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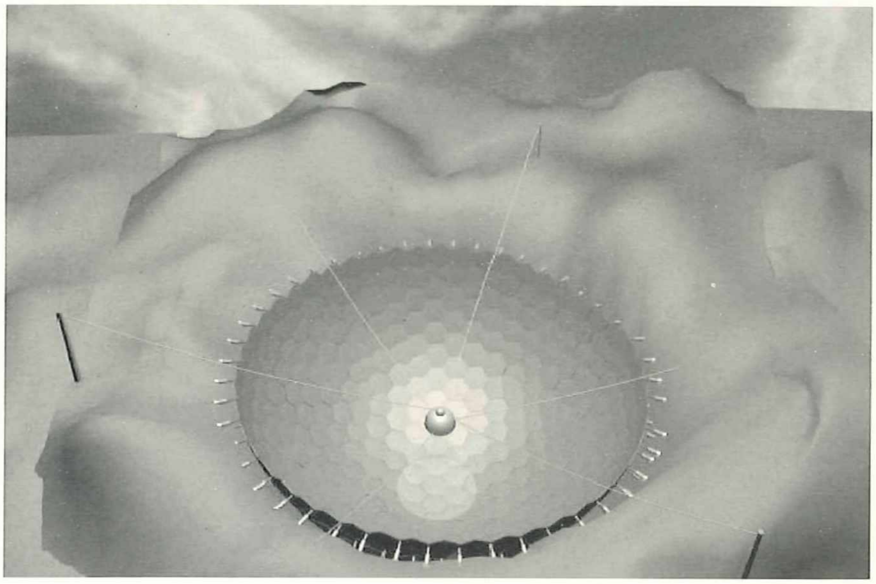

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Front cover: The cable support system, without a platform. (more on pp. 12 - 21)

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

Editorial

Our 300th issue!

Happy New Year – well, at least welcome to the first issue of *The Radio Science Bulletin* for 2002! This is also the 300th issue of the *Bulletin*. The first issue of this publication was called the *Information Bulletin d'Information* (recognizing URSI's bilingual nature), and was published in 1938. It continued under this name until December, 1993 (No. 267), when it became *The Radioscientist & Bulletin*. Since December, 1994 (No. 271) it has been *The Radio Science Bulletin*. [My thanks to Inge Lievens for doing the research on the *Bulletin*'s publishing history.]

That's a long and proud history, and one that we hope to enhance by bringing you interesting and useful technical content, along with information of importance to the URSI community. We depend on *you* for most of the content. The *Bulletin* is the primary mechanism URSI has for communicating with the community of radio scientists. It continues to be effective to the extent that *you* make it effective, by using it. I urge you to share reports of your meetings, Commission and Member Committee activities – and technical papers of broader interest about your work – with the radio science community, through these pages.

The XXVIIth General Assembly is Coming!

The XXVIIth General Assembly will be held in Maastricht, The Netherlands, 17-24 August 2002. We have had a *very* good response to the call for papers. This is going to be a *great* General Assembly! The meeting registration form and the hotel reservation form are in this issue, along with an invitation from the Local Organizing Committee to attend. You should make your plans to attend *now*.

What's in this Issue

Given the historic milestone represented by the 300th issue of the *Bulletin*, it is both appropriate (and fortuitous) that we have two historical contributions in this issue. The first is by Brian Austin, who provides a historical survey of some of the early research on lightning and its interactions with the ionosphere. This paper focuses on the work of Basil Schonland, a South African researcher who worked and corresponded with C. T. R. Wilson on the subject from 1920 until Wilson's death, in 1959. The results of the work of Schonland and his colleagues were fundamental to the understanding of the polarity and distribution of the charges in thunderclouds that produce lightning; the source and nature of electromagnetic fields and energetic electrons associated with thunderclouds and lightning; the formation of lightning, including upward-striking lightning and the leaders and return stroke; sferics, the electric fields radiated by lightning; and the propagation of lightning-produced electromagnetic fields and their interaction with the ionosphere.

Our second technical paper, by Bo Peng and R. Nan, describes plans for a Five-hundred-meter-Aperture Spherical Telescope, known as FAST. This radio telescope is to be built in southwest China, taking advantage of naturally occurring rock depressions found in that area. Although the basic shape of the antenna will be spherical, the figure of the surface will be controlled by actuators that can deform the portion of the surface being illuminated by the feed into a parabola. An unusual design is also used for the platform supporting the feed. This involves an integrated, active mechanical, electronic, and optical system to insure that the feed is properly pointed toward the dish at all times during the relative motion of sources across the sky. The integration and operation of the whole proposed radio-telescope system are described in the paper, along with the scale-model experiments that have been carried out to test the design. The result is a fascinating design that is planned to result in an instrument with wide bandwidth, full polarization capabilities, the ability to use standard feeds, and about twice the angular coverage of the sky as the 305 m Arecibo radio telescope.

Our second historical contribution is by Brian Robinson. He has provided us with a most interesting set of recollections of the Xth URSI General Assembly, held in Sydney, Australia, in 1952. This was the first General Assembly to be held in the southern hemisphere. Sixty radio scientists, representing 12 countries, made the trip, which was done by ship: a five week voyage from Europe to Australia! The total number of delegates and attendees was about 175. This contribution provides a fascinating look at where radio science was a half century ago, and it is also a most effective reminder of how far we've come since then.

In his column on Radio-Frequency Radiation Safety and Health, Jim Lin looks at the issue of what is needed to provide a *scientific* basis for the determination of the health and safety issues surrounding mobile phones. He argues for a substantial number of coordinated, well-planned, and relatively low-cost research efforts, funded independently of the "stakeholders" in the mobile-phone business. Perhaps most importantly, these efforts should be rigorously science-based, as opposed to some of the other approaches that have been (and are being) taken. I think you'll find this a very thought-provoking contribution.

We Welcome John Volakis to the Staff

John Volakis has agreed to take on the role of Senior Associate Editor for the *Bulletin*. He will be helping me to coordinate the peer reviews of the papers submitted to the *Bulletin*. I really appreciate his willingness to help.

Please Send Good Papers

The *Radio Science Bulletin* can only serve as a mechanism for building communication among radio scientists if you, our readers, are willing to help. As you think of places to publish your papers of broader interest, consider the *Bulletin*. As you attend conferences and hear what others are doing, encourage them to submit those papers to the *Bulletin* that are appropriate for our audience. We need your help.

I began this column with a wish for a Happy New Year, since this was the first issue of the *Bulletin* for 2002. Of course, most people's calendars are well into the new year. However, in some parts of Asia (for example), the Spring Festival that heralds the new year on some calendars is being held as this is written. Regardless of the actual date, I hope the year is a most happy, healthy, and prosperous one for you – and a rewarding one for your science.

Attend the URSI XXVIIth General Assembly !

All radio scientists are invited to attend the XXVIIth General Assembly of URSI, to be held 17-24 August, 2002, in Maastricht, the Netherlands. Attendees are urged to make travel plans, hotel reservations, and to register for the General Assembly as early as possible. Complete information, including registration and reservation forms, can be found at http://www.ursi-ga2002.nl/information.html.

The Scientific Program

The scientific program of the General Assembly includes individual sessions of the ten URSI Commissions, and joint sessions organized by two or more Commissions on topics of common interest (a report on the status of the organization of the scientific program appears elsewhere in this issue of the *Radio Science Bulletin*; more than 1600 papers have been submitted). Each Commission will also offer tutorials delivered by distinguished scientists. Three one-hour General Lectures, of broad interest to the URSI community, will be presented:

1. "Probing the Origin and Evolution of the Universe with the Cosmic Microwave Background Radiation," John Carlstrom, Commission J;
2. "Health Effects of Electromagnetic Fields," Michael Repacholi, Commission K;
3. "Synthesizing Optical Frequencies with a Femtosecond Laser," Theodor Haensch, Commission A.

On the last day of the conference, a special session will be held focusing on "Radio Science in the Low Countries," organized by the Dutch and Belgian National URSI Committees. There will also be a Public Lecture, "A Century of Radio Science in the Low Countries." An industrial exhibition of companies active in all areas related to radio science and engineering will be held during 20-22 August as part of the General Assembly. There will also be an Internet Café, with 30 computer workplaces available only to conference and exhibition participants, and accompanying persons.

Venue

The General Assembly will be held at the Maastricht Exhibition & Congress Centre (MECC; see http://www.mecc.nl). The MECC is the second-largest conference facility in the Netherlands. It is compact enough to ensure minimal distances between session locations, and yet large enough to provide ample space to host the 2002 General Assembly. Moreover, the MECC is near the center of Maastricht, the oldest city in the Netherlands. Maastricht dates back to Roman times, and was once a bi-principality under the Duke of Brabant and the Prince-Bishop of Liege. It was French for some time after the French Revolution, until it became part of the newly founded Kingdom of the Netherlands, in 1815. The city is noted for its art, antiques, dining, and hospitality.

Maastricht has can be reached via the local Maastricht-Aachen Airport, which has direct connections with Amsterdam Schiphol and London Gatwick airports. There are also convenient train and highway connections with all of Europe.

Social Activities

A comprehensive social program is planned in conjunction with the scientific sessions. The Opening Reception, on Sunday, 18 August, is included in the registration fees. A Young Scientists Reception will be held Monday evening in the City Hall of Maastricht. The Banquet will be held Wednesday evening, 21 August, in "La Caverne de Geulhem." This party center is located in a complex of large caves, hewn out of the cretaceous rock typical for the surroundings of Maastricht. Reservations can be made via the registration form on the Web page.

A full range of sight-seeing tours is available for accompanying persons and conference participants. Planned tours (subject to sufficient registration) include the following (these must be selected on the registration form):

- Visit Domein Bokrijk: Several farms and buildings from a Belgian city were brought to Domein Bokrijk and restored. On this 300 ha estate, the old Flemish countryside has been rebuilt with farmhouses, watermills, and small roads; typical inhabitants and crafts are also displayed.
- A cultural walk in Maastricht: Our guides will show you the most beautiful city of the Netherlands and will take you to the oldest places in town, including St. Servaas church, with its beautiful relics from Roman times.
- Visit and lunch in La Bonbonnière: This former Jesuit monastery is over 300 years old. In 1786, it was transformed into a beautiful theatre. You can enjoy a lovely buffet in this beautifully restored and impressive location.
- Visit the Zonneberg caves: You will visit a part of the impressive underground network of the St. Pietershill. These caves were constructed in the marl to harbor a large part of the Maastricht population during the Second World War. You will find a modern bakery, a sickbay, and a chapel. It is also possible to see some interesting fossils in the marl.
- Visit the caves of the Jesuits: This underground network used to be owned by the Jesuits of Maastricht, and was used as a leisure room, where the priests could draw and sculpt. In the marl walls you will find the most beautiful works of art.
- Bonnefantenmuseum: This museum is in a very special building. The permanent collection includes pieces of Limburgian archaeology, medieval sculpture, and modern art.
- Maastricht adventure: This is a beautiful bicycle tour, taken in small groups through the surroundings of Maastricht.
- A visit to a vineyard in Maastricht: You will visit a vineyard in Maastricht, located on the southern slopes of the Cannerberg. The "patron" will show you the rooms where the grapes are crushed and then bottled to make wine. Of course, you will also get a chance to taste the wines of Maastricht.

Registered participants and students may attend all scientific sessions and the Opening Reception. They will also receive copies of the *Proceedings* on CD-ROM and of *The Review of Radio Science, 1999-2002* on CD-ROM. Coffee and tea during breaks and (sandwich) lunches for all participants are included in the fee. Since the participants automatically become URSI Correspondents, the fees also cover a subscription to *The Radio Science Bulletin* during the three-year period following the Assembly. Correspondents will thus be kept fully informed of the activities of the Union. Registered accompanying persons are entitled to attend the Opening Ceremony and the Reception. The fee also includes coffee and tea during conference breaks, (sandwich) lunches, and the use of the facilities of the MECC during the sessions. Registration terms and conditions, and further information, are available at http://www.ursi-ga2002.nl/information.html.

A limited number of hotel rooms in the Maastricht area has been set aside until 15 June 2002. The General Assembly registration form and the hotel registration form can be downloaded from http://www.ursi-ga2002.nl/registration.html. Attendees are urged to make early reservations!

Registration and Accommodations

Attendees are encouraged to register as early as possible.

	Before 15 May 2002	After 15 May 2002*
Participants	• 585	• 645
Students**	• 475	• 515
Accompanying Persons	• 125	• 135

* After 1 August 2002, registrations will be accepted only at the conference at these rates.

** With proof of full-time student status or a letter of endorsement from the student's supervisor.

Deadlines

Early registration and payment of reduced fees: 15 May 2002

Guaranteed Accompanying Persons' Program: 15 June 2002

Guaranteed hotel reservation: 15 June 2002

Late advance registration and payment: 1 August 2002

Lightning and the Ionosphere: Some Reflections from an Earlier Era

B.A. Austin

Abstract

The interaction between lightning and the ionosphere is a subject of much research interest within the geosciences. This is particularly true in relation to the discovery, within the last decade, of sprites and other high-altitude phenomena that are apparently related to lighting. However, the first reported sighting of upward-striking lightning was made in 1876 by C. V. Boys, and this was followed by numerous others when lightning itself became the subject of intensive study in the 1930s, especially by B. F. J. Schonland in South Africa. In particular, the observations made in the southern hemisphere were most significant.

Introduction

The part played by lighting in generating the upper-atmospheric effects known as whistlers is now well understood, and their study is an important aspect of radio science. A more recent discovery, and one that is exciting considerable research interest, is the existence of so-called red sprites, blue jets, and elves, which are unusual both in their appearance and in their distribution [1]. All three are optical phenomena that occur above the tops of cumulonimbus clouds, so typical of thunderstorms, but seemingly have their roots in the lightning activity taking place beneath them. However, recent evidence [2] suggests that sprites may actually emanate even higher up, within the ionosphere, and that they link up with lightning to provide a momentary short-circuit between the ionosphere and the Earth beneath. Such ideas seem astounding and, if true, their implications could be profound. Researchers are therefore redoubling their efforts to unravel these fascinating displays of atmospheric electricity.

For all their apparent novelty, evidence of some of these strange electrical effects may well be even older than some assume. As far as can be established, the first systematic (though possibly serendipitous) study of the interaction between lightning and the ionosphere was undertaken by workers in Australia as long ago as 1937. It led soon after to an even more detailed investigation of the phenomenon in South Africa. That such discoveries should have first been made in the southern hemisphere is not surprising, since parts of both countries "enjoy" above-average levels of lightning activity at certain times of the year, and this makes them ideal as natural laboratories for the study of atmospheric pyrotechnics.

Intriguingly, during those investigations in South Africa (and on a single occasion in England), occasional sightings were made of what appeared to be lightning striking not downwards towards the ground, nor even from cloud to cloud, but upwards from the cloud tops to the upper reaches beyond. Could these have been glimpses of the same ethereal javelins – the sprites and other related manifestations – that are now attracting much attention in various places? If they were, few today seem aware of these early observations. This article is an attempt to provide a brief overview of some of the work on lightning, the upper atmosphere, and the ionosphere, done fifty and more years ago. It touches, too, on some of the scientists who made such great contributions in the field.

Atmospheric Electricity

It was the Scottish physicist, C. T. R. Wilson (1869-1959) (see Figure 1) who elevated the study of electrical phenomena in the atmosphere to a science that now truly has a multitude of dimensions [3]. In 1900, almost simultaneously with Elster and Geitel in Germany, Wilson discovered that the conductivity of air was due to the presence of positive and negative ions, and he immediately began to search for their cause. The fact that the Earth, itself, has a predominantly negative charge led him to postulate that some extra-terrestrial source of radiation, of great penetrating power, was depositing cathode rays upon the Earth. This hypothesis was subsequently shown to be wrong – for the charges emanating from space were found to be predominantly positive – but it certainly kindled the search for what came to be called cosmic rays and led, eventually, to many important discoveries.

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Figure 1: C. T. R. Wilson (1869-1959) (by permission of Godfrey Argent [3]).

The source of the Earth's charge lay elsewhere and to find it, Wilson turned his attention to the thunderclouds and the lightning they produce [4]. His genius was manifold, and his influence on generations of physicists who followed him surely makes him one of the greatest of all experimentalists. The sheer elegance and simplicity of his apparatus was astounding. A pot plant on a conducting plate provided a measure of the charge in air. The brilliance of his cloud chamber for visually tracking radioactive particles, and the momentous discoveries that he and others made when using it, brought him a share of the Nobel Prize for Physics in 1927, as it did for one of his students, P. M. S. Blackett, some twenty years later. Another of Wilson's most admiring and enthusiastic students was a South African by the name of B. F. J. Schonland (Figure 2), whose own contributions to our knowledge of lightning were hugely significant [5].

Basil Schonland (1896-1972) first encountered Wilson (who was always known as "CTR" to his colleagues and students alike) at the Cavendish Laboratory in Cambridge in 1920, when – as a young graduate from Rhodes University in Grahamstown and just returned from service in the First World War – he attended Wilson's lectures on physical optics. The depth of CTR's insight and his impressive grasp of the subject – for all his hesitancy in its delivery – made a huge impression on Schonland, and cemented a relationship between them that would last until Wilson's death. On returning home to Cape Town, in 1923, Schonland initially continued the research he had started at Cambridge on the scattering of β particles. However, South Africa's isolation from the active centers of world physics (of which the Cavendish Laboratory was pre-eminent at the time) soon caused him to abandon that work in favor of something with truly African dimensions: *Umpundulo*, the lightning of the Zulus.

It was Wilson's assertion that the lower regions of a thundercloud were negatively charged that provided Schonland with his first exposure to the subject. The research was not without controversy, for such views flew in the face of the prevailing wisdom of the time, which held that the clouds, as seen by an observer on the Earth, were always sources of positive charge. However, within a short space of time, Schonland's measurements – conducted on the family farm in the eastern Cape with ingenious equipment of astoundingly simple design – showed that CTR was indeed correct. The polarity and distribution of the charges were determined indirectly by measuring the electric fields produced by the thunderclouds. The device for doing this was the Lippmann capillary electrometer, an ingenious arrangement consisting of a minute glass tube linking two mercury-filled chambers, one of which was connected to ground, the other to a field sensor. A bubble of sulpheric acid, lying between the mercury filaments, indicated both the magnitude and sign of any accumulated charge by the amount of its deflection, either left or right. Photographing the position of the bubble on a continuously moving film provided a record of charge, and hence field, variation. Use of Wilson's simple mathematical model of the bipolar thundercloud then defined the polarity and position of the charges within the cloud that produced these changes in field.

Schonland published his results in 1927 [6], but there were still some powerful critics who remained to be convinced. It was not until a meeting held in London in 1931 that Schonland made his case with such authority and conviction that the prevailing dogma was finally overturned.

The Penetrating Radiation

Wilson and Schonland corresponded regularly, and their letters kept the South African in close touch with his mentor and, particularly, with his latest thoughts on the subject of atmospheric electricity. The burning issue now was the source of the highly energetic radiation, known then as the

Figure 2: B. F. J. Schonland (1896-1972).

"penetrating radiation," which could readily be detected on the Earth. Wilson was of the view that some of it might originate in the intense electric fields within a thundercloud, which would accelerate the naturally occurring β particles (electrons) in air and lead, after multiple collisions, to the generation of what was thought to be γ-ray quanta. The man best placed to make the defining measurements was Schonland. But letters are no substitute for personal contact and, in 1928, Schonland returned to Cambridge to work under Wilson's guidance on the construction of an electroscope of imaginative design and great sensitivity that, it was hoped, would yield the results. That instrument would soon be used in Johannesburg, where thunderstorms and pyrotechnic displays of lightning were almost a daily occurrence during the summer months.

After a measurement campaign that lasted throughout the summers of 1929 to 1932, Schonland had amassed a great amount of data. However, its analysis yielded some unexpected results. Instead of an increase in flux in the region directly below a thunderstorm, he found that the opposite effect actually seemed more likely. It appeared that the presence of highly active thunderclouds above the electroscope – or Geiger-Müller counters that he used subsequently – actually caused the penetrating radiation to decrease, almost as if the storm clouds had interposed a shield in its path. On the other hand, electrical storms lying to the west of the observation point produced increased counts of "runaway electrons," as Wilson now described them, using the terminology first introduced by A. S. Eddington.

This was decidedly puzzling. Then, in 1933, Schonland offered an explanation [7]. Any b particles within the body of the thundercloud would be accelerated upwards by the massive potential difference between the cloud's upper and lower regions, estimated at the time to be as much as 5×10^9 volts. On being ejected from the cloud, these rapidly moving charged particles would encounter the Earth's magnetic field, and this interaction would cause them to be bent back towards the Earth. However, there was one serious shortcoming with this model. That was the effect of the opposing field between the cloud-top and the ionosphere, which would surely block the ejection of this "electron spray," an evocative Wilson term. But an explanation was to hand from CTR. He suggested that if the first lightning stroke was *upward*, then the opposing field would momentarily collapse, thus allowing the runaway electrons to escape. Interaction with the Earth's magnetic field would then follow and the electrons' path would rotate, causing them to reach the Earth to the east of the storm cloud that had produced them, just as Schonland had found.

To consolidate his findings, Schonland was able to refer to evidence of this upward-striking lightning, for he himself had seen it and had reported as much in his paper of 1927. But he was not the first. The year before, Charles Vernon Boys (1855-1944) disclosed how, in 1876 in England, he had witnessed as many as seven simultaneous lightning strikes taking place from the upper regions of an active thundercloud into the clear night skies above [8]. And, then again in 1947, Schonland and his colleague in South Africa, D. J. Malan, reminded the world of Malan's own observation, reported so eloquently a decade before [9]. Then, Malan had described the discharge as "...une longue et faible bande d'une lueur rougeâtre. Deux fois le phénomène se présente comme un rideau auroral composé de cinq ou six de ces bandes" ("a long and weak beam of faint red light. Twice, the phenomenon appeared like a curtain of sunlight at dawn, composed of five or six of these beams"). The Wilson mechanism therefore seemed to have some credibility, and upward-striking lightning was an observed, natural phenomenon of much curiosity.

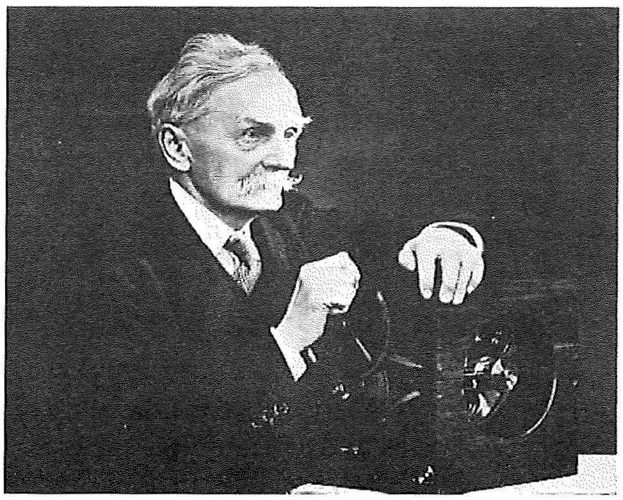

Figure 3: C.V. Boys (1855 -1944) with his rotating-lens camera (by permission of Oxford University Press [10]).

Lightning

The challenge to unravel the mysteries of lightning now consumed all Schonland's time. The instrument he used for doing this was a very special camera, developed by the same C. V. Boys in 1900 (Figure 3). It was equipped with two rapidly rotating lenses that made it possible to capture on film every changing feature of a lightning stroke. For the next 26 years, Boys tried to photograph lightning, but succeeded only once. Then, in 1932, Schonland had three such cameras manufactured, based on the Boys design, and within four years he and his colleagues had taken 150 photographs of lightning flashes to ground, which showed 600 separate events in intricate detail (Figure 4). The photographs revealed that lightning began with an intermittent or *stepped leader* that probed faintly in staccato fashion, with many tentative side-branches on its route from cloud to ground. This was followed, almost instantaneously, by the dramatic *return stroke*, which started at the ground and streaked skyward toward the cloud that gave rise to it, illuminating every branch and tentacle with blinding luminosity on the way. And so the process then continues, often with as many as forty leaders and return strokes in a sequence, but with only the solitary stepped leader that initiates it all.

To provide yet more information on the characteristics of lightning, Schonland used a technique – pioneered by J.

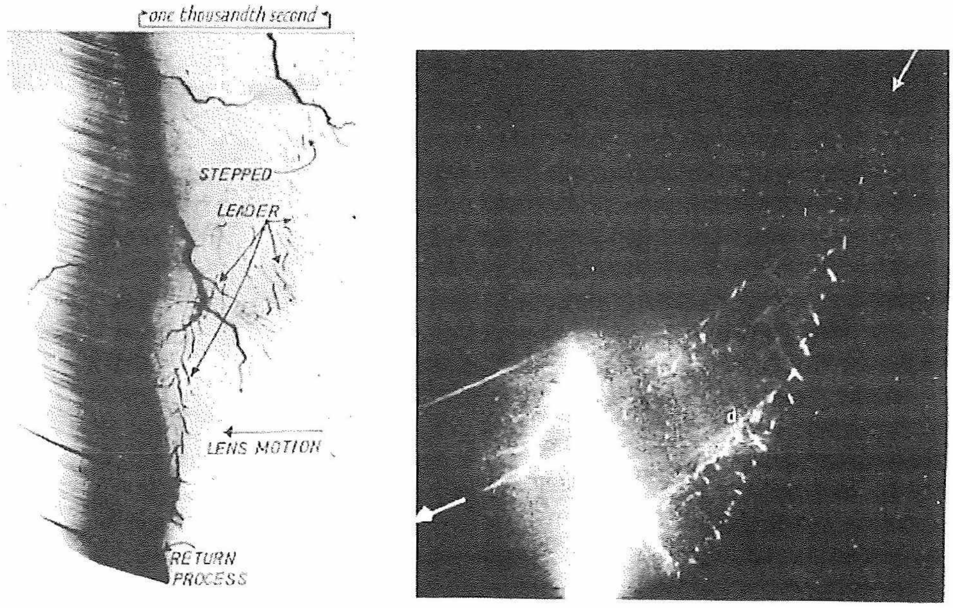

Figure 4: Positive and negative images showing the stepped leader and return strokes of a lightning flash (by permission of Oxford University Press [10]).

H. Norinder in Sweden and E. V. Appleton and R. A. Watson-Watt in England – of recording the electric fields radiated by lightning. These sferics, as they subsequently came to be called, were displayed on an oscillograph (a type of early recording oscilloscope), photographed at high speed, and then viewed in conjunction with those of the lightning that produced them. The results were fascinating, and provided huge amounts of hitherto unknown information.

Figure 5a shows, in diagrammatic form, Schonland's portrayal of the various processes of three nearby lightning strokes, observed optically, with time advancing from left to right [10]. On the left is the stepped leader followed, at 1, by the intense return stroke, and then by a period of continuing luminosity. After that, the process starts again, but now the leader progresses quite smoothly along an already ionized path to the ground. Its return stroke follows at 2, and so on. Figure 5b is the oscillograph record of the electric-field strength measured within a few kilometers of the discharge. The advance Earthwards of the stepped leader causes multiple ripples and an increasingly negative component in the electric-field record. At the onset of the return stroke the field collapses rapidly, then recovers during the period of continuing luminosity, only to decrease again as the next leader appears from another charge-center within the cloud, but this time it produces no ripple on the trace. Eventually, with only the positive charge left in the upper regions of the cloud, a strong residual positive field remains.

When the same processes are recorded at about 40 km from the lightning discharge, the electric field exhibited a much simpler form, as shown diagrammatically in Figure 6 for a flash consisting of just two strokes. Now, only the stepped leader (A) and the two return strokes (B and B') produced fields of any consequence; all other events took place too slowly to propagate into the far field. If, however, the lightning activity was considerably further away from the recording instruments, then the recorded field strengths underwent a remarkable change, with multiple components now seen to follow each of the return-stroke signals. These findings were perplexing, and remained so until the publication, in 1937 and 1938, of two papers from Australia that provided the answer.

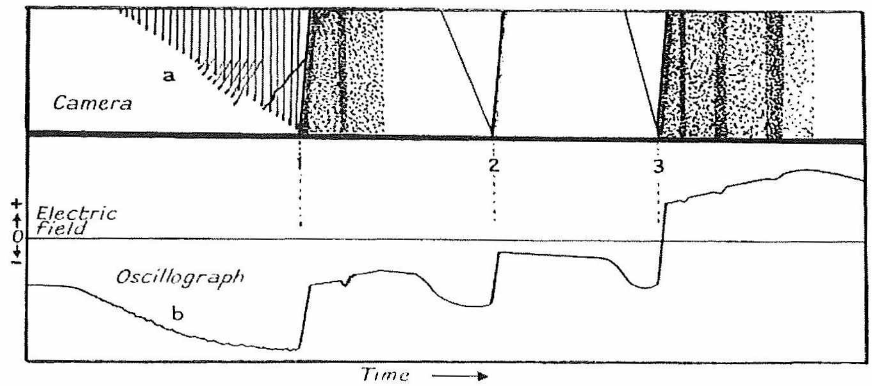

Figure 5: (a) A diagrammatic view of the various processes of a lightning stroke; (b) The typical variation of the E field corresponding to the optical

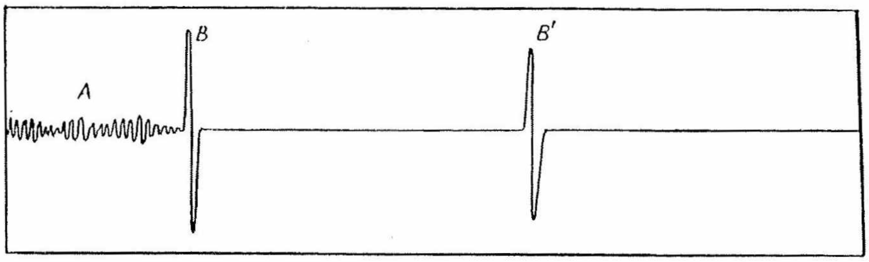

Figure 6: A diagram illustrating the E fields produced by the stepped leader and subsequent return strokes, as observed at about 40 km (by permission of Oxford University Press [10]).

Lightning and the Ionosphere

A group at the University of Melbourne, under T. H. Laby, had also been recording the electric fields radiated by the lightning discharge. They concluded that the multiple components of the waveform seen on the oscilloscope were indicative of reflections from the ionosphere [11]. For a time, there was some controversy as to the details of the initiating lightning waveform, since this would influence directly the interpretation of the many subsequent components seen on the oscilloscope. However, in 1939 and then again the following year, Schonland and his colleagues in Johannesburg and Durban published their findings and a detailed analysis. These showed that the lightning return stroke radiated a single cycle of energy, corresponding closely to the duration of the return stroke [12, 13]. They also agreed entirely with their Australian colleagues that the multiple components seen to follow the return-stroke signal, shown diagrammatically in Figure 7a, were indeed caused by its successive reflection between the ionosphere and the Earth.

Detailed examination of the waveforms (Figure 7b) yielded a considerable amount of information about the lightning pulse, the propagation path over which the energy traveled from lightning-source to the receiver, and about the ionosphere, itself. There was clear evidence of a ground-wave component that reached the receiver after propagating directly over the surface of the Earth. Following this were numerous components that exhibited an increasing period between successive pairs. In addition, there was repeatable evidence showing that the first received pulse dominated over short distances, but as the distance between lightning and receiver increased, the second, or even the third pulse, had the largest amplitude. Finally, atmospherics recorded at night were always easier to interpret than those obtained during the day, with up to forty successive recorded pulses being common.

An analysis of all the data accumulated over many years showed that the reflections were taking place at a mean height of 88 km, which they believed placed it at the lower limits of the E region of the ionosphere. The increasing period between successive pulses confirmed that the energy reaching the receiver did so over ever-increasing path lengths: the first to arrive being almost tangential to the Earth, the last being almost at normal incidence to the ionosphere. Attenuation of the ground wave, and of the tangential components in close proximity to the Earth, would cause their amplitudes to decrease with distance, and so cause the second or possibly even the third received pulse to have the largest amplitude, as was apparent in the data. The fact that nighttime records contained both more pulses than those recorded during the day, and exhibited less merging of those at the beginning of the sequence, indicated two things: a lower path attenuation at night, and increased height of the reflecting layer during the hours of darkness. The latter was well known, while the former was still under investigation in ionospheric-research circles. The absorbing

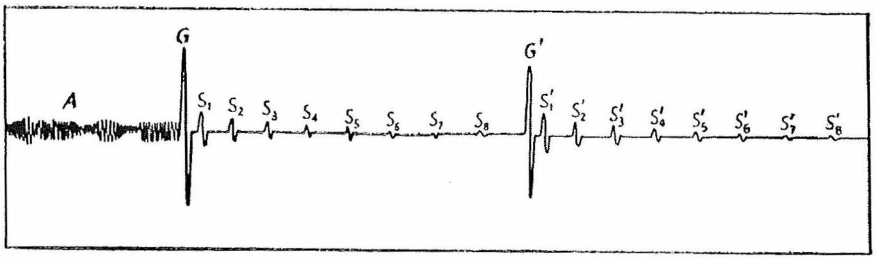

Figure 7a: The E fields at a considerable distance from lightning, showing the multiple reflections from the ionosphere (by permission of Oxford University Press [10]).

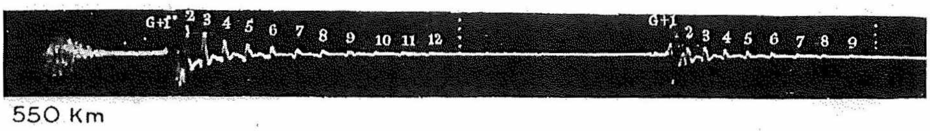

Figure 7b: Photographic evidence of the same phenomenon as shown in Figure 7a, recorded at 550 km (by permission of The Royal Society [13]).

D region, as we know it today, remaining a matter of some speculation until the 1940s, even though it was first mooted by Appleton in 1927, and named as such by him in 1930 [14].

Barkhausen's Contribution

Even though the link between lightning-related events and the ionosphere was first established unequivocally in the years immediately preceding the Second World War, it was actually during the previous conflict that such phenomena were first noted, though not fully understood. While operating a listening station intended to overhear enemy communications, Heinrich Barkhausen – then a German Army signaler stationed in France and subsequently a radio scientist of distinction – attributed the sounds he had first heard on headphones (connected via an audio amplifier to two, widely separated ground stakes) to lightning impulses reflected by the Heaviside layer. Though Barkhausen first reported this in 1919, little or no notice was taken until 1930, when he offered an explanation for what he described as "peou-like" sounds in his headphones [15]. They turned out to be the whistlers as we know them today, and it was that paper of Barkhausen's that first brought them to our attention. Intriguingly, both Basil Schonland and Edward Appleton were signalers in the British Army during the First World War. Schonland, certainly, had heard the same strange sounds, while Appleton, presumably, would have been aware of them. However, Barkhausen, Schonland, and Appleton could only have guessed at their cause at that time, since proof of the existence of the ionosphere – though suggested by both Oliver Heaviside and A. E. Kennelly in 1902, and by Balfour Stewart even earlier – remained elusive until Appleton's work, amongst others, of a few years later.

Conclusion

The interaction between lightning close to the surface of the Earth and the ionosphere a considerable distance above it has been part of the planet's evolution since primeval times. Indeed, such linkages may even have had a significant part to play in the way that evolution unfolded. But it was the advent of radio, within the last century, that first revealed such interaction. Only during the 1930s, when radio was combined with the optical methods used to study lightning, was it possible to explain the complex processes involved. Since then, world-wide research into upper-atmospheric phenomena has increased enormously, and it has produced a rich harvest of results. Much of the credit for such progress must be given to scientists in the southern hemisphere, and this is as true today as it was nearly 75 years ago.

Acknowledgements

Acknowledgement is made to the various copyright holders for permission to use relevant material. The author also greatly appreciates the useful comments and suggestions made by Dick Dowden when he was preparing this paper, and by Duncan Baker, Ken Davies, Bob Hunsucker, and, especially, Pat Hawker, in connection with the discovery of the D region of the ionosphere.

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Modeling FAST, the World's Largest Single Dish

B. Peng
R. Nan

Abstract

A Five-hundred-meter-Aperture Spherical Telescope (FAST) has been proposed to be built in the unique karst area of southwest China. In a sense, it will act as a prototype for the Square Kilometer Array (SKA). It will be over twice as large as the Arecibo radio telescope, coupled with much wider sky coverage. Some results from site surveys and scale models are briefly presented for such a SKA concept. Technically, FAST is not simply a copy of the existing Arecibo telescope, but rather it has a number of innovations. First, the proposed main spherical reflector will enable the realization of both wide bandwidth and full polarization capability, while using standard feed designs. It will do this by conforming to a paraboloid of revolution in real time, through active-control actuators. Second, a feed-support system – which integrates optical, mechanical, and electronic technologies – will effectively reduce the cost of the support structure and the control system. Pre-research on FAST has become a key project in the Chinese Academy of Sciences, and great progress has been achieved.

1. Introduction

In 1993, a large radio telescope (LT, now called the SKA) was proposed by astronomers from 10 countries at the XXIVth General Assembly of URSI. The SKA is to be a telescope array with a total (effective) collecting area of about one square kilometer, consisting of about 30 individual elements, each roughly 200 m in diameter. There are various concepts, worldwide, for realizing the SKA project. Extensive efforts have been made, e.g., by project teams of The Netherlands (a wide-band phased array), Australia (an array of spherical Luneburg lenses), Canada (a large adaptive reflector of very long focal length), China (an Arecibo-style dish), United States (the Allan telescope array), India (an array of steerable parabolic dishes); for details, see http://skatelescope.org. In this paper, we will summarize the Chinese concept for the SKA, and modeling experiments for this concept.

Chinese astronomers are going to build a set of large (Arecibo-style) spherical reflectors by making use of extensive existing karst landforms, which are bowl-shaped

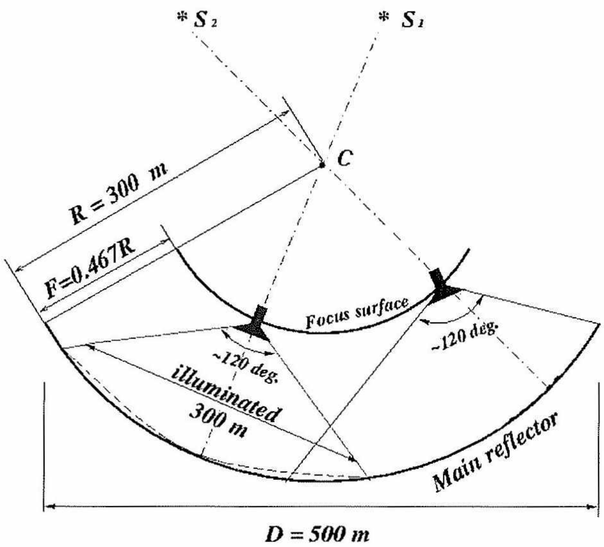

Figure 1a. The geometry of the FAST configuration. The related parabola, to which the spherical surface is deformed, is shown by the dashed line.

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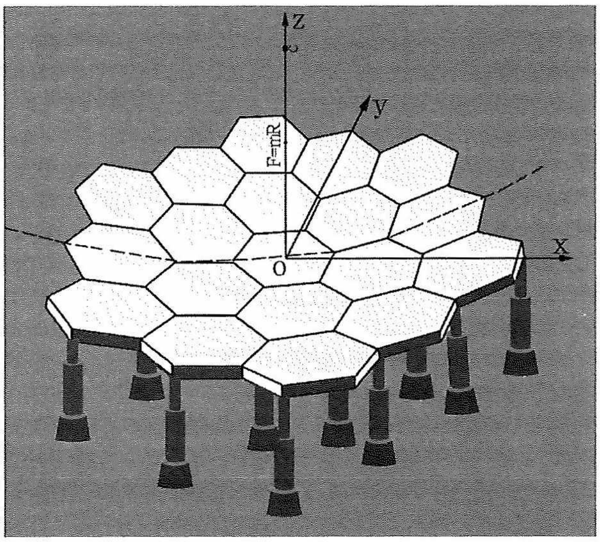


Figure 1b. The FAST surface, showing the hexagons and actuators. The coordinate system used in the analysis of Section 3 is also shown.

limestone sinkholes named after Karst, a Yugoslavian geologist. As a forerunner for the SKA, a Five-hundred-meter Aperture Spherical Telescope (FAST) is planned to be constructed as a National Megascience Project of China, with an estimated cost of ~ 60,000,000 US$, around the year 2004.

Some basic parameters of the FAST are demonstrated in Figure 1. It will have a main spherical-reflector radius of $R = 300$ m, a total projected diameter of up to 500 m, and an effective aperture of about 300 m. Since the focal length of FAST is to be set to $< R/2$, a portion of the related parabola (to which the spherical surface is deformed, shown by the dashed line in Figure 1a) lies above the sphere. Then the two curves have three points of intersection, the first being at the common point of tangency (the point of osculation), and two more points, on opposite sides of the first, that move away from it. Somewhere between these points and the point of osculation, the displacement between the two curves clearly reaches a maximum. The geometrical configuration in Figure 1 will enable the FAST to have a larger sky coverage (> 40° zènith angle) than the Arecibo telescope (~ 20° zenith angle). The simplified feed system will continuously cover most of the frequency range between 200 MHz and 2000 MHz, with possible capability up to 5 GHz or even 8 GHz, depending upon the cost. The FAST obviously will achieve the largest collecting area in the world.

2. Site Survey

A large number of karst (bowl-shaped limestone) depressions in Guizhou province and at least 400 depressions in Pingtang and Puding counties were investigated with Remote Sensing (RS), the Geographical Information System (GIS), and on-the-spot observations, and were selected as candidate site locations [1] for the SKA. As an example, Figure 2 shows the statistical results for Pingtang county. More than 10 depressions were imaged at a high resolution of 5 m/pixel, showing suitable profiles for a large spherical reflector [2]. At the selected sites, carbonate rock is the main hydrous layer. Wind-speed measurements, made near the ground at various heights above depressions, were started in January, 1999. The observed speeds grew from ~ 1 m/s in the bottom of the depressions, to a maximum of ~ 7 m/s at the top. There are less than five days of snowfall per year, and no ice build-up at the sites [3].

A series of measurements at various sites was carried out to check on the suitability of the sites from the point of view of radio interference, for realizing the FAST/SKA. The first measurements were made at eight karst-depression sites in November, 1994, in both Pingtang and Puding counties. Further measurements were made in March, 1995, for a period of one month, in an attempt to understand distance effects. In June, 2000, we re-monitored half of the above sites to see the change of interference with time. The results of these measurements provided information about the frequency, strength, and characteristics of the interfering signals. Most of the interfering signals found appeared to be narrowband (< 10 kHz) beacon signals of unknown origin. Due to the remoteness of this region and the shielding by local terrain, the preliminary results of the radio-interference monitoring were quite promising [3, 4].

3. Active Main Spherical Reflector

It is well known that the central part of a spherical surface deviates little from a paraboloid of revolution, when the proper focal length is chosen. Based on this, a novel design for a giant spherical reflector has been proposed [5]. The illuminated part of the main spherical reflector (Figure 1) is continuously adjusted, in real time, to fit a paraboloid of

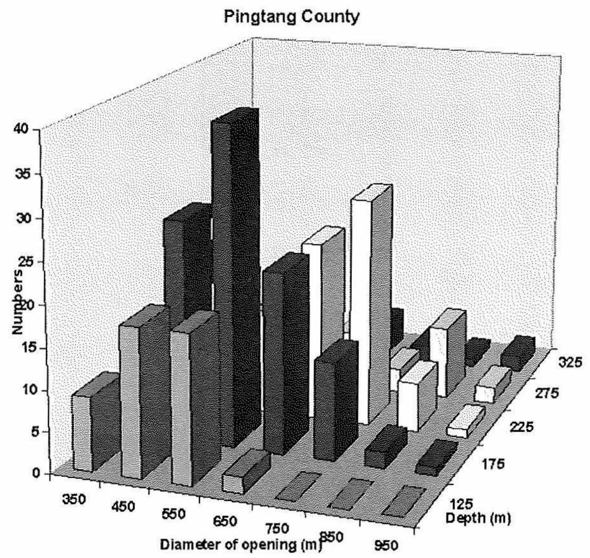


Figure 2. The statistics of the depressions in Pingtang county.

revolution. This is done by actuating an active control system synchronously with the motion of the feed while tracking an object. A standard feed system can then be adopted, to achieve broad bandwidth and full polarization capability through the total elimination of spherical aberrations. In the actual configuration, a schematic cross-section of which is shown in Figure 1, the center of the sphere is labeled point C. Let the origin of a rectangular coordinate system, *x*, *y*, *z*, be O, at the lowest point of the sphere. The *z* axis points toward the zenith, the *x* axis lies in the plane of the figure, and the *y* axis points into the paper. Some basic equations of the cross section at $y = 0$ are then as follows (the following exposition, including Figure 4, was suggested by Dr. Allan W. Love):

The equation of the sphere is given by

$$X(z) = \sqrt{2Rz - z^2}$$

The equation of the parabola to which the spherical surface is deformed is given by

$$x(m, z) = \sqrt{4mRz}$$

where mR is the focal length of the parabola. It can then be shown that the displacement between the two curves in the radial direction, normal to the sphere, is given by

$$\Delta r(m,\theta) = R - \sqrt{\left[R - z(\theta)\right]^2 + 4mRz(\theta)},$$

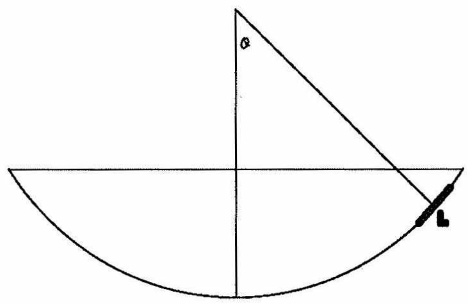


Figure 3. The definition of the angle θ.

where

$$z(\theta) = R\left[1 - \cos(\theta)\right]$$

θ is the angle shown in Figure 3. The results of calculating the displacement between the paraboloid and the sphere are shown in Figure 4, for three values of m: $m1 = 0.44$, $m2 = 0.467$, and $m3 = 0.5$. For $m = 0.467$, the middle curve of Figure 4 shows that the displacement is approximately zero at $\theta = 0$ rad and at $\theta = 0.52$ rad. Thus, if the focal length is set to $0.467R$ (~ 140 m), the range of travel required for the actuators is less than 65 cm across the entire ~ 300 m of illuminated aperture. Note that the effective aperture diameter is given by

$$D_{eff}(\theta) = 2R\sin(\theta) = 298.128 \text{ m}$$

when $\theta = 0.52$ rad.

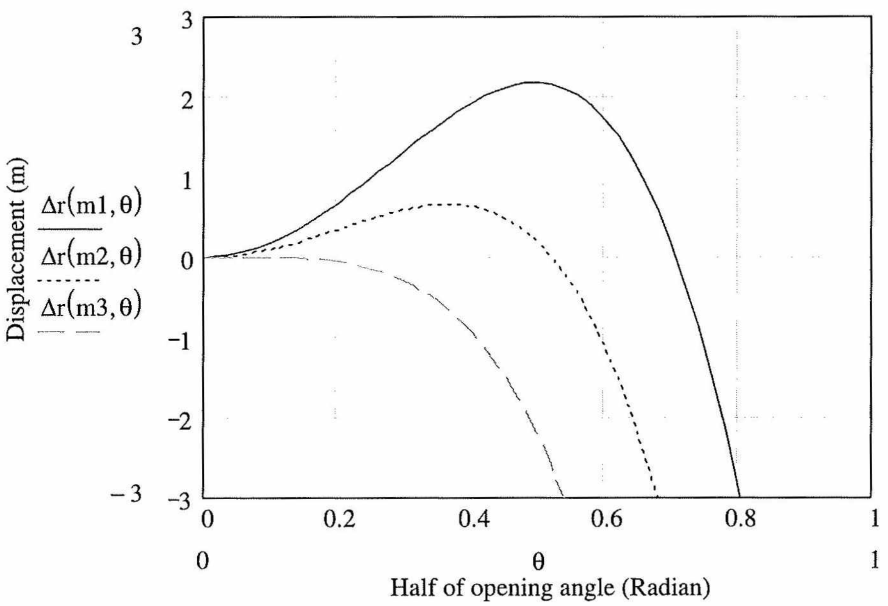


Figure 4. The displacement in the radial direction, normal to the sphere, between the sphere and the parabola, for three different values of m: m1=0.44 ,m2 = 0.467, and m3 = 0.5.

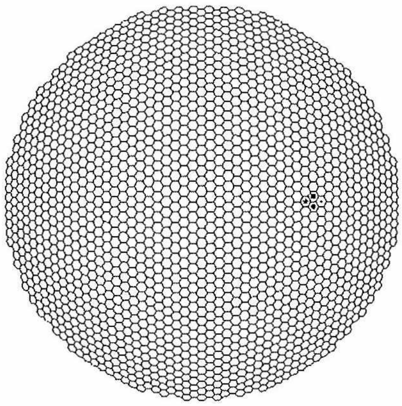


Figure 5. The FAST main reflector is segmented into about 1800 hexagons.

For the maximum apparent motion of the celestial objects, the rate of variation is found to be very small, lower than 5 cm/min. This enables inexpensive solutions for the mechanical control. The time required to switch between target sources that lie far apart is expected to be within 10 minutes.

For construction, it is necessary to divide the giant main spherical surface into smaller elementary units. Each element is a small part of the spherical surface, and its curvature should be optimized to give the best fit to the paraboloid. Figure 5 shows one of the segmentation methods proposed [6, 7]. First, the segmentation is done in a flat plane, divided into ~ 1800 identical hexagons with sides ~ 7.5 m long. These are computer controlled (Figure 1). Second, the plane is dropped into the spherical cap, keeping the length along the radial direction unchanged, while the dimension of the hexagon along the azimuth direction is shortened by a factor of $\mathrm{sinc}(\theta)$.

Each element has three actuators to fix its position, and to connect it with adjacent elements. There would thus be an average of one actuator per element, as shown in Figure 1. The support, with its actuator, is directed towards the center of the sphere. A control system based on one of the up-to-date field-bus technologies – LonWorks – has been suggested. The LonTalk protocol that is implemented in firmware on the Neuron chip provides the foundation for the LonWorks interoperability. The control system, based on the LonWorks technology, is pictured in Figure 6 [8]. The system consists of two levels. The upper level is the master computer. The lower level consists of about 1800 intelligent nodes, connected with the master computer via a network. The master computer may consist of several personal computers. LonWorks control networks offer a feature called "distributed processing," whereby each device in the network can receive, transmit, and process network information independently of other devices. This means that devices in a LonWorks control system can make decisions and process information without the need for a PC, a programmable logic controller (PLC), or some other form of central host processor.

If the rms error of the aperture is expected to be smaller than $\lambda/16$ (~ 4 mm) at 5 GHz, the largest dimension of each element in Figure 5 should not exceed 15 m. Two possible means of supporting the surface have been considered: steel cables and concrete pillars. The final choice will depend upon the shape of the valley.

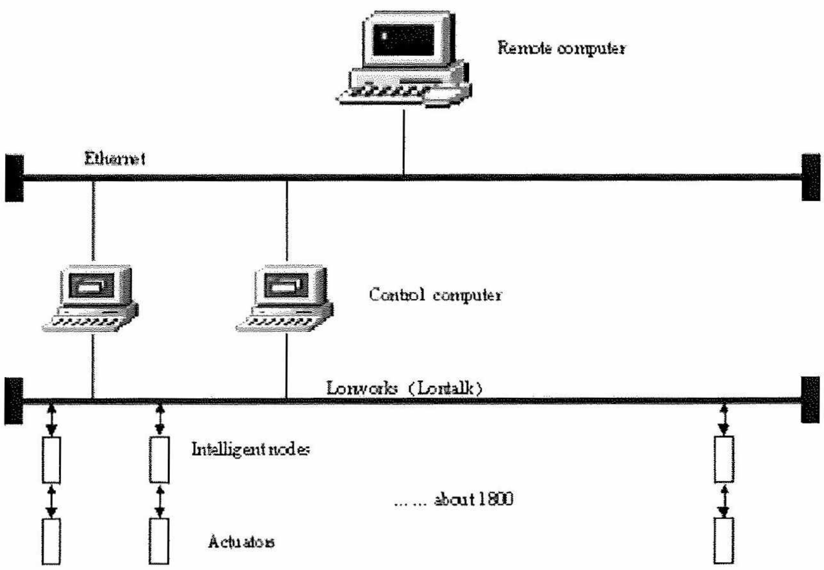


Figure 6. A block diagram of the control system for the active main reflector.

4. Feed Support

FAST can be seen to be an "Arecibo-type with active main reflector." The telescope is "pointed" by moving the feed cabin, while the reflector surface is deformed in synchronism with the feed-pointing motion.

4.1 Cable Support System

A new design for the feed-support structure (Figure 7) for FAST has been proposed by using six suspended cables connected to mechanical servo-control systems [9]. Compared with the Arecibo 305 m radio telescope, the total weight of the feed-support system could evidently be reduced by two orders of magnitude or more with such a design, to a few tens of tons. If Arecibo-like support were to be employed for the FAST feed structure, the weight would probably be of the order of 10,000 tons.

The tracking will be done by means of integrated mechanical, electronic, and optical technologies, i.e., "optomechatronics." The whole system will primarily consist of three parts. First, the six cables will be driven by six sets of servo-mechanisms, controlled by a central computer, so that the movement of the focus cabin along its caustic trajectory can be realized. Given the difference between the apparent and required positions where the feed (cabin) should point, the central computer will drive each servo-mechanism to adjust the position of the feed. Second, a group of receivers with multi-beam feeds will be mounted on a stabilizer in the focus cabin. This is to provide a second adjustment, since the cabin driven by cables alone may not achieve the pointing accuracy required. A laser ranging system (in our case, three Total Stations of TCRA 1101 plus), being the third part, will be adopted to accurately measure the position of the feed in real time. This information will be fed back to the central computer for global loop control.

Numerical simulations have been carried out for such a design. This has been done using both nonlinear-response analysis of the cabin-cable system with respect to a random wind [10], and a precision study of the fine-tuning stabilizer, using inverse positional computation, kinematics, and singularity analysis [11, 12]. Detailed deductions from this [13, 10-12] have shown that the optomechatronics design is capable of satisfying the required pointing accuracy.

To demonstrate the design, a 5 m model has been successfully built. This precedes the construction of a 50 m model, which is now in the final testing stage, as shown in Figure 8. For FAST, the focus cabin can be positioned to some tens of centimeters of accuracy using only the cable-driven system. It can then be further positioned to millimeter accuracy with a fine-tuning stabilizer, i.e., the Stewart platform (see the discussion below). A typical Stewart platform consists of six variable-length actuators, connecting a mobile plate to a base. As the lengths of the actuators change, the mobile platform is able to move in all six degrees of freedom with respect to the base.

4.2 Cable-Car Configuration

A small cable car, which serves as the focus cabin, housing the feed and receivers, is to be driven by eight cables (Figure 9). Two pairs of parallel supporting cables will be suspended from two pairs of opposite towers (instead of the three towers in the concept discussed above). Another four downward cables are securely fastened to four anchors, which are symmetrically arranged about the main spherical reflector [14]. The lengths of the connecting cables are adjusted appropriately as the cabin location changes. Such a design aims to increase the stiffness of the "platformless" cable-support structure, discussed above.

The positioning of the cabin will be achieved by driving the car on two crossed sets of supporting cables,

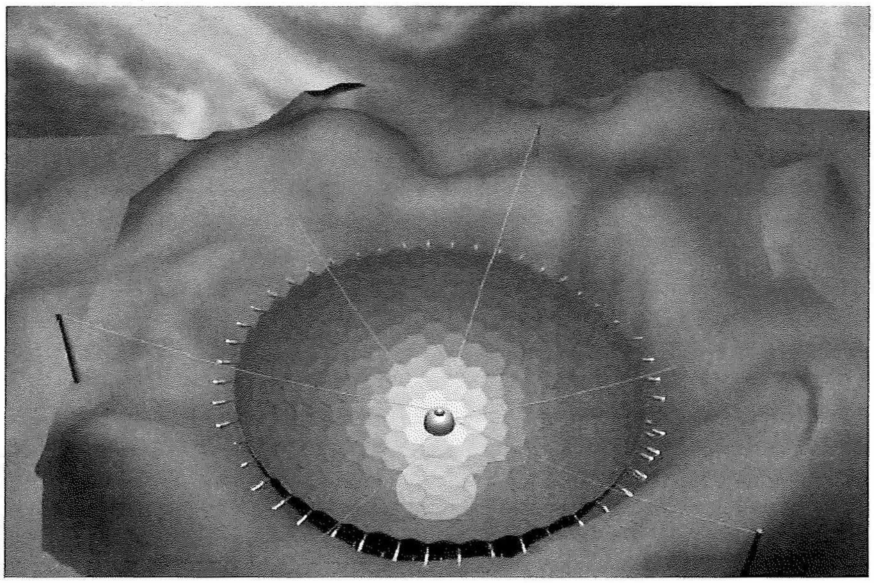
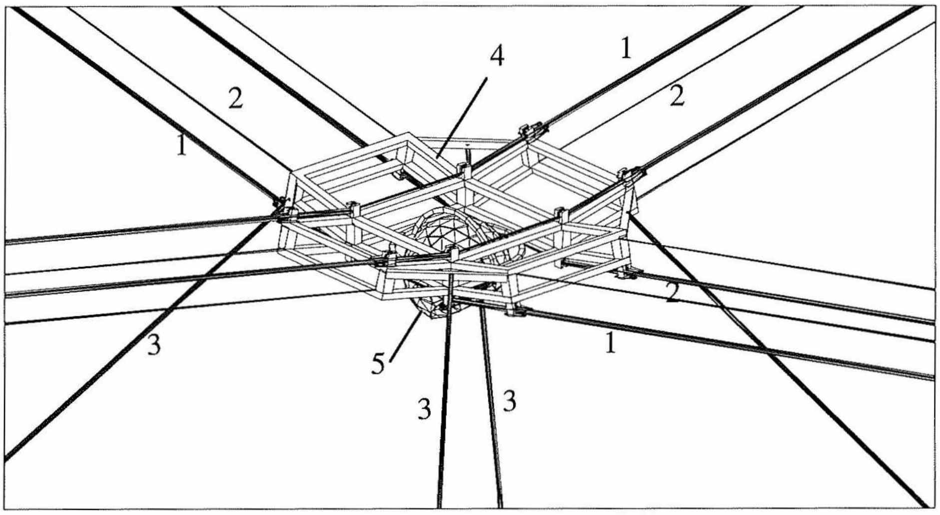


Figure 7. The cable support system, without a platform.

Figure 8. A 50 m model of the cable support structure, under development.



1: suspension cable; 2: driving cable;
3: pre-tension cable; 4: cable car; 5: feed cabin

Figure 9. The cabin car, driven by two pairs of parallel support cables, with four downward cables

which is like a trolley on the cable tramway in the mountains. The car will be able to move in two directions, with the two sets of suspension cables as tracks. The cabin has two rotational degrees of freedom relative to the cable car, which allows the feed to be arbitrarily pointed, irrespective of the orientation of the cable car. Rotation of the feed can be realized by a special mounting in the car, the axis of which should intersect the center of gravity of the cabin. Rotating the feed about its phase center is a way to gain a significant increase in scan range. Beam pointing is unaffected, and the net result is that the aperture is fed in an offset manner. The only penalty incurred is the appearance of cross-polarized lobes in the plane orthogonal to the plane of scan. For circular polarization, this becomes a small beam squint in that plane. Actuators are to be employed for actively controlling any oscillations of the cabin induced by the motion.

The cable-car configuration is demonstrated in Figure 10. The pre-tension cables were introduced to adjust the stiffness of the feed-support structure. The effect of the pre-tension cable for suppressing unwanted vibration can be obtained by finite-element dynamic analysis, with the excitations generated according to the measured wind conditions of candidate sites. Although a precision of about 0.5 m can be expected for a reasonable tension level in the stabilizing cable, it is wise to have a secondary feed-stabilizing device, instead of increasing the stiffness of the whole structure to an unrealistic level. Trim masses can be used to balance the static load of the suspension cable for energy efficiency during operation of the telescope.

The cable-car configuration separates the positioning and pointing of the feed, but uses seven degrees of freedom to control six degrees of freedom in the feed. The characteristics and vibration-reduction effects of the pre-tension cables in the cable-car configuration have been discussed by Ren et al. [14]. A 1:30 scale physical model for the cable-car system, and a 1:5 scale model for the Stewart stabilizer (to stabilize its lower platform, by compensating for any vibration of its upper platform with variable-length actuators) have been constructed, as shown in Figures 11 and 12. These are being used for feasibility studies with the available and proposed technologies. A positioning accuracy of less than 2 cm is reached by the support of the cable car for the model. An accuracy of about 36 cm can be predicted by similarity for FAST under a wind loading of 8 m/s.

The main advantages of this cable-car configuration are as follows. First, the maximum length of the cable's extension will be relatively short, and the change may be as small as ~ 30 m when observing a target. Second, the downward cables (with a radius of ~ 1 cm in the design) can be used to adjust the stiffness and to improve the dynamic characteristics of the system. Third, the car could be used as a crane during construction and maintenance of the main spherical reflector, and access for maintenance can be achieved by lowing the car down to a ground platform, close to the foot of a tower.

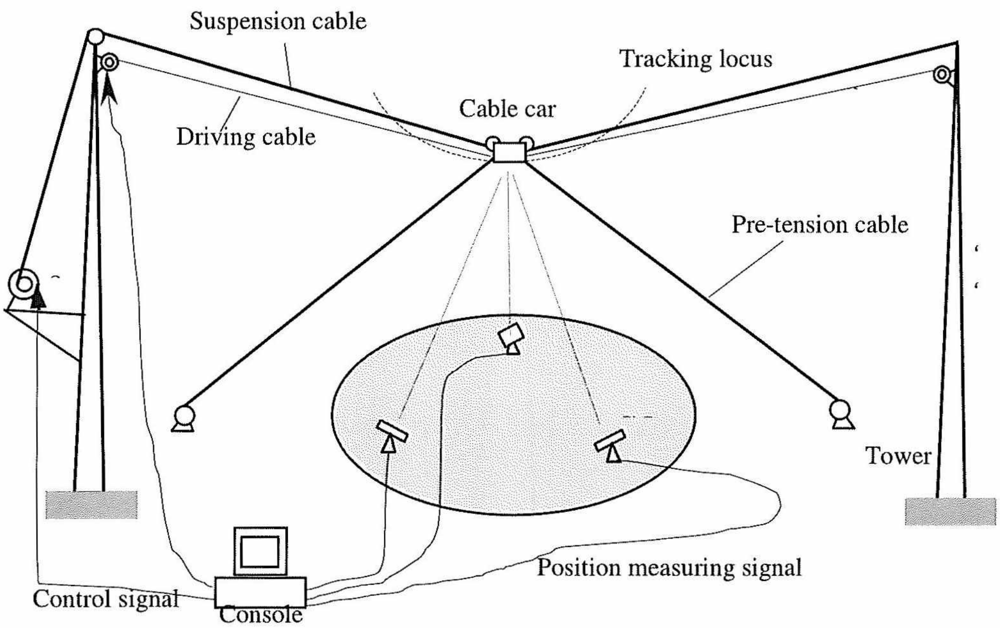


Figure 10. An overview of the cable-car feed-support configuration.

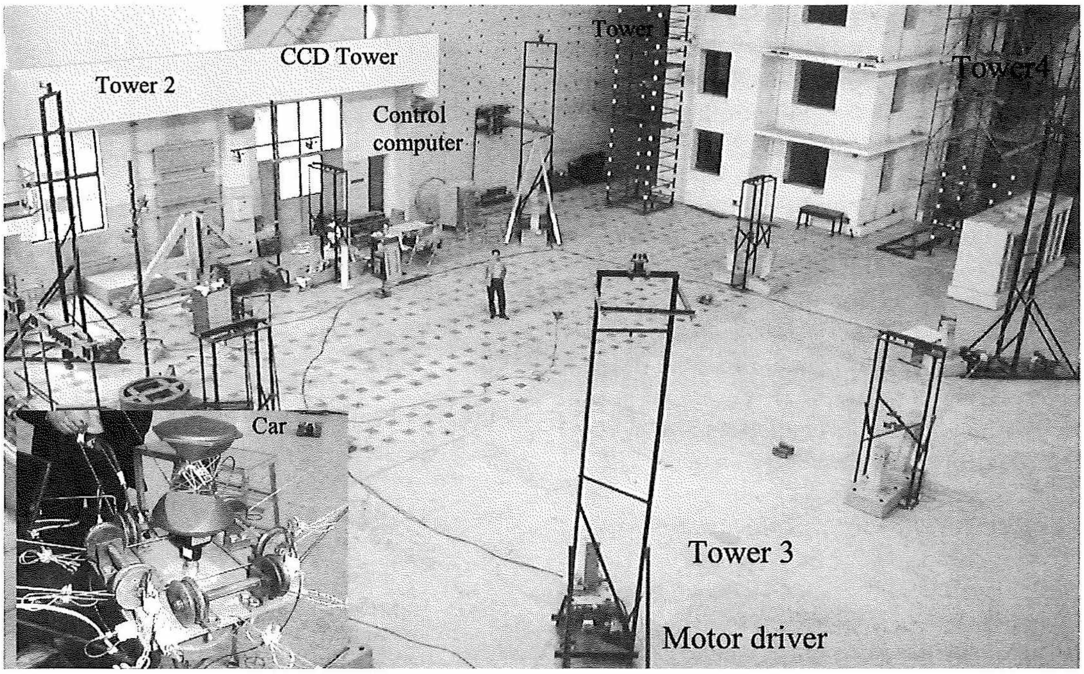


Figure 11. A 1:30, 20 m × 20 m × 6 m scale model of the cable-car configuration.

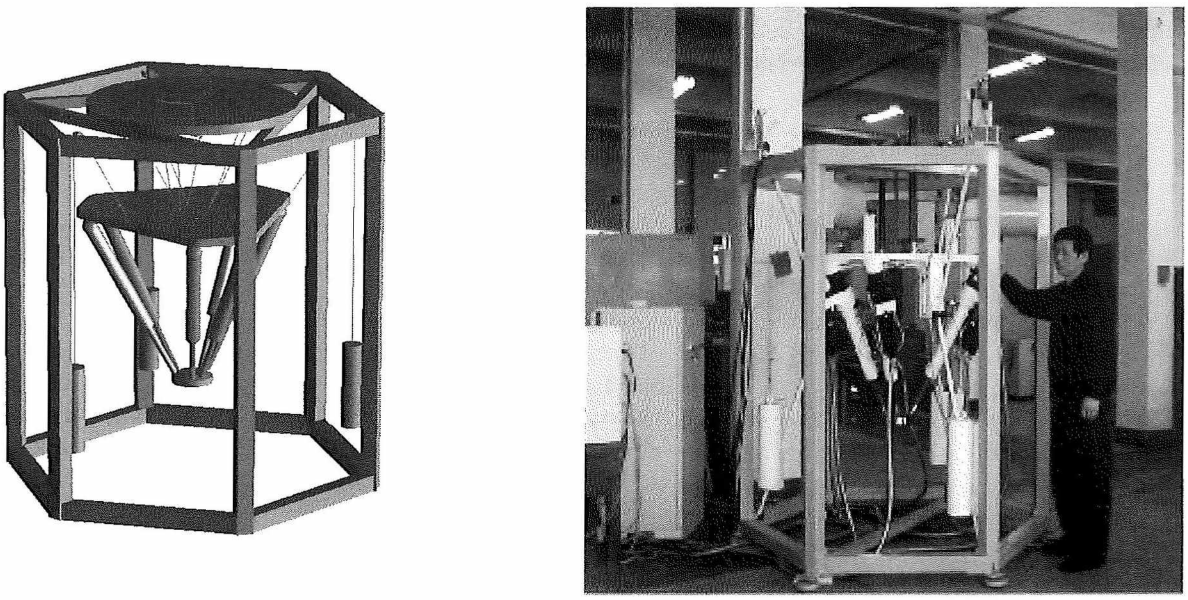


Figure 12. A 1:5 scale model of the Stewart platform for FAST.

5. Receiver System

The receivers are to be mounted on a stabilized station, connected to the main body of the focus cabin as a Stewart platform. A collaboration on FAST was established between the Beijing Astronomical Observatory (now the National Astronomical Observatories) and the University of Manchester's Jodrell Bank Observatory (JBO), by a memorandum of understanding signed in July, 1999. The joint discussions of the low-noise receivers for FAST have been based on the use of existing, proven technology, to minimize the technical risk for the project. Table 1 summarizes the low-noise amplifier (LNA) types recommended for the FAST receivers. Most are either existing designs, or are currently under development at JBO. All are based on the use of high-electron-mobility transistors (HEMTs) and, with the exception of the UHF receivers, all would be operated at temperatures between 10 K and 20 K, cooled by closed-cycle helium refrigerators [15].

6. FAST science

The collecting area of a telescope is a figure of merit for that instrument's capability. In this context, it should be remembered that if we have twice as much sensitivity, for a uniformly distributed object we will look twice as far in space, and we should find eight times as many objects. It is notable that almost all of the outstanding astronomical discoveries could not have been anticipated at the time that a telescope was being planed.

The study of atomic hydrogen (HI), through the 21 cm line, has been one of the most fruitful lines of radio-astronomy research. HI emission provided us with our first glimpse of the obscured disk of the Milky Way, right to the other side of the nucleus. It enabled kinematic studies of other galaxies well beyond their optical disks. It gave some of the strongest evidence for the existence of "dark matter," and has led to the discovery of some of the most massive galaxies known. A large fraction of the total baryonic mass of the universe may be locked up in a sea of faint but gas-rich objects. FAST may discover faint gas in the outer disks of galaxies, and it may provide clues to the mystery of dark matter. FAST can find HI-rich galaxies, the distances of which can be determined by the Tully-Fisher method, providing a measurement of the cosmological density parameter.

The 18 cm OH line has been important for the study of star formation and evolution, and the mega-masers found in some galaxies make them visible to great distances. HI and OH investigations with FAST will detect objects to red-shift $z \sim 1$ and beyond, and will provide astronomers with fundamental data about the universe.

Most pulsars have been discovered in large-scale surveys using single-dish telescopes. FAST would provide the first opportunity to investigate, in some detail, the pulsar population in another galaxy. The FAST will be especially effective in deep surveys for sources such as rare types of pulsars, and neutral hydrogen clouds at moderately high red-shifts. Details in the structure of individual pulses, or in their polarization, might be vital. Such measurements rely on raw sensitivity: a single pulse can only be observed once. FAST will give us the best information on the greatest number of pulsars.

An important question to which FAST might provide an answer is at what epoch did primordial gas come together in cluster-sized clumps, prior to forming the clusters of galaxies we see today? It is expected that the pre-cluster agglomerations of gas will have sizes of a few to tens of arc-minutes and, hence, be well-suited for detection with FAST.

A 300 m telescope, in combination with a 25 m telescope, has the same response as two dishes of 87 m. FAST as a VLBI station will be the hub of the most highly sensitive network.

Rx No.	Frequency Band (GHz)	Type	Notes
1	0.30 – 0.55	Balanced	Based on NFRA design
2	0.55 – 0.64	Tuned	Based on existing JBO design
3	0.63 – 1.15	Balanced	Based on NFRA design
4	1.15 – 1.72	Tuned	JBO version of NRAO design (same as Rx 5)
5	1.23 – 1.53	Tuned	JBO version of NRAO design (same as Rx 4)
6	2.15 – 2.35	Tuned	New JBO design (same as Rx 7)
	8.00 – 8.80	Tuned	New JBO design
7	2.00 – 3.00	Tuned or balanced	New JBO design (same as Rx 6)
8	4.50 – 5.20	Tuned	Currently under development at JBO (same as Rx 9)
9	5.70 – 6.70	Tuned	Currently under development at JBO (same as Rx 8)

Table 1. Low-noise amplifiers.

Studies of distant planets in the solar system are essential for understanding its evolution, the origins of life, and for investigating how the deep-space environment will affect human beings, with a view towards potential colonies in space. FAST will play an important role in the deep-space network, and in SETI (search for extraterrestrial intelligence) research.

7. Acknowledgments

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Recollections of the URSI Tenth General Assembly, Sydney, Australia, 1952

Brian Robinson

The birth of the idea of URSI – long ago, in 1912 – took place in conversations between Abraham, Duddell, Goldschmidt, and Wien, directed toward setting up an international body to study wireless telegraphy from a scientific point of view. But it was not until 1922 that the first General Assembly of URSI took place, in Brussels, with only five countries represented. Up to 1950, URSI had held its General Assemblies in Europe or, once, in Washington (1927): it had never met further south (nor further east) than Venice (1938). In 2002, it is interesting to look back to see what had drawn URSI to travel to the Antipodes in 1952.

Edward Appleton had been President of URSI for 18 years, since the URSI General Assembly in London in 1934, and so his role in choosing Sydney would have been significant. But we know that an URSI General Assembly is also very dependent on invitations from host countries: URSI has sometimes experienced awkward times when invitations for the next General Assembly were slow in coming. URSI had always been tied to summer vacations in the Northern Hemisphere – and here was an invitation from Australia to URSI to meet during the southern winter! The invitation had been initiated by David Martyn (seen in Figure 1), who also "masterminded the organization and funding" (see [1]).

URSI was the first of the family of ICSU (International Council for Science, formerly the International Council of Scientific Unions) Unions to stray to the Antipodes. Twelve countries were represented, and sixty radio scientists made the long trip. The Chairman of the National Research Council (H. K. Ward) said in welcome, "Our pride on this occasion is mingled with gratitude to you and the hope that this is a sign that Australia is coming of age in the scientific world, and that other international unions will follow your lead." Most Unions did later come this way.

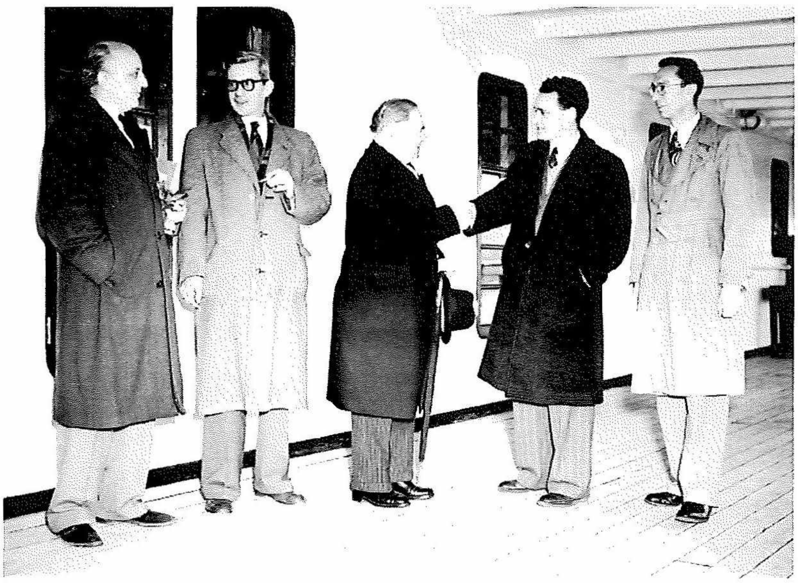

Figure 1. Edward Appleton (center) being welcomed to Sydney by Taffy Bowen, accompanied by Joe Pawsey (far right), while David Martyn (far left) greets Colonel E. Herbays (photo ©1952 CSIRO/ATNF; used with permission).

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For the General Assembly in Sydney, 1952, the invitation came from the Australian National Committee for Radio Science. The Committee was strongly based on the Radio Research Board, under Chairman John Madsen, and representatives from the Commonwealth Scientific and Industrial Research Organisation (CSIRO). Figure 1 shows Edward Appleton and Colonel Herbays being greeted when their ship arrived in Sydney on a wintry day by Taffy Bowen, David Martyn, and Joe Pawsey. The greeting aboard the P&O ship reminds us that international air travel was then rare and somewhat risky, so long-distance travel was often by sea. In the 1950s, a ship took five weeks to travel from Southampton to Sydney: a marvelous voyage by the Mediterranean, Suez, Aden, and across via India or Ceylon, on to Singapore, Fremantle,...all of which the URSI delegates would have greatly enjoyed. Since the delegates on board the ship would have spent more time in each others' company coming and going than they did at the URSI General Assembly, it would be interesting to know what friendships grew and ideas were nurtured as a result of this. A group photograph of the delegates and attendees in Sydney is shown in Figure 2.

The great distances and transit times were themselves just the thing for radio communication. With its vast internal distances, Australia had been quick to take up the opportunities for the application of radio for communications and for broadcasting, which was ideal to tie far-flung towns into an Australian nation. Effective communication called for what Appleton called "objective fundamental research on wave propagation and atmospherics." Australia also had its Flying Doctor Service, which responded to emergency radio calls from people on remote cattle stations in the north. Children in "the outback" of Australia also had their schooling by the "School of the Air," using two-way wireless links to Alice Springs to supplement their "correspondence" lessons (as they still do).

Backing this widespread use of radio for communications, education, health, and broadcasting was a major national research program into the ionosphere and radio propagation. This was one major factor leading to URSI traveling to Australia in 1952. Appleton's opening address in Sydney paid "tribute to the distinction which Australian workers have won for themselves in the field of scientific radio." Appleton had himself trained and advised most of the Australian researchers. David Martyn's shipboard welcome to Appleton in Figure 1 shows one such link.

Appleton's Presidential Address highlighted "Tides in the Ionosphere," mentioning URSI Special Report No. 2, by an URSI committee chaired by David Martyn. Appleton also said that there was need for further experimental studies of the amplitudes and phases of ionospheric solar and lunar oscillations in all parts of the world.

Another link, equally tied to Appleton via his probing of the ionosphere, was the development of radar. Taffy Bowen had developed the first airborne radar in the UK, and it had been his role to take the first UK magnetron to the United States (a marvelous story that Taffy always loved to tell). In Sydney, the CSIR Radiophysics Laboratory had been set up in 1939, to develop radar for the Pacific War (that war did not start until 1942). The CSIR work resulted from a secret visit to London, in 1939, by David Martyn. He went from Sydney to London by Sunderland flying boat, to be told (by Robert Watson Watt) the highly secret and dramatic story of what was then called RDF. By 1942, Jack Piddington and Brian Cