but presumably Morning Star plans to deliver movies and Internet service, both of which would originate at the gateway earth stations.

*3.2.7 - Teledesic*

The Teledesic system has been described in a number of technical papers, but now appears to be undergoing complete redesign. As originally conceived, a LEO system was chosen because it was felt that very large data rates were incompatible with the delay (or latency) encountered with geostationary distances. Also, to mitigate rain fading, the service area of each satellite was to be limited to a cone of ±40° about the nadir (i.e., subsatellite point). This, together with the low altitude chosen, drove up the number of satellites needed for global coverage to 840. Each satellite in the system was capable of cross-linking with its eight nearest neighbors and employed phased-array antennas to scan "cells" on the ground from which to collect and deliver traffic.

Teledesic has announced a change of plans in which the number of satellites is to be reduced to 288 and the orbit raised to 1,400 km. Also, Teledesic seems to have shelved the idea of serving thousands of consumers who need only modest rates to connect to the Internet. Rather, it now intends to interconnect Internet service providers (ISPs) at high rates. The parameters given in Table 2 are for the old design. As details of the new one are unavailable, little more can be said about this system at present.

Teledesic probably remains the most advanced of all the systems being proposed, and with 288 satellites is likely to prove to be the most expensive. Given that Motorola has elected to join the Teledesic project and will be technical manager, it seems that further changes to the design and/or number of satellites are probable to reduce the capital outlay and increase the chances of financing the system.

*3.2.8 - Skybridge*

Not a great deal has been reported concerning foreign systems that may be planned for operation at Ka-band. However, Alcatel-Alsthom of France has proposed a $3.9 billion project to place 64 satellites (later increased to 80) in low-earth orbit in a system known as Skybridge. Loral has apparently agreed to take a stake in Skybridge, and Alcatel a stake in Cyberstar.

What is unique about Skybridge is the intent of operating at Ku-band (thereby greatly reducing rain fade) and the use of a scheme to avoid interference with existing geostationary Ku-band satellites. The original plan called for 64 satellites at an altitude of 1,457 km arranged into two subconstellations of 32 satellites. Each subconstellation would employ four satellites in eight orbit planes, with the planes inclined 55° and spaced 45° at the equator. By adjusting one constellation to be slightly displaced from the other (Figure 5), the satellites can cross the sky in pairs. Each user earth station/gateway pair can then be commanded to switch from one satellite to the other when either the user station antenna or the gateway antenna would be pointed within ±10° of the geostationary orbital arc.

Each satellite is proposed to have 48 spot beams 350

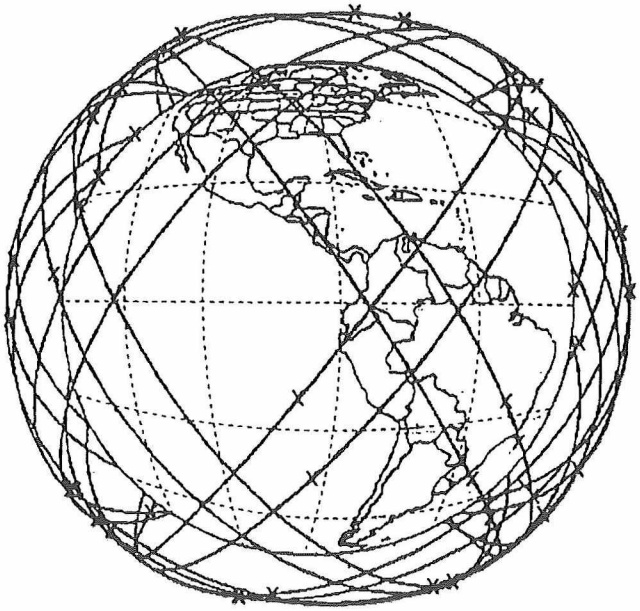

*Figure 5: The Skybridge system.*

km in radius and steerable over ±53°. Each satellite then serves an area 3,000-km in radius by means of beams that illuminate fixed locations on he ground as the satellite flies by and then hop to cover a new territory. The system provides dual-satellite visibility between 30° and 60° latitude 100 percent of the time, and between the equator and 30° over 85 percent of the time. Since there is no beam-to-beam connectivity, the system requires that a gateway earth station occupy each beam. Thus, a total of 387 gateways would be required to cover all the land between ±68° latitude. However, Alcatel notes that 253 gateways would serve 90 percent of the anticipated demand.

This scheme enjoys an obvious advantage over other proposed LEO systems in that it operates at Ku-band rather than Ka-band, although it does require two tracking antennas at each user location. However, two tracking antennas may be required in any LEO system to avoid gaps in connectivity. The requirement to use tracking antennas is, however, a serious cost driver for the earth terminals for all of the LEO systems and would almost certainly limit their use to large-volume subscribers who could afford the investment this would represent.

*3.3 - Outlook for Multimedia Satellite Systems*

The fielding of the Ku- and Ka-band multimedia satellite systems described here seems less certain than fielding of the cellular-like satellite systems described in Section 2. Most proponents are presently seeking industrial partners, financing, and operating agreements with potential service providers. Most committed at this stage would appear to be Alcatel (Skybridge), Hughes (Spaceway), Lockheed Martin (Astrolink), and Teledesic/Motorola (Teledesic). It is likely that the advantage will go to those companies with the financial resources and internal commitment to begin developing their systems with their own funding. Further complicating this picture is the fact that the availability of capital may well depend upon how quickly investors in Iridium, Globalstar, and ICO are expected to reap rewards. However, the demand is believed to be so great that several of the proposed systems seem likely to proceed, albeit with possible design changes aimed at reducing the technical and financial risks.

## 4. Conclusions

Development of the fleets of satellites described here will affect some of us profoundly. By 2000 it will be possible to call home from essentially anywhere on the planet using a handheld terminal similar to one of today's cellular phones. For better or worse, we need never be out of touch, no matter where we are.

Besides the obvious benefits to commerce and tourism, universal service will become possible (at least for those who can afford it) in countries where none now exists. Within a decade, it will probably be possible to live in a remote area and yet be connected to the worlds of commerce and entertainment via the Internet and other sources of multimedia at rates high enough to support movies-on-demand. The world will soon be a place where not just communications, but also torrents of information, will be available just about everywhere. Whether this world will seem smaller, larger, or more interesting will probably depend on your point of view.

# The Way to UMTS: How Can We Bring a Vision to Reality?

Josef F.Huber

## 1 – Introduction

By the end of the year 1998 the cellular market reached 300 mio. users world wide. This picture of the mobile market development is underlined by the dramatic growth of subscribers of the first digital mobile cellular system GSM, which meanwhile counts for more than 140 mio. From the view of such market growth it is obvious, that the situation has to be reconsidered to secure a long-term development of the mobile communications market into third Generation services.

In the year 1992, it was not known yet, what type of services the third Generation would carry and even today, we cannot define them so clearly. But we know more than in 1992. We know, that multimedia services will be a new market for telecommunications business in addition to the already developed speech and low speed data mobile communications. We know, that Internet will be the main driver for mobile applications and that it is important for the economy to bring Internet onto the air. In the year 2002, when the first UMTS services will start, Internet will have more than 500 million registered users world wide. This user potential will be large enough to drive the applications forward in this business. Putting Internet (and Intranets) onto the Air adds mobility to this wireline market base which can be seen as a world wide mass market.

In this context, the UMTS Forum recognised that it is of high relevance to analyse the recent market developments and to verify, whether the available spectrum will be

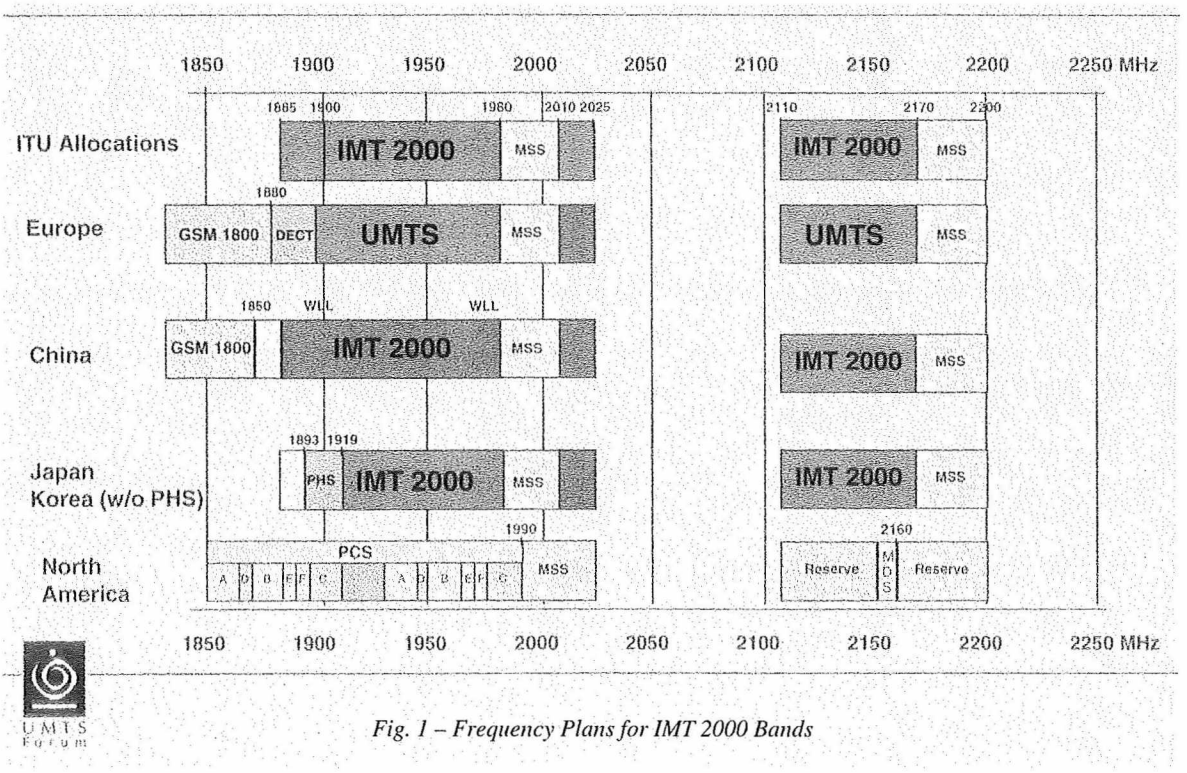


*Fig. 1 – Frequency Plans for IMT 2000 Bands*

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[1] This paper is a modified version of one presented at Commsphere 99.

sufficient to satisfy customers' needs or not. In addition to 2nd generation bands the WRC '92 identified a total of 230 MHz of spectrum in the 2 GHz bands on a global basis (see Fig. 1). These 230 MHz are split into 170 MHz for global terrestrial use and 60 MHz shared with satellite use with the understanding that IMT 2000 includes a terrestrial and a satellite component. [The name IMT 2000 indicates that the system will begin in the next century and that it makes use of spectrum in the 2000 MHz range] As shown in Fig. 1 a number of regions in the world converged in the direction of the WARC-92 agreement:

- CEPT in Europe can make available all ITU spectrum except 15 MHz which are already allocated for DECT. This results in 155 MHz of spectrum for terrestrial services with an additional 60 MHz set aside for UMTS satellite services.
- China: The recent discussion of the UMTS Forum in China reflects the ITU allocations as being quite similar to those in Japan and Korea. It may be assumed that the major part of the ITU bands could be made available. Some segments are designated for wireless access systems. However, there has no final plan or decision been made yet.
- Korea already indicated spectrum allocations for paired and unpaired use: 1895 - 1920 MHz, 1920 - 1980 MHz, 2010 - 2025 MHz, 2110 - 2170 MHz.
- The Japanese Ministry of Post and Telecommunications MPT is planning to designate the WARC-92 spectrum for third generation systems in the same way as the Europeans with the difference, that the frequency band 1895 MHz to 1918.1 MHz is already allocated to PHS services.
- North America has a slightly different scenario: the introduction of PCS services and the auctioning led to a split into licenses of 2 x 15 MHz and 2 x 5 MHz up to 1980 MHz. This spectrum utilisation leads to the question how radio equipment could be harmonised with IMT 2000 services in Europe and in Japan and in the rest of the world. One example is that the Air Interface standard has to fit into 5 MHz frequency blocks.

The remaining regions in the world like Africa may continue with the WARC-92 decision. There are no indications in a different direction, which means that the ITU objective, to come to a world wide harmonised IMT 2000 spectrum allocation, is still valid for the most parts in the world.

## 2 – The Universal Mobile Telecommunications System UMTS / IMT 2000

UMTS - the **U**niversal **M**obile **T**elecommunications **S**ystem is born as a vision. It is a vision which takes the personal communication user into the information society of the next century. It is a member of the IMT 2000 systems family. Processing and delivery of information, video and voice, fax and data between users and information providers characterise the information society of tomorrow (Fig. 2). UMTS comprises the 3rd generation of mobile radio system technologies dealing with broadband multimedia applications. The information's age, however, is expected to generate demand for personalised multimedia telecommunications in which the customer bundles the available basic services before and during the communication. Flexible allocation of radio resources with unpredictable bit rate and asymmetric transmission throughput is required as well as high processing power in end user equipment. This is the challenge for the telecoms industry as well as for the IT industry and probably the media market.

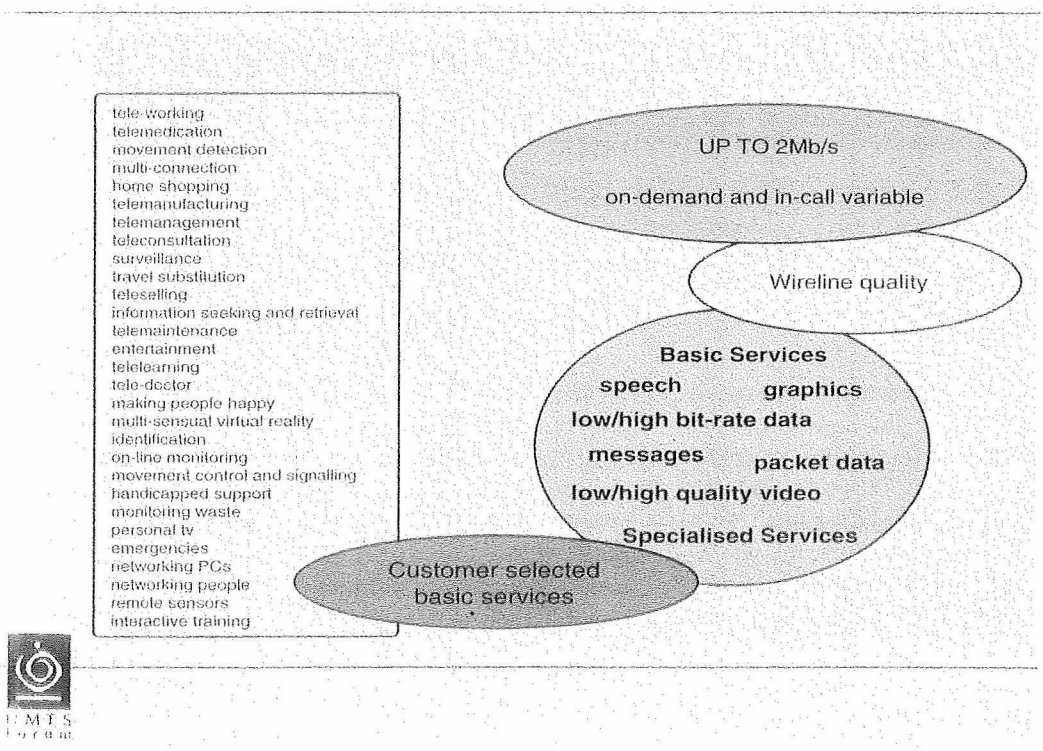


*Fig. 2 – Customised Multimedia*

The world wide liberalisation in telecommunications will enable mobile operators to offer fixed network services and viceversa. In this situation a broadband-capable multi-environment UMTS technology becomes essential to ensure mobile operators can compete in the resulting highly competitive telecommunications market.

In this context, some operators are already preparing for the convergence of fixed and mobile networks. They will benefit from developments such as network intelligence, service creation and personal numbering. Support of fixed and cellular network convergence is therefore a key UMTS qualification for both - operator and customer.

One of the main objectives of UMTS is to integrate the heterogenous world of different radio systems with different standards, different applications and features, cell sizes from pico cells up to hyper cells.

## 3 – The Mobile Market

The UMTS market is characterised by the need of manyfold services: there are the current „voice-band" compatible services like fax and medium speed data. There will be audio-video services with higher bandwidth demands. And there will be multimedia services with asymmetrical traffic profiles. Such a scenario describes the market base for UMTS. Mobility is another but dominant success factor for UMTS as it can be seen by the fast developments of mobile networks today. *The main questions considering a UMTS market are:*

- Who are the users, what market segments will they come from?
- How is mobility affecting services?
- What kind of terminals will be used?

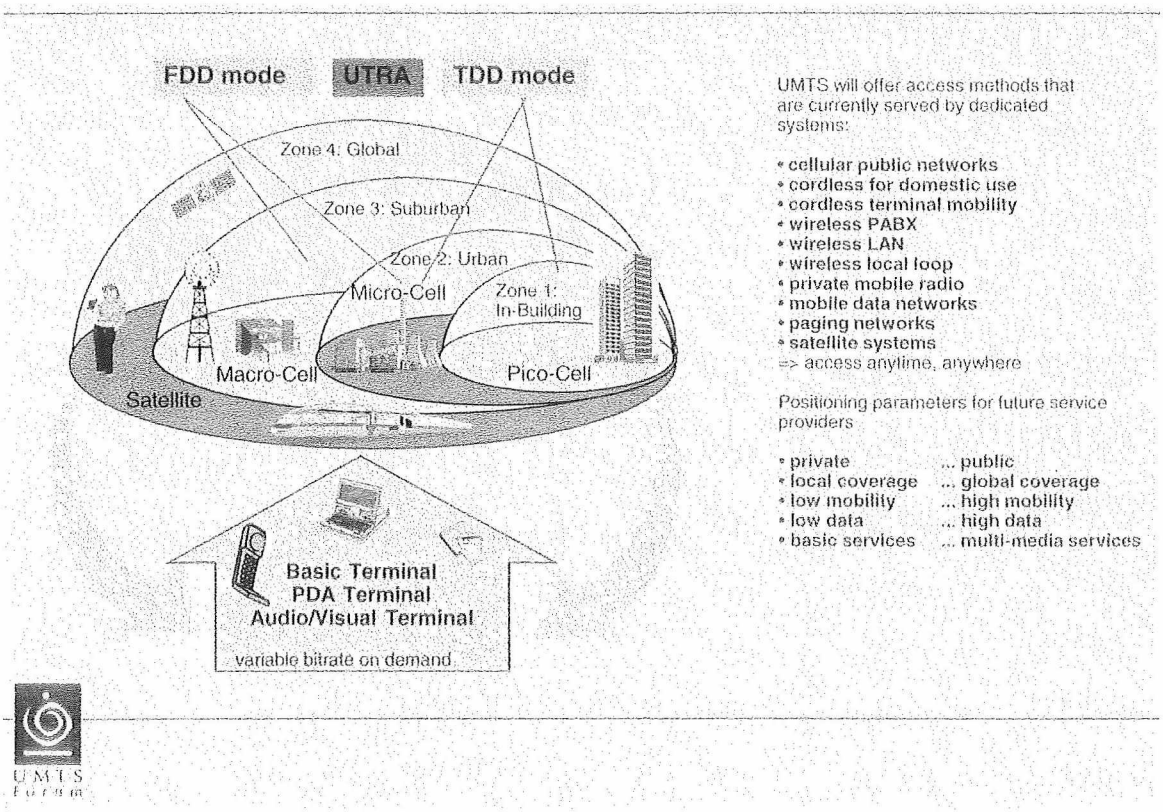


*Fig. 3 – Telecommunications Environments*

The integration of various radio zones and radio standards facilitates roaming. As the recent standardisation developments show, first steps of integration already began in GSM. Examples are the Dualband capability GSM 900/1800 and the tri-band phone GSM 900/1800/1900, the Satellite-PCN-Integration on the GSM Platform. As a natural consequence it makes sense to continue this way as an evolutionary development from existing systems towards UMTS and to add revolutionary what is needed as a new technology for the 21st century instead of substituting them by a complete new solution. Such a process avoids high investment on the operator's side in the future and utilises investment already spent on the wireless side as well as on the wireline side.

A market model needs to be developed looking at segments such as business and private, tariff schemes and price structures need to be taken into account.

What about market and competition? Competition of suppliers, network operators or service providers? This is an important factor to develop the UMTS market as already realised by the world wide liberalisation in the telecommunications business. Regulatory items play an important role to boost the market for UMTS services.

If we look into the telecommunications market up to 2005 (Fig. 4), we recognise a shift in the market potential from wireline services to mobile personal services and Internet-type services. The UMTS market is planned to begin in 2005. There is no clear picture foreseeable today

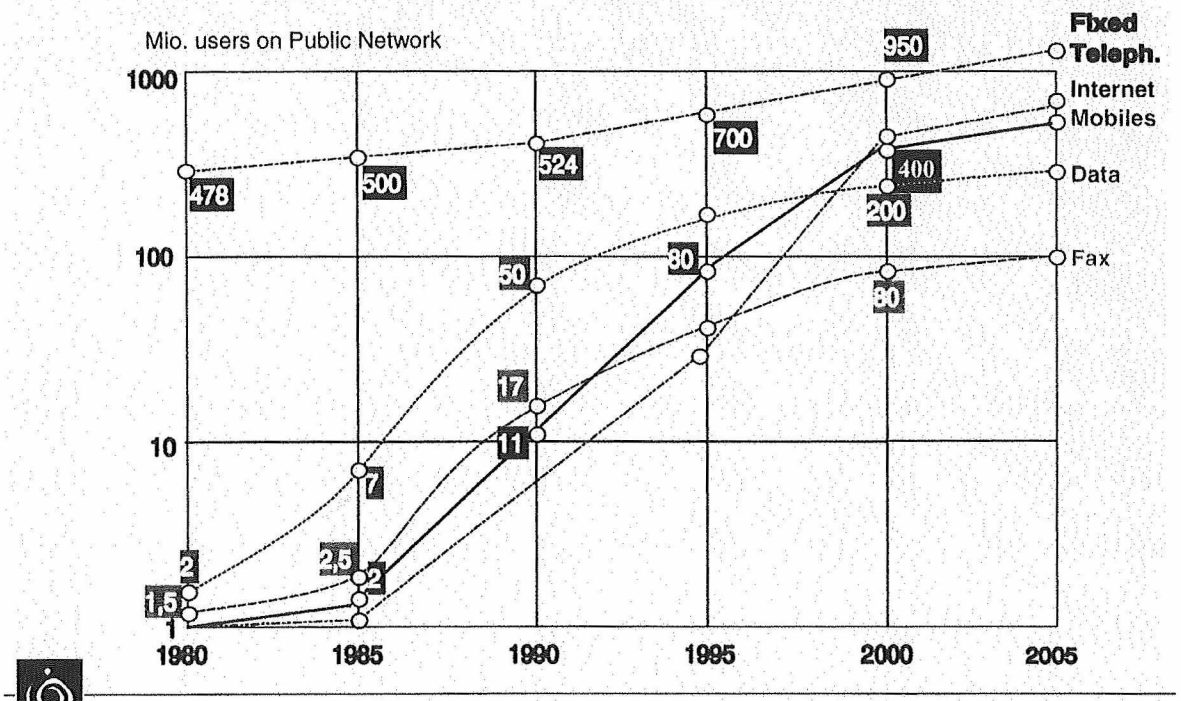


*Fig. 4 – Telecommunications Market Worldwide*

regarding combined audio-video services and multimedia services. But there are indications from the Mobile Market and Internet Market developments. The upcoming work for UMTS must therefore concentrate on these issues to find the best way to penetrate the right market for a mass consumer business as the final goal. A first indication how the world wide mobile market will develop is shown in Fig. 5. The question what market segment will use UMTS services cannot be answered today. However, it seems evident that such a huge market growth needs new technology, that is more spectrum efficient and provides attractive services on a global basis.

GSM is a good example how to develop the personal mobile market successfully, because it has already reached a global footprint. The market forecast study shown in Fig. 5 considered the societal and economic developments

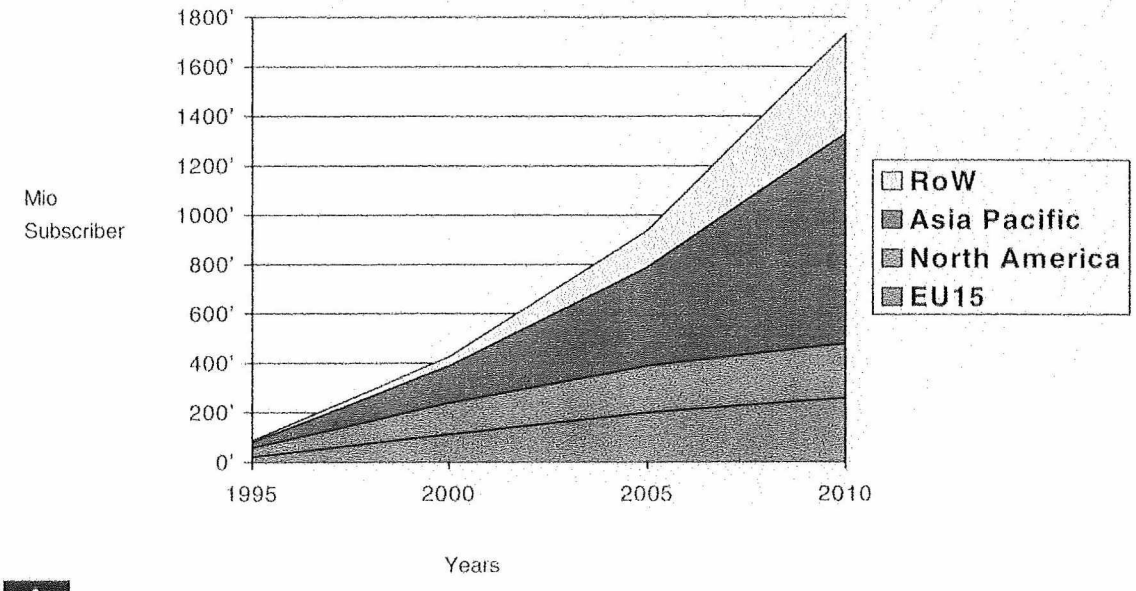


*Fig. 5 – World Mobile Subscribers*

(GNP) on a world wide basis. The strong influence from Internet and Intranet was considered, too. The figures include the market for satellite services, which is – on a world wide basis – in the order of 4–5 million users in the year 2005 and around 10 million users in the year 2010.

## 4 – The UMTS Technology

It is recognised today that personal communications are mainly linked with a „voice-band" structured transmission capability. Personal voice communications are dominant, the world wide popular handhelds are mainly personal communicators for one application and this is telephony.

It can be expected that the dominant role of voice will not change dramatically. If we look into the worlds' market forecasts for the years beyond 2000, we realise more than a billion users in the telephony networks, more than 400 million handheld users in the cellular mobile networks and perhaps between 300 to 500 million users in Internet-type applications (usually registered as exhouse + inhouse users and not public termination points in telephony and mobile cellular networks).

UMTS Terminals:

In the year 2005 far more Internet-type users than voice users may be expected. We also can see the technology development progressing towards adaptive codecs for video and voice.

UMTS in the year 2005 has to provide the means to transport, switch and process applications for combined video, voice and data. Multimedia communicators should be available at this point of time comparable to „Voice Handhelds" today for an acceptable price, volume and weight. The channel bandwidth for the user may vary from 16 kbps up to 2 Mbps.

The positioning of UMTS on the network infrastructure side can be considered in two parts:

The UMTS Radio Part

UMTS is likely to cover a large variety of radio environments from indoor to outdoor - satellite coverage included. Adaption of the mobile terminal to a specific radio environment takes place through negotiation mechanism. The radio part must concurrently support multiple public and private networks, dynamic and asymmetrical user bit rate demands. The transmission bit rate objectives for UMTS are determined by service requirements. It is proposed to reach bit rates up to 2 Mbit/s to the terminal in the micro/pico cell areas, up to 144 kbit/s or probably up to 384 kbit/s in macro cells. They should offer dynamic allocation of radio bearer services.

The UMTS Switching Part

The UMTS switching part comprises the core network and the value-added service functions including intelligent network capabilities. UMTS will serve the user with many different interfaces for

- Public mobile networks
- Cordless systems including wireless PABX, wireless LANs, cordless Terminal Mobility (CTM)
- Wireless Local Loop
- Satellite PCNs
- Private mobile radio networks
- Mobile data networks
- Paging networks

Parts of the UMTS infrastructure will be operated by competing public carriers, other parts will be in private ownership on a non-regulated basis. A core set of standardised services will support the various applications. Open interfaces must also exist on the switching platforms

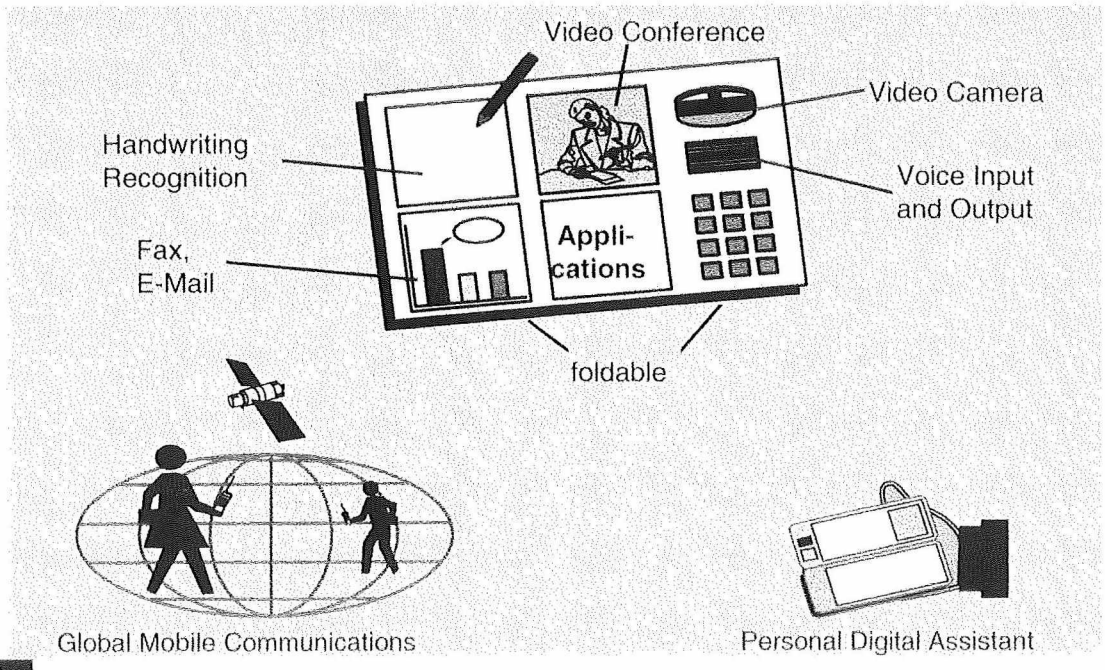


*Fig. 6 – Technology Development for Mobile Multimedia Communications Terminals*

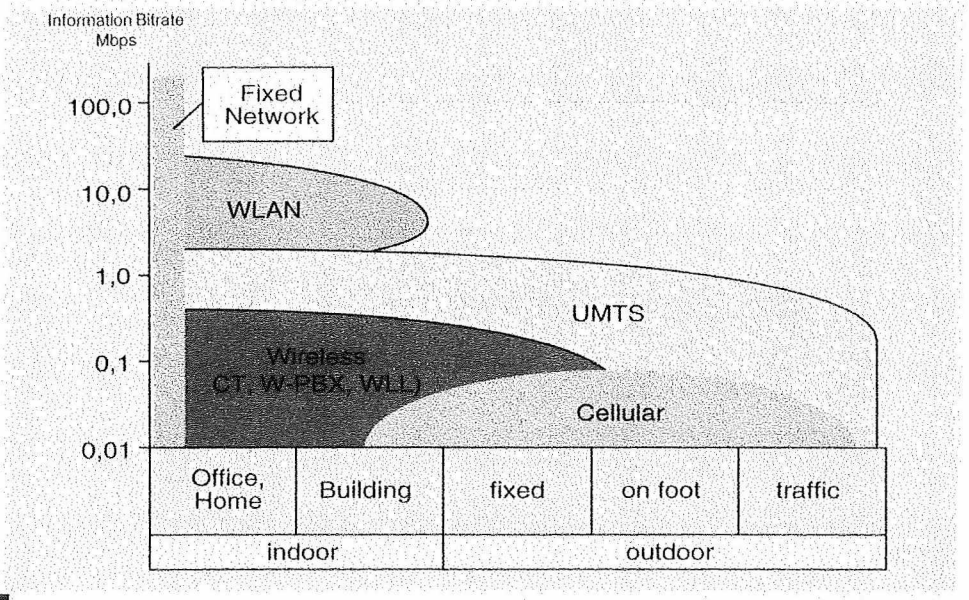


*Fig. 7 – UMTS Position – Radio Part*

to allow easy interworking. With IN, rapid creation and deployment of services can be offered spanning over the core networks involved in UMTS. Transmission and switching must be state-of-the-art technology. As UMTS goes far into the next century, in addition to circuit switching TCP/IP and ATM will be the dominant switching principles. The positioning of UMTS is shown in Fig. 8. It illustrates clearly that UMTS can harmonise existing services and expand with higher bandwidth allocations also on the transport and switching side. To make optimum use of the available bandwidths, service access and control procedures need to be enhanced to allow for multimedia cell handling, negotiating network and terminal capabilities etc. Such extensions are to be built in a way which ensures compatibility of fixed and mobile access to integrated end user services.

Let us conclude: UMTS enables mobile access to an integrated personal communication environment and supports Universal Personal Telecommunications (UPT). Interworking with PSTN, ISDN, B-ISDN, TCP/IP, PSPDN and GSM family networks must be defined.

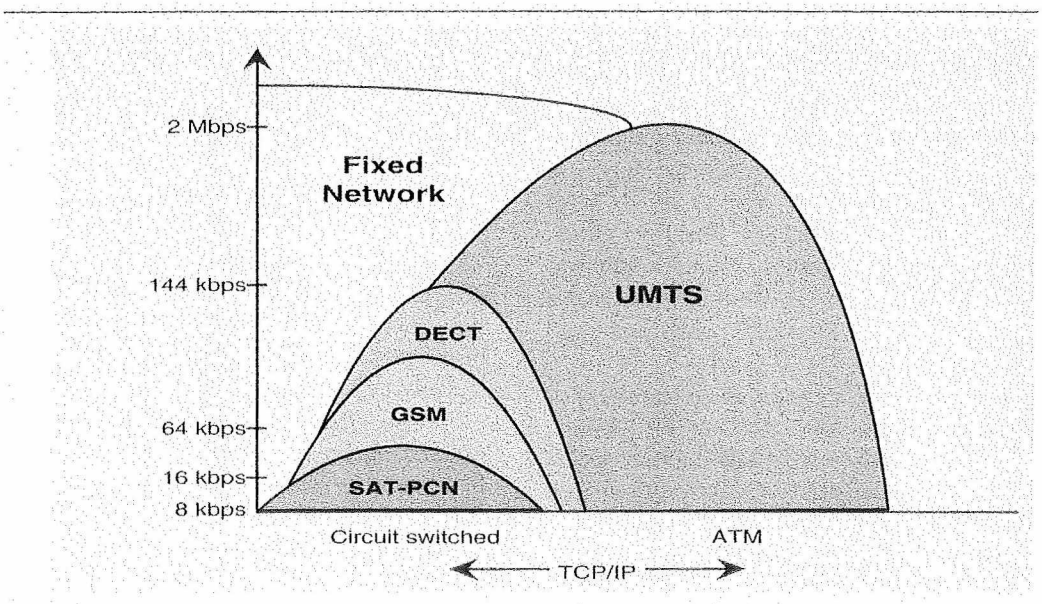


*Fig. 8 – UMTS Position – Switching Part*

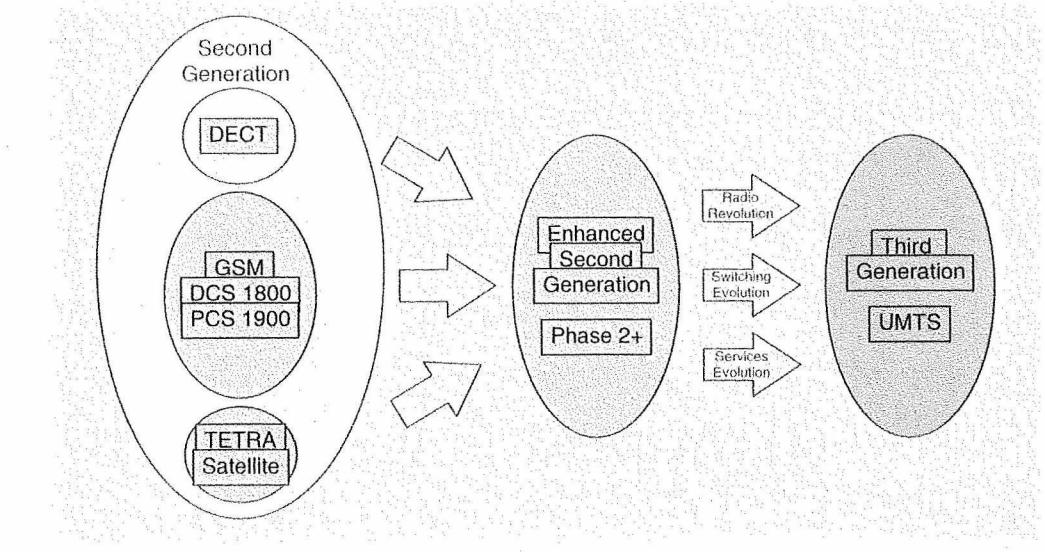


*Fig. 9 – The Way from 2nd Generation Mobile Systems to UMTS*

## 5. The Evolution Path

UMTS is not so far away for considering technologies now to develop UMTS services for the multimedia future. Presently, there is big investment taking place in 2nd generation systems like GSM for the upcoming years to satisfy the huge mobile market demand. This leads to the discussion about an evolution strategy from 2nd generation systems towards UMTS. It does not make sense to understand the UMTS vision in the spirit of substituting existing networks by a completely new technology.

The GSM development over the last five years has demonstrated quite clearly how innovation can be promoted within a standardisation framework that comprises nearly all entities of a telecommunications network. It seems that the way of GSM in the direction of UMTS can be realised step by step as an economical approach.

A basic understanding how to evolve existing systems from GSM towards UMTS was already reached in Europe. This is shown in Fig. 9. It describes a system evolution on the switching and services path and a system revolution on the radio path.

The UMTS report published in the year 1997 results in the following statements regarding system evolution:

- UMTS network requirements shall be consistent with a managed evolution from the GSM family and N/B-ISDN.
- The full set of UMTS service requirements can only be achieved from a revolutionary radio-interface design.
- UMTS shall address also the broadband multimedia needs of the information society and therefore support service evolution and enhancement.

This leads to a timewise evolution of systems. *The main target dates for UMTS are:*

- Regulatory issues clarified by the end of 1998
- First licenses, standards by the end of 1999
- Basic UMTS Pilot by 2002 and service start-up
- Mass Market by 2005

For Europe, the first objective will be achieved on time. Let us hope that other regions will follow soon, Japan will probably be next making a regulatory decision.

## 6. Driving UMTS and Co-ordination of Activities

The definition of UMTS - its vision, its evolutionary way from 2nd generation systems into the future, all its dimensions will be a result of co-operation between many organisations representing all interests. The telecoms industry agreed that UMTS must have an effective decision process to achieve broad consensus on policy and strategy matters. The result is the creation of the „UMTS Forum" with the mandate to assist this process and to promote UMTS. Fig. 10 illustrates the UMTS Forum in its environment of standardisation bodies, industry groups, the political authorities, the frequency administrations and regulators.

The Forum started its work in early 1996 focussing on four main issues: Regulatory, Spectrum, Market and Society, and Technology Impact

The first Mission Statement was that UMTS will use the present IMT 2000-spectrum as a core band. The UMTS Forum claims, that additional spectrum is required for broadband services in the order of 180 MHz for terrestrial and 30 MHz for satellite services.

The UMTS Forum has started to support the preparations for getting more spectrum for mobile multimedia services in future. The World Radio Conference WRC-2000 from 20 March to 14 April 2000 in Istanbul/ Turkey will discuss this under Agenda Item 1.6.1. We are expecting a positive decision in the interest of the mobile community. Fig. 11 shows the present spectrum allocations for GSM, DECT, PCS and IMT 2000.

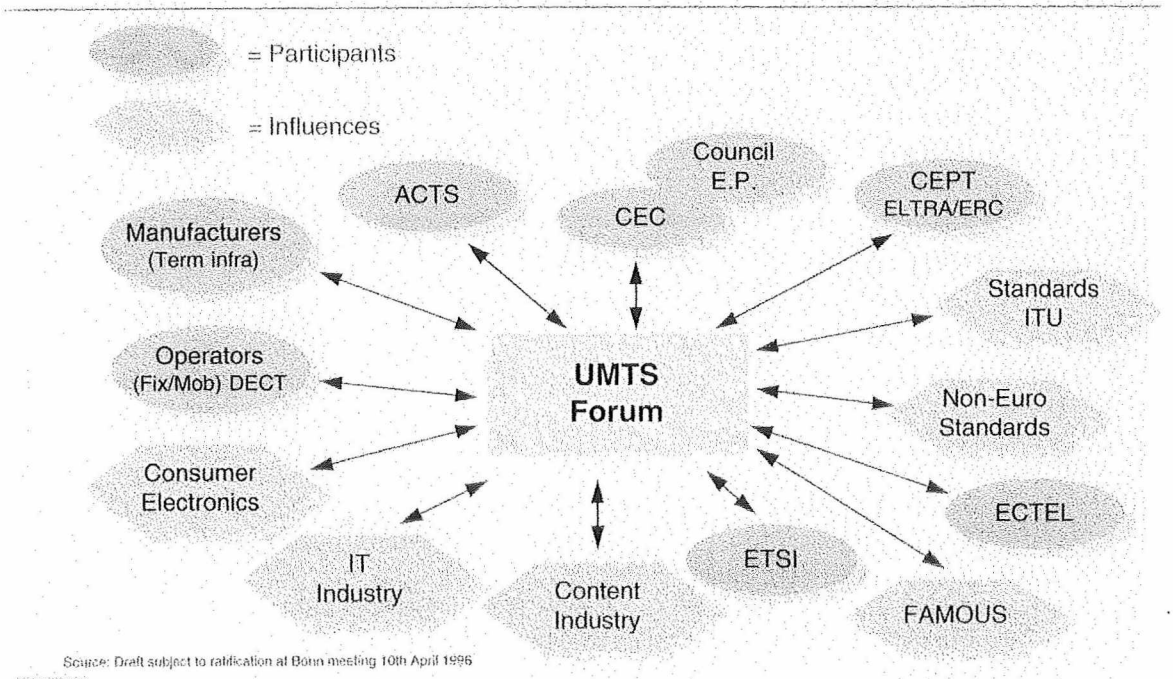


*Fig. 10 – Spheres of Influence*

## 7 – Conclusions

The motivation for UMTS results from recognising the future developments towards multimedia combined with personal mobility. In addition to the technical innovations in the existing networks, only new broadband radio technologies can completely reflect such requirements. This needs to be combined with the achieved level of world wide mobility in GSM using network intelligence. Convergence between fixed and mobile networks will arise together with the upcoming demand for mobility independent from user location and user needs to be developed in an evolutionary way.

The 21st century customer will demand services independent from the access method. UMTS will find its way to satisfy this customer by providing „**U**niversal **M**obile **T**elecommunications **S**ervices".

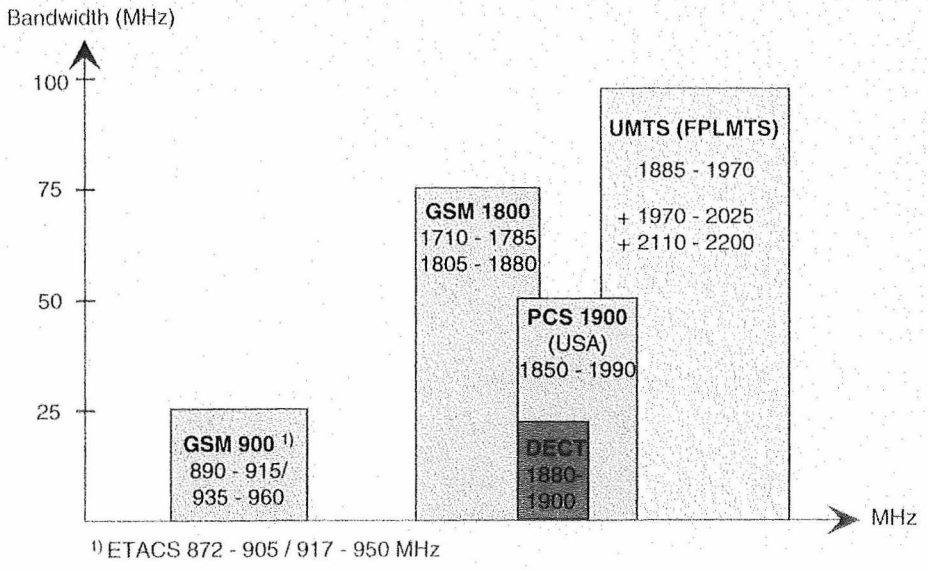


*Fig. 11 – Spectrum for UMTS (2002-2008) in contrast to GSM, DECT and PCS 1900*

# Triennial Reports Commissions

## COMMISSION A

*This triennium report was prepared by Dr. M. Kanda, Commission A Chair 1996-1999. The Commission Members would like to thank Dr. Kanda for his great efforts in organizing this report and also for his dedication to Commission A activity.*

### 1. Chairpersons

The chair-persons of Commission A during this triennium were: Chairman: Dr. M. Kanda, USA,
Vice-Chairman:Professor E. Bava, Italy.

### 2. Commission A Sponsored Meetings

Budget 1996-1999: 360,000 Belgian francs

| details meeting | Mode | Amount of sponsorship in Belgian francs |
|---|---|---|
| ISEM, Int. Symp. on Non-Linear EM Systems, Braunschweig, Germany, 12-14 May 1997 | B | = BEF 96,000 |
| 12 European Frequency and Time Forum, Warsaw, Poland, 10-12 March 1998 | A | =BEF 0 |
| EMC Conference, Wroclaw, Poland, 23-26 June, 1998 | B | =BEF 87,000 |
| CPEM □98 – Conference Precision Electromagnetic Measurements, Washington, DC, USA, 6-10 July 1998 | B | =BEF 35,000 |
| PIERS □98, Nantes, France, 13-17 July 1998 | A | = BEF 0 |
| EMC □98 Roma, Rome, Italy, 14-18 September 1998 | B | = BEF 71,000 |
| EMC □99 Zurich, Switzerland, 16-18 February 1999 | B | = BEF 71,000 |

### 3. Review of Radio Science - M. D'Amore

Commission A: Electromagnetic Metrology edited by Marcello D'Amore

Chapter 1. Broadband Electromagnetic-Field Sensors with Optoelectronic Links by Keith D. Masterson, Motohisa Kanda, and David R. Novotny

1. Introduction...3 2. System concept and analysis...4 3. Antennas 4. Modulators...10 5. Detectors and lasers...20 6. Conclusions...22 7. References...23

Chapter 2. Two-Way Satellite Time and Frequency Transfer (TWSTFT): Principle, Implementation, and Current Performance by D. Kirchner

1. Abstract...27 2. Introduction...27 3. Principle...28 4. System elements...33 5. Operational links and planned links...37 6. Current performance...38 7. Concluding remarks...40 8. Acknowledgments...40 9.References...41

Chapter 3. A Study of the Influence of AC-Mains Impedance and Frequency-Domain EMI Evaluation Methods on EMI Measurements by Shuichi Nitta and Atsuo Mutoh

1. Abstract...45 2. Introduction...45 3. The influence of the LISN and 50 -input-impedance instruments.....47 4. The influence of AC-mains impedance on radiated-emission measurement.....59 5. Introduction of a VHF/UHF LISN.....67 6. The relationship between the EMI evaluation method and the poor reproducibility of measured results.....71 7. Future issues...77 8. References...77

### 4. Disk of Collected references - S. Cellozi

References on arguments of interest for Commission A have been collected through National Commission A Chairs. They have been contacted in 1997 through e-mail, fax or surface mail, in order to submitt the disk of collected references. I have also suplemented this by adding references published mainly in IEEE and IEE Journals. I finally submitted the desk of 238 references which were mainly from 14 National Commission A Chairs.

### 5. CPEM'96 - U. Stumper

The Conference on Precision Electromagnetic Measurements, CPEM'96, took place in the Civic Hall of Braunschweig, Germany, from 17 June to 20 June 1996. This Conference which is permanently sponsored by URSI has acquired an outstanding reputation over more than three decades as an international forum for precision electromagnetic measurements. It is held every two years, either in the USA (or Canada) or in a country outside North America. Besides the URSI, other permanent sponsors of the CPEM are the Bureau International des Poids et Mesures (BIPM), the IEEE Instrumentation and Measurement Society, the National Institute of Standards and Technology (NIST), USA, and the National Research Council (NRC) of Canada. The Commission A Chairman is a member of the CPEM Executive Committee. Traditionally, the Conference is organized mainly by members of the hosting national institute of metrology, but individual members of URSI are involved to a considerable extent. The CPEM was held in Braunschweig for the second time, after 1980, and again

was organized by the Physikalisch-Technische Bundesanstalt (PTB), Braunschweig. The Conference Chairman was Professor Volkmar Kose, Vice President of the PTB.

The number of attendants has considerably increased from about 470 at the CPEM´94 to about 600 scientists from 42 countries, who participated in the Conference this year. An increasing interest of companies and national calibration services in precision electromagnetic metrology was also observed. In 26 oral and 28 poster sessions, about 350 papers and posters were presented, among these 16 invited talks. One oral session was dedicated to post-deadline papers. The authors of the ²best poster of the day² were honoured with a prize. In an extended Young Scientists Program, a financial contribution to the travel expenses was given to 23 young scientists from 13 different countries. Candidates to be included in this program were suggested by the members of the CPEM Honorary Committee, and the final selection was made by a commission of members of the CPEM Technical Program Committee. An additional financial contribution by various institutions allowed financial aid to be given to another 60 participants from developing countries and East European states.

The Conference opened with three plenary papers held by outstanding scientists who introduced three of the essential topics of CPEM´96: Nobel Laureate Klaus von Klitzing, Max-Planck-Institut für Festkörperforschung, Stuttgart, Germany, gave an overview of new developments in the field of the Quantum Hall Effect (QHE). It was at CPEM 1980 in Braunschweig, that he gave his very first report on this effect before an international audience, for the discovery of which he was later awarded. In the two other lectures, Konstantin Likharev, State University of New York, Stony Brook, USA, reported on electronic devices in the nanometer range, the characteristics of which are determined by single electrons, and Herbert Walther, Max-Planck-Institut Garching, Germany, reported on the quantum optics of single atoms. Following the Plenary Session, Richard Deslattes, Klaus von Klitzing, Volkmar Kose, Konstantin Likharev, and Barry Taylor were appointed Honorary Members of the Academy of Metrology of Russia by Professor Yuri Tarbeyev, Director of the Mendeleyev Institute of Metrology (VNIIM), St. Petersburg.

Compared with the 1994 Conference, the number of submitted papers on frequency standards and electric quantum standards has considerably increased. Many of these sessions were dedicated to topics such as cesium beam and optical frequency standards and metrology, and time keeping and distribution, as well as to the different aspects of quantum metrology and fundamental constants. In the field of frequency standards, new fountain geometries and mechanisms of excitations are being developed and investigated, which will allow the uncertainty of Cs clocks to be reduced. On the other hand, novel optical frequency standards are developed on the basis of laser-cooled atoms and ions. As radiation sources for these standards, lasers are used which are based on new technologies such as laser diodes or solid-state lasers pumped by laser diodes and whose efficiency is considerably larger although their dimensions are small. It was reported that, for the first time, the frequency of the radiation of an optical Ca frequency standard could be successfully traced back to the frequency of the primary frequency standard (i.e. the Cs atomic clock) with coherent phase, thus reducing the uncertainty of the realization of the unit of length by a factor of 25.

Among the highlights in the field of electrical metrology were reports of the National Metrological Laboratory (NML) in Lindfield, Australia, and of the NIST, USA, on new determinations of the von Klitzing constant. T. Kinoshita, Cornell University, USA, presented a corrected value for the fine structure constant, which has been obtained, using quantum electrodynamics methods, from the experimentally determined anomalous magnetic moment of the electron. J. Martinis, NIST, Boulder, USA, reported on the development of an electron pump using the single electron tunneling effect (SET ) and consisting of seven SET elements by which the charge of a capacitor is determined by counting the electrons with a relative uncertainty of $10^{-7}$. In several sessions, a large number of papers covering DC and AC measurements, magnetic measurements, power, energy and high voltage measurements and SQUIDS were presented. Several groups reported on precision AC measurements of the QHE. About 20 papers dealt with AC-DC transfer. As a further step towards a more accurate value for the Avogadro constant, the molar mass of a silicon single crystal could be precisely determined by prompt (n, g)-spectrometry. The CPEM´96 included for the first time sessions on novel sensors and automated measurement methods and their applications in precision metrology. In these sessions, too, all papers were well received, followed by extensive discussions which indicated the significance of the topics chosen. In the field of RF measurements, 61 papers were presented in five oral and five poster sessions, which covered topics such as microwave and millimeter wave metrology, power and noise metrology, network analysis and antennas and EMC, including an invited talk by K. H. Gonschorek, Dresden Technical University, on modern computer tools for EMC analysis. There were two very informative reports on RF power standards in the Eastern European countries. Among the highlights were an invited paper on the development of RSFQ shift registers of 8 bit length for applications in RF noise metrology, which will operate at a clock frequency of about 70 GHz, and a paper describing a novel thin-film barretter in 3,5 mm coaxial technique serving as a broad-band RF power standard for frequencies up to 26,5 GHz with high efficient efficiency and low reflection. Two sessions on material measurements also aroused lively interest; these sessions also included several papers on permittivity measurements at high temperatures. Concurrently with the Conference, a very well-attended exhibition was held by more than 20 firms from the USA, the UK, Japan and Germany presenting precision measuring instruments.

## 6. CPEM 98 —— M. Kanda

The National Institute of Standards and Technology (NIST) hosted the 1998 Conference on Precision Electromagnetic Measurements (CPEM >98) in the Washington Renaissance

Hotel, Washington, DC, the week of July 6-10, 1998. In it, 506 metrologists, physicists, and engineers from National Measurement Institutes, industry, and universities around the world discussed the latest advances in standards, instrumentation, measurement techniques, and practice with the ultimate objective of providing a more uniform international measurement system through the advancement of metrology and physics.

The conference covered the entire spectrum of electromagnetic measurements from dc to light in 310 talks, with the two largest technical fields being time and frequency and dc low frequency. The conference was opened by then-NIST Acting Director, Dr. Robert E. Hebner, who welcomed the participants on behalf of the Institute and its Electronics and Electrical Engineering, and Physics Laboratories. The keynote speaker, Prof. Daniel Kleppner of the Massachusetts Institute of Technology, kicked the program off with a talk on the evolution of quantitative experimentation in physics and the consequent increasing importance of uncertainties and their determination.

Kleppner was the first in a slate of outstanding plenary speakers, including: William D. Phillips (NIST), 1997 Nobel laureate in physics; Carl Wieman of the JILA/ University of Colorado team, first to demonstrate Bose-Einstein condensation; Barry Inglis, a leading expert in precision ac-dc difference metrology and head of the NML/Australia; Ulrich Stumper (PTB), who spoke on rf and microwave power developments; Bryan Kibble (NPL), a forefront researcher in monitoring the kilogram by electromagnetic means.

Thanks to our sponsors, the conference was able to support 11 young scientists from around the world. Under this program, the conference invites promising young scientists to present their work to the world metrology community with the hope that they will become its future citizens and leaders. The winners were: Ralf Behr, Germany; Claus Braxmaier, Germany; Luca Callegaro, Italy; Sze Wey Chua, Singapore; Richard Dudley, U.K.; Ling Hao, U.K.; Damir Ilic, Croatia; Savely Karshenboim, Russia; Michel Poulin, Canada; Serge Svitlovb, Ukraine; Zhang Wei, China; Peter Yegorov, Russia.

The CPEM Executive Committee met during the week to discuss plans for the next two conferences and decide the venues for the following two. We urge you to participate in CPEM 2000 in Sydney, Australia, hosted by the CSIRO National Measurement Laboratory (see http://www.tourhosts.com.au/cpem2000); CPEM >02 in Ottawa, Ont., Canada, hosted by the NRC Institute for National Measurement Standards; CPEM >04 in London, U.K., hosted by the National Physical Laboratory; and CPEM >06 in Forino, Italy, hosted by the Politecnico di Torino, Istituto Elettrotecnico Nazionale Gaileo Ferraris, and Istituto di Metrologia AGustavo Colonnetti.@ We want to express my gratitude to the members of the Conference Organizing Committee and the Technical Program Committee for their efforts in putting on a successful conference, and to Courtesy Associates, who provided all the administrative and logistics support for the Conference and a great deal of much-needed advice to the organizers. Thanks also to our sponsors for making our AYoung Scientists Program@ possible and to our exhibitors.

Finally, we want to thank the speakers and authors whose talks and papers made the CPEM >98 such a success!

CPEM >98 Sponsors: American Association for Laboratory Accreditation, Andeen-Hagerling, Anritsu Corporation, APS Instrument and Measurement Science Topical Group, APS Topical Group on Precision Measurement and Fundamental Constants, Baltimore Gas and Electric Co., Cal Lab Magazine, Clarke-Hess Communications Research Corp., Creative Marketing Associates, Fluke Corp., Guildine Instruments, Hewlett-Pacard Company, IEEE Instrumentation and Measurement Society, Washington, DC, Chapter, IEEE National Capital Area Council, International Union of Pure and Applied Physics, National Conference of Standards Laboratories, Organization of American States, Physikalisch-Technische Bundesanstalt, Wavetek Corporation

Permanent CEPM Sponsors: Bureau International des Poids et Mesures, IEEE Instrumentation and Measurement Society, National Institute of Standards and Technology (NIST), National Research Council of Canada, and URSI.

## 7. The 14th Meeting of the CCTF - J. Steele

The Consultative Committee on Time and Frequency, BIPM, met in Sèvres, on 20-22 April, 1999. The previous Consultative Committee for the Definition of the Second met for the first time under its new style and with a new chairman, Professor Sigfrido Leschiutta, President, IEN, Italy and a past chairman of Commission A. The meeting attracted the largest recorded attendance, with 48 representatives from metrological establishments world-wide together with three scientific unions, IAU, IUGG and URSI. A total of seven Recommendations were agreed, three (S1-3) addressed to primary frequency standards and their operation and the remainder (S4-7) to methods of satellite time and frequency comparison. An additional output was a circular letter from the Director, BIPM, emphasising the utility of TAI, as opposed to UTC, for systems requiring uniform time, i.e. free from the discontinuities arising from the application of leap seconds.

At a meeting of the Consultative Committee for Time and frequency (CCTF) held here in April 1999, attention was drawn to potential problems that might arise if a number of new, independent, uniform atomic time scales were developed for satellite navigation and electronic communication systems. There is apparently a perceived need for such uniform time scales to avoid problems in navigation systems resulting from discontinuities in UTC produced by the periodic introduction of leap seconds.

There was no consensus within the CCTF for any proposal to change the definition of UTC. Instead, I was asked as Director of the BIPM to draw your attention and that of agencies developing satellite navigation systems, to the option of using TAI which is, of course an international uniform time scale. I remind you of the ITU Recommendation ITU-R 485-2 (1974-1982-1990) in which

it is recommended that Atime data should be issued wherever possible either with reference to Coordinated Universal Time (UTC) or to International Atomic Time (TAI)@. It is clear that if the leap seconds of UTC cause problems in any particular application, the preferred alternative is TAI.

The CCTF recommends, therefore, that in conformity with this ITU Recommendation developers of future satellite navigation systems and electronic communication systems should link their time scales to TAI as the only alternative to UTC and that, insofar as it is feasible, existing systems take steps to align their time scales with TAI. This is in conformity with the CCDS Recommendation S4 (1996) on the Acoordination of satellite systems providing timing@, in which it was recommended that Athe reference times (modulo 1 second) of satellite navigation systems with global coverage by synchronized as closely as possible to UTC@. To facilitate the direct use of TAI for satellite navigation systems, the time community is willing to take any steps that are necessary to make TAI easily accessible to users. UTC remains the basis for worldwide timekeeping, but TAI is recommended for those applications requiring uniform time. I urge you to take the necessary steps to inform your constituents of the characteristics of both UTC and TAI so that appropriate use may be made if these international scales. I enclose a few documents that may be of help in this respect.

At its recent meeting, the CCTF also considered the question of terrestrial reference frames. It recalled that the above-mentioned Recommendation $4 (1996) states that Athe reference frames for these [satellite navigation] systems be transformed to be in conformity with the terrestrial reference frame maintained by the International Earth rotation Service (ITRF)@. Considering the increasing requirements expected for the accuracy of time transfer techniques in view of the present and future progresses of atomic clocks, as well as those expected for navigation and positioning, the CCTF expressed the opinion that it is of utmost importance that satellite systems plan to use a well-defined terrestrial reference system, such as the one realized by the ITRF.

The development of primary standards in the form of 'cesium fountains' in a number of laboratories has propelled the uncertainties in the realization of the second to the level of about $10^{-15}$. Consequently, it has been necessary to develop a *mise en practique* (S1) for the application of the increasingly important small perturbations in these standards. Equally, the statements of uncertainty become critical at this level and procedures are recommended (S2, S3) for stricter accountability in assessing and comparing primary standards. The formation of TAI in entirely dependent on satellite time transfer and S4 extends the range of international coordination by the use of combined GPS and GLONASS receivers. S5 encourages cooperation with the IGS (International GPS Service) in achieving precise time transfer using both code and phase measurement while S6 recognises the importance for future global navigation systems in designing a format so that the signals are available for T/F comparisons and also adhere to UTC or TAI. Finally, S7 encourages the continued development of two-way satellite time transfer which is now fully operational and offers an independent alternative to the GPS/GLONASS common-view technique.

## 8. Technical Activities in Time and Frequency Metrology, 1996-1998 - E. Bava.

Studies and experiments on the Cs-fountain clock in Paris have been carried out with a better understanding of the standard and with an the experimental evaluation of the most important frequency shifts. At the moment the frequency accuracy is estimated at the level of $10^{-15}$. In the meantime in many laboratories the development of this standard has started and in one laboratory experiments have been carried out on a Rb fountain . Other microwave standards based on cold Cs atoms are also under develpment looking at experiments in microgravity conditions or in continuous operation as an alternative to the pulsed fountain clock. In the more traditional area of thermal atomic beams efforts have been performed on laboratory optically-pumped standards, increasing accuracy through a better evaluation of Doppler and microwave-power effects. In a high-C field standard improvements in the magnetic field homogeneity have been obtained to the $10^{-5}$ leve, not too far from the project goal. Moreover an interesting device based on coherent population trapping of Cs or Rb atoms has been studied and is under development: a reduced light-shift has been obtained and an excellent short-term stability is expected.

Trapped ion frequency standards have offered new developments and results both in the microwave ($Hg^+$ cooled) and in the optical region ($Hg^+$, $Sr^+$ single, $Yb^+$ single). Moreover the cooled Ca atom beam standard has reached an accuracy level of 2.5 $10^{-13}$ . These reserch activity have also promoted the development of phase-coherent frequency chains to perform frequency mesurements on these standards; parametric oscillators and comb generators are relatively new devices used to this purpose.

The acetilene frequency standardat 1.5 mm, an interesting device for fiber optic communications, has been improved and new frequency measurements against the two-photon Rb standard have been carried out. Efforts towards a 1.5 mm standard exploiting an Er-Yb:glass laser have been started.

The list of recommended frequencies for the realization of the meter has been updated in 1997 and now includes twelve frequency references (H, Ca, $Sr^+$, Rb, CH4, OsO4 and many I2 absorptions). Stabilized lasers have been developed and compared aiming at improving their stability and to ascertain reproducibility; most of the work has been concentrated on I2 at 532 nm, but experiments have been carried out also on other I2 transitions at 633 nm, 612 nm, 605 nm and 543 nm.

Cryogenic resonators made of saffire or ULE material to stabilize sourses for high-spectral-purity microwave and optical signals have been developed and experimentally tested showing interesting short-term and medium-term stability characteristics.

As regards frequency and time comparisons, experimental activities mainly on the two-way methods led

to the introduction of this method on the time scale formations, both at national and international stage. Moreover earth station errors due to the environment and to modulation/demodulation scheme have been investigated. A novel method of time synchronisation using laser and space techniques using the japanese Ajisai satellite fitted with retroreflectors and lasers has been studied. The INSAT satellite has been used for accurate time synchronization and frequency calibration in India. Residual errors of 1 ms are achieved with a differential method.

## 9. ISEM - U. Stumper

The 8th International Symposium on Non-Linear Electromagnetic Systems (ISEM Braunschweig) was held in the Civic Hall, Braunschweig, Germany, 12 to 14 May 1997. The Symposium was the eighth of the ISEM series organized to cover the inter-disciplinary field of research and applied electromagnetics. Previous ISEMs were held in Japan, Korea and the United Kingdom. The objective of ISEM Braunschweig was to exchange information on various topics as: - Advanced Mathematical Methods, Computational Techniques - Material Properties and their Modelling - Microelectromechanics - Inverse Problems - Design of Magnetic Devices - Biomagnetism and Biomagnetic Applications - Non-destructive Testing and other topics of interdisciplinary interest. ISEM Braunschweig covered the present state of the art in these fields and offered the participants the bonus of its interdisciplinary character. Over 260 papers were presented in oral and poster sessions. The program included 22 oral presentations, eleven of which were invited talks, and four tutorial lectures. There were 240 poster contributions presented in six poster sessions. The conference was attended by 261 participants from 27 countries. Financial support was granted to 22 young scientists in an extended Young Scientists Program partly sponsored by URSI, Commission A, where the final selection was made by a commission of members of the Technical Program Committee. In order to give an opportunity for attending the conference to participants who would otherwise have been unable to participate, 35 additional students and 77 attendants from Middle and East European countries have been substituted.

## 10. EMC Zurich '97 - G. Meyer

EMC Zurich '97, the 12th International Zurich Symposium and Technical Exhibition on Electromagnetic Compatibility was held from February 18 to 20, 1997 and EMC Zurich '99 from February 16 to 18, 1999 at the Swiss Federal Institute of Technology in Zurich, Switzerland. The 1997 event was attended by 1029 participants from 38 countries and the 1999 event by 997 paticipants from 40 countries, respectively. At EMC Zurich '97, a total of 126 carefully selected technical papers were presented in 18 sessions devoted to: standards, component and subcircuit EMC, lightning and its effects (part I and II), electrostatic discharge, system EMC and radio communications, EMC instrumentation and measurement, shielding, numerical modeling for EMC, test facilities, EMC education, coupling and transmission lines, emission and immunity testing, low frequencies and power systems, circuit oriented techniques in EMC, surges and transients, EM field standards and sensors as well as modeling. For EMC Zurich '99 a total of 129 papers have been presented in the following 18 >sessions: protection and mitigation, EMC management, bio-electromagnetic interactions, ESD and fast transients, EMC in extended systems I and II, antenna calibration for EMC testing, transients, board and chip-level EMC I and II, measurements technology I and II, power system EMC, numerical methods, transmission lines, EMC innovation, lightning physics and effects as well as EMC test chambers. As in previous symposia the program did not exclusively address experts. An introduction to EMC technology for newcomers is always offered by tutorial lectures and workshops. A number of international and national professional organizations were cooperating, e.g. ITU, IEEE and URSI. With the support of the URSI Young Scientists Program it was possible to invite four researchers from Belarus, Russia and India for EMC Zurich '97. URSI Support from Commission A and E was given in 1999 to four young scientists from Croatia, Russia and Turkey.

## 11. EMC'96 Roma - M. D'Amore

The Second International Symposium on Electromagnetic Compatibility (EMC'96 ROMA) was held at the Faculty of Engineering, University of Rome „La Sapienza", Rome, Italy, September 17- 20, 1996. The Symposium was organized by the University of Rome „La Sapienza" and Associazione Elettrotecnica ed Elettronica Italiana (AEI), sponsored by URSI, CNR - National Research Council, Italferr-Sis. T.A.V., and cooperated by IEEE North Italy Section and IEEE Central and South Italy Section. The International Steering Committee (ISC) was composed by M. D'Amore, Chairman, (Italy), P. Bernardi, Vice-chairman, (Italy), M. Feliziani, Secretariat, (Italy), N.G. Alexopoulos (USA), F.G. Canavero (Italy), J. Catrysse (Belgium), C. Christopoulos (UK), P. Corona (Italy), G. Costache ( Canada), J. Cristina (Italy), V. Daniele (Italy), P. Degauque (France), R. De Leo (Italy), K. Feser (Germany), J.L. ter Haseborg (Germany), M. Ianoz (Switzerland), B. Jecko (France), A.C. Marvin (UK), C. Mazzetti (Italy), E. Nano (Italy), R.G. Olsen (USA), J.C. Sabonnadiere (France), R. Sato (Japan), V. Scuka (Sweden), F.M. Tesche (USA), P.C.T. van der Laan (NL). The Editorial Board was composed by all the members of the ISC and by B. Audone (Italy), C. Baum (USA), D.J. Bem (Poland), S. Caniggia (Italy), A. Ciccolella (NL), V. Cooray (Sweden), R. Cortina (Italy), J.F. Dawson (UK), J.L. Drewniak (USA), B. Demoulin (France), G. D'Inzeo (USA), P. Excell (UK), R. Feuillet (France), Z. Flisowski (Poland), O.P. Gandhi (USA), C.J. Georgopoulos (Greece), J.J. Goedbloed (NL), K.-H. Gonschorek (Germany), R. Graglia (Italy), C.L. Holloway (USA), M. Kanda (USA), J.C. Lin (USA), C.A. Marshman (UK), S. Maruvada (Canada), L. Millanta (Italy), I. Novak (Hungary), C.A. Nucci (Italy) C.R. Paul (USA), F. Rachidi (Switzerland), J. Roudet (France), T. Rozzi (Italy), D. Serafin (France), H. Singer (Germany), M.A. Stuchly (Canada), R. Thottappillil (Sweden), P.L.E. Uslenghi (USA), E.F. Vance (USA).

More than 250 summary papers have been submitted for presentation to EMC'96 ROMA Symposium by authors of 35 different countries. Each summary has been reviewed by three members of the Editorial

Board, experts in the subject of the paper and with a different nationality from that of the authors. Each main author then received a copy of the anonymous Paper Review Forms completed by the referees.

A meeting of the ISC was held in Rome on February 29 - March 1, 1994, to complete the review process and define the technical programme composed by three-day oral and poster presentations plus workshops and tutorials. In the final programme 178 technical paper presentations have been scheduled, 108 presentations in oral sessions including 2 invited papers and 70 presentations in poster sessions. The maximum six-page, double-column papers have been published on the two-volume, 894 page Symposium Proceedings. The Workshops and Tutorial notes have been published in two separate volumes. In order to promote a wide participation, only two parallel oral sessions have been scheduled in the technical programme. The oral presentations have been subdivided in 18 oral sessions on the following EMC subjects: EMC Measurements - Transmission Lines - Human Exposure to EM Fields - Immunity/Emission - Communications Systems - Shielding Modelling - Protection Devices - EMC Standards - Numerical Modelling - Field Probes - Cables - Shielding Measurements/ESD - PCBs I - PCBs II - Railway Systems/ Power Electronics - Lightning - Power Systems - Rooms & Cells. The final programme has included the invited opening session "EMC Aspects related to the European Standards on Human Exposure to EM Fields with the participation of B. Kunsch, Chairman of CENELEC TC211. The poster presentations have been scheduled in the afternoon without overlapping with the oral sessions and have been subdivided in the following 10 poster sessions: EMI in Power Apparatus and Systems - Harmonics & Power Electronics - EMC Education - Antennas & Communication Systems - Electronic Devices - Biological Interactions - Measurements & Instrumentation - Lightning and EMP - EM Coupling/ Transients - Computational Electromagnetics.

In order to encourage discussion and participation during the sessions, Oral Presentation Best Paper and Poster Presentation Best Paper awards of ITL 1.000.000 have been established. The best papers have been selected during the symposium by the ISC members and the session chairmen on the basis of content, presentation and discussion of the paper. The Oral Presentation Best Paper award was given ex-aequo to the paper "Electromagnetic field coupling to shielded cables: methodology and approximations" by D. Orzan, M. Ianoz, F. Rachidi, (EPFL, Switzerland), and B. Nicoara (Polytechnic of Bucarest, Romania), and to the paper "Interconnect Model for Commercial Simulators" by I. Maio, F.G. Canavero, (Polytechnic of Turin, Italy) F. Muzio, B. Dilecce (Centro Ricerca FIAT, Italy). The paper "The influence of finite ground conductivity on characteristics of a vertical mast (monopole) antenna with elevated feeding", by P.D. Rancic, J.V. Surutka and M.I Kitanovic (University of Nis, Yugoslavia) won the award for Poster Presentation Best Paper.

In the Symposium six workshops and four half-day tutorials took place. The six workshops have debated the hot topics listed in the following:

- WS1: "Control of ELF Field", organized by Prof. R. G. Olsen (Washington State University, USA);
- WS2: "European EMC Directive & its Application", organized by R. Cortina (ENEL, Italy);
- WS3: "EMC Testing & Certification", organized by G. Santagostino (CESI, Italy);
- WS4: "Protection against Lightning Electromagnetic Pulse (LEMP), organized by Prof. C. Mazzetti, (University of Rome "La Sapienza", Italy);
- WS5: "Power Electronics & EMC Effects", organized by Dr. J. Roudet (INPG - LEG - ENSIEG, France);
- WS6: "Methodologies for EMC-Adequate Design of PCB's and Systems", organized by Dr. W. John (Siemens Nixdorf, Germany)

The four tutorials were taken on the following relevant EMC topics:

- Tutorial A: "Field -Excited Multiconductor Transmission Lines" organized by Prof. M. D'Amore (University of Rome "La Sapienza", Italy);
- Tutorial B: "Personal Communication Systems: EMC and Human Health Concern" organized by Prof. P. Bernardi (University of Rome "La Sapienza", Italy);
- Tutorial C: "Numerical Methods in EMC" organized by Prof. M. Feliziani, (University of L'Aquila, Italy);
- Tutorial D: "Basic EMC Measurements" organized by Dr. M. Kanda (NIST, USA).

The Symposium has been accompanied by a technical exhibition related to EMC; 21 exhibitors have been registered. The Technical Visit was to the satellite and antenna test facilities of Alenia. All the activities related to the symposium have taken place around the antique cloister inside the Faculty building, which is located very close to the Colosseum and the archeological areas of Rome. Social Programme has included a welcome cocktail at the Villa Giulia and Etruscan Museum and a banquet at the Villa Miani. Interesting tours have been also organized to visit some well known, tourist areas of the city (St. Peter and Vatican Museums, Roman Forum, christian basilicas and catacombs).

The technical programme has been appreciated by the participants if considering the relevant number of attendees (more than 500 people) at all oral and poster sessions. Particularly the poster sessions have been a success for the friendly atmosphere which has encouraged informal discussions among the participants.

## 12. EMC'98 Roma - M. D'Amore

EMC '98 Roma, the third International Symposium on Electromagnetic Compatibility organized by the University of Rome "La Sapienza" and AEI "Associazione Elettrotecnica ed Elettronica Italiana", took place at theFaculty of Engineering, University of Rome "La Sapienza", from 14 to 18 September 1998.

The International Steering Committee was composed as follows: Chairman M. D'Amore, Italy; Vice-Chairman P. Bernardi, Italy; Secretary M. Feliziani, Italy; Members D.J. Bem, Poland, F.G. Canavero, Italy, J. Catrysse,

Belgium, C. Christopoulos, United Kingdom, P. Corona, Italy, R. Cortina, Italy, V. Daniele, Italy, P.Degauque, France, R. De Leo, Italy, G. Dragan, Romania, K. Feser, Germany, J.J. Gavan, Israel, M. Hayakawa, Japan, M. Ianoz, Switzerland,, B. Jecko, France, M. Kanda, USA, P.S. Maruvada, Canada, A.C. Marvin, United Kingdom, C. Mazzetti, Italy, R.G. Olesn USA, C.R. Paul, USA, J.C. Sabonnadière, France, R. Sato, Japan, V. Scuka, Sweden, J.L. ter Haseborg, Germany, F.M. Tesche, USA, P.C.T. van der Laan, The Netherlands, Y.B. Zubarev, Russia.

224 summaries were submitted to EMC '98 ROMA by authors coming from 40 different Countries. All the contributions, consisting of a wide abstract of the paper, were selected by three reviewers of different nationality from authors and experts in the specific field of the proposed summary. The review result with relevant documentation was sent to the authors. The 174 papers accepted were subdivided into oral and poster sessions respectively. The EMC '98 ROMA final programme was composed of 16 oral sessions, 10 poster sessions, 7 workshops, 4 tutorials, 4 panel sessions, an Erasmus course.

The oral and poster sessions dealt with aspects on electromagnetic compatibility in the following fields: measurements and instrumentations, transmission lines, human exposure to EM fields, radiated emission, telecommunication sytems, numerical modelling, field sensors, electrostatic discharges, cables, regulations, printed circuits design, power electronic systems, absorption and compound materials, railway systems, , anechoic chambers and TEM cells, , EMC education and management .Two awards of one Million It.lire each were assigned to the best papers selected by the International Steering Committee and proposed for the oral and poster sessions respectively.

The best contributions were:

- oral session: F. Pezin, L. Kone, B. Demoulin, Ch. Girard, A. Reinex, B. Jecko "Experimental characterization of the attenuation and radiation dueto bended transmission lines"
- poster session, ex aequo:
  - G.S. Ferreira, A. Raizer, C. Christopoulos "Simulation of the effects of printed circuits board layout on current flow and emission"
  - S. Silverskiöld, M. Backstrom, J. Loren "Microwave field- to-wire coupling measurements".

The event opened with the greetings of the academic authorities of the University La Sapienza - Rome, and AEI Associazione Elettrotecnica ed Elettronica Italiana. The new trends in reserach and industrial activities in EMC were discussed during the plenary session.

The programme of the symposium also included 7 workshops on the following items:

- WS1 Technical aspects and human protection in mobile communication systems
- WS2 EMC in railway wehicles
- WS3 Testing and certification
- WS4 Developments in EMC measurement chambers
- WS5 New development in EMC
- WS6 Popourri of EMC
- WS7 IEEE EMC Society

4 Tutorial sessions were held with the attendance of researchers and eminent experts :

- Tutorial A Signal integrity and radiated emission from PCBs in complex digital systems
- Tutorial B EMC in power electronics
- Tutorial C Software tools for EMC design
- Tutorial D Reverberation chamber measurements technique

4 Panel sessions on topical subjects closed the technical programme:

- PS1 Portable electronics and medical devices on airplanes
- PS2 Fifth framework programme exploitation of research and technological results -EMC research aspects
- PS3 Critical levels for human exposure to EM fields
- PS4 EMC in space

More than fifty students from European Universities attended the three-days Erasmus course. Four URSI awards were assigned to young researchers. A technical exhibition with 16 domestic and overseas companies and a technical visit to CRAV (Regional Centre of Assistance to the Flight-Ciampino Airport ) were also organized. The social programme included a welcome cocktail at Palazzo Barberini and a Gala Dinner at the Grand Hotel.

EMC'98ROMA achieved a great success both for the overall attendance (about 500 delegates from 36 Countries) and for the quality of the scientific contents.

The International Steering Committee of EMC'98 ROMA gave life to a new event: "EMC Europe 2000" scheduled for 11-15 September 2000 at Bruges, Belgium.

## 13. EMC'99 Tokyo - S. Nitta

The fourth international symposium on Electromagnetic Compatibility, EMC'99 Tokyo was held at the Surugadai Memorial Hall, Chuo University, in Tokyo, Japan on May 17-21 1999. The number of participants: 493 (including twenty-three accompanying persons one hundred and twelve foreigners from twenty-one countries )

The number of papers presented:

1) General session:196
2) Invited Papers: 20 Total : 216 ( including eighty-six papers by foreigners)
3) APTS:22 (Advanced Products and Technology Session)

It is specially remarkable that the number of papers of PCB (Printed Circuits Board) was thirty-one, and the numbers of papers of " Transmission lines", "ESD + lighting" and " Biological effects" were fifteen, fourteen and thirteen, respectively. Exciting and fruitful discussions were watched at all session rooms.

Many people were interested in APTS including experiments and measurements demonstrations and eagerly discussed each subject, observing demonstrations. The IEEE events such as standards committee, workshop, BOD meeting and so on were held in parallel with technical sessions and many participants were enlightened.

THE book about " Information about Advanced Knowledge " was published and distributed to all participants.

Many people enjoyed two technical tours ( Mitsubishi Electric Co.Ltd. and historical Kamakura , and NTT and Metropolitan Tokyo )

## 14. 13th EMC Wroclaw - H. Trzaska

### BACKGROUND

The first Wroclaw Symposium on Electromagnetic Compatibility was held in 1972, when there was no regular conference on that topic in Europe. Since 1976 this biennial gathering has been successful in attracting world-class personalities and leading global organizations. Among others, Professor F.L. Stumpers, Honorary President of URSI, has directed without interruption the Program Committee over the twenty years of its existence. The symposium has enjoyed the sponsorship and cooperation of the most prestigious global organizations such as URSI, the International Telecommunication Union - ITU, the International Electrotechnical Commission - IEC, the Institute of Electrical and Electronics Engineers - IEEE, to list only few of them. The year 1982 was peculiar: program, authors, papers and Proceedings were ready, but there were no participants. Because of the martialow status declared in Poland, the organizers decided not to gather participants. Over the years, the Wroclaw symposium earned recognition of the scientific and engineering world. In his review of URSI activities from 1922 until 1995, at the occasion of 75 anniversary of URSI, Dr. P. Bauer wrote in The Radio Science Bulletin (No. 277, June 1996, page 17):

*„Our Commission on Electromagnetic Noise and Interference deals, among others, with terrestrial and planetary noise of natural origin and man-made, the composite noise environment the effects of noise on system performance and the scientific basis of noise and interreference control. Ever since 1975, the Commission participates actively in the planning and organisation of the very successful series of international symposia on Electromagnetic Compatibility, which are held alternatively in Wroclaw and in Zurich. According to our Honorary President, Professor Stumpers: >EMC is really a multidimensional field of research and, in our highly technological civilization, an indispensable one<„.*

The history of the twenty four years during which the Wroclaw EMC symposium gathered every two years eminent scientists, engineers and administrators from around the world confirms that opinion.

### 1996 SYMPOSIUM

As in previous years the Symposium was organized by the Association of Polish Electrical Engineers, the Institute of Telecommunications, and the Wroclaw Technical University. It was co-sponsored by URSI and supported by other international organizations as well as by national associations of electrical and electronics engineers from 21 countries.

The Symposium Council was chaired by Prof. W. Majewski (Poland) with v-chairman Prof. A. Pi³atowicz (Poland), and the Scientific Program Committee by Prof. F.L.H.M. Stumpers (The Netherlands) with v-chairman R.G. Struzak (Poland). The co-chairmen of the Symposium were Prof. D.J. Bem and Mr. J. Rutkowski, and the Organizing Committee was chaired by Mr. W. Moroñ. There were 298 participants from 31 countries. The most numerous groups were from Poland (140), Russian Federation (29), Germany (18), Japan (15), Italy (10), Hungary (8), France (7), Switzerland (7). Some people came from Canada, Egypt, Israel, Korea (Rep. of), Turkey. Proceedings containing 161 papers accepted for presentation, delivered by 317 authors and co-authors from 32 countries were available to all the participants at the opening the Symposium.

*Accompanying events*

On the day before the Symposium three events took place:
- URSI Commission E „EM NOISE and Interference" open meeting on EM noise and its impact on systems and equipment (chairman: Prof. V. Scuka, Sweden);
- COST*) 243 „Electromagnetic Compatibility" Workshop on EMC in Telecommunications (chairman: Prof. P. Corona, Italy);
- Tutorial "EMC-Adequate-Design of Printed Circuit Boards (Simulation-Analysis-Measurements)" given by Dr. W. John from Siemens Nixdorf Informations-Systeme AG, Paderborn, Germany.

On the day after the Symposium one event took place:
- COST*) 244 „Biomedical Effects of EM Fields" plenary meeting.

*) COST - European Cooperation in the field of Scientific and Technical Research

*Opening*

The Symposium was opened by its chairman, Prof. D.J. Bem. PTT V-minister, Dr. M. Rusin greeted the audience on behalf of Symposium Patron.

*Plenary sessions*

Three plenary sessions were held on the first three days of the symposium. The following papers were presented:
- „EMC-Globalisation: The Role of Scientific Societies" by Dr. F. Mayer (France), representing IEEE-EMCS,
- „EMC of Printed Circuit Boards and Microelectronic Engineering Techniques" by Dr. W. John (Germany),
- „Key Issues in Spectrum Management" by Prof. R.G. Struzak (Poland),
- „Menace to Human Environment and Biological Effects of EM Radiation of Unspecified Frequency and Intensity Caused by Careless High Technology Implementations in the Near Future" by Prof. T. Yoshino (Japan).

*Sectional sessions*

Twenty five regular and nine poster sessions covered different fields of EMC. Among regular sessions - the following invited sessions were organized:
- Terrestrial EM Noise, organized and chaired by Prof. M.Hayakawa (Japan); URSI Commission E sponsored session,
- Lightning, EMP and LEMP - I and II, organized and chaired by Prof. M. Ianoz (Switzerland); URSI Commission E sponsored session,

- EMC for PCB Design and Microelectronic Applications, organized and chaired by Dr. W. John (Germany),
- Electrobiology for Defeating Cancer and Other Diseases, co-organized by Prof. H. Kikuchi (Japan), and co-chaired by Prof. H. Kikuchi and Prof. S.F. Alfas (Denmark); URSI Commission E and K sponsored session,
- EMC in Wireless Communication Systems, organized by Prof. W.C. Lee (USA), and chaired by Prof. K. Fujimoto (Japan),
- Signal Integrity, organized by Prof. I. Novak (Hungary), and chaired by Dr. F. Canavero (Italy),
- EMC Testing and Testing Requirements in View of the New European Standards Proposals, organized and chaired by Prof. A.S. Podgorski (Canada),
- Electromagnetic Compatibility in ISM Applications, organized and chaired by Prof. W.M. Van Loock (Belgium),
- EM Emissions Associated with Seismic Activity, organized and chaired by Prof. T. Yoshino (Japan); URSI Commission E sponsored session.

The titles of the other sessions were:

- Antennas and Propagation, EMC Aspects (chaired by Mr. K.A. Hughes - ITU, Switzerland);
- Antennas and Propagation, EMC Aspects (poster session);
- Biological Effects of EM Radiation (poster session);
- Computational Electromagnetics - I and II (chaired by Prof. A. Karwowski, Poland);
- Education in EMC (chaired by Prof. J.A. Catrysse, Belgium);
- EMC in PCB (chaired by Prof. S. Nitta, Japan);
- EMC in Power Engineering (chaired by Prof. A. Piatowicz, Poland);
- EMC in Wire Communication (chaired by Prof. G. Varju, Hungary);
- EMC Measurements and Instrumentation - I (chaired by Mr. M.C. Vrolijk, The Netherlands);
- EMC Measurements and Instrumentation - II (chaired by Dr. D. Hansen, Germany);
- EMC Measurements and Instrumentation (poster ses.);
- EMC Prediction, Analysis, Modelling (chaired by Prof. S.M. Radicella, Italy);
- EMC Prediction, Analysis, Modelling (poster session);
- EMI Sources and EMI Reduction Techniques (chaired by Prof. H. Trzaska, Poland);
- ESD, Lightning, EMP (chaired by Prof. V. Scuka, Sweden);
- ESD, Lightning, EMP (poster session);
- Grounding and Shielding (chaired by Dr. F.P. Dawalibi, Canada);
- Grounding and Shielding (poster session);
- Immunity (chaired by Prof. E. Habiger, Germany); Immunity (poster session);
- Natural and Man-Made EM Environment (poster session);
- Spectrum Management, Engineering, Sharing, Monitoring (chaired by Prof. R.G. Struzak, Poland);
- Spectrum Management (poster session).

The review of the content of papers offered is given in the overview presented by Prof. F.L. Stumpers.

*Workshops*

Four workshops took place during the Symposium:

- Advantages of Using a Competent Body for CE-EURO-Certification, organized by EU Association of Component Bodies. Organizer and Moderator: Dr D. Hansen from EURO EMC SERVICE, Teltow, Germany,
- Surge Voltage Protection for Data and Telecom Systems, organized by Phoenix Contact, Blomberg, Germany. Speaker: R. Hausmann,
- Interoperability of National Spectrum Management Systems, organized by European Radiocommunications Office, Copenhagen, Denmark. Speaker: T. Cesky,
- Protection and Certification of Aircraft Avionic Systems from Lightning Indirect Effects, organized by Lightning Technologies Inc., Pittsfield, USA. Speaker: R. Kolodziejczyk.

*Young scientists*

Young Scientists Program was organized with the financial support of URSI. Support was offered to two young scientists (from Belarus and Russia).

*Technical Exhibition*

The technical exhibition was held during the Symposium with the participation of 10 companies. The exhibition was well attended.

*Literature Exhibition*

The literature exhibition was organized in which exhibited were the publications of international organizations such as International Union of Radio Science - URSI, International Telecommunication Union - Radiocommunication Sector and Telecommunication Standardization Sector (ITU-R, ITU-T), European Telecommunication Standards Institute - ETSI, European Broadcasting Union - EBU, European Electrotechnical Standards Committee - CENELEC, and International Electrotechnical Committee - Special Committee on Radio Interference - CISPR and Technical Committee 77 "Electromagnetic Compatibility". Besides some books on EMC, spectrum management and electromagnetics, yearly editions such as ITEM, and some specialized periodicals as e.g. Microwave News were shown. The exhibition, a unique initiative on such symposia, was well received and well attended.

*Computer network*

A computer network with dedicated server was available to all participants to enable software presentations and in depth discussions. The network was connected to Internet. Free of charge service was offered.

*Council and Program Committee Meeting*

A Joint Meeting of the Symposium Council, the Scientific Program Committee, and the Organizing Committee, together with Session Chairmen was held on the last day.

The meeting was co-chaired by Prof. A. Piatowicz v-chairman of the Symposium Council, and Prof. R.G. Struzak, v-chairman of the Scientific Program Committee. Prof. Stumpers, who did not come to the Symposium, wrote a letter to participants and those present at the meeting signed a greeting letter to him. During the meeting the present Symposium was evaluated and improvements and possible changes for the future were discussed. The current event was positively evaluated and it was stressed that the broad range of the Symposium topics, resulting from the accepted EMC definition, should be continued. The prevailing opinion was that such a strategy can lead to fruitful new ideas, and duplication of efforts can be avoided thanks to contacts and discussions among specialists involved in various fields of EMC. But also some people were of the opinion that each consecutive symposium should have limited topics. More scientific atmosphere of the Symposium in comparison with some other, more commercially oriented, events was praised. It was also emphasized that mixing of theoretical and engineering topics is very fruitful and should be retained. The positive influence of the interaction between those involved in theory and those involved in the engineering practice cannot be overestimated.

## 15. 14th Wroclow Symposium - R.G. Struzak

The 1998 Symposium, as all the previous ones, was organized by the Association of Polish Electrical Engineers, the Institute of Telecommunications, and the Wroclaw University of Technology. It was co-sponsored by URSI and enjoyed cooperation of other international organizations as well as national associations of electrical and electronics engineers from 21 countries .

The following organizations supported the Symposium: National Radiocommunication Agency (Poland), Polish Telecommunications Co., Plus GSM - Digital Mobile Telecommunication Network (Poland), Polish Digital Telephony ERA GSM Ltd. The Symposium Council was chaired by Prof. W. Majewski (Poland) with v-chairmen Prof. A. Pilatowicz (Poland), and Dr M. Rusin (Poland). The Scientific Program Committee was chaired by Prof. R. G. Struzak (Poland) and Prof. F.L.H.M. Stumpers (The Netherlands) was Honorary Chairman. The co-chairmen of the Symposium were Prof. D.J. Bem and Mr. J. Rutkowski, and the Organizing Committee was chaired by Mr. W. Moron. There were 355 participants from 34 countries. The most numerous groups were from Poland (178), Germany (18), Russian Federation (17), USA (15), Japan (14), France (13), United Kingdom (12), Belarus (9), Italy (8), Ukraine (7). The Proceedings containing 143 papers accepted for presentation, delivered by 292 authors and co-authors from 32 countries were available to all the participants at the opening the Symposium. The Proceedings contain also materials of workshops which took place during the Symposium.

*Accompanying event*

During the Symposium Working Group 1 „Spectrum Management/Utilisation and Wireless Telecommunication" of URSI commission E conducted a special workshop on „Mathematical Methods in Frequency Planning". It was organized by J. Finnie (Radiocom Agency, UK), R.A.Leese (University of Oxford, UK), and R.G. Struzak (Co-chair of URSI WGE1). The workshop was generously supported by the United States Air Forces European Office of Aerospace Research and Development.

*Opening*

The Symposium was opened by its chairman, Prof. D.J. Bem. Then the Rector of the University of Technology greeted the audience, and PTT V-minister, Dr. M. Rusin, had a speech on behalf of the Symposium Patron. Prof. Struzak, Program Committee Chairman, read out the letter to participants from the absent Honorary Program Chairman, Prof. F.H.L.M. Stumpers.

*Plenary sessions*

Three plenary sessions were held. One session took place on every day of the symposium. The following papers were presented:
First session:
„EM Terrorism - A Real Danger" by R.L. Gardner, (V-chairman URSI Commission E),
„ETSI - Standards for the Global Marketplace - Radiocommunications" by K.H. Rosenbrock,
(Director General of ETSI),
Second session:
„World Radiocommunications Conference 1997 - Consequences for Europe" by Th. Boe (Director of European Radiocommunication Office),
Third session:
„Power Quality" by G. Goldberg (Immediate past chairman of IEC - ACEC).

*Sectional sessions*

Twenty regular and ten poster sessions covered different fields of EMC.

Among regular sessions - the following invited sessions were organized: Terrestrial Electromagnetic Environment, organized and chaired by Prof. M.Hayakawa (Japan); URSI Commission E sponsored session, Co existance of Radio Services after 2000; a „passive" view, organized and chaired by Dr T.A. Spoelstra (Netherlands); ESF CRAF sponsored session, Factors and Methods in Radio Frequency Assignment, organized and chaired by Dr. J. Finnie (UK), EM Emissions in High and Low Frequency Ranges Related to Earthquakes, organized and chaired by Prof. T. Yoshino (Japan), Beverage - like Aerials and EMC, organized and chaired by Prof. H. Kikuchi (Japan); URSI Commission E sponsored session, Architectural Shielding, organized and chaired by Prof. J. A. Catrysse (Belgium), New Trends in Computer Support for Frequency Spectrum Management, organized and chaired by T. Cesky (Denmark), Computational Electromagnetics in Wireless Personal Communications, organized and chaired by Prof. A. Karwowski (Poland), EMC in Amateur Radio Service, organized by Prof. H. Trzaska (Poland) and chaired by C.M. Verholt (Denmark); IARU Region 1 EMC WG sponsored session, NATO

Naval Approaches to EMC, organized by Capt. R. Azzarone (Italy),Capt. A. Simi and S. Beaton (NATO HQ), chaired by Capt. R. Azzarone; NATO Special WG10 „EM Environment Effects" sponsored session.

The titles of the other sessions were: Antennas and Propagation, EMC Aspects (poster session); Biological Effects of EM Radiation (poster session); EMC Related to PCB and IC (poster session); EMC in Power Systems (chaired by G. Goldberg, Switzerland); EMC in Telecommunication (poster session); EMC Measurements and Instrumentation - I (chaired by Dr. D. Hansen, Germany); EMC Measurements and Instrumentation - II (chaired by P. J. Kerry, UK); EMC Measurements and Instrumentation (poster session); EMC Prediction, Analysis, Modelling - I (chaired by Dr. J. Kelly, Ireland); EMC Prediction, Analysis, Modelling - II (chaired by Prof. K. H. Gonschorek, Germany); EMC Prediction, Analysis, Modelling (poster session); EMI Sources and Coupling Path to Victims (chaired by B. Despres, France) EMI Reduction Techniques (poster session); EMI Reduction Techniques (chaired by G. M. Kunkel, USA); ESD, Lightning, EMP (chaired by Prof. C. Mazzetti, Italy); ESD, Lightning, EMP (poster session); Immunity (chaired by Prof. J. Kolodziejski, Poland); Natural and Man-Made EM Environment (poster session); Spectrum Management, Engineering, Sharing and Monitoring (chaired by R.J. Mayher, USA); Spectrum Management (poster session).

*Workshops*

Six workshops took place during the Symposium:

- European Union EMC Directive in Practice. Organized by M.C. Vrolijk, N.V Philips, Netherlands.
- EMC Quo Vadis - What Standards Will We Need in the Future. Organizers: P. J. Kerry, President of IEC - CISPR, (UK); B. T. Szentkuti, Chairman of IEC - TC77 EMC, (Switzerland).
- Transient Immunity Tests on Different Ports, Flicker and Harmonics Measurements on Power Line Port. Organizer: M. Lutz, EMC PARTNER AG, (Switzerland).
- EMC From Hewlett Packard. Organizer: Hewlett Packard (UK).
- New Era of Communications Technologies; EMC Aspects. Organizer: H. G. Kimball, Immediate Past Chairman of ITU SG7 „Scientific Services", (USA).
- Penetration of EM Field Trough Shielding Materials and Components. Organizer: G. M. Kunkel, SPIRA Manufacturing Corp., (USA).

*Young scientists*

Young Scientists Program was organized with the financial support of URSI. The support was offered to seven young scientists (from Belarus, Brasil, China, Georgia, Russia - 2 persons, and Turkey).

*Technical Exhibition*

The technical exhibition was held during the Symposium with the participation of 15 companies.. The exhibition was well attended.

*Literature Exhibition*

The literature exhibition was organized in which exhibited were the publications of international organizations such as International Union of Radio Science - URSI, International Telecommunication Union - Radiocommunication Sector and Telecommunication Standardization Sector (ITU-R, ITU-T), European Telecommunication Standards Institute - ETSI, European Broadcasting Union - EBU, European Electrotechnical Standards Committee - CENELEC, and International Electrotechnical Committee: Special Committee on Radio Interference - CISPR, and Technical Committee 77 "Electromagnetic Compatibility". Besides some books on EMC, spectrum management and electromagnetics, annual editions such as ITEM, and some specialized periodicals e.g. Microwave News, were shown. The exhibition, a useful initiative on such symposia, was well received and well attended.

*Computer network*

The computer network with direct connection to Internet was available, free of charge, to all participants to enable software presentations, and in depth discussions.

*Council and Program Committee Meeting*

A Joint Meeting of the Symposium Council, the Scientific Program Committee, and the Organizing Committee, together with Session Chairmenwas held on the last day. The meeting was co-chaired by Dr M. Rusin, v-chairman of the Symposium Council, and Prof. R.G. Struzak, chairman of the Scientific Program Committee.

During the meeting the present Symposium was evaluated, improvements and possible changes for the future were discussed. The current event was positively evaluated, and it was stressed that the broad range of the Symposium topics should be continued. The prevailing opinion was that such a strategy can lead to fruitful new ideas, and duplication of efforts can be avoided thanks to contacts anddiscussions among specialists involved in various fields of EMC. More scientific atmosphere of this Symposium in comparison to some other more commercially oriented events, was praised. It was also emphasized that mixing of theoretical and engineering topics is very fruitful and should be retained. The positive influence of the interaction between those involved in theory, and those involved in the engineering practice, cannot be overestimated.

The 15th Wroclaw Symposium on EMC is planned for year 2000. The exact date will be set down at a later date. For the details please refer later to: www.emc.wroc.pl. In the case of questions, send e-mail to: emc@il.wroc.pl.

Copies of the Symposium Proceedings (786 pages) are available from:

EMC Symposium
Box 2141, 51-645 Wroclaw 12, Poland
fax: +4871-372-8878, e-mail: emc@il.wroc.pl
or: (mail address): Institute of Telecom.
ul. Swojczycka 3851-501 Wroclaw, Poland

## 16. Technical Activities in ESD - R. De Leo

*Conferences completely dedicated to Electro Static Discharges (ESD) problems:*

The ESD Association, in cooperation with the IEEE, organises every year the International EOS/ESD Symposium and exhibition on Electrostatic Discharges and Electrical Overstress.

1. The 1996 Edition took place in Lake Buena Vista, Florida, USA, Sept. 8-12.
2. The 1997 Edition took place in Santa Clara (CA), USA, on Sept. 21-25
3. The 1998 Edition took place in Reno, Nevada, USA, on October 4-8.
4. The 1999 Edition will take place in Orlando, Florida, on Sept. 26-30.

The several presented papers, together with the tutorials and workshops, allows to have a large view on standards, coupling mechanisms, and suppression techniques against ESD.

*Conferences with sessions completely dedicated to ESD*

1. International Zurich Symposium and technical exhibition on Electromagnetic Compatibility, Zurich Feb. 18-20, 1997. In session D six papers were presented on several ESD topics, such us
   - a Statistics approach to the test result evaluation (Chiaraluce et al. and Wendsche et al.),
   - an investigation on partial discharges (Striker),
   - a method to explain why different ESD simulators give different results (Hall et al.),
   - the simulation of the current and the field produced by an ESD (Jobava et al.),
   - and finally an investigation on ESD in fluid lines (Green et al.).

*Conferences with sessions not completely dedicated to ESD*

1. International Wroclaw Symposium on EMC, Wroclaw, Poland, June 25-28, 1996.
   In session XVI, ESD/Lightning/EMP, a paper related to the ESD source model was presented (Fujiwara).
2. IEEE International Symposium on EMC, Aug. 19-23, 1996, Santa Clara, California, USA. In session C8, Non Sinusoidal EMC effects, a paper was presented regarding the susceptibility of CMOS components to ESD (Mahinfallah et al.)
3. XXV General Assembly of the International Union of Radio Science, Lille, France, Aug. 28- Sept. 5, 1996.
   In session EA, Electromagnetic Compatibility and EM Pollution, a paper on the ESD coupling into linear systems was presented (Cerri et al.)
4. EMC'96 ROMA, Int. Symposium on EMC, Rome, Italy, Sept. 17-20, 1996.
   In session N, Shielding/ESD, two paper were presented:
   - thin shields against ESD (Aiello et al.)
   - statistics applied to ESD (Cancellieri et al.)

   In session J, Numerical modelling, a paper was presented on the penetration of ESD into shielded enclosures (Cerri, et al.).
5. International Conference on Electromagnetics in Advanced Application, ICEAA 1997, Sept. 15-18,Torino, Italy.
   In session EMC/EMP a paper on the field radiated by an ESD suppressor was presented (Cerri et al.).
6. PIERS 98, Progress in Electromagnetics Research Symposium, July 13-17,1998, Nantes, France.
   In session EMC, a paper on the effects produced by the insertion of ESD suppression devices was presented (De Leo et al.).
7. IEEE International Symposium on EMC, Aug. 24-28, 1998, Denver, Colorado, USA. In session TH1D, Broadband EMI, a paper was presented on the spectrum radiated by an ESD (Fujiwara et al.).
   In session TH2B, Transients, a system for the validation of the ESD pulse was presented (Hendrikx et al.) together with another paper describing the new ANSI ESD standard (Maas et al.).
8. IEEE International Symposium on EMC, Aug. 2-6, 1999, Seattle, Washington, USA.
   In session 6D, EMC Topics, a paper on the effect of lead length on the response of ESD suppressor devices will be presented (Fallah et al.).
9. XXVIth URSI General Assembly, Aug. 13-21, 1999, Toronto, Ontario, Canada.
   In the poster session EP, Electromagnetic noise and interference, a paper on the computer simulation of hand/metal discharge will be presented (Jobava et al.).
   In session EA, Electromagnetic Compatibility and EM Pollution, a paper on the reduction of the field radiated by an Esd using ferrite materials will be presented (Fujiwara et al.), and the poster session EB a paper on the transient electrodinamics of an ESD from object will be resented (Shubitidze et al.)

## 17. 1996 CEEM) conference - Y. Gao

The 1996 Conference on Environmental Electromagnetics (CEEM) was held in Xien. Some Topics Related to EMC Measurements.

1. Measurement of Electromagnetic Environment in Office from 1 to 3 GHz, by Yasuhisa KITANI et.al.
   The Authors measured the EM Environment in an office, a computer room & an outdoor, focusing on the 1-3 GHz band, and obtained amplitude probability distribution of the field strength. From these results , shield attenuation of the building was estimated 13-15 dB in this frequency band.
2. Measuring of Radiated Power from Ratio Equipment Using a Reverberating Chamber, by A. SUZUKI et al.
   The Authors have been performing experiments with the Reverberating chamber method to study optimal methods for rotating Stirrers, techniques for averaging obtained data, linearity of results & the influence of metal walls. Results indicate that using a reverberating chamber is a promising method for measuring the average radiated power of radio equipment having a built-in antenna.

3. The Characteristics of Scattering Wave in Semi-Anechoic Chamber, by ZUO Peng et al.
   A systematic measurement was done in a semi-anechoic chamber. The amplitude characteristic & polarization characteristics of scattering wave & the normalized site attenuation characteristics & the maximum test space of the semi-anechoic chamber were measured! Some useful data & information were provided.
4. A Model to Analyze Noise Data Measured on Frequency Domain, by Qinqin Chen et.al.
   From the analysis result based on this model, the authors clarify the cause of poor reproducibility of noise measurements on frequency domain by analyzing the measuring data in consideration of the phases’ difference across the frequency components included in noise.
5. Measurement of Electromagnetic Noises Accompanying Strong Earthquake in MF & HF Bands, by Y.H. Ohtsuki et al.
   The authors have organized a group with amateur volunteers for observations of electromagnetic waves (MF & HF bands) which is radiated before & when earthquakes occurred. This observation system is simple & it is easy for amateur people to detect. Furthermore, the authors compared the monthly distribution of the electromagnetic noises with that of ball lightning phenomena.
6. "Theory and Experiment for Passive Imaging of Electromagnetic Sources", by Toru UNO et al.
   This paper implements the frequency domain inverse - procedure for searching the electromagnetic radiation sources located in an arbitrary region.The analysis is a full-wave & the solution is mathematically exact. The validity of the imaging method is confirmed by an experiment.
7. "Forecast Analysis of Electromagnetic Radiation of Chinese High Speed Railway" by ZHANG Chen et al.
   This paper carried out forecast analysis on Electromagnetic Radiation of “ Beijing — Shanghai high speed electrified railway” which will be built in near future. Some feasible methods for reducing electromagnetic radiation were put forward in this work according to research achievements at home and abroad.

# COMMISSION B

*This triennium report was prepared by Prof. Chalmers M. Butler, Commission B Chair 1996-1999.*

Commission B on Electromagnetic Fields and Waves has had another active triennium between the Lille and Toronto General Assemblies. The Commission embraces a large worldwide community of radio scientists with interests in the varied aspects of *fields and waves.* The Commission participates in and supports the activities of URSI, and those scientists and engineers affiliated with Commission B are very active in other organizations whose activities encompass fields and waves.

The officers of Commission B during the 1997 – 1999 triennium are Professor Chalmers M. Butler, USA, Chair, and Professor Staffan Ström, Sweden, Vice Chair. They have been assisted in carrying out their tasks by a large number of enthusiastic B colleagues.

Commission B's principal triennial activity between General Assemblies is its International Symposium on Electromagnetic Theory. The sixteenth symposium in the series, spanning 45 years, was held in Thessaloniki, Greece, during 25-28 May 1998. Approximately 470 synopses were submitted to the Technical Program Committee, of which 290 (260 oral and 30 poster) were accepted. Accepted papers were published in the 854 page Symposium Proceedings and were presented during the four-day meeting. The symposium featured a number of invited and tutorial papers, plus six special sessions organized by experts on topics of current interest and relevance. Two of these special sessions included panel discussions. Topics covered in special sessions were

- Wave Interrogation of Complexity: Deterministic—Stochastic Interactions
- Recent Developments in Asymptotic Analysis of Wave Problems
- Nonlinear Phenomena
- New Leakage and Radiation Effects on Waveguiding Structures
- Electromagnetic Compatibility
- Electromagnetic Theory Borderlands

A Young Scientist Program enabled twenty Young Scientists, most of whom otherwise would not have been able to have traveled to Thessaloniki, to attend the EMT Symposium. Travel funds were provided for the recipients of the Young Scientist Fellowships. The funds came partly from the Commission B triennial allocation from the URSI Secretariat and partly from a portion of the general registration fees assessed all symposium attendees. The enthusiasm of the Young Scientists was very evident. The Young Scientists participated fully in the program and took advantage of the opportunities to interact with the general attendees.

For the first time, synopses submitted to the EMT Symposium were accepted electronically. The synopses were received in several different electronic forms, and, of course, a few synopses were submitted on paper. All synopses were converted to .pdf files and it was in this form that they were sent to the nineteen members of the Technical Program Committee for review. The entire review process was conducted electronically. This experiment with

electronic information transfer was not without a few minor difficulties but, in general, it was successful. Except in the cases of six persons, all communications associated with the technical program with authors, session convenors, and session chairs were conducted via e-mail.

The Thessaloniki Host Committee and the Technical Program Committee did an excellent job of planning the symposium program and administering the logistical details necessary for the success of the event. The technical program was very good from all points of view and the ancillary social program was outstanding, especially for the many attendees who were interested in the history of the ancient world. The Commission is grateful to both committees for jobs well done.

A special issue of the journal **Radio Science** based on selected papers presented at the Electromagnetic Theory Symposium is being planned. Outstanding papers from the symposium were selected and their authors were invited to submit full-length manuscripts to the journal. The review by experts of all manuscripts should be completed by the end of August 1999 and the special issue will be published in due course.

Commission B's 2001 Electromagnetic Theory Symposium will be in Victoria, BC, Canada.

Consistent with the practice of past years, Commission B has sponsored meetings held by other organizations on topics which fall within the general purview of the Commission's terms of reference. All such meetings during the 1997 – 1999 triennium were sponsored under mode A (without financial contribution). Among those meetings sponsored during 1997 – 1999 were ICAP'97, Edinburgh; 1997 International Symposium on Non-Linear EM Systems, Braunschweig; Bianisotropics'97, International Conference and Workshop on Electromagnetics of Complex Media, Glasgow; Radio Africa'97, Nairobi; ISAE'97, Xian; 1997 International Symposium devoted to Galileo Ferraris, Torino; 1998 International Wireless and Telecommunications Symposium and Exhibition, Kuala Lumpur; 1998 International Symposium on EM Theory, Thessaloniki; MMET'98, Kharkov; International Workshop, "Day on Diffraction'98," St. Petersburg; 1998 Bianisotropics, Braunschweig; 1998 Physics and Engineering of mm and submm EM Waves, Kharkov; 1998 IEEE AP-S Conference on Antennas and Propagation for Wireless Communications, Waltham; JINA98, Nice; APMC'98: Asia-Pacific Microwave Conference, Yokohama; IWTS'99 — 1999 International Wireless and Telecommunications Symposium and Exhibition, Shah Alam; and International Workshop, "Day on Diffraction'99," St. Petersburg.

Commission B has planned an extensive technical program for the Toronto General Assembly. There will be approximately 375 B papers presented in eighteen sessions. An additional twenty papers will be presented in two joint-with-other-commission sessions that were organized primarily by Commission B. Finally, Commission B will participate in, but has not had the primary organizational responsibility of, another seven joint sessions. There will be more papers from Commission B radio scientists than from any other commission.

# COMMISSION C

*This triennium report was prepared by Professor J. Godfrey Lucas, Commission C Chair 1996-1999.*

Following the General Assembly considerable efforts were expended in attempting to contact all National Representatives and thoroughly involve them in the activities of this Commission – inviting feedback – inviting ideas. The document which was distributed at that time is appended as Attachment 1 to this submission.

With some spectacular exceptions the result of all of that has been an ordinary response of perhaps 20% of the respondents.

I am aware that similar problems exist in only some of the other Commissions but I would like to highlight this area of National Contributions and **real** involvement in the URSI process as one of URSI's real challenges for its survival and positive development into the future.

Certainly in Commission "C" we are acutely aware that the lack of real quality contributions to Commission activities together with real commitment to its future is causing stress and raising real questions about our ability to survive. Commission "C" covers a vast area of expertise, but, despite all of that advantage , there is little doubt that we find ourselves struggling to attract outstanding talent and superb up to the minute research content to the General Assembly.

There is no doubt that we find ourselves in very changing times which really question the whole idea of what "quality" and even what "excellence" is all about. That is the environment in which URSI must find methods to attract and then choose only the very best presentation material at the General Assembly. There is no room to compromise on the whole area of research excellence and academic provision – at all levels!

During the triennium Commission "C" has contributed hugely to the survival and development of the between GA meetings of both "Commsphere "and "ISSSE". Particularly with Commsphere there is a real possibility of redeveloping and rebuilding real and useful links with the ITU. It is a link which is considered vital for the future of URSI (and realistically it is probably considered to be irrelevant by the ITU) but we need to really work to find ways to overcome the chasm between a "penniless" Scientific Body and a "Multimillion Dollar" Industry. In our discussions we are aware that those interactions are not wholly "Scientific" or even "Engineering" but also encompass huge political considerations. We really need to explore whether URSI can cope with such a complex future.

This all exemplifies the challenge for the future of URSI.

In Commission "C" I believe that we can look forward to a period of strong leadership which will really lead and shape the future of the Commission.

In particular if we can establish those essential partnerships with the prime Telecommunications Industries the support for a strong and vibrant URSI – particularly in the key areas of Commission "C" will be ensured.

*Attachment 1.*

## Ursi Electronic DIScussion IDEAS

(UELDISS)

The following points are about things which need to be robustly discussed and lots of ideas shared and debated to arrive at the best basis for the years ahead.

*1. Terms of Reference for Commission "C" - SIGNALS and SYSTEMS.*

The Commission promotes research and development in:
(a) Telecommunications systems;
(b) Spectrum and medium utilisation;
(c) Modulation and Coding;
(d) Signal and Image processing;
(e) Circuit Theory and Design;
(f) Information Theory.
The design of effective communications systems requires the balance of Scientific, Engineering and Economic factors. The Commission emphasises research into the Scientific factors, and provides expertise in other areas of Radio Science required for System Design.

These were very thoroughly haggled at Kyoto,but we decided to make no changes at all at Lille.

These terms of reference are extraordinarily broad. Some topics have not been addressed AT ALL at the last two general Assemblies. For example : Information Theoretic topics

*2. Format of the "C" part of the General Assembly at Toronto.*

The General Assembly in Toronto will commence its scientific sessions on a Monday and carry through until the following Tuesday. This will allow us to plan for 5 intensive days during the first full week and include tutorial and "workshop" material during the two days of the second week. This is intended to encourage attendees to stay a bit longer at a GA than they presently seem to.

*3. Draft topics of interest for Toronto GA:*

# General Lecture - ideas and speakers
# Tutorial Lecture - ideas and speakers
# Workshops (for the two days of the second week)???
* Mobile and Personal Communications - probably two sessions and definitely joint with "F"
* HF - propagation and digital (joint with "G")
* Spectrum spreading (non-linearities) and Image Processing techniques in the radio field(both joint with "J")
* Wavelets et al (popular at Lille)
* Millimeter and sub- millimeter (Joint with "D")
* Space Division Multiple Access (SDMA) - A new domain for multiple radio access.
* Software Radio
* Multimedia in mobile environments
* Mobile and Personal Communications

We had some sessions at Lille which had less than 10 attendees! That is either due to the topic area OR the quality of the presenters!! In either event I would plan to steer clear of these areas in their present form for the next time! These include:
* Synthesis and Analysis of Systems
* High frequency technology for mobile/personal communications
* Multimedia and Broadband Networking
* Digital Signal Processing in Telecommunications

Some of the presentations in these sessions were quite superb so perhaps it is a matter of repackaging so that the real message about the content gets through!!

*4. Telecommunications and Wireless Communications*

During the Assembly at Lille Council decided to disband its "Scientific Committee on Telecommunications" and in its place has established a "Working Group on Wireless Communication". There are no terms of reference available at this time.

URSI Vice President Jo Shapira has been charged by the Board with the responsibility of developing all aspects of the Working Group. The prime intention of this new initiative is to ensure that URSI interacts in a much broader and more effective way with the ITU. There has been talk of URSI having lost its 'status' and 'standing' with ITU. It is also a fact that the ITU has changed quite remarkably during the last few short years - it is changing in order to cope with having become a megabillion dollar 'industry' and there are literally thousands of people involved in both technical and regulatory support areas. It is not at all clear how URSI will interact (easily) with such an unusual structure.

Shapira will first focus his efforts on the definition process of the new working group through the "Commsphere" meeting which will be held in Lausanne in February 1997. Lucas will therefore endeavour to attend that meeting.

The Working Group as it is loosely proposed includes some of Commission C's major terms of reference and is undoubtedly a hugely important area of interest for the future.
More details will be provided as they eventuate.

*5. Major Meetings involving "C" between now and the Toronto GA:*

* Commsphere - Lausanne, Switzerland - February 11-14, 1997
* ISSSE - an inter commission steering group has been set

up and a call for proposals (see Attachment 1) to run the meeting has been made - closing 15/12/96.

* Workshop - joint with "F" - a North American venue is probably favoured - perhaps first half 1998.

*6. The Future*

We need to consider making ALL sessions of the General Assembly INVITED papers with contributions becoming poster sessions - would this markedly improve the quality of what we do?

Timing of individual presentations at the GA is a real issue! Many attendees want to be able to "pick the eyes" out of what is there by moving between parallel sessions. Some Commissions actually REFUSE to timetable their content - "C" will be strictly timetabled next time around and strictly adhered to irrespective of "no shows"!!

There was some talk of starting up a "NEW" Commission on Telecommunications - being a trend which URSI should not resist. That is a real issue for "C".

Future leadership. We need to ensure the strongest possible succession for the future. We need a strong and enthusiastic set of candidates for the next election (of Vice Chairman) at Toronto.

*7. Contact Coordinates:*

Ernst Bonek : Austria - ebonek@email.tuwien.ac.at
Chris Drane : Australia - cdrane@ee.uts.edu.au
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Guido Tartara : Italy - tartara@elet.polimi.it
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David Thomson : USA - djt@research.bell-labs.com
Ilja Zolotarev : Russia - zolotarev@omgtu.omsk.su
Raymond Pickholtz : USA - pickholt@seas.gwu.edu
Ilja Zolotarev : Russia - zolotarev@omgtu.omsk.su
Godfrey Lucas : Australia - g.lucas@uws.edu.au

*ATTACHMENT 1.*

*Call for Proposals to run ISSSE '98*

Due: by 15 December 1996
To: Prof Tatsuo Itoh - itoh@ee.ucla.edu

URSI Commissions C and D have formed a joint group to act as a Steering
Committee for the (ongoing) ISSSE series of meetings. The Steering Committee is now soliciting proposals for ISSSE '98 consistent with the following guidelines.

1. ISSSE '98 should be held in the period September to December 1998.
2. The duration should be 2 - 3 days.
3. ISSSE '98 should include a significant stream of sessions on a focussed theme, while also remaining open to papers in other areas of interest to Commissions C and D. Note that this is a departure from previous ISSSE meetings. The focussed theme should feature prominently in the call for papers.
4. Association of ISSSE '98 with another meeting of interest to Commission C and/or D is encouraged.
5. A suggested format is a combination of invited plenary talks, say one each morning and afternoon, plus two parrallel sessions at other times.
6. A Young Scientist program should be included.
   Proposals should address each of these guidelines and include the following information:
7. Names of the Chairperson and members of the local Organising Committee ( the Commission Chairpersons are joint conference Vice-Chairpersons).
8. Names of the Technical Program Chairpersons ( One each for Commissions C and D).
9. Venue.
10. Dates.
11. Budget based on conservative break-even number of attendees.

# COMMISSION D

*This triennium report was prepared by Professor R. Sorrentino, Commission D Chair 1996-1999.*

Because of the increased importance and the new developments in the area of telecommunications, particularly in wireless and multimedia technologies, URSI Commission D "Electronics and Photonics" has gained an autonomous character, in contrast to its conventional mission of being a "service" commission for the other traditional URSI Commissions.

Low power electronics associated with advances in new devices and materials, as well as novel photonic technologies are acquiring a key role for wireless communication. These and other important topics, such as high bandgap semiconductor devices, interconnections and packaging for high speed and high frequency devices, Photonic BandGap (PBG) devices, 3D electromagnetic modelling of microwave devices and circuits will be discussed in the proposed Commission D program for the Toronto General Assembly, including other more traditional subjects on electronics and photonics.

The major event during the past three years is the successful accomplishment of ISSSE '98. In addition, Commission D supported a number of scientific and technical symposia and meetings throughout the world.

*1. International Symposium on Signals, Systems and Electronics (ISSSE '98)*

As the wireless technology becomes increasingly more pervasive to our lives, International Symposium on Signals, Systems and Electronics (ISSSE) becomes one of the most

important meetings for URSI that is emphasizing the telecommunication.

ISSSE series has been organized by Commissions C (Signals and Systems) and D (Electronics and Photonics). The first meeting was held in Erlangen, Germany in 1989, which was followed by Paris in 1992 and San Francisco in 1995.

At Lille General Assembly, Commissions C and D formed the ISSSE Steering Committee to maintain continuity and to enhance visibility for the future ISSSE series as well as to assist organizers. The Steering Committee has also the task of receiving and evaluating proposals and selecting the conference site. Professor Tatsuo Itoh, immediate past Chair of Commission D, was appointed as Coordinator and point of contact of the committee.

One of the recommendations by this Steering Committee is that the meeting be held in close proximity (in time and space) of a major meeting of interest to either Commission. Another recommendation is to select a well-meaning theme to the meeting, rather than a collection of papers.

ISSSE '98 was held on 29 September – 2 October, 1998 at Palazzo dei Congressi in Pisa, Italy. The dates fall in the week prior to the European Microwave Conference in Amsterdam to satisfy the recommendation of the Steering Committee as described above. The conference theme was "Co-design of Radiocommunication Terminals: From Waves to Silicon through DSP." General Chairman was Professor Marco Luise of University of Pisa who was assisted by Giorgio Vittetta for local arrangement and by Filippo Giannetti for publication, both from University of Pisa. Technical Program Committee consisted of three co-chairs, T. Itoh (UCLA), U. Mengali (University of Pisa) and C. Trullemans (Catholic University of Louvain, Belgium). The TPC Co-chairs were assisted by 6 Vice Co-chairs and 18 committee members from various parts of the world. The meeting was technically co-sponsored by IEEE Communications Society, Microwave Theory and Techniques Society and Electron Devices Society. The meeting was financially co-sponsored by URSI Commissions C and D.

The conference theme "Co-design of Radio-communication Terminals: From Waves to Silicon through DSP" was particularly timely. According to Professor Luise, "It is likely that by the year 2010 the number of wireless communication links for information transmission will exceed the number of *wired* ones. Each and every wireless communication application, be it high-speed point-to-point or switched cellular, terrestrial or satellite-based, UHF or mm-wave, has benefited in terms of spectral and power efficiency by advances in VLSI, microwave and DSP components and techniques. The ultimate goal of the radiocommunication engineer is currently to exploit the *sinergy* of those advances through clever *co-design* of different, previously separately-designed subsystems. The Symposium will develop through parallel sessions in three main areas of *DSP-based Communication Equipment and Systems, VLSI design and Components,* and *Microwave Theory and Techniques.*" All TPC shared his view in forming the technical program.

Following the reception in the evening of 29 September, the conference started on the morning of 30 September by a brief opening ceremony. Each morning of the following three days was started with an Invited Plenary Talk. These talks were:

- "Microwave Power Amplifiers Fabricated from Wide Bandgap Semiconductor Transistors," by R. J. Trew, U. S. Department of Defense, on September 30,
- "3G Wireless Communication System: The Design Challenge," by H. Meyr, RWTH Aachen, Germany, on October 1,
- "Single-chip CMOS Wireless Transceivers: Current Status and Future Prospect," by A. Abidi, UCLA, USA, on October 2.

After the Plenary Talk, there were three parallel sessions, a total of 21, typically one for Microwaves, one for Telecommunications and one for VLSI.

Microwave Sessions were:

WM1: Advances in Devices
WM2: New Materials and Architecture for Microwave and RF Circuits
TM 1: Progress of Numerical Characterization
TM 2: Millimeter Waves
TM 3: MW/Optical Interactions
FM 2: Nonlinear Circuit Design and Modeling

Telecommunication Sessions were:

WT1: Broadband Wireless Access
WT2: Transmission Systems
WT3: Multiple Access
WT4: DSP for Telecommunications
TT 1: Signal Detection and Synchronization
TT 2: Wireless Transceivers
TT 3: Modulation, Coding and Compression
FT 1: Third-Generation Wireless Systems
FT 2: Wireless Channel Equalization

VLSI Sessions were:

WV1: Wireless Transceivers
WV2: VLSI Technologies for RF Circuits
WV3: Broadband Techniques
TV 1: Data Communication/Processing Circuits
TV 2: Hardware / Software Co-Design of Telecommunication Systems
FV 1: Modeling and Design Techniques

The TPC received 57 submitted papers (including 37 in telecommunications) from 23 countries of which 41 papers were accepted. In addition, there are 53 invited papers. Therefore, 94 papers were given in 21 sessions. Essentially, no incidence of no-show was encountered. The number of participants was about 125 that includes 20 students and 8 Young Scientists who received full service at the registration fee identical to that for students.

The Conference Chairman, Professor Luise, was successful in raising a considerable amount of sponsor funds (more than 20,000 US$) from Italian

telecommunication companies and from the University of Pisa.

The conference was very well organized and carried out in an relaxed and congenial atmosphere. There were ample occasions of technical exchange at coffee breaks and on-site luncheons for all participants. An excellent banquet was organized at a local restaurant with excellent Italian cuisine. On the afternoon of the third day, there was an optional excursion to a nearby town of Lucca.

During the conference, a meeting of the ISSSE Steering Committee was held including several guests and organizers and TPC members. The next venue was discussed. The recommended candidatewass Japan; United States was to be considered as a second option.

*2. Conference Support*

Commission D supported ISSSE as the main conference of the Commission by providing $4,000 which was matched by another $4,000 from Commission C. The commission also provided type-A sponsorship to a number of conferences around the world.

*3. Travel Grant Program for URSI Toronto General Assembly*

Commission D has decided to partially defray the cost of some of the Convenors and Invited Speakers for Commission D Sessions including the joint sessions led by Commission D. At the time of writing this report, Commission Chair and Vice Chair are finalizing the award recipients.

According to the guidelines adopted for the previous General Assemblies, travel grants will be awarded based on the following criteria: 1. Economic hardship; 2. Only one award to an institution; 3. As much as possible, distribute equally to all sessions, and 4. Geographical distribution. Award will be announced through the respective Convenors.

# COMMISSION E

*This triennium report was prepared by Prof. M. Hayakawa, Commission E Chair 1996-1999.*

During the last triennium, most of the Commission E activities have been devoted to the organization of meetings and conferences and to the preparation of scientific sessions for the Toronto General Assembly.

Most of the Commission E activities have been conducted by the following Commission E working groups:

E1 Spectrum Management/Utilisation and Wireless Telecommunication
E2 Non-Gaussian Noise in Communication.
E3 High Power Electromagnetics
E4 Terrestrial and Planetary Lightning Including Generation of Electromagnetic Noise
E5 Interaction with, and Protection of, Complex Electrical System
E6 Effect of Transients on Equipment
E7 Extra-Terrestrial and Terrestrial Meteorologic-Electric Environment with Noise and Chaos
E8 Terrestrial Electric and Magnetic Fields, Propagation, Global Circuit and Geomagnetically Induced Currents
E9 Interference and Noise at Frequencies above 30MHz

Each working has tried to organise the sessions in different international EMC conferences and workshops.

Newsletter of Commission E has been established during this triennium, and two issues (No. 1, March 1997 and No. 2, May, 1997) have been distributed to national representatives. Especially, the people in developing countries have shown a lot of interest in these newsletters.

Commission E has sponsored the following meetings: in Mode B (with financing),

1. EMC '96 Roma, Rome Italy, 17-20 September 1996.
2. EMC '97 Zurich, Zurich Switzerland, 18-20 February 1997.
3. Wroclaw EMC Conference, Wroclaw Poland, 23-26 June 1998.
4. EMC '98 Roma, Rome Italy, 14-18 September 1998.
5. EMC '99 Zurich, Zurich Switzerland, 16-18 February 1999.
6. Workshop on Radio Methods for Studying Turbulence, Urbana, Ill. USA, 9-12 August 1999.

and in Mode A (without financing),

1. 8ème Coll. Int'l. sur Compatibilité Electromagn., Lille France, 3-5 September 1996.
2. ICPL, Firenze Italy, 23-27 September 1996/
3. Commsphere '97, Lausanne Switzerland, 11-14 February 1997.
4. International Symposium on EMC, Beijing China, 21-23 May 1997.
5. 7th International Conference on HF Radio Systems and Techniques, Nottingham UK, 7-9 July 1997.
6. Telecom '97, Fès Morocco, 15-17 October 1997.
7. Commsphere '99, Toulouse France, 25-28 January 1999.

*This triennium report was prepared by Mr. Martin P.M. Hall, Commission F Chair 1996-1999.*

## Introduction

Commission F has the title "Wave Propagation and Remote Sensing (including radio-meteorology, radio-oceanography and remote sensing of non-ionised media)" and as its terms of reference: "The Commission encourages:

(a) The study of all aspects of wave propagation at all frequencies in a non-ionised environment: (i) wave propagation over the Earth's surface, (ii) wave propagation in, and interaction with, the neutral atmosphere, (iii) wave interaction with the Earth's surface, oceans, land and ice, (iv) wave propagation through, and scattering by, the subsurface medium, (v) characterisation of the environment as it affects wave phenomena;

(b) The application of the results of these studies, particularly in the areas of remote sensing and communications;

(c) The appropriate co-operation with other URSI Commissions and other relevant organisations.

Prime responsibilities this triennium, as previously, have been shared between the Chairman (Mr Martin P M Hall) and Vice Chairman (Dr Yoji Furuhama).

## Scientific Programme

Setting up a scientific programme for a triennium is the prime activity of an URSI Commission in order to achieve an exchange of ideas and research results amongst individual scientists throughout the world. This is carried out at General Assemblies and other meetings.

At General Assemblies, Commission F selects (largely from proposals made at business meetings in the previous GA) a number of topics and convenors to cover specific matters of interest. The convenors are then given the responsibility to invite speakers to give a balance of scientific content and geographical representation. In the current triennium, there is a Commission F Tutorial entitled "Remote characterisation of geophysical phenomena using EM waves" and Commission F sessions entitled: "Mobile terrestrial and satellite propagation modelling" (F1) (RRS chapter), "Climatic parameters in propagation prediction" (F2) (RRS chapter), "Millimetric, sub-millimetric and optical wave propagation" (F3), "Remote and in-situ sensing of clouds and their effects on radiowave propagation" (F4), "Atmospheric dynamics in the lower atmosphere: Measurement, modelling and effects" (F5), "Space-borne remote sensing of precipitation from TRMM" (F6) (RRS chapter), "Remote sensing of the Earth's surfaces" (F7) (RRS chapter), "Radar interferometry" (F8) (RRS chapter), "Polarimetric techniques in remote sensing" (F9) and "Synergetic use of remote sensing instruments" (F10). There is also a poster session entitled "Wave propagation and remote sensing" (FP) to cover the whole subject area of the commission, and joint sessions entitled: "Techniques and applications for sub-surface remote sensing" (FAB), "Mobile and personal communications" (CF), "Interference in communication" (EF), "Ionosphere and troposphere parameters retrieved from GPS/GLONAS measurements" (GF), and "Tropospheric path delay correction" (JF). The sessions marked "RRS chapter" have chapters on that topic in the URSI book entitled "Review of Radio Science 1996-1999".

In addition there are the Workshop sessions on: "Interfacing propagation with transmission and antenna system studies for mobile/personal communications" (WSF1), "Synergy of active and passive remote sensing instuments" (WSF2) and "WISIP - Wideband (ULF to UV) Interferometric Sensing and Imaging Polarimetry - theory and applications" (WSF3). These are slightly different in nature and it is the first time that such workshops have been organised.

As to other meetings, between GAs, Commission F has had a busy triennium, with 6 scheduled Mode B meetings (financial support requested) and 13 Mode A meetings (no financial support requested). The former comprised:

- ISRP: International Symposium on Radiowave Propagation; Qiangdao, China, 12-16 August 1997. (RSB Dec'97 pp 14-16)
- MST8: Eighth International Workshop on Technical and Scientific Aspects of MST Radar; Bangalore, India, 15-20 December 1997. (RSB June'98 pp 32-33)
- Microwave Signatures in Remote Sensing; Moscow, Russia, 11-13 March 1998, cancelled at short notice and grant returned in full.
- Climpara'98: Climatic Parameters in Radiowave Propagation Prediction; Ottawa, Ontario, Canada, 27-29 April 1998.
- Physics and Engineering of Millimetre and Submillimetre EM Waves; Kharkov, Ukraine, 15-17 September 1998. (RSB Mar'99 pp 28-30)
- Commission F Open Symposium; Aveiro, Portugal, 22-25 September 1998.(RSB Mar'99 pp 30-31)
- Workshop on Radio Methods for Studying Turbulence; Urbana, Illinois, USA, 9-12 August 1999. (RSB Mar'99 pp 30-31)

In the list above, "RSB—-" indicates the edition of the Radio Science Bulletin and page numbers where reports have been given.

Special mention should be made of the open symposium as this is the prime Commission F meeting held every three years in the year before an URSI General Assembly. The 1998 symposium, held in Aveiro, Portugal, was the eighth, the series being started in 1977. There were 70 participants from 22 countries and a total of 66 papers from 17 countries, including four keynote invited papers. There were eight oral sessions and a poster session, and the meeting maintained the excellent atmosphere of those before it. Whilst these meetings have been much appreciated

by a loyal following, Commission F may wish to consider whether the next event should be enlarged.

Also some mention should be made of Climpara'98, held in Ottawa, which was the fourth in a series of meetings which link closely with ITU-R Working Parties 3J and 3M. This has been a valuable exchange in what has been a productive area of work. There were a total of 51 papers covering a range of mapping, modelling and measurement aspects of clear-air and precipitation. Having many people strongly involved in both (i) URSI Commission F and (ii) ITU-R Study Group 3 helps to give a strong sense of current application priorities to the former and scientific input to the latter. This is a valuable association for both organisations.

The Mode A meetings comprised:

- ISAP'96: International Symposium on Antennas and Propagation; Chiba, Japan, 24-27 September 1996. (RSB Sept'97 pp 14-15)
- ICAP'97: International Conference on Antennas and Propagation; Edinburgh, UK, 14-17 April 1997.
- Radio Africa'97: Second Regional Workshop on Radio Communications in Africa; Nairobi, Kenya, 4-8 August 1997. (RSB June'98 pp 30-32)
- IGARSS'97: International Geoscience and Remote Sensing Symposium; Singapore, 4-8 August 1997.
- URPS'97: Urban Radiowave Propagation Symposium; Tomsk, Russia, 2-4 September 1997. (RSB Dec'98 pp 17-18)
- IWTS'98: 1998 International Wireless and Telecommunications Symposium and Exhibition; Shah Alam, Malaysia, 11-15 May 1998. (RSB Mar'99 pp 21-22)
- EUSAR'98: European Conference on Synthetic Aperture Radar; Friedrichshafen, Germany, 25-27 May 1998. (RSB Dec'97 p 18)
- International Workshop "Day on Diffraction'98"; St. Petersburg, Russia, 2-4 June 1998. (RSB Dec'97 p 19)
- IGARSS'98: International Geoscience and Remote Sensing Symposium; Seattle, Washington, USA, 6-10 July 1998.
- COSPAR Scientific Assembly; Nagoya, Japan, 12-19 July 1998. (Council meeting: RSB Mar'99 pp 27-28)
- PIERS'98: Progress In Electromagnetic Research Symposium; Nantes, France, 13-17 July 1998.
- 10th Microcoll; Budapest, Hungary, 21-25 March 1999.
- International Workshop "Day on Diffraction'99"; St. Petersburg, Russia, 1-4 June 1999.
- IGARSS'99: International Geoscience and Remote Sensing Symposium; Hamburg, Germany, 28 June - 2 July 1999.

Particular mention should be made of the three IGARSS meetings. These are the largest remote sensing meetings (comparable in size with URSI GAs), primarily organised by IEEE GRSS, in which URSI Commission F has had responsibility for specific sessions. They cover some 76 topic areas of remote sensing and draw more than 1000 papers.

## Communication

As probably for some other commissions, communication with individual scientists has been a problem for Commission F. Specific communications to the 43 National Committee Official Representatives (e.g. for voting purposes) has had only partial success, and in four cases there is no specific Commission F Representative. It is not clear as to what extent communication within the various 43 member countries is effective. Those who run individual meetings under the Commission F banner develop their own lists of people to contact, and of course make use of the URSI Radio Science Bulletin to advertise their meetings. The triennial Commission F Open Symposium uses the same methods. Setting up and frequently refreshing a Commission F Home Page on the internet might improve publicity somewhat.

## Publications

The chapters for the Review of Radio Science have been mentioned above and the tutorial paper will appear in the URSI publication "Modern Radio Science, 1999"; thanks are expressed to Prof D Gjessing, Prof F Perez-Fontan, Dr Y Karasawa, Dr T Tjelta, Mr J P V Poiares Baptista, Prof P A Watston, Dr A J Illingworth, Prof C Kummerow, Dr K Okamoto, Dr J Hallikainen, Mr B Arbesser-Rastburg, Dr J Hjelmstad and Dr J van Zyl, and to Dr Y Furuhama as Commission F Editor for RRS.

A particular instance of communication (and publications) is in the preparation of the Disk of References associated with the six chapters in the URSI book entitled "Review of Radio Science 1996-1999" mentioned above under Scientific Programme. Not all commissions take part in this, but the 1996 Business Meetings of Commission F voted to do so. The major task was kindly undertaken for the commission by Dr Rod Olsen and the disk is now available. It comprises 1374 references from 24 countries as follows: Belarus, Belgium, Brazil, Canada, Czech Republic, China, Germany, Greece, Hungary, Italy, Japan, Netherlands, Nigeria, Norway, Poland, Portugal, Russia, South Africa, Switzerland, Sweden, Taiwan, Ukraine, UK and USA. Thanks are also due to those National Representatives who contributed.

## Conclusion

It has been a busy three years for the commission and I am glad an honoured to have served as chairman.

*This triennium report was prepared by Prof. Bodo W. Reinisch, Commission G Chair 1996-1999.*

During the triennium 1996-1999, URSI Commission G has been active through its Working Groups and 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 membership. The following Commission G Working Groups have been active:

*G.1. Ionosonde Network Advisory Group (INAG)*

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

INAG has maintained a constant membership of around 230. The main medium for contacting INAG members remains the Bulletin. During the last three years one Bulletin (INAG-62) was produced. In addition, INAG produced the Proceedings with 24 papers from the Session G5 at Lille General Assembly titled "Computer Aided Processing of Ionograms and Ionosonde Records". Copies of this report, reference number UAG-105, are still available from Ray Conkright, NGDC, STP, E/GC2, 325 Broadway, Boulder, Colorado 80303, USA. Copies of past Bulletins and the two Proceedings are also available from Phil Wilkinson, IPS, PO Box 1386, Haymarket NSW 1240, Australia. Work commenced on the INAG Website, http://www.ips.gov.au/INAG/, but is not completed because of limitation of resources. A reasonably reliable e-mail address list for INAG members has been compiled.

INAG has endorsed the SAO format for information derived from ionograms using automatic scaling techniques. This format was described in INAG-62 and the latest version is available on the Web at http://ulcar.uml.edu/~iag/SAO-4.htm.. As a result of INAG initiative, users of the world can see ionosonde data online through the Internet. NGDC along with IPS and the University of Massachusetts Lowell has set up a system where users can login to display and analyze ionosonde data in real time and through the WDC archives.

*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)

Working Group G.2 has a long tradition as the „Beacon Satellite Group" and deals with all aspects of ionospheric plasma effects on satellite signals observed on the ground or by receivers onboard satellites. The Working Group takes into account both scientific and application aspects and is truly interdisciplinary in its membership. Working Group G.2 seeks continuation and proposes to accept the following chairpersons who have been elected in a Working Group Assembly during the Beacon Satellite Symposium 1997:Reinhart Leitinger (Austria) as chairman,

Jack A. Klobuchar (USA) and P.V.S. Rama Rao (India) as co-chairmen. The Working Group G.2 communicates through correspondence and its regular Beacon Satellite Symposia. The Beacon Satellite Symposium 1997 at Sopron, Hungary, from June 30 to July 5, 1997 brought together 35 participants, including eight young scientists, from 15 countries (see section on URSI sponsored conferences). The Business Session reviewed once again the link to URSI Commission G and the internal structure of the Working Group with the conclusion that no changes are necessary. Another important topic was time and location of the next Beacon Satellite Symposium. In view of the continuing need for international cooperation and in view of the success of the Symposia, including especially BSS97, the group members present voted unanimously for a continuation of the Symposia series and for maintaining the traditional time interval of two to three years between Symposia. The d decision on the venue for the next symposium will have to take into account travel and local expenses on the one hand and available financial support on the other hand. The goal is to attract young scientists, and traditionally beacon satellite studies have found nearly global distribution.

*G.3 Incoherent Scatter*

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

There are presently ten Incoherent Scatter (IS) radars making regular observations throughout the world. These are located near Arecibo (Puerto Rica), Boston (USA), Irkutsk (Russia), Jicarmarca (Peru), Kharkov (Ukraine), Kyoto (Japan), Longyearbyen (Svalbard), Sondrestromfjord (Greenland), and two at Tromso (Norway). The ISWG's principal activity is the creation and execution of a series of coordinated IS Radar observing intervals during which all the world's IS radars attempt to observe. About 20 days of such coordinated activity are scheduled each year, the dates are carefully arranged in conjunction with other instrument programs and significant geophysical events and are published in the International Geophysical Calendar. The data from these intervals also form the main component of the IS Radar data held in the World IS database maintained by NCAR in Boulder, USA.

During the last three years, the observing schedule has been developed through email contact between the members of the Working Group followed by publication of a straw-man schedule on the World Wide Web (WWW) and subsequent refinement following discussions at various meetings. The number of days of observations as risen by general agreement by about 10 percent with most periods dedicated to the aims of specific major programs. An important innovation of the last two years has been the scheduling and operation of 'floating' observations where alert intervals have been scheduled one year ahead but the exact timing of operations has been decided much later based on actual geophysical conditions. Several of the IS radars now routinely distribute analyzed data in real time

via public links on the WWW and demand for existing and new data sets continues to grow both for individual studies as in collaboration with other instruments, satellites and models. Since the last General assembly, a new IS radar facility has come into operation at high latitude in the European sector and plans are well developed to locate, at least part of the time, a further radar at even higher magnetic latitude in the American sector.

*G.4 Ionospheric Informatics*

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

Working Group G4 held three meetings at the International Center for Theoretical Physics (ICTP) in Trieste, Italy, during the IRI Task Force Activity meeting. Formatting and exchange of ionospheric data and applications software was the main objective. The URSI recommended SAO data format for ionogram characteristics has been expanded. The current status is documented in http://ulcar.uml.edu/~iag/SAO-4.htm. New databases for improved IRI bottomside profile parameters were established. Results are given in the ITCP Reports IC/IR/99/5 (June 1999), IC/IR/98/9 (September 1999), and IC/IR/97/11 (November 1997).

The Commission participated in the following Joint and Inter-Union Working Groups:

*CGH.1. Wave and Turbulence Analysis*

Co-Chair for Commission G : A.W. Wernik (Poland)
Co-Chair for Commission H : F. Lefeuvre (France)

*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)

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

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

Working Group GF.1 has organized and supported a large number of sessions at conferences as well as workshops and symposia. A topical session on "Ionosphere and Atmosphere Sounding Applying New Methods" was held at the German URSI Meeting in Kleinheubach 6-10 October 1997. Eight papers resulting from the session "Advanced radar studies of the ionosphere and middle atmosphere" at the URSI General Assembly in Lille, France, were published in Radio Science. The School on Atmospheric Radar (SAR) on 10-13 December 1997 in Tirupati/Gadanki, India, produced extensive lecture notes that were printed with ISRO support. The 8th International Workshop on Technical and Scientific Aspects of MST Radar (mst8) took place thereafter on 15-10 December 1997 in Bangalore, India. Both activities were sponsored by URSI through Commissions F and G. At mst8, five Permanent Working Groups on "System calibrations and definitions", "Analysis and data validation", "Accuracy and requirements for meteorological applications", "International collaborations" and "Studies of transient phenomena" were established or reaffirmed. The Proceedings of mst8 were published as part of the Solar-Terrestrial Energy Program publications of SCOSTEP. Reports on mst8 and SAR were published in the Radio Science Bulletin and the International SCOSTEP Newsletter. A symposium on "Mesopause region structure, dynamics and composition" was organized for the 32nd COSPAR Scientific Assembly in Nagoya, Japan, 12-19 July 1998, sponsored by URSI through GF.1. Two special sessions "Ionospheric irregularities" and "Radar observations of the Earth's atmosphere" at the Western Pacific Geophysics Meeting 21-24 July 1998 in Taipei, Taiwan were convened as GF.1 activities. Papers from Session C2.1 were published in Advances of Space Research. An extended four-day plenary session on "Radar observations of the Earth's ionosphere and atmosphere" held at PIERS 1999 (Progress in Electromagnetics Research Symposium) in Taipei, Taiwan, 22-26 March 1999, was initiated by the WG. This session covered the topics: HF-radars (Digital Ionosondes, OTH Radar and SuperDARN), MF and meteor radars, MST radar and wind profilers, meteorological and weather radars, as well as incoherent and coherent scatter radars. Selected papers of this session will be published in a special issue of the Journal of Atmospheric and Solar-Terrestrial Physics. A session "Recent radar systems and scientific highlights in polar ionosphere and atmosphere research" is scheduled for the URSI General Assembly in Toronto. The GF.1 co-chair J. Röttger will present the Commission G tutorial at the URSI General Assembly: "Radar systems for ionospheric research". The Ninth International Workshop on Technical and Scientific Aspects of MST Radar - mst9 - will be combined with the final profiler conference of the COST76 European Commission project in Toulouse, France, 13-17 March 2000. The 3rd International School on Atmospheric Radar (isar3) will be held in connection with mst9-COST76 in March 2000 in Toulouse.

*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)

*GH.1. Active Experiments in Plasmas*

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

The Working Group GH.1 on Active Experiments in Space Plasmas reports very enthusiastic response to its call for papers for this XXVIth URSI General Assembly. A session entitled, "Ionospheric Modification with High Power Radio Waves: Coupling of Plasma Processes" has been organized that features 15 oral presentations and 22 poster papers. The Working Group reports continued international cooperation in the field during the triennium. Co-operative research has been performed at the Sura, the EISCAT ionospheric modification facilities, in Russia and Norway respectively. The HF facility at the Arecibo Observatory and the newly emerging heating facility of HAARP (High Frequency Active Auroral Research Program) and HIPAS

in Alaska have also supported similar activity. Research on Langmuir turbulence, SEE, artificial periodic inhomogeneities has been performed with great success. Breakthrough results on ionospheric irregularities have been obtained with the Cutlas radar and the Tromso heater. Magnetospheric turbulence experiments have been performed at HAARP as well as by heaters in Ukraine and Russia. The Working Group very regretfully records the untimely death of Dr. Lev Erukhimov of the Radio Physics Laboratory at Nizhny Novgorod. Dr Erukhimov's scientific enthusiasm and untiring efforts towards cooperative research in the area of ionospheric modifications will be remembered by the community.

*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)

*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)

The working group serves as a forum for researchers studying the behavior of the magnetosphere and ionosphere by means of ELF and VLF radio waves, both naturally and artificially generated. It is a joint working group constituted under the auspices of URSI - International Union of Radio Science (Commissions G and H) and IAGA - International Association of Geomagnetism and Aeronomy (Divisions II and III). Originally the emphasis was on probing of the magnetosphere by whistlers, but recently the scope has become somewhat broader. The group aims to promote research in this field by facilitating the exchange of ideas, information and experience between active research workers and other interested scientists. This is done through regular meetings at URSI and IAGA Assemblies, via the circulation of a newsletter, and through the World-Wide-Web. The group has also been active in sponsoring scientific symposia at IAGA and URSI Assemblies, in areas relevant to its field of interest, and in coordinating observational campaigns. At present the main areas of interest are Plasma structures and boundaries - morphology and dynamics, Wave-particle and wave-wave interactions, Wave-induced precipitation, Wave propagation in magnetospheres and ionospheres, and Sprites and the effects of lightning on the ionosphere. Meetings of the VERSIM group at Lille and at the 1997 IAGA Assembly in Uppsala, Sweden, recommended that the working group continue in existence. The well-attended Lille meeting, held on 4 September 1996, was reported in VERSIM Newsletter No. 10. M. Parrot (France) was elected as URSI co-chair of the working group replacing U.S. Inan (USA) who was stepping down after 12 years service. A successful VERSIM half-day session (Session 2.14) on Localized Ionospheric Perturbations related to lightning and VLF transmitters was convened by D. Nunn and A.J. Smith, and held on Monday 11 August 1997 during the IAGA Assembly at Uppsala, Sweden. It was a good session, attended by about 40 scientists. A meeting of the VERSIM Working Group also took place at Uppsala. Full reports of both these meetings were published in VERSIM Newsletter No. 12, and are also available on the VERSIM Web site. As a new initiative, a recent VERSIM bibliography has been compiled by M Parrot and is available on the VERSIM Web site. The VERSIM mailing list has now been replaced by an electronic mailing list, which was set up in June 1999. For details see: http://www.nerc-bas.ac.uk/public/uasd/versim/vrsmeml.html. The list currently has 84 scientists from 21 different countries. There is an email directory on the VERSIM Web site. Four newsletters (Nos. 10-13) have been circulated since the 1996 URSI Assembly in Lille, in December 1996, July 1997, March 1998 and June 1999 respectively.

*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)

This inter-agency task force is mandated to develop the standard reference ionosphere. The main activities are the annual workshops. The 1997 IRI Workshop was held jointly with the European COST 251 Project at the Institute for Atmospheric Physics in Kühlungsborn, Germany from 27 to 30 May. The European Union Cooperation in Scientific and Technical Research (COST) project 251 deals with "Improved Quality of Service in Ionospheric Telecommunication System Planning and Operation". The Workshop focus was on "New developments in Ionospheric Modeling and Prediction". A selection of papers from the workshop was published in Volume 22, Number 6 of Advances in Space Research (32 papers, 918 pages). An IRI session on the "Lower Ionosphere - Measurements and Models" was held during the Scientific Assembly of the Committee on Space Research (COSPAR) in Nagoya, Japan, 13-15 July 1998. 32 papers from the session were accepted for publication in Advances in Space Research. The 1999 IRI Workshop will be held at the University of Massachusetts in Lowell in the week just preceding the URSI General Assembly. Abstracts for 51 presentations have been submitted to the organizers. The annual IRI Task Force Activity continues at the International Center for Theoretical Physics (ICTP) in Trieste, Italy. During the weeklong activity a team of about dozen experts tackles a set of very focussed and specific IRI modeling problems hands-on with the help of the ICTP computers and Internet access.

The IRI Newsletter is published quarterly by K. Oyama (ISAS, Japan). Information about software updates and corrections are distributed through an electronic mailer to a list of more than 250 users. The WWW IRI interface of NSSDC records about 600 accesses per month and the IRI anonymous ftp site lists about 700 accesses per month. A proposal has been submitted to the International Standardization Organization (ISO) to make IRI the ISO standard for the ionosphere. A Windows/NT interface to the IRI software is under development at UML. The IRI

model is recommended as standard in NASA (TM-4527) and ESA publications (System Engineering Space Environment, European Cooperation for Space Standardization, ESA, 1997).

*The following conferences and meetings have been organized and attended by members of the URSI Commission G with URSI support in mode B:*

**1. Fifth International School / Symposium for Space Simulations, Kyoto, Japan, 13-19 March 1997**
Representative for Comm. G: H. Matsumoto
Radio Science Bulletin, No 281, p. 13, June 1997

This symposium provided a unique opportunity to facilitate the interactions and collaborations among the scientists and students working on space simulations, theories, and observations. Session topics included: Micro-scale phenomena, Meso-scale phenomena, Macro-scale phenomena, and New areas of research, Supercomputing. The total number of scientists and students participating was 182 from 14 different countries. A series of lectures on space physics and tutorials on simulation codes were given along with oral and poster presentations of recent results of theoretical, observational and simulation studies.

**2. IRI/COST Workshop on New Developments in Ionospheric Telecommunications Systems Planning and Operations, Kühlungsborn, Germany, 27-30 May 1997**
Representative for Comm. G: B.W. Reinisch
Radio Science Bulletin, No 283, p. 10, December 1997

This jointly organized meeting provided an opportunity for a large number of European scientists to present their IRI-related studies and to participate in the IRI improvement effort. Session topics included: Ionospheric models and HF propagation, E and D region, Topside ionosphere, Ionospheric storms and trough, Long-term variation and variability, Ion composition and plasma temperatures, Ion drift and spread F. There were 86 participants representing 21 countries, and more than 100 presentations. A special issue of Advances of Space Research has published selected papers.

**3. Beacon Satellite Symposium 1997, Sopron, Hungary, 30 June - 5 July 1997**
Representative for Comm. G: P. Bencze, Hungry
Radio Science Bulletin, No 284, p. 17, March 1998

The primary topics included: Ionospheric tomography with emphasis on results and including "space tomography", Electron content from networks of GNSS (Global Navigation Satellite System) receivers - replacement of classical methods (Faraday effect on signals of geostationary satellites) - data for nowcasting applications - data for near real time modeling, Electrón content as input for regional and global ionospheric models, Progress in scintillation modeling with emphasis on satellite to satellite probation, and New experiments and requirements of novel applications of transionospheric propagation of radio waves. The symposium was attended by 35 participants from 15 countries, among them were 8 young scientist and graduate students. 38 papers were given orally, 6 were presented as posters. Written versions of the majority of the papers will appear in the journal "Acta Geodetica et Geophysica Hungarica".

**4. MST8: Eighth International Workshop on Technical and Scientific Aspects of MST Radar, Bangalore India, 15-20 December 1997**
Representative for Comm. G: J. Röttger, Germany
Radio Science Bulletin, No 285, p. 32, June 1998

Since the beginning of the MST (mesosphere-stratosphere-troposphere) radar era in the middle 1970's this workshop has become the standard 'International Workshop on Technical and Scientific Aspects of MST Radar'. The four main topics included Scattering processes, Atmospheric dynamics, Meteorology, and New developments and facilities. A total of 130 scientists and engineers took part in MST8, where 52 were from outside India, and from 17 countries. A total of 162 papers were presented, whereof 124 were given orally and 38 displayed as posters. The extended abstracts of the workshop proceedings were published in the Handbook for STEP.

**5. ESGAP 2, Electromagnetic Scattering from Gases and Plasmas, Lviv, Ukraine, 30 March - 2 April 1998**
Representative for Comm. G: C. Hanuise, France
Radio Science Bulletin, No 281, p.14, June 1997

Topics included: Coherent scattering from space plasmas (ionosphere and magnetosphere), Coherent scattering from fusion plasmas (magnetic and inertial confinement), Collective scattering from aerodynamic flows, Bragg scattering from atmospheric turbulence, Scattering from condensed matter, Theory of scattering from turbulent media.

**6. C4.1 - COSPAR Scientific Assembly '98, Nagoya, Japan, 12-19 July 1998**
Representative for Comm. G: B. W. Reinisch, USA
Radio Science Bulletin, No 287, p. 20, December 1998

The session C4.1 Lower Ionosphere: Measurements and Models was organized by the COSPAR/URSI interunion Working Group on the International Reference Ionosphere (IRI) and was held the first three days of the 32nd COSPAR Scientific Assembly. The main topic was Lower Ionosphere (the D and E region; altitude range from about 50 to 150 km). Different IRI half-day sessions dealt with the following topics: D Region Modeling, D Region Data, IRI Improvements - Middle Ionosphere, New Models and Data for IRI, Lower Ionosphere - Data, Ion Composition. A total of 46 papers was presented, including 17 invited, 12 contributed and 17 poster presentations.

**7. 5th International Suzdal URSI Symposium, Moscow, Russia, 26-29 August 1998**
Representative for Comm. G: S. Pulinets, Russia
Radio Science Bulletin, No 287, p. 22, December 1998

This symposium addressed the modification of the ionosphere by powerful radio waves. The program included the following topics: Powerful HF radio wave interaction with the ionospheric plasma, ELF-VLF waves excitation in the ionosphere and magnetosphere, Action of powerful microwave emission and particle injections on the Earth's atmosphere, Modification of the ionosphere by electrostatic atmospheric electric field. The symposium attracted sixty participants from Germany, Finland, Norway, Russia, Sweden, Ukraine and the USA. There were 27 invited reports, 21 oral papers and 30 posters presented.

**8. Workshop on Radio Methods for Studying Turbulence, Urbana, Illinois, USA, 9-12 August 1999**
Representative for Comm. G: A. Wernik, Poland
Radio Science Bulletin, No 286, p. 36, June 1998

The Workshop is intended to meet the general need for an exchange of information and ideas between scientists working on turbulence in various environments. It will bring together experts from all over the world that work on turbulence using radio methods. The main topics are Data analysis, Characterization and interpretation, and Theoretical results. The Workshop is a joint effort of URSI Commissions: E - Electromagnetic Noise and Interference, F- Wave Propagation and Remote Sensing, G - Ionospheric Radio and Propagation, H - Waves in Plasmas, and J - Radio Astronomy.

**9. URSI/COSPAR International Reference Ionospheric Workshop, Lowell, MA, USA, 9-12 August 1999**
Representative for Comm. G: B.W. Reinisch, USA
Radio Science Bulletin, No 288, p. 33, March 1999

The IRI annual meetings are the primary venue for improvements and refinements of the IRI representation of ionospheric electron density, electron temperature, ion composition and ion temperatures. Special emphasis for the 1999 Workshop is on Specification of the variability of ionospheric characteristics, The use of IRI for ray tracing studies and applications. Other topics include Comparisons of IRI with measurements and with other models, Suggested improvements and additions for IRI, and Applications of the IRI model. Attendees from 17 countries will present 48 papers.

*In mode A Commission G sponsored:*

1. Bianisotropics '97
International Conference and Workshop on Electromagnetics of Complex Media, Glasgow, UK, 5-7 June 1997. The Radio Science Bulletin, No. 282, September 1997, p. 20.

2. ISRP'97
International Symposium on Radiowave Propagation, Qingdao, China, 12-16 August 1997. The Radio Science Bulletin, No. 283, December 1997, p. 14.

3. IWTS'98
1998 International Wireless and Telecommunications Symposium/Exhibition, Shah Alam, Malaysia, 11 -15 May 1998. The Radio Science Bulletin, No. 288, March 1999, p. 21.

4. International Workshop Day on Diffraction '98
St. Petersburg, Russia, 2-4 June 1998. The Radio Science Bulletin', No. 287, December 1998, p. 19.

5. COSPAR Scientific Assembly
Sessions C1.2, C2.1, C2.3, C2.6, D0.3, D0.8, Nagoya, Japan, 12-19 July 1998.

# COMMISSION H

*This triennium report was prepared by Dr. Vladimir Fiala, Commission H Chair 1996-1999.*

The activities of the commission in this triennium has been devoted mostly to the organisation of meetings and conferences and to the preparation of sessions for the Toronto General Assembly.

*The following working groups have been active:*

- IAGA/URSI joint WG on VLF/ELF Remote Sensing of Ionospheres and Magnetospheres, VERSIM
  IAGA Co-Chair: A.J. Smith, (A.J.Smith@bas.ac.uk)
  URSI Co-Chair: M. Parrot (mparrot@cnrs-orleans.fr)
  VERSIM has its own Homepage at url : http://www.nerc-bas.ac.uk/public/uasd/versim.html.
  VERSIM has its own Newsletter, edited by A.J. Smith is available.
- joint WG, with CGH, on Wave and Turbulence Analysis, comm H Co-Chair: F. Lefeuvre
- joint WG, with GH, on Active Experiments in Plasmas, comm H Co-Chair: W.J. Raitt
- joint WG, with GH, on Computer Experiments, Simulation and Analysis of Wave Plasma Processes, comm H Co-Chairs: H. Matsumoto & M. Ashour-Abdalla
- joint WG, with EGH, on Electromagnetic Effects Associated with Seismic Activity, comm H Co-Chair: M. Parrot

*Commission H sponsored the following meetings and conferences:*

In mode B (with financing):

1. 5th International School/Symposium for Space Simulations, Kyoto, Japan, March 1997
2. 3rd Volga Space Plasma Physics Summer School, Nizhny Novgorod, Russia, June 1997
3. 23rd International Conference on Phenomena in Ionized Gases, Toulouse, France, July 1997
4. Workshop on International Reference Ionosphere, Lowell, MA, USA, July 1999
5. Workshop on Radio Methods for Studying Turbulence, Urbana, Ill., USA, August 1999
6. Workshop on Plasmasphere Rediscovered: A Tribute to Donald Carpenter, Toronto, Canada, August 1999
7. 26th General Assembly of URSI, Comm H and joint GH sessions, Toronto, Canada, August 1999

In mode A (without financing):

1. International Conference on Plasma Physics, Nagoya, Japan, September 1996
2. International Conference on Physics of Dusty Plasmas, Goa, India, October 1996
3. Conference on Electromagnetic Scattering from Gases and Plasmas, Lviv, Ukraine, April 1998
4. International Workshop Day on Diffraction'98, St. Petersbourg, Russia, June 1998
5. COSPAR Scientific Assembly, Nagoya, Japan, July 1998

Information on commission activities is available to the Waves in Plasmas community and other interested at:
http://terezka.ufa.cas.cz/ursi/index.html

# COMMISSION J

*This triennium report was prepared by Prof. Roy Booth, Commission J Chair 1996-1999.*

Commission J has had an active triennium with some exciting technical and scientific achievements and some important developments in international collaboration. However, our observations have continued to be plagued by man-made of interference and various measures have been taken to deal with the problem. Commission J together with Commission 40 of the International Astronomical Union, arranged a meeting of the directors of most of the world's radio astronomy observatories at the IAU General Assembly in Kyoto in 1997. This resulted in the 'Kyoto declaration', a pledge to work together to better inform the public, and fellow scientists and engineers in the communications industry, of our work and the problems of interference, to make efforts to devise techniques to mitigate the effects of interference and to intensify participation in the regulatory processes conducted through IUCAF and by the ITU.

In another forum, the OECD Megascience Forum, a working group for Radio Astronomy identified the conflicting interests of radio astronomy and satellite communications as a serious challenge for the current regulatory mechanisms. This was acknowledged at Ministerial level and Ministers endorsed the formation of a small, informal, one-year Task Force with participation from industry, astronomy, regulatory bodies and governments to investigate the problem and look for solutions,

*International meetings*

Conference support in the last triennium is confined very strongly to 1999, there being only one sponsored conference before then: 'Radio Emission from Galactic and Extragalactic Compact Sources' in Socorro, New Mexico, USA, in April, 1997. In 1999 we have co-sponsored Commsphere'99, held in Toulouse, France in January, and we will sponsor a workshop on 'Radio Methods for studying Turbulence' at the University of Illinois in Urbana-Champaign, USA immediately before the General assembly, and a conference on the 'Early Universe' in St Petersberg just after the GA. Finally we support a timely conference on 'The Universe at Low Radio Frequencies' in Pune, India in November 1999.

*Technical developments*

One of the most exciting development of the last triennium was the successful launch, on February 12, 1997, of the Japanese VSOP satellite, bearing an 8m antenna and associated VLBI receivers.. The satellite, renamed HALCA on launch, is in an orbit with apogee 21,400 km. It is now routinely possible to make VLBI observations, at wavelengths of 18 and 6 cm, with baselines up to 3 times the Earth's diameter using HALCA and the ground VLBI arrays. Among other important technical developments in VLBI was the opening of the JIVE correlator in October, 1998; full operation is expected before the end of 1999.

At millimetre/submillimetre wavelengths, significant progress in array receivers has been demonstrated by several groups, eg Edinburgh, MPI Bonn, Caltech and UMass and Chicago. SCUBA, the first in a new generation of submillimetre arrays built at the Royal Observatory, Edinburgh in collaboration with Queen Mary and Westfield College, London, became available at the James Clerk Maxwell Telescope in 1997. It consists of two arrays of bolometers – 37 pixels in the wavelength range 750 – 850 micron and 91 pixels in the range 350 – 450 micron.

Another important technical achievement was the launch of the US submillimetre wave satellite, SWAS in late 1998. Observations with the SWAS indicate abundant interstellar water but no oxygen line indicating a low abundance. A similar satellite, instrumented for astronomy

and aeronomy observations, is under construction by a consortium led by Sweden. It will be launched in 2000.

Towards the other end of the wavelength range, 21 cm, a new large 13 beam focal plane array on the Parkes telescope is facilitating large surveys at this wavelength as well as being used to detect pulsars at a great rate.

*Scientific results*

It was at the beginning of the triennium that detections of CO and dust at redshifts of 4.69 with both the Nobeyama and IRAM interferometers were reported. (Redshift signifies both distance and epoch and z=4.69 implies that the radiation left the quasar when the Universe was only about 7% of its current age). A second detection of CO at a redshift greater than 4 was reported more recently by IRAM scientists. These and recent Scuba results put into question whether the epoch of galaxy formation was at z~2 as has been discussed, or significantly earlier.

Molecular maser research has been prominent during the past few years. 22 GHz water masers in the accretion disc surrounding the central black hole in the galaxy NGC 4258 have been known for some time and their position – rotational velocity measurement has shown the central mass to be some 35 million times that of the Sun. New observations with the US VLBA have detected and located the core of an active galactic nucleus relative to the black hole – the positional offset is consistent with theoretical predictions. Masers, methanol this time, are also being used to delineate discs around newly forming stars according to results from the Australia telscope and the European VLBI network and VLBA observations of SiO masers show them to lie in rings around evolved stars.

Finally, another result of note is the role played by the VLA in the detection of a gamma-ray burst at radio wavelengths. This detection and the measurement of radio brightness variations helped astronomers begin to measure a size limit to the object and together with its redshift, determined optically, to begin to understand the physics of gamma-ray bursters

*New instrumental projects*

Such considerations as high redshift CO and the epoch of galaxy formation referred to above are important scientific drivers for a large millimetre/submillimetre array. Three arrays were being discussed in 1996 but the US and Europe have formally agreed to co-operate to build a single large array, the Atacama Large Millimetre Array (ALMA), on the mountain Chajnantor, at an altitude of 5000 m in the Chilean Andes. The project is in a study/prototyping phase until the end of 2001 when it is hoped that full production of the 64-telescope array will be built. The individual antennae are to be 12m in diameter (total collecting area 7000 $m^2$) and their wavelength range will be 3.5 mm to 350 micron. It seems likely that the third group, from Japan, will also become partners in ALMA.

Another large array under discussion is the 'Square Kilometre Array'. This instrument is intended for observations, among other things, of hydrogen in the early universe and so will be required to operate at wavelengths where communications are already dominant. It will rely upon interference mitigation technology and must, presumably, be built in a remote, relatively interference-free part of the Earth.

Meanwhile the construction of the Smithsonian millimetre array continues apace, the Green Bank telescope has made significant progress, despite some manufacturing problems and a 50 m diameter millimetre telescope (LMT) is being constructed in Mexico, as a joint project between the Mexican Instituto National de Astrofisica and the University of Massachusetts.

# COMMISSION K

*This triennium report was prepared by Prof. James C. Lin, Commission K Chair 1996-1999.*

The Commission on Electromagnetics in Biology and Medicine is charged with promoting research and development in the following domains :

(a) physical interactions of electromagnetic fields with biological systems;
(b) biological effects of electromagnetic fields;
(c) interaction mechanisms;
(d) human exposure assessment;
(e) experimental exposure systems;
(f) medical applications.

The Commission emphasizes its interdisciplinary character and fosters research co-operation among various disciplines.

Considerable progress has been made in fulfilling these objectives during the 1996-99 triennium. This report shall spotlight some of the major activities in the areas of research initiatives, conference organization and sponsorship, international cooperation, young scientists awards, publications, and participation in organizing the Centennial General Assembly in Toronto, Canada.

**Research initiative**

Mobile and Personal Communications and the Health and Safety of Radiofrequency Radiation

The advent of wireless communication service has delivered mobile and personal telecommunication to vast segments of the world's population. The wide spread impact of this new technology has raised concerns about the safety of human exposure to radiofrequency (RF) energy emitted by these telecommunication devices. A better understanding of the biological effects of RF electromagnetic field is needed to safeguard the general population against possible harm. Within the last few years there has been a resurgence of research interest in achieving

a quantitative understanding of the relationships between the biological effects of RF radiation and the physical variables that may cause them.

At sufficiently high power levels RF radiation can produce deleterious thermal effects. Wireless telecommunication systems use low power modulated forms of RF radiation that was not investigated extensively in the past. Specific questions must be answered before any consistent, dependable and scientific conclusions can be drawn for the biological effects and safety of wireless mobile and personal telecommunication systems. Nevertheless, it is noteworthy that available data do not suggest any immediate cause for concern of a impending threat to public health from acute or short term exposure to low level RF radiation. A critical need is the investigation of effects of long term or repeated exposure over extended periods of time.

URSI and its Commission (K) on Electromagnetics in Biology and Medicine recognize the problem, the scientific uncertainty, and that there is public concern about health effects of all RF systems and have adopted specific resolutions. The objectives of the resolutions are to stimulate domestic research, encourage international cooperation, and to provide coordination, if necessary.

Accordingly, it is recommended that broadly based research programs be established nationally and internationally to address the following key questions:

1. What are the interaction mechanisms with living systems, especially weak electromagnetic fields of various characteristics;
2. What biological effects - and particularly potentially harmful effects - are caused, and under what exposure conditions;
3. How to evaluate the exposures through proper measurements and dosimetric modeling.

Furthermore, it is noted that there is now increasing evidence that electromagnetic fields from wireless communication devices may affect the operation of some medical devices - either implanted or connected to the human body - and as a result may pose a problem to the operation and health; URSI and Commission K recommend accelerated scientific and industrial research to ensure the safety of medical devices in the presence of electromagnetic fields. Specifically, studies are to be aimed at clarifying (a) the specific behavior of implanted equipment; (b) the characteristic of connected medical equipment; (c) modeling methods; (d) specific measurements; and (e) influence of the person on electromagnetic interference (EMI).

To ensure that these global research programs respond to local environmental concerns and societal goals, URSI encourages each member Committee and Commission K to actively promote research in their territory and to urge appropriate authorities to create research centers devoted to electromagnetics in biology and medicine. Few country has the resources capable of sustaining a large scale research program, let alone linking it to the rest of the world.

URSI, as an international organization with a long-standing interest and has fostered the development of this scientific area for many years, is committed to providing the platform for cooperative research, exchange of data, and the sharing of knowledge. The research effort of national commissions will be connected to the global effort by the URSI Commission to facilitate this process and to provide knowledgeable scientific expertise in each member committee, well coupled to the-state-of-knowledge in the global community.

## Conference organisation and sponsorship

*A. Organization of the 3rd International Scientific Meeting on Electromagnetics in Medicine, Mode B, November 3-5, 1997 (Radio Science Bulletin, No. 284, 1999, pp19-20)*

This meeting was the third Scientific Meeting on Microwaves in Medicine. In the tradition of past meetings, this Scientific Meeting was organized by Commission K) with the cooperation of the Institute of Electrical and Electronic Engineers (IEEE) through its Microwave Theory and Techniques Society (MTT-S).

After observing the technology changes and receiving many feedbacks from attendees of the 2nd meeting and the 25th URSI General Assembly, we have decided to expand the meeting to cover both low and high frequencies instead of microwaves only. To reflect this expansion of the meeting's scope, we changed the name of the Scientific Meeting.

General information regarding the Third International Scientific Meeting on Electromagnetics in Medicine was available on our WWW site.

The technical program was designed to render a broad coverage of the recent advances in the field of electromagnetics in medicine. A coordinated, single session format provided a comprehensive well-balanced scientific program. The International Scientific Meeting had become an outstanding forum for interdisciplinary discussion on key issues in research and technological development. It provided an opportunity to hear many interesting and challenging papers and learn a wide spectrum of new technologies and applications.

The meeting had a total of 76 attendees that include 21 students. The quality of presentations and level of discussions were very high. All scheduled speakers (with the rare exception of two) showed up including Russian scientists.

The technical program covered three full days. A single session format was adopted to encourage interdisciplinary dialogue. Sessions began on Monday morning and run through Wednesday afternoon. An invited lecture started the meeting at 9:00 am each morning on a topic of emerging interest. It was followed by sessions with six contributed papers each. Refreshments was available both mid-morning and mid-afternoon. The last session on Tuesday afternoon was a laboratory tours arranged for the benefit of registered participants and their guests.

Some of the papers (13 in toto) presented at the Third Scientific Meeting were published as a collection in Bioelectrochemistry and Bioenergetics, vol. 47, December, 1998.

The organizers would like to take this opportunity to acknowledge the generous financial and material support of the International Union of Radio Science, the IEEE Microwave Theory and Techniques Society, the Motorola Corporation, the College of Engineering and the Department of Electrica.l Engineering and Computer Science of the University of Illinois at Chicago, and lastly the committee members and authors. Their collective effort has allowed this Scientific Meeting to become a reality.

*B. Sponsorship of International Conferences and Symposia*

One of the most rewarding undertaking of Commission K was the co-sponsorship of 11 conferences and symposius: 5 scheduled Mode B meetings (with financial support) and 6 Mode A meetings (with no financial support). A chronological listing of these with references to articles reporting on them in the Radio Science Bulletin where appropriate is given below.

1. Commsphere'97, Mode B, Lausanne, Switzerland, February 11-14, 1997 (Radio Science Bulletin, No. 282, 1997, pp15-19)
2. 2nd World Congress for Electricity and Magnetism in Biology and Medicine, Mode A, Bologna, Italy, June 11-13, 1997 (Radio Science Bulletin, No. 283, 1997, p11)
3. Radio Africa '97, Mode B, Nairobi, Kenya, August 4-8, 1997 (Radio Science Bulletin, No. 285, 1999, pp30-32)
4. PIERS'98, Mode A, Nantes, France, July 13-17, 1998
5. Symposium on Electromagnetic Fields in Biological Systems, Mode B, Prague, Czech Republic, September 13-16 (Radio Science Bulletin, No. 287, 1998, p24)
6. EMC '98 Roma, Mode B, Rome, Italy, September 14-18, 1998 (Radio Science Bulletin, No. 283, 1997, pp8-9)
7. Physics and Engineering of MM and Sub-MM EM Waves, Mode B, Kharkov, Ukraine, September 15-17, 1998 (Radio Science Bulletin, No. 285, 1999 pp28-30)
8. 4th EBEA Congress, Mode B, Zagreb, Croatia, November 19-21, 1998 (Radio Science Bulletin, No. 288, 1999, pp32-33)
9. Asian Pacific Microwave Conference '98, Mode A, Yokohama, Japan, December 8-11, 1998
10. Commsphere '99, Mode B, Toulouse, France, January 25-28, 1999
11. Day on Diffraction '99, Mode A, St Petersburg, Russsia, June 1-4, 1999

**International Cooperation**

In addition to the Commission K efforts in cooperation with many other scientific, health, and engineering organizations mentioned above, it had also made a proposition for cooperation to the World Health Organization (WHO) between 1997 and 98. However, to date, neither Commission K nor URSI has received any response from WHO.

**Young Scientist Program**

A salient aspect of URSI activity is the Young Scientists Award and support of recipients to attend the Triennial General Assemblies. This year, 13 awards are selected from a total of 21 applications through Commission K. Our congratulations to the young scientists.

**Review of Radio Science**

In correspondence of the General Assembly a book reviewing the developments of Radio Science related to the triennium and a disk reporting the international literature published in the triennium are edited.

The triennial URSI "Review of Radio Science" is published by the Oxford University Press. The book is divided into sections edited by the Vice-Chair of each URSI Commission. The Commission K section is edited by Professor Shoogo Ueno of Tokyo University. There are 5 chapters in the K section. The titles and the authors of these chapters are:

1. "Cell and Molecular Biology Associated with Radiation Fields of Mobile Telephones" by W. R. Adey
2. "Review of Exposure Assessment for Handheld Mobile Communications Devices and Antenna Studies for Optimized Performance" by M. Burkhardt and N. Kuster
3. "Bioelectric and Biomagnetic Measurements" by T. Katila and R. J. Ilmoniemi
4. "Medical Applications of Static and Low-Frequency Pulsed Magnetic Fields" by S. Ueno
5. "Biomedical Applications of Electromagnetic Fields and Waves: Radio Frequencies and Microwaves" by J. C. Lin

**Disk of references**

Commission K is participating in the effort ot produce a diskette of references to archival publications during 1996-99. The Commission K portion of the disk is edited by Professor Masao Taki of the Tokyo Metropolitan University. Assistance was solicited from the Official Members of Commission K. The final list of 643 references included in the K section consist of suggestions from official members and references selected from journals and other archival publications.

Although the disk is not intended to be an exhaustive bibliography for the years covered, it gives a broad representation of the international literature published during the triennium.

**Scientific Program at the General Assembly**

A major function of the commission is the development of an international scientific program at the triennial general assembly. Commission K has scheduled a record number of 137 platform and poster presentations at the General Assembly in Toronto. Specifically, they include one tutorial lecture, 78 platform and 58 poster presentations divided into 8 oral sessions and 5 poster sessions. Four of the sessions are organized jointly with Commissions A, B, C, and E. A brief listing of the program is given below.

**Tutorial Lecture**

"The Biology and Epidemiology of Human Exposure to Power Line Electromagnetic Fields." Russel Reiter , USA

**Platform Sessions**

K1 Mechanisms and Modeling of Electromagnetic Interaction with Biological Systems
Co-convenors: C. Polk (USA) and G. D'Inzeo. (Italy)

K2 Biological Effects of Electromagnetics Fields
Co-convenors: L.Kheifets (USA) and R. Korenstein (Israel)

K3 Hazard Assessment for Wireless Communication
Co-convenors: P. Bernardi (Italy) and B. Veyret (France)

K4 Biomedical Applications of Electromagnetic Fields and Waves
Co-convenors: C. Gabriel (UK) and S. Ueno (Japan)

**Joint Sessions**

KA Exposure Assessment for Cellular and Personal Telecommunications
Co-convenors: C. Chou (USA) and M. Taki (Japan)

KB Computation of Electromagnetic Fields in the Human Body
Co-convenors: O. Gandhi (USA) and Y. Rahmat-Samii (USA)

KC Health Effects of Mobile Telephones
Co-convenors: R. Adey (USA) and N. Kuster (Switzerland)

KE Electromagnetic Interference with Medical Devices
Co-convenors: D. Witters (USA) and O. Fujiwara (Japan)

**Finally**

It has been a busy triennium for Commission K during which it had seen considerable progress in our field of radio science. Commission K had cooperated with many other scientific and engineering organizations in presenting its programs. I believe its active involvement demonstrates the maturity of this young commission, born during the last decade of the 20th Century. I appreciate the opportunity to serve the commission, URSI and radio science.

AWARDS CEREMONY

## Presentation of the Balthasar Van der Pol Gold Medal

*Mr. Balthasar van der Pol, Grandson and namesake of Professor Balthasar van der Pol gave the following introductory speech*

Thank you very much, Dr. Bauer, for your introduction and kind words. I was very honoured to be asked by Professor Senior to be here today to present the van der Pol Gold Medal at this 26th General Assembly.

I am very grateful that my wife, my mother and my two sons could also be here today. This is a very special occasion for us and one that I am sure my sons will remember for the rest of their lives.

My grandmother, the late Mrs. Pietronetta van der Pol – Le Corbeiller initiated the van der Pol Gold Medal in 1963 where at the 14th General Assembly in Tokyo she presented it for the first time. As my grandmother stated and I quote "the purpose of the medal is to keep alive the memory of my husband and to stimulate, especially the younger scientists among you, to work patiently and seriously with the Officers of URSI for radio science in its widest scope."

Throughout his life, my grandfather, Balthasar van der Pol, had a long association with URSI. As one of its founders he served as Vice President from 1934 to 1952 and at the time of his death in 1959 was Honorary President.

My grandfather was born in 1889 in Utrecht, the Netherlands and died in 1959 at his home in Wasanaar, also in the Netherlands. He graduated cum laude in physics from the University of Utrecht in 1916. The next three years were spent in England working under Ambrose Fleming at the University of London and later under JJ Thompson at Cambridge in the famous Cavendish laboratories. It was here that he developed his thesis entitled "The Effect of an Ionized Gas on Electromagnetic Wave Propagation and its Flow Discharge Measurements". He had created an artificial ionosphere in the laboratory and proved that it had a refractive index of less than one for short radio waves. The implication of this was that short waves would reflect back to the ground when contracting the earth's ionosphere. This was an important discovery at that time as long distance transmission and reception of short waves had not been realized. This thesis earned him the degree of Dr. of Physics from the University of Utrecht in 1920.

Later he went on to receive Honorary Doctorate degrees from the Technical University of Warsaw and from the University of Geneva.

From 1919 to 1922 he served as theoretical assistant to the great HA Lorentz in Haarlem, the Netherlands.

In 1922 he became head of the Philips Research Laboratories in Eindhoven, a position he held until his retirement in 1949. In that year he was appointed a Director of the International Consultative Committee on Radio Communications and moved to Geneva, Switzerland. He loved Switzerland and considered it his second home, after Holland. In a lecture he once compared Switzerland to the element Helium, he said it was stable and neutral, just like Helium. He also alluded to some other countries but diplomatically declined to make any analogies.

He returned to Holland in 1956 and during the last three years of his life he was invited as a "Visiting Professor" at the American Universities of, Berkeley and Cornell.

In the 1930's he published a paper on "Relaxation Oscillations" the resulting equation of which he developed became known as the van der Pol equation. He realized that the beating of the human heart was in fact a relaxation oscillation and this prompted him to construct an electrical artificial heart. As he put it "the mathematical equation showed me the way." In studying possible deviations in relaxation circuits he compared them with heart diseases and even predicted some physical heart irregularities that had not yet been recognized or understood by physicians at that time.

Although known primarily as a physicist he had a great interest in and passion for mathematics. He was fascinated with prime numbers and developed a solution to the problem of complex prime numbers. This solution was in the form of a graph that illustrated that all prime numbers are not indivisible in the same sense. A Dutch textile manufacturer was so taken with the design of this chart that he had the design woven into linen tea towels. To my grandfather the greatest beauty in the tea towels was in their ability to reveal the properties of prime numbers.

My late father, also named Balthasar van der Pol used to tell the story of how whenever the family went on a car trip, my grandfather used to bring along pencil and pad of paper to record any license plate numbers that he suspected of being prime numbers. Upon returning home he would disappear into his study only to emerge minutes later to exclaim that indeed they were prime numbers.

Another great passion of my grandfather was music. He possessed "absolute pitch" meaning that he could identify a pitch in absolute value. He used to test this every

morning at the Philips laboratory by singing middle C and having it checked electronically. He lectured and prepared a number of papers on the relationship between music and mathematics. In particular he recognized the mathematical nature of the music of Johann Sebastian Bach. He was an accomplished musician, being proficient at the piano, violin and cello. He used to say that "music was the most beautiful of the arts and that mathematics was the most beautiful of the sciences."

My grandfather was also known as a great lecturer and educator, he was knighted in Holland for his work as President of Temporary University at Eindhoven, that was set up in Holland during the war.

At Philips he was know as "The Grand Old Man of Radio" but to me, he was always known as "Opa". Unfortunately I was only four years old when my grandfather passed away, so although I didn't get to know him personally, I grew up hearing many stories about "Opa".

My father described my grandfather as, and I paraphrase, one of those deeply involved men, whose mind was active all the time. During what little time he afforded himself for leisure, one was always aware that he was thinking of something new and intriguing. On many occasions during the family dinner hour he would take out a pencil and slide rule and then scribble a few mathematical symbols on the beautiful white linen tablecloth, then exclaim, "isn't that elegant!" To my father's dismay he was quickly reprimanded by the lady of the house when he attempted the same, this was to be my grandfather's privilege only.

My grandfather often spoke of living in an ivory tower where he could work undisturbed at his mathematics and research. Fortunately for my father ivory towers are hard to find in Holland, instead my grandfather found the needed tranquility and inspiration he desired in his study at home and my father assured me that he spent many hours there.

*Prof. Shlomo Shamai (left) shakes hands with Mr. Balthasar Van der Pol (right) at the Opening Reception of the Toronto General Assembly at Hart House on the University of Toronto Campus. In the picture Mr. Van der Pol shows the golden medal named after his grandfather Prof. Balthasar Van der Pol.*

Ladies and Gentlemen, it is with great pleasure and respect that I present the Balthasar van der Pol Gold Medal to Professor Shlomo Shamai for *"Contributions to the basic understanding of the potentials for and the limitations to information transfer through various communication channel models"*

## Reply by Professor Shlomo Shamai

I am deeply honoured to be selected the recipient of the van der Pol gold Medal. A medal named after the great scientist Balthasar van der Pol, who has been closely associated with URSI and contributed immensely to the development of Radio Sciences.

It gives me great pleasure to thank the grandson and namesake of this eminent scientist for presenting the Medal. My deep gratitude is extended to URSI Board of Officers for bestowing upon me this prestigious recognition. My thanks go also to the President, Professor Senior, Past President and Chair Dr. Bauer, the Secretary General, Professor Lagasse, and Vice President Dr. Shapira for his continued support and leadership.

It is an everlasting joy and pleasure to be active and contributing to such exciting and rapidly evolving fields of wireless communications and information transfer, which are embraced in full by the URSI Commissions, and in particular Commission C (Signals and Systems). In this discipline, theory and practice act in full synergy to continually extending the frontiers of Radio Sciences and provide new information processing and transfer capabilities, facilitating worldwide international cooperation to the benefit of mankind. International scientific collaboration in Radio Sciences and related domains should serve as a model for other human endeavors. In fact, it is the close international interaction which has played a central factor in the astounding achievements of our fields so far, and it is even more essential for further expediting the progress of Radio Sciences. I acknowledge with pleasure my colleagues and coworkers worldwide, particularly at Technion, Bell Laboratories, Princeton and MIT, to whom I express my profound appreciation for incessant fruitful scientific collaboration and friendship.

My gratitude is extended to my institute, the Technion-Israel Institute of Technology,, and the Electrical Engineering Department therein, for providing an amicable, vibrant and stimulating research environment.

Last, I thank all members of URSI, primarily the Israeli URSI section, and you, attendants of the Twenty Sixth URSI General Assembly, for sharing with me this special and precious moment.

## Presentation of the John Howard Dellinger Gold Medal

*Professor Susan K. Avery, President of the US National Committee for URSI, gave the following introductory speech*

The John Howard Dellinger Gold Medal honors a scientist that demonstrates not only outstanding scholarship but also a devotion to science in public service. Such was the emphasis of Dr. Dellinger's work, a physicist who performed research in many of the areas of radio science that form the foundation of URSI. He combined interests in radio science with pragmatic radio engineering issues. These interests led to the development of the radiosonde, which is still used today as a fundamental observing platform for weather observations, as well as radio aids for navigation. The correlation between visible solar eruptions and sudden radio fadings was first discovered by Dellinger and opened the field of solar-terrestrial research. Dr. Dellinger's committed service to URSI is an example to us all of what can be achieved through leadership and work in a professional organization.

The 1999 Dellinger Gold Medal is awarded to Professor Akira Ishimaru, an individual who exemplifies the qualities of Dr. Dellinger. Professor Ishimaru began his education at the University of Tokyo where he received his B.S. degree in Electrical Engineering. He was awarded a Ph.D. from the University of Washington in 1958 and spent his faculty academic career there as well. He is known for his work in wave propagation and scattering in random media. His scholarship has resulted in many seminal papers and a two-volume treatise used by scientists, engineers, and students. These works address a broad range of engineering problems in communications, remote sensing, and imaging.

Professor Ishimaru's first observations of photon localization, exhibited as backscattering enhancement, was noted as a major discovery in The Decade of Optics. His work on scattering from dense random media describes and predicts the many applications used in today's polarimetric radar. Approximately 40 students have been fortunate to receive their Ph.D.'s under the tutelage of Professor Ishimaru. Many of these students have gained international recognition in their own right. Although he has retired from his faculty position, he continues to be active in his research and in the mentoring of students.

Professor Ishimaru has been active in the United States National Committee of URSI and in the Antenna and Propagation Society of IEEE. He has served as editor of three outstanding journals and was founding editor of the international journal, *Waves in Random Media.* He has received many honors for his work.

It is my pleasure to award the John Howard Dellinger Gold Medal to Professor Akira Ishimaru for *"Contributions to the theories and applications of wave propagation and scattering in random media and backscattering enhancement".*

Please join me in warm congratulations to Professor Ishimaru.

## Reply by Professor Akira Ishimaru

I am greatly honoured to receive the Dellinger Medal, and I am grateful to the URSI Board and in particular, USNC, for the recognition of my work. My main interest is in the theory and application of wave propagation and scattering in random media. Random media refers to the many natural and man-made media whose characteristics vary randomly in space and time. Examples are air and ocean turbulence, particulate matter in the atmosphere, ocean surfaces, terrain, and geophysical media. It also includes biological media where tissue characteristics may vary randomly and must be expressed by their statistical characteristics. Another example is composite materials composed of various elements.

Wave propagation and scattering in such a medium can be formulated in several ways. Examples are the Booker-Gordon formula for wave scattering in the troposphere, ionospheric scintillations, atmospheric optics, thin phase screen theory in astrophysics, Feynmann diagram method, path-integral formulations, and Dyson and Bethe-Salpeter equations. Also important is the radiative transfer theory or transport theory which has much in common with the neutron transport theory. Partially coherent waves in optics can also be viewed as part of this general field. In addition, wave scattering by rough surfaces and applications to polarimetric radars, SAR, and active and passive remote sensing are also important parts of this field.

My interest in this field started in the 1960's when considerable activities in microwave and optical propagation in the atmosphere were taking place together with the emerging field of partial coherence in optics. At that time I was involved in a study of optical beam propagation in the atmosphere and microwave scattering in the planetary atmosphere. In the late 1960's and early 1970's, bioengineering programs were initiated at many universities. I was very much involved in a study of optical diffusion in blood and tissues, and this became an important basis for many other studies in tissue optics which are continuing today. This also naturally led to the study of radiative transfer and diffusion theories.

Since the 1980's, I have been very much interested in the general topic of multiple scattering in random media. In particular, there were some interesting studies reported on the enhanced backscattering from turbulence in the early 1970's. Together with my former Ph.D. student, Professor Yasuo Kuga, we conducted optical experiments on backscattering from discrete particles to see if we could

observe phenomena similar to the turbulence case. Our experimental data showed a very narrow peak in the back direction within a fraction of a degree. This initial study was then quickly recognised as an optical equivalent of the weak Anderson localisation of electron diffusion in disordered media. This enhancement phenomenon has attracted considerable attention not only in optics but also in microwave scattering by planetary surfaces, imaging through the ionosphere, and high-slope rough surfaces.

The enhanced backscattering is outside the radiative transfer theory and must be studied starting with Maxwell's equations rather than the heuristic transport of power. Rough surface scattering and low-grazing angle scattering are other examples of analytical multiple scattering theories. It should also be mentioned that this whole field of waves in random media is now being re-examined with various computer Monte-Carlo simulations and numerical solutions which promise to be an important tool of the future.

At this time, I would like to thank the URSI Community. URSI is my professional home, where I interact with many scientists and learn new and exciting research. I am particularly grateful to the USNC for this recognition and to all my URSI colleagues for their friendship.

I would also like to thank my co-workers at the University of Washington for their encouragement and friendship. In particular, I would like to thank all my graduate students who have given me inspiration and stimulation and have performed most of the work.

Finally, I would like to thank my family, particularly my wife Yuko, for their constant support and encouragement. Thank you.

## Presentation of the Appleton Prize

*Professor A. David Olver, President of the UK Panel for URSI, presented the Appleton Prize as follows*

The Appleton Prize is awarded to a distinguished scientist in the field of the Ionospheric Physics by the Council of the Royal Society on the recommendation of the Board of Officers of URSI. The prize commemorates the life and work of Sir Edward Appleton, who was a former president of the URSI.

Sir Edward first demonstrated in 1924 the existence of the ionosphere by measuring the time of arrival of radio waves reflected by the layers of the ionosphere. His highly significant discoveries led to his being awarded the Nobel Prize in 1947 for his work in Ionospheric Physics and Radio Propagation. He worked on ionospheric propagation all his working life, even as he held increasingly distinguished posts. His contribution to URSI was immense where he valued interaction with radio scientists throughout the world. He once said, " the big things in science occur when an adventure takes place in the mind of an individual." Since the creation of the Appleton Prize, URSI has awarded it to distinguished scientists who fulfill Sir Edward's dream.

This years' recipient, Professor Ronald F. Woodman fulfills this criteria well. He is an enormously creative scientist who has made major contributions to a wide range of topics related to radar probing of the upper atmosphere. He is one of the few scientists, active in South America, who has made major contributions to a wide range of topics related to radar probing of the upper atmosphere. He is one of the few scientists, active in South America, who has made major contributions to many areas of URSI interest. Professor Woodman was born in Peru and after graduating from the National University for Engineering went to the USA and obtained his PhD Degree from Harvard University on the subject of incoherent scatter. He then embarked on a distinguished career which has combined radio science with management of ionospheric and atmospheric research, notably Head of the Atmospheric Physics Group at the Arecibo Observatory and Director of the Jicamarca Observatory in Peru. He is now Executive President of the Institute of Geophysics in Peru.

His major contributions included work on incoherent scatter, where he provided the first theory to explain exactly how ion-ion collisions affect the ion gyro-resonance. He pioneered and recently improved the measurement of plasma drift velocity in Peru to permit the better measurement of ionospheric studies. This technique and its more recent extensions to multi-radar imaging are widely used in studies of plasma instabilities at the equator and in the auroral zone. He also created the entire field of mesosphere, stratosphere, and troposphere wind profile measurements with VHF radars. A large network of wind profilers exists throughout the world because of his insights.

His leadership of the radar ionospheric community has been exemplary and this makes him a worthy recipient of the Appleton Prize. The citation reads *"for major contributions and leadership in the radar studies of the ionospheric and neutral atmosphere."*

## Reply by Professor Ronald F. Woodman

For a scientist there is no greater satisfaction than receiving recognition from his own peers. You can imagine how honoured, happy, satisfied and proud I feel. Receiving the Appleton prize is for me the true culmination of my professional career. I couldn't aspire to more.

I also think that this year's Appleton prize has a special meaning: For the first time it is being awarded to a scientist from an underdeveloped country. Don't let my name fool you. As my accent probably suggests, I am a Peruvian national. My English grandfather came to Peru

more than a century ago. I was born in Piura, Peru, and was brought up in the same city. I mention this for two reasons: first, because of the greater significance an international scientific prize has within my own society, and second, because of what I hope it could mean for the future of science in Peru.

Receiving a prize like this brings a feeling of pride that extends to one's family and beyond, no matter the nationality of the recipient, but I doubt this happens in a well-developed society to the same degree that I have experienced. It is front page news for a Peruvian to get an international scientific prize. Ever since the news was made public, I have continued to receive sincere congratulations from people and Peruvian institutions that want to share with me the honour I brought to them, as well as to myself. This reaction has multiplied by hundreds my feeling of satisfaction and accomplishment. Thus, I have received hundreds of prizes, not just one.

My second point is one I hope will be heard by my countrymen and women in Peru. It can be said very succinctly in Spanish: "¡Perú puede!"(Peru can do it!). Our science and technology is poorly developed, but we are not limited by our culture or basic education. I received my primary and secondary education in typical Peruvian private and public provincial schools. I spent six of my school years at the Santa Rosa School in Sullana, a sister city of Piura, which at that time had only two of its main streets paved. But it was there that I was first exposed to the beauty of mathematics as a perfect example of deductive reasoning through a high school course in Euclidean geometry. My teachers were young Maristas Brothers, Spanish missionaries who sacrificed their lives for the benefit of their fellow men in a truly Christian spirit. I earned my Mechanical and Electrical Engineering degree at the Universidad Nacional de Ingenieria in Lima, Peru. But, on the other hand, I was one of the few Peruvian professionals fortunate enough to receive a postgraduate education, which had to be done abroad, in my case at Harvard. I was also able to return home to a challenging scientific position. These are two circumstances I would like to underline and elaborate on. But, before doing it, I should add that, while at Harvard, I never felt handicapped by my earlier education in Peru.

Nowadays, as in my time, if an ambitious Peruvian professional — of whom there are many— wants to obtain advanced technical and scientific knowledge, he or she has to go abroad. Some do, as I did, if they can find the support, but in most cases they do not return, not for a lack of willingness but because of the lack of opportunities in Peru. I was a fortunate exception, because the Jicamarca Radio Observatory —where I have done most of my research work— existed, and because Jicamarca is one of the only few institutions in Peru where world recognised science is done.

The lesson to be learned by Peru from my experience and my receiving the Appleton prize is that if it wants to develop (and this may hold true, as well, for other developing countries), it should improve its almost non-existent post-graduate education and research laboratories and programs. We must develop our human resources at the frontiers of knowledge since, nowadays, the wealth of a nation is found not in the abundance of its natural resources but in the abundance and quality of the knowledge available to its people. Look at the examples provided by Japan, Taiwan, South Korea, Israel and Singapore.

As I said, I was fortunate to have access to the Jicamarca Observatory, one of the most powerful instruments in the world for the study of the upper atmosphere, a facility of the Geophysical Institute of Peru since 1969. But an observatory is more than equipment; it requires people, well-trained scientists, engineers and technicians and the willingness and hard work of all its personnel, which I was also fortunate to have. I would like to share this prize with all of them.

Most of my research work has been done with the repeated collaboration of many colleagues. This can be seen in the co-authorship of my papers. I would like to share the prize with them too.

My special thanks to the colleges who proposed me for the prize; to the URSI Board, the Awards Advisory Panel and to the London Royal Society for their decision; and to all of you for being here with me today.

I dedicate the honour of this prize to my wife, Gladys, and to my six children: Karina, Randy, Pauline, Suzzette, Christian, and Elgin.

## Presentation of the Issac Koga Gold Medal

*Dr. Yoji Furuhama, President of the URSI Committee in Japan, presented the 1999 Issac Koga Gold Medal with the following words*

It is a great pleasure for me, as the President of the Japan Member Committee of URSI, to present the 1999 Issac Koga Gold Medal to Dr. Eric Michielssen, Professor of the University of Illinois in the United States of America.

I would like to start by describing briefly the rules for the Issac Koga Gold Medal, as well as the career of the late Professor Koga. The medal is endowed to a young scientist under age 35 who has made outstanding contributions to any of the branches of science covered by the ten Commissions of the URSI. It honors the memory of the late Professor Issac Koga, who was Vice President of the URSI from 1957 to 1963, President of the Union from 1963 to 1966, and Honorary President from 1981.

Professor Koga was born in Japan in 1899. He studied at the University of Tokyo, and became, first, Professor at the Tokyo Institute of technology; later, professor at the University of Tokyo; and finally, Dean of its Faculty of Engineering.

Professor Koga's researches covered a wide variety of topics in radio science. Particularly noteworthy among

these was the invention, in 1932, of a piezo-electric crystal oscillator having an almost zero frequency-temperature coefficient. This is widely known as the Koga-cut crystal, and has been used in a variety of applications, in particular to international radio communications and broadcasting.

Professor Koga was a strict educator of young students and researchers, but at the same time a warm-hearted research leader. When he passed away in 1982, the URSI Committee in Japan proposed the establishment of this Gold Medal for young scientists in commemoration of Professor Koga as a great educator as well as a distinguished researcher. The first Koga Medal was awarded fifteen years ago at the General Assembly in Florence, and this is the sixth award.

Let me now mention the distinguished scientific achievement of Professor Eric Michielssen, for which he is receiving the 1999 Issac Koga Gold Medal today. The citation for the award mentions that he has made *highly significant contributions to computational electromagnetics, in particular the development of fast frequency and time domain integral equation analysis techniques and nature-driven synthesis methods.*

Professor Michielssen, would you accept our hearty congratulations?

## Reply by Professor Eric Michielssen

President Senior, Dr. Bauer, Dr. Furuhama, distinguished guests, dear colleagues, ladies and gentlemen, I would like to thank the International Union of Radio Science for the great honour of awarding me the Koga Gold Medal.

During the past six years, I have pursued two rather different research goals: First, the development of robust, genetic algorithm (GA) driven electromagnetic synthesis techniques, and second, the construction of fast multipole method (FMM) based electromagnetic analysis tools. Today, I am both proud and happy to receive this award. I am proud because this award recognises the modest contributions that I have made to the state of the art in computational electromagnetics. And furthermore, I am happy because this award confirms the coming of age of these new design and analysis techniques. I therefore would like to thank the URSI Awards Committee for giving me the chance to publicly recognise some of the people who played a key role in the development of these two areas.

In 1992, when I started developing GAs for synthesising electromagnetic filtering devices, the time was ripe for such endeavours. By that time, it had been three years since Professor David Goldberg of the University of Illinois at Urbana-Champaign published his influential book "Genetic algorithms in search, optimisation, and machine learning," and researchers from many different branches of engineering already had discovered the beauty and power of these nature-inspired optimisers. Virtually at the same time that I ventured into this new area, other researchers in computational electromagnetics started applying GAs to their own synthesis problems: Professor Randy Haupt from Utah State University applied GAs to the design of thinned arrays and Professor Yahya Rahmat-Samii used them to tackle a variety of antenna design problems. Since, many more in our community have joined the bandwagon and recently, GAs have appeared in commercial electromagnetic design environments. I believe that the role of GAs in electromagnetic design will continue to expand, with future emphasis placed on multiobjective, and "smart" optimisers capable of solving highly computational problems quickly.

In 1995, I turned my attention to the development of fast schemes for analysing electromagnetic phenomena. Again, I was fortunate to find much inspiration in previous work. In 1990, Professor Vladimir Rokhlin from Yale-a mathematician with engineering inclinations-developed a fast scheme for solving electromagnetic scattering problems, namely the FMM. For several years, however, a mathematical shroud rendered all FMM theory virtually inaccessible to the electromagnetic engineering community, until, in 1992, our own Professor Weng Chew from the University of Illinois at Urbana-Champaign-an engineer with mathematical inclinations-re-engineered the FMM; he not only extended it to permit the analysis of very large-scale electromagnetic phenomena, but also unveiled its physical interpretation to the engineering community at large. Others, including Drs. Ben Dembart at Boeing and Stephen Wandzura at HRL soon followed suit. My own efforts in the field of fast solvers recently have focused on extending FMM technology to time domain analysis. We have constructed fast integral equation based schemes for analysing both linear and nonlinear electromagnetic transients and constructed fast global boundary conditions for FDTD simulations. I would like to stress however, that all this work constitutes no more than a variation on the work of the trailblazers I just mentioned: the invention of diagonal translation operators for wave fields was a breakthrough of enormous proportions. While much work remains in the development of quality preconditioners, higher order schemes, and parallelisation, I believe that there is no turning back the clock: FMM technology-possibly hybridised with other computational schemes-is here to stay and will be a component in the majority of future computational electromagnetics tools.

Therefore, I believe that these are very exciting times for all of us working in the area of computational electromagnetics. Indeed, the introduction of GAs and the FMM into the computational electromagnetics arena are only two events in a series of recent developments that I believe will have a lasting impact on our community. I have no doubt that robust electromagnetic analysis and design tools, capable of reliably dealing with not only stand-alone

components but also entire systems, are just around the corner. Therefore, I would like to thank all of you, my colleagues, for making electromagnetics research as exciting today as it was a century ago when the foundations for URSI were being laid.

Before I close, I would like to thank several people whom I have been fortunate to be closely associated with over the years. First of all, there is my Ph.D. advisor, Professor Raj Mittra, now at Penn State, who always encouraged me to do research in many novel areas, and that includes GAs. Secondly, there are those who make the Center for Computational Electromagnetics at the University of Illinois at Urbana-Champaign a very desirable place to be. I would like to thank my colleagues in the Center, Professors Andreas Cangellaris, Jianming Jin, and Jose Schutt-Aine, but especially Professor Weng Chew, the Center's Director, whose keen research insights, dedication to teaching excellence, mentorship of students and junior faculty, and leadership in running a quality operation serve as a continuous source of inspiration to me and many others. Finally, I would like to thank my postdoctoral associates and former students, Drs. Balasubramaniam Shanker, Jianguo Wang, Daniel Weile, and Vikram Jandhyala, and my current students Kemal Aygün, Robert Chao, Nan-Wei Chen, Arif Ergin, Mingyu Lu, and Nick Schuneman. I owe this award to them.

I am deeply honoured by this award. I will treasure it and forever will strive to be a worthy recipient. Thank you very much.

# NEWLY ELECTED OFFICERS, 1999-2002 TRIENNIUM

*Following the elections at the XXVIth General Assembly in Toronto, Canada, the Officers of the Board, the Scientific Commissions and Scientific Committee for the 1999-2002 triennium are as given below. Following the request of many Correspondents, the address, phone, fax and e-mail of these officials are given below.*

## Board 1999-2002

President : Hiroshi Matsumoto (Japan)
Vice-Presidents :
- Kristian Schlegel (Germany) (Treasurer)
- Joseph Shapira (Israel)
- Andrzej W. Wernik (Poland)
- Paul H. Wittke (Canada)

Secretary General : Paul Lagasse (Belgium)

## Chairs 1999-2002

Commission A : Elio Bava (Italy)
Commission B : Staffan E.G Ström (Sweden)
Commission C : Ernst Bonek (Austria)
Commission D : Alwyn J. Seeds (U.K.)
Commission E : Robert L. Gardner (U.S.A.)
Commission F : Yoji Furuhama (Japan)
Commission G : Phil Wilkinson (Australia)
Commission H : H. Gordon James (Canada)
Commission J : Jackie N. Hewitt (U.S.A.)
Commission K : Shoogo Ueno (Japan)
SC on Telecommunications : Paul Delogne (Belgium)

## Vice-Chairs 1999-2002

Commission A : Quirino Balzano (U.S.A.)
Commission B : Makoto Ando (Japan)
Commission C : Masami Akaike (Japan)
Commission D : Peter Russer (Germany)
Commission E : Pierre J. Degauque (France)
Commission F : Martti T. Hallikainen (Finland)
Commission G : Christian Hanuise (France)
Commission H : Umran Inan (USA)
Commission J : Makoto Inoue (Japan)
Commission K : Bernard Veyret (France)

*The next URSI General Assembly will be held in Maastricht, the Netherlands, in August 2002.*

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# UNION RESOLUTIONS ADOPTED AT THE TORONTO GA

**U.1. Organisation of URSI General Assemblies**

The URSI Council,

*Considering*

a) that Member committees are often confronted with practical difficulties (financial, organisational) in the preparation of the venue of URSI General Assemblies in their territories;

b) that a mutual advantage, for the local organising committee of a General Assembly and for URSI, could be gained from a stronger direct involvement of URSI in the setting up of a General Assembly;

c) that the recurrent organisation of such large events, once a format has been approved and a structure has become operational, should be facilitated;

d) that the current financial situation of URSI provides several degrees of freedom;

*Resolves*

to allow the URSI Board to take control of the organisation, and of the financing, of URSI General Assemblies, to the extent deemed appropriate.

**U.2. URSI standing committees**

The URSI Council,

*Considering*

a) that URSI standing committees have been set up to achieve important tasks for the Union;

b) that each Standing Committee chairman has to co-ordinate actions with the committee members in full interaction with the URSI Board of Officers;

c) that in many instances the operation of these standing committees has proven to be difficult and sometimes impossible due to a lack of proper articulation with the URSI instances (Board, Secretariat...);

*Resolves*

1. to re-examine the need of each Standing Committee and to eliminate those which are not indispensable;
2. to give to the remaining Standing Committees the means to be active, e.g. by inviting the Standing Committee chairmen to the relevant meetings of the Board of Officers or through establishing the appropriate procedure allowing them an optimal operation.

**U.3. Network of Correspondents**

*(adding of articles 2, 4 and modification of 7)*

The URSI Council,

*Resolves* to maintain the Network of Correspondents with the following provisions :

1. Any scientist attending a General Assembly or an URSI Symposium will become a Correspondent for the three-year period following the Assembly, the cost financed by a special fee included in the registration fee;
2. Any Correspondent must explicitly indicate if he/she authorises the URSI Secretariat to use his/her name and address exclusively in relation with the objectives of the Union, e.g. the publication of a Correspondent directory;
3. Other scientists may seek inclusion in the Network of Correspondents for the same three-year period by applying directly to the URSI Secretariat and paying the special fee;
4. After each General Assembly the URSI Secretariat shall contact the the Correspondents who did not attend this last General Assembly and propose to them that they pay the relevant fee;
5. The Board may decide to waive the special fee for a scientist, indicated in resolves 3, above, who requests this dispensation;
6. Correspondents will be issued a numbered card allowing reduced registration fees at certain URSI-sponsored symposia and conferences, and will receive the Radio Science Bulletin;
7. Correspondents will have no voting rights, but will be encouraged to express their views to the Commissions.

**U.4. Support for Bioelectromagnetic research**

The URSI Council

*Recognising:*

a) that all lives on earth thrive in a natural electromagnetic environment. Over the past few decades, we have learned to understand some of its characteristics and we have applied them in abundant ways to embellish our lives. Indeed, we have come to depend on the electromagnetic environment for life, health, safety, information, comfort, and conveyance.

b) Bioelectromagnetic research has developed a unique body of new knowledge and it is crossing a threshold from the traditional boundaries of biological and biophysical sensitivities. This new knowledge provides an invaluable bridge between health hazards of exposures to electromagnetic fields and waves and new diagnostic and therapeutic uses of electromagnetic fields and waves.

c) As scientific understanding of the interaction of electromagnetic interaction with biological systems increases, the prospect for its use in biology and medicine becomes greater also.

*Resolves*

that URSI Member Committees encourage appropriate international and national organisations to promote research on the effects of electromagnetic fields and waves in biology, and their uses in diagnostic and therapeutic medicine, for the benefit of human society.

**U.5. URSI Resolution on Criminal Activities using Electromagnetic Tools**

The URSI Council

*Considering*

a) At the URSI General Assembly of 1984 a resolution was adopted on the adverse effects of a High Altitude Electromagnetic Pulse due to a Nuclear Explosion.

b) The present resolution is intended to draw the attention of the scientific community to the effects of criminal activities using electromagnetic tools. This kind of action can be defined as an intentional malicious generation of electromagnetic energy introducing noise or signals into electric and electronic systems, thus disrupting, confusing or damaging these systems for terrorist or criminal purposes.

c) Criminal activities using electromagnetic tools is an outgrowth of more familiar disciplines: Electromagnetic Compatibility (EMC) and Electromagnetic Interference (EMI). In this case, however, the terrorist produces the offending currents or radiation intentionally. Accidental radiation can cause severe and inopportune damage to electronics, so those fields or more severe field levels can certainly also be intentionally impressed on vulnerable equipment. The electromagnetic compatibility community must be prepared to deal with new threats as they emerge.

*This resolution is intended to make people aware of:*

- *the existence of criminal activities using electromagnetic tools and associated phenomena.*
- *the fact that criminal activities using electromagnetic tools can be undertaken covertly and anonymously and that physical boundaries such as fences and walls can be penetrated by electromagnetic fields.*
- *the potential serious nature of the effects of criminal activities using electromagnetic tools on the infrastructure and important functions in society such as transportation, communication, security, and medicine.*
- *that in consequence, the possible disruption on the life, health and economic activities of nations could have a major consequence.*

*It should be noted that the International Electrotechnical Commission (IEC) under Subcommittee 77C is developing a program to protect systems against these new EM threats.*

*Resolves*

That URSI should recommend to the scientific community in general and the EMC community in particular to take into account this threat and to undertake the following actions:

1. Perform additional research pertaining to criminal activities using electromagnetic tools in order to establish appropriate levels of vulnerability.
2. Investigate techniques for appropriate protection against criminal activities using electromagnetic tools and to provide methods that can be used to protect the public from the damage that can be done to the infrastructure by terrorists.

3. Develop high-quality testing and assessment methods to evaluate system performance in these special electromagnetic environments.
4. Provide reasonable data regarding the formulation of standards of protection and support the standardisation work which is in progress.

**U.6. URSI Resolution on Seismo-Electromagnetics**

The URSI Council

*Considering*

that there have been recently increased interests and a lot of achievements in seismo-electromagnetics. There have been many convincing reports on the presence of electromagnetic noises immediately preceding earthquakes and also on the atmospheric and ionospheric perturbations (plasma disturbances and waves) associated with earthquakes. The overall understanding on the lithosphere-atmosphere-ionosphere coupling will be a new, challenging science field, and also this would be important for the short-term earthquake prediction.

*Resolves*

that URSI Member Committees encourage studies to be undertaken of the relationship of electromagnetic phenomena and atmospheric and ionospheric perturbations with earthquakes. Support for the research in this interdisciplinary field is encouraged, and collaboration with other societies is highly required.

**U.7. Scientific Committee on Telecommunications**

The URSI Council

*Considering that*

a) Scientific aspects of telecommunications are present in the terms of reference of most Commissions and that this situation calls for some liaison,
b) URSI research activities in the telecommunications domain would greatly benefit by an increased collaboration with ITU-R and, to some extent, with industry,
c) The interests of Science Services in the frequency allocation process are represented by IUCAF,
d) A Scientific Committee on Telecommunications (SCT) had been created at the XXIIIrd GA (Prague, 1990) to deal with relevant matters, but it was deactivated at the XXVth GA (Lille, 1996),

*Resolves*

1. To reactivate the SCT with Terms of Reference as defined below,
2. To appoint Prof. P. Delogne as the Chairman of the SCT. The SCT will include a representative of each Commission, appointed by the Chairs of the Commissions, and will also include a representative of the ITU Radiocommunications Bureau.

Terms of Reference

1. To initiate, promote and co-ordinate inter-commission activities in the telecommunications area through the formation of inter-commission working groups on specific topics to be identified, and through the organisation of joint symposia such as Commsphere.
2. To identify areas of common interest to URSI and ITU-R and, where appropriate to exchange relevant information between the URSI Commissions and the ITU-R Study Groups, and to promote URSI/ITU-R activities,
3. To keep the URSI community informed on ITU-R matters through the Radio Science Bulletin,
4. To initiate, co-ordinate and liaise URSI contributions with ITU-R.

# UTC Time Step

On n'introduira pas de seconde intercalaire à la fin de décembre 1999.

La différence entre UTI et le Temps Atomique International Tai est :

De 1999 janvier 1, 0h UTC, jusqu'à nouvel avis : UTC - TAI = -32 s

Des secondes intercalaires peuvent être introduites à la fin des mois de décembre ou de juin, selon l'évolution de UT1-TAI. Le Bulletin C est diffusé deux fois par an, soit pour annoncer un saut de seconde, soit pour confirmer qu'il n'y aura pas de saut de seconde à la prochaine date possible.

No positive leap second will be introduced at the end of December 1999.

The difference between UTC and the International Atomic Time TAI is :

from 1999 January 1, 0 h UTC, until further notice : UTC - TAI = -32 s

Leap seconds can be introduced in UTC at the end of the months of December and June, depending on the evolution of UT1-TAI. Bulletin C is mailed every six months, either to announce a time step in UTC, or to confirm that there is no time step at the next possible date.

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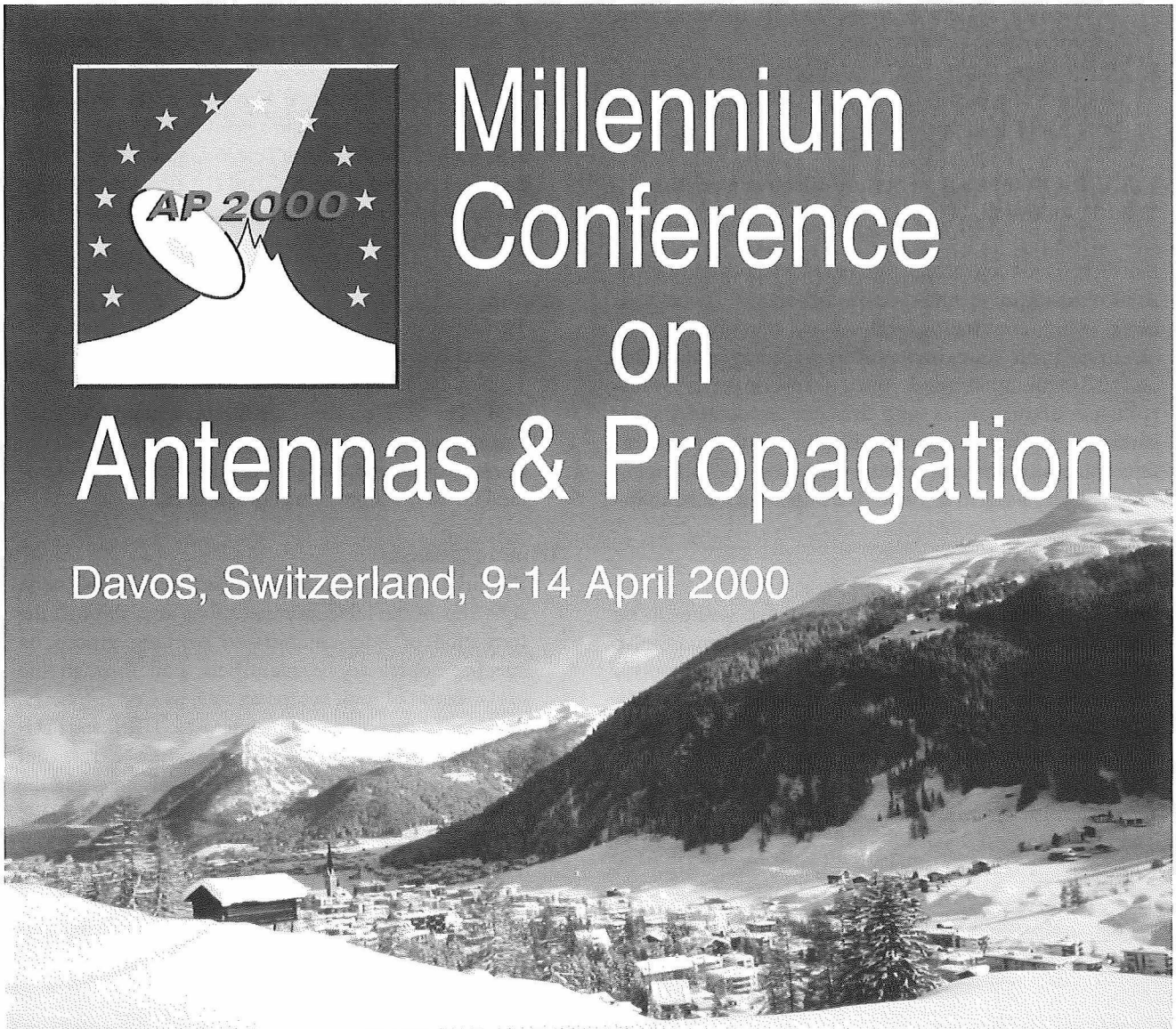


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# News from ITU-R

## ITU-R issues at the General Assembly

Many of the technical sessions held during the General Assembly made reference to studies undertaken within the ITU Radiocommunication Sector (ITU-R). This was in relation either to items on the agenda of the next World Radiocommunication Conference (WRC-2000) or to the development of ITU-R Recommendations on various areas of radio technology and spectrum engineering.

Although particularly strong in the field of radiowave propagation, topics of mutual interest were found in the sessions of several Commissions. Of note were those on spectrum management and utilization and, in pursuance of an ever-important theme, the Assembly closed with a tutorial on spectrum congestion. Radiowave propagation and the use of the spectrum by passive radio services are clear examples of topics where URSI makes valuable contributions to the activities of ITU.

## URSI/ITU collaboration

At the first meeting of the URSI Council, a special session had been arranged on "URSI collaboration with ITU" at which Mr. Bob Jones, Director of ITU Radiocommunication Bureau, gave a short presentation on the structure, objectives and current work programme of ITU-R. He explained the relationship between World Radiocommunication Conferences (WRC) and the Radiocommunication Assembly, the latter being responsible for the organisation and work programme of the ITU-R Study Groups. The two main tasks of the Study Groups are:

- to prepare technical bases for the Radiocommunication Conferences,
- develop ITU-R Recommendations on technical characteristics and operational procedures relating to the various radiocommunication systems and services, and on associated issues of spectrum management.

The agenda for WRC-2000 was outlined, noting some issues of particular interest and relevance to URSI such as sharing between the radio-astronomy service and other services, and spurious emission limits.

The session continued with discussions as to how and in what areas URSI could become more involved in ITU affairs and, in particular, make contributions to its Study Groups. Two principal points emerged: i) that URSI should make more use of its sector member status for accessing ITU-R information and documentation, and ii) it should seek ways to prepare and coordinate input contributions to ITU-R Study Groups. The suggestion was also made to reactivate the Scientific Committee for Telecommunications (SCT) which had hitherto been responsible for URSI/ITU coordination and which had been deactivated at the previous General Assembly (Lille, 1996).

During the week, discussions on ITU/URSI liaison continued in Commission Business meetings. The final decision, taken at the last Council meeting, was to approve a Resolution re-establishing the SCT, with Professor Delogne as Chairman. The SCT will include a representative of each Commission (appointed by the chairmen) and also a representative of the ITU Radiocommunication Bureau. It now remains for the SCT to consider the most effective way to initiate appropriate liaison activities between the two organisations.

## ITU-R activities during the Quarter

Meetings of ITU-R Study Group 1 (Spectrum management) Meetings were held in August, (Assen, The Netherlands), of ITU-R Study Group 1 and its working parties and task groups. The following items of business are of potential interest to URSI:

- development of draft new Recommendation ITU-R SM.[IM-REC] "Definition and measurement of inter-modulation products in transmitters using frequency, phase, or complex modulation techniques" and a draft new Report ITU-R SM.[IM-REP] "Production and mitigation of intermodulation products in transmitters". These two texts address five types of intermodulation that can be found in radiocommunication systems;
- revision of Recommendation ITU-R SM.329 "Spurious emissions" which now includes the concept of a boundary between spurious and out-of-band emissions;
- initiation of studies leading to the development of a new ITU-R Recommendation on out-of-band emission limits;
- development of a methodology based on the Monte Carlo technique that may be used for the derivation and control of radio parameters that have an impact on maintaining acceptable levels of radio interference between different spectrum assignments. A detailed understanding of the correlation between the relevant radio parameters and of the probability of interference should lead to more effective spectrum use;
- studies concerning interference calculations between radio-astronomy telescopes and non-GSO satellite systems.

## Future ITU-R meetings and events

*The Conference Preparatory Meeting (CPM)*

The CPM for WRC-2000 will be held in Geneva from 15 to 26 November 1999. The task of the meeting is to produce a report to the WRC containing the technical bases underpinning the agenda items of the conference. A draft report, based on studies undertaken within the ITU-R Study Groups over approximately the past two years, is contained in Document CPM99-2/1 and is available to ITU members. In line with the conference agenda, the report addresses each of the major topic areas: IMT-2000, maritime and aeronautical issues; mobile-satellite and radionavigation-satellite services; non-GSO FSS issues; space science services and radio astronomy; satellite-broadcasting plans (Appendices S30 and S30A); fixed and fixed-satellite services; other matters (which include spurious emissions and earth station coordination).

The calendar of future ITU-R meetings, together with other information on activities of the sector, can be found on its website at: http://www.itu.int/ITU-R/index.html

Kevin A. Hughes

CONFERENCE REPORTS

# CPEM'98

Washington, DC, USA, 6-10 July 1998

NIST, the National Institute of Standards and Technology, organised and hosted the 1998 Conference on Precision Electromagnetic Measurements (CPEM '98) in the Washington Renaissance Hotel during the week of July 6 - 10. It was attended by 519 metrologists, physicists, and engineers from National Measurement Institutes (NMIs), industry, and universities around the world. The program consisted of 343 papers, 129 of which were presented in 33 oral sessions and the remaining 214 as poster presentations. As can be seen in the table below, the conference covered the full range of electromagnetic measurements quite well, with the heaviest coverage in time and frequency-related topics (79 papers), dc/lf metrology, and quantum standards. The number of papers per measurement area were : Antennas & dielectrics: 11, Automated measurement systems: 12, DC/LF measurements & standards: 64, Fundamental constants: 36, High voltage: 8, International compatibility of measurements: 4, Magnetics: 17, Microwave/mmwave measurements (RF and EMC): 29, Nanotechnology (Cyroelectronics): 4, Optical wavelength metrology: 51, Power & energy: 15, Quantum standards: 51, Realisations of units: 13, Time & frequency: 28.

Six plenary speakers were recruited:

Keynote:

Prof. D. Kleppner, Massachusetts Institute of Technology
- Precision measurements in atomic physics

Plenary:

Dr. B. Inglis, National Measurement Laboratory, CSIRO, Australia
- Overview of ac voltage and current measurements

Dr. B. Kibble, National Physical Laboratory, United Kingdom
- Monitoring the kilogram by electromagnetic means

Dr. W. Phillips, Co-recipient of the 1997 Nobel Physics Prize, NIST, USA
- Cold atoms and clocks

Dr. U. Stumper, Physikalisch-Technische Bundesanstalt, Germany
- New developments of rf and microwave power standards

Dr. C. Wieman, JILA/University of Colorado, USA
- Bose-Einstein condensation in a dilute gas

In recognition of the need to provide a more uniform international measurement system and thereby reduce related technical barriers to trade, a special Tuesday evening session, organized by NORAMET, featured a panel of international experts on conformity assessment discussing the need for laboratory accreditation and its impact on the NMI community. There was a spirited discussion after the talks about the BIPM effort to create a multilateral framework for comparisons and mutual recognition of measurement capabilities.

A Conference Digest (T. Nelson, NIST, Editor) containing summaries of the presented papers was distributed to attendees.

As is customary, a number of auxiliary meetings were accommodated: CCEM working group on international comparisons, Quantum Hall effect (*ad hoc*), Josephson effect (*ad hoc*), AC-DC difference measurements (*ad hoc*), CCEM working group on radio frequency quantities, CCEM working group on ac voltage ratio comparisons, NCSL Josephson standards round-robin meeting, Italian delegates' meeting (*ad hoc*), IUPAP SUNAMCO, Single electron tunnelling (*ad hoc*), Avogadro constant (*ad hoc*), CODATA task group on fundamental constants

On Friday afternoon following the conference, tours of the NIST campus in Gaithersburg were offered. The plan was to take people to Gaithersburg by motor coach, with a box lunch to be eaten on the bus in order to maximise the visit time. Three mandatory stops per person were planned with some free time at the end. The response to this tour offer was unexpectedly high; in the pre-registration nearly 200 people indicated interest (twice that anticipated). A total of 290 visitors went on the NIST tour.

The conference had 519 registrants. We supported 22 attendees. Of these, eleven were in the Young Scientist Program, six were the Plenary Speakers, and the remainder were invited speakers, session chairs, or authors of particularly noteworthy papers.

The Young Scientists were supported by waiving registration fees, defraying lodging and partially defraying transportation costs. Of the six plenary speakers, three were transient visitors to the Conference, all attending an atomic physics meeting in Italy later in the week. (We were fortunate that Bill Phillips chose to honour the commitment he made prior to winning the Nobel Prize by flying in from vacation in Italy to speak before returning to Italy for the afore-mentioned meeting.)

CPEM '98 benefited from the generous sponsorship of the organisations listed below:, American Association for Laboratory Accreditation (A2LA), American Physical

Society, Anritsu, Baltimore Gas and Electric, Cal Lab Magazine, Clarke-Hess Communication Research Corporation, Creative Marketing Associates, Fluke Corporation, Guildline Instruments, Hewlett Packard Company, Institute of Electrical and Electronics Engineers , International Union of Pure and Applied Physics, National Conference of Standards Laboratories, National Institute of Standards and Technology, Organisation of American States, Physikalisch-Technische Bundesanstalt, Wavetek Corporation.

CPEM's permanent sponsors are: Bureau International des Poids et Mesures (BIPM), IEEE Instrumentation and Measurement Society, National Institute of Standards and Technology, National Research Council of Canada (NRCC) and URSI.

The conference also held a commercial exhibit.

The attendance of the conference was : Western Europe: 166, North America: 158, Asia Pacific 84, Eastern Europe: 18, South America: 6, Other: 3.. Areas of weak representation are South America, Africa, and the Near East.

The most significant 125 papers were published in the April 1999 IEEE Transactions on Instrumentation and Measurement. The issue, edited by Barry Bell of NIST and Brian Ricketts of NML/CSIRO, is organised as follows : International Comparisons: 6, SI Realizations & Fundamental Constants: 18, Josephson Standards: 10, Quantised Hall Effect: 8, R, I, & V Measurements: 6, Impedance Measurements: 3, Cryogenic Current Comparators: 5, AC-DC Transfer: 8, Power & Energy Measurements: 4, High Voltage Devices & Measurements: 6, General Instrumentation: 6, Interferometry: 2, Cesium Frequency Standards: 5, Atomic Fountains and Clocks: 3, Cryogenic Resonators: 2, Optical Frequency Standards: 9, Optical Metrology: 3, Stabilised Lasers: 6, High-Resolution Spectroscopy: 3, Microwave Networks and Measurements: 8, Time Keeping and Time Transfer: 1, Noise Thermometry: 1, Magnetic Measurements and Fields: 2.

The Conference appears to have been a modest financial success, but the exact figures will not be available until later this year.

Norman B. Belecki

# EMC Zurich '99

Zurich, Switzerland, 16-18 February 1999

The 13th International Zurich Symposium and Technical Exhibition on Electromagnetic Compatibility was held from February 16 through 18, 1999 at the Swiss Federal Institute of Technology in Zurich (ETH Zurich), Switzerland. The meeting was attended by 997 participants from 40 countries and has included 56 exhibitor booths. As in the preceding years, the Symposium has been organised by the Communication Technology Laboratory of the Swiss Federal Institute of Technology Zurich under the auspices of Mr. F. Rosenberg, Swisscom. Prof. Dr. P. Leuthold and Dr. G. Meyer acted again as symposium president and symposium chairman, respectively. The technical program committee was chaired by Dr. F. Tesche (Dallas, USA). A number of international and national professional organisations were co-operating, e.g. ITU, IEEE and URSI. As in the past URSI has sponsored again the participation of young scientists.

A total of 129 carefully selected technical papers were presented in 18 sessions devoted to: protection and mitigation, EMC management, bio-electromagnetic interactions, ESD and fast transients, EMC in extended systems I and II, antenna calibration for EMC testing, transients, board and chip-level EMC I and II, measurements technology I and II, power system EMC, numerical methods, transmission lines, EMC innovation, lightning physics and effects as well as EMC test chambers.

The sessions covered virtually all EMC "hot" topics and reviewed the current status as well as future trends of EMC technology. The full text of the presentations has been made available in the symposium proceedings comprising 692 pages. An insight into the work of URSI Commission E was offered by open meetings dealing with the progress in the different working groups and identifying outstanding topics and new lines of future research. As in previous symposia the program did not exclusively address experts. An introduction to EMC technology for newcomers was offered by two tutorial lectures and four workshops. Once again, a number of national and international organisations used the opportunity of the symposium to held open and closed meetings in co-ordination with EMC Zurich. In the open meeting on the ESPRIT Project ESDEM (electrostatic discharge protection design methodology) which belongs to the European Union Information Technology R&D Program, an overview was given of the state of the art, future requirements and development trends with respect to the design of ESD structures considering submicron MOS processes. Standardised exposure systems are essential for international research projects on biological effects in electromagnetic fields. The aim of the open meeting of the COST Action 244bis (European Co-operation in the field of Scientific and Technical Research), Biomedical Effects of Electromagnetic Fields, was to discuss methods and quality issues of exposure systems and their dosimetry. A further open meeting was organised by the IARU (International Amateur Radio Union) on EMC problems experienced and caused by radio amateurs.

The contributions of these joint events have been made available in the 254-page supplement to the symposium proceedings. Centres of gravity of this symposium have been the field of EMC testing with five sessions and free workshops devoted to this area. Better defined and simpler test methods, with reduced measurement uncertainty, could significantly reduce the cost of design and testing of the final product. EMC in extended systems

is a challenge for management, modelling and testing. More than two sessions have dealt with this area. Extended systems are either physically large systems compared to the wavelength, or a complex combination of subsystems. It is difficult to point out general trends in the field of EMC but with the growing interest in theoretical models and numerical methods, the role of computers is becoming more and more important. Also with the trends to higher integration and to microsystems EMC models and tools for MMCs, microsensors and micromachines are gaining attention.

As usual, the Technical Exhibition has significantly contributed to the success of EMC Zurich '99 by demonstrating the fast conversion of theoretical knowledge into state-of-the-art hard- and software. The traditional inquiry returned some very interesting suggestions for the next EMC Zurich Symposium which is planned for February 20 through 22, 2001. The call for papers of the 14th International Zurich Symposium and Technical Exhibition on EMC is scheduled for November 1999.

More information about EMC Zurich may be found at: http://www.nari.ee.ethz.ch/emc/emc.html

We also maintain a list of major recurrent EMC meetings and offer the possibility to complete it by new events. The dissemination of further information is planned for the future.

Contact address:

Dr. G.V. Meyer, ETH-Zentrum, IKT
CH-8092 Zurich, Switzerland
e-mail: gmeyer@nari.ee.ethz.ch

# CONFERENCE ANNOUNCEMENTS

## COMMSPHERE 2000

Chennai, India, 28 February - 2 March 2000

"COMMSPHERE 2000", an International Millennium Conference on"Affordable Telecom and its Solutions for Developing Countries" will be held at the Indian Institute of Technology at Chennai, India.

### Objective

Accessibility to telecom and Internet network is fast becoming a major factor determining the competitiveness of an individual, group or society. Telecom and IT systems and solutions prevalent in the developed countries are not necessarily the best options for developing countries for making the network affordable and available to large sections of their people.

This conference will focus on technologies and innovations which could make this possible in a not too distant time-frame. The interconnection of computers spread over wide areas is the key to the growth of Information Technology. Low-cost innovative IT solutions are a must if IT is to make a mark beyond the top few percent of the population of developing countries. Hence non-conventional telecom, computer networking and IT solutions, that promise value-added services at significantly lower cost, will be explored at this conference.

Chennai (formerly Madras), the venue of the conference, has a large number of hotels of varying tariffs.

### Topics

- Hierarchy of Telecom & IT needs in different developing countries and regions
- Recent Innovations in technologies and systems
- Affordable Telecom and IT network
- Multi-service networks - education, health
- Innovations in access terminals and Software Components
- Manpower needs for creating and operating networks in developing countries
- Regulatory and policy issues.

Topicas tutorials : Wireless Access, Fiber Access, xDSL Access, Access on Cable, Internet Networking, Network Operation and Management and, Communication Terminals

### Deadlines

Submission of manuscripts : Sept 15,1999
Notification of acceptance : Oct 15,1999
Submission of camera-ready paper : Jan 1, 2000
Last date of pre-registration : Jan 1,2000

### Organisation

International Advisory Committee : S. Pitroda, G. Swarup, W.A.Baan, B. Rimoldi, K.B.Chandrasekhar, T.Itoh, J. Shapira, K. Keniston, H. Matsumoto, M.G.K. Menon, A. Paulraj, R. Stata, S. Channakeshu, T.B.A. Senior, N.K. Sinha, B.S.Sonde, T. Hossain, Yashpal

Steering Committee Co-Chairs : Joe Shapira, and Ashok Jhunjhunwala (Co-Chair)

### Contact

Prof. Ashok Jhunjhunwala
Chennai - 600 036, INDIA
email:commsphere@tenet.res.in
Telefax: +91-44 235-2120
Ph : +91-44 235-2120/445 8414/445 8366/4909048.
http://www.tenet.res.in/commsphere/commsphere.html

# EuroEM 2000

Fukuoka, Japan, 21-25 August 2000

The Organising Committee has great pleasure in inviting you to submit papers for the EUROEM 2000 conference being held in Edinburgh, Scotland from 30 May - 2 June 2000.

EUROEM 2000 continues the tradition of the EUROEM/AMEREM Conference Series, drawing together the 12th High Power Electromagnetics Conference, the 5th Ultra-Wideband Short Pulse Electromagnetics Conference and the 5th Unexploded Ordnance Detection and Range Remediation Conference.

Papers are solicited which describe original work suitable for the three conferences comprising EUROEM 2000.

The deadline for receipt of abstracts is Friday, 14 January 2000.

Authors are requested to submit a one page abstract, original plus 3 copies in camera-ready format by the deadline date to: EUROEM 2000, Concorde Services Ltd, Suite 325, Pentagon Business Centre, Washington Street, Glasgow G3 8AZ, Scotland, UK. Acknowledgement of financial support is not deemed appropriate. Please note that it is the authors' responsibility and not that of the Conference Committee, to see that their abstract and paper are cleared for public release.

All abstracts must be written in English. Instructions will be sent to the relevant authors.

For further information, please contact the Conference Secretariat, Concorde Services at Tel +44 141 221 5411 or Fax +44 141 221 2411 or visit our web site at : http://www.mcs.dundee.ac.uk:8080/~euroem

# ISAP 2000

Fukuoka, Japan, 21-25 August 2000

The 2000 International Symposium on Antennas and Propagation (ISAP2000) - Radiation Illuminating A New Millennium - will be the seventh ISAP to treat all aspects of antennas, propagation, electromagnetic wave theory, and radiowave systems. ISAP2000 will be held under the sponsorship of the Institute of Electronics, Information and Communication Engineers (IEICE), and in cooperation with the International Union of Radio Science (URSI), the Professional Society on Antennas and Propagation of the Institute of Electrical and Electronics Engineers (IEEE/AP-S), and the Electronics and Communications Division of the Institution of Electrical Engineers (IEE).

## Topics

- Antennas and Related Topics
- Propagation and Related Topics
- Electromagnetic Wave Theory
- Systems and Related Topics
- Special Topics on Emerging Technologies toward the 21st Century

## Deadlines

- YSTG(*) paper submission: 1 February 2000
- Hard-copy submission: 20 February 2000
- Electronic submission: 1 March 2000
- Notification of acceptance: 20 April 2000
- Advance registration: 10 July 2000

(*): Young Scientist Travel Grant

## Contact

For further information, please see the ISAP2000 WEB page: http://www.crl.go.jp/pub/ISAP2000/

# URSI CONFERENCE CALENDAR

*URSI cannot be held responsible for any errors contained in this list of meetings.*
*The Guidelines and Rules for URSI Sponsorship of Meetings can be found at* ***http://www.intec.rug.ac.be/ursi/Rules.html***

## October 1999

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

## November 1999

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

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

## December 1999

**ISDRS'99**
**Semiconductor Device Research Symposium**
*Washington DC, USA, 1-3 December 1999*
Contact : Dr. William C.B. Peatman, University of Virginia, 1590 Ravens Place, Charlottesville, VA 22901, USA

**ISRAMT'99**
**International Symposium on Recent Advances in Microwave Technology**
*Malaga, Spain, 13-17 December 1999*
Contact : Dr. B.S. RAWAT, Dept. of Electrical Eng. 260/ College of Engineering, University of Nevada-Reno, Reno, NV 89557-0153, USA, Phone : (1-702) 784-6927, Fax : (1-702) 784-6627

## 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/

BOOK PUBLISHED BY AN URSI CORRESPONDENT

# Principles of the Markovian Theory of Random Fields Nonlinear Processing

*(monograph* in Russian, *Moscow Inst. of Physics & Technology Press, 1998)*

by A.B.Shmelev

In the **introduction** we show the practical necessity of non-Gaussian random fields processing. Non-Gaussity leads to non-linear optimal reception and estimation algorithms. The typical example is reception of the phase disturbed signal on large antennas, which have now wide applications in radio physics, acoustics, optics, modern radar and communication systems. The non-linear processing theory was earlier described in detail for Markovian processes fluctuating in time only. This book deals with generalisation and application of this theory to random fields fluctuating both in time and space.

In the **first chapter** we consider the apriori and aposteriori statistical description of random fields on the basis of their representation by Markovian processes in Hilbert space. The fields under consideration obey causality and Markovian property only in time but not in space. For the apriori description we apply functional derivative equations for the probability density functional, which generalise correspondent equations for multidimensional Markovian processes. Side by side with the fields caused by diffusion processes and described by generalised Fokker-Plank equations we consider fields caused by non-diffusion processes (in particular jump processes) and described by means of a generalised operator equation for the probability density functional. The aposteriori description is based on the nonlinear equation which generalises the well known Stratonovich equation for the aposteriori probability density function in random processes non-linear filtering theory. Using the generalised Stratonovich equation we obtain then Gaussian approximation equations for mean values and second order cumulants of aposteriori distribution concerning random fields non-linear filtering, prediction and smoothing problems. These equations represent the quasi optimal processing algorithms. Peculiarities of these algorithms are analysed both for diffusion and non-diffusion processes.

In the **second chapter** we consider some problems of non-linear estimation of spatial phase fluctuations of the harmonic wave, observed in mixture with white Gaussian noise field on a continuous aperture, a linear antenna array and in two-positional receiving system. We fulfil the synthesis of the space-time sub optimal estimation algorithm realisable by means of interactive phase-lock loops situated along the receiving aperture. Expressions for aposteriori spatial covariance functions and estimation errors are obtained and analysed. The case of phase fluctuations caused by a turbulent atmosphere is investigated in detail.

In the **third chapter** we consider stationary filtering problems of space-time phase fluctuations described apriori by a Gauss-Markov process in Hilbert space. Peculiarities of stationary non-linear filtering are revealed and expressions for aposteriori covariance functions and filtering errors are obtained and analysed. Side by side with filtering problems the smoothing ones are considered both for statistically homogeneous and locally homogeneous (turbulent) phase fluctuations. The effect of observation noise's spatial correlation on optimal algorithms and estimation errors is investigated. These results are applied then for solution of space-time quasi coherent reception problems. We consider two such problems - reception of amplitude-modulated and phase-modulated signals in presence of additive Gaussian noise and space-time phase disturbances.

In the **fourth chapter** we deal with the analysis of non-linear estimation algorithms when their parameters and apriori data are inaccurate. General equations for aposteriori second order cumulants in such a situation both for random processes and fields are obtained. Problems of sensibility analysis with respect to choice of phase-lock loops parameters and signal to noise ratio are considered. Formulas and graphics are presented which enable us to make conclusions about permissible parameters and apriori data deflection from their nominal values. Sometimes it becomes possible to simplify optimal algorithms without significantly decreasing the estimation accuracy.

In the **fifth chapter** we investigate the relation between optimal detection and estimation problems for non-Gaussian processes and fields observed in Gaussian noise background. General formulas are obtained, which enable the calculation of aposteriori moments and cumulants of estimated signals with arbitrary statistical distribution using the likelihood ratio expression. Thus Bayesian filtering and smoothing problems can be reduced to a likelihood ratio calculation problem. In case of noise delta-correlated in time we obtain expressions which allow calculation of smoothing cumulants if current aposteriori estimates are known. Some examples are presented illustrating the efficiency of such an approach to the solution of smoothing problems. Likelihood ratio expressions describing general structure of random fields optimal detectors are obtained. These expressions lead to the estimation-correlation-compensation principle of random fields reception.

In the **sixth chapter** we present the apriori and aposteriori statistical description of impulsive interference as first and second order Markovian jump processes. The apriori description is based on the Kolmogorov-Feller equation for the probability density function. Aposterion cumulants submit to the infinite chain of non-linear differential equations being the consequence of the Stratonovich equation for aposteriori probability density function. We calculate exactly detection and false alarm probabilities for linear detectors influenced by white Gaussian noise and impulsive interference in the form of impulsive Poisson process. Conditions for Gaussian distribution of the likelihood ratio logarithm are established and investigated.

In the **conclusion** some further problems of random fields non-linear processing are mentioned.

In the **appendix** necessary data concerning functional approach to random processes statistical description are included.

# EGYPT
## 17th National Radio Science Conference

The 17th National Radio Science Conference, NRSC'2000, is to be held in Minouf, Egypt. The Faculty of Electronic Engineering in Minouf, Minufiya University, will host the conference over the period 22-24 February 2000. The conference will provide a valuable opportunity to exchange and update information and stimulate discussions on current and future research activities in the field of the committee.

The technical program will consist of invited and submitted papers covered by the URSI Commissions A-K: A) Electromagnetic metrology, B) Fields and waves, C) Signals and systems, D) Electronics and photonics, E) Electromagnetic noise and interference, F) Wave propagation and remote sensing, G) Ionospheric radio and propagation, H) Waves in plasma, J) Radio astronomy, K) Electromagnetics in biology and medicine.

Invited papers will be solicited from leading experts in the listed topics. Papers are expected to review in a tutorial manner the state of the art and developments in the field.

Papers: Prospective authors are invited to submit four copies of the complete manuscript of a maximum of eight pages A4 (typed single space) to the conference chairperson. The Conference language will be English.

Deadlines : Submission of the manuscript : Sep. 30, 1999
Notification of acceptance : Nov. 11, 1999
Submission of camera-ready material and electronic copy: Dec. 02, 1999

Sponsors: Academy of Scientific Research and Technology, Ministry of International Cooperation, IEEE EGYPT Section, Egyptian Radio & Television Union, Minufiya University, Egyptian Telecommunication Company, Ain Shams University, International Electronics Company, Military Technical College

Conference chairman: Prof. Ibrahim A. Salem, President of Egyptian URSI Committee , Academy of Scientific Research and Technology, Department of Scientific Societies & International Unions. 101 Kasr El-Eini St., Cairo, Egypt. Tel:(202) 2580256, FAX:(202) 5941270, E-mail: isalem@brainy1.ie-eg.com

Conference vice-chairman: Prof. Mohamed M. Sharaf, Vice Dean of the Faculty of Electronic Engineering, Minufiya University, Minouf, 32952, Egypt Tel:(2048) 661518, FAX:(2048) 660716, E-mail: msharaf@compunetegypt.com.eg

General secretary: Prof. Sayed M. Hamdy, Military Technical College, Tel: (202) 2660434

# IRELAND
## Joint Ireland-UK Radio Science Symposium

The 10th Radio Science Symposium of the URSI Sub-Committee, Royal Irish Academy, took place at Academy House, Dublin on 3-4 December 1998. A unique feature was the participation for the first time of the UK Royal Society URSI Committee.

The meeting attracted 70 participants over 1,5 days involving 6 sessions and 18 invited papers with 9 each from the UK and Ireland. A special session involved students from both countries and a particularly satisfying feature was the presence of 22 non-academic telecommunications engineers.

Two excellent keynote addresses were presented : Professor David Olver, London, Chairman of the UK URSI Committee on "A Century of Radio Waves" and Mr. Alfie Kane, Chief Executive of Telecom Eireann on "Ireland and the Information Age". The topics, in general, clearly reflected the main interests of URSI Commissions as shown by the following table :

Radio Astronomy
Signals and Systems
Mobile Cellular Communications
Radio and Optical Systems
Ionosphere, Magnetosphere and Plasma
Remote Sensing
Electromagnetics in Biology and Medicine
History of Radio Science

A booklet of Abstracts of all the papers is available from the undersigned.

The standard of presentation from all participants was considered to be very high and it is hoped that a second joint symposium may be held in the UK at a mutually convenient time in the future. The symposium was generously sponsored by Irish-based telecommunications companies, in particular Alcatel, Ericsson, Esat Digiphone, Nortel and Telecom Eireann. The Government funded Teltec Ireland also contributed as well as the Bank of Ireland.

M.C. Sexton, MRIA
Conference Director
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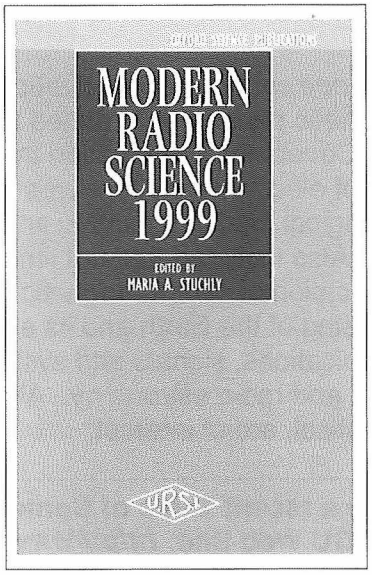


## Modern Radio Science 1999

Editor: Maria Stuchly
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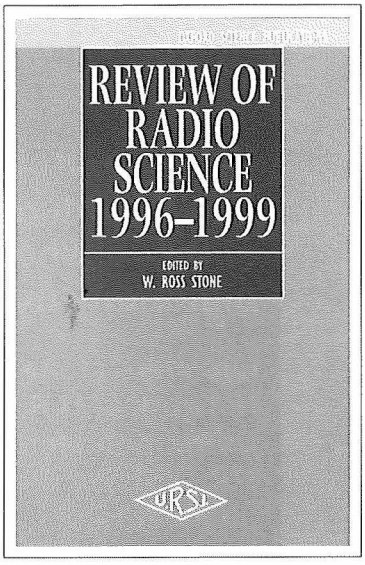


## Review of Radio Science 1996-1999

Editor: W. Ross Stone
August 1999/Hardcover/1044 pp
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## Handbook on Radiopropagation Related to Satellite Communications in Tropical and Subtropical Countries

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

Available from the URSI Secretariat
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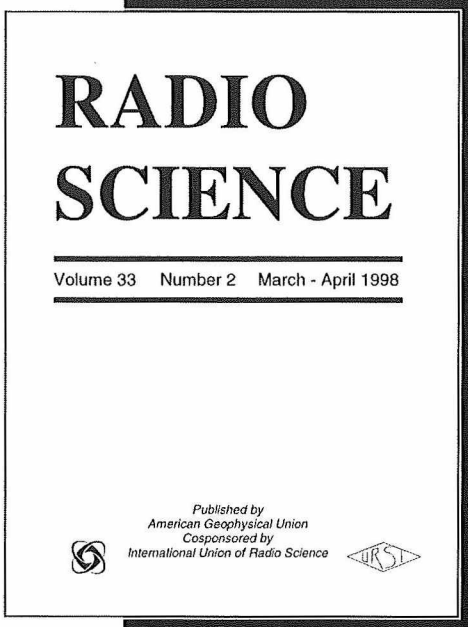


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# *The Journal of Atmospheric and Solar-Terrestrial Physics*

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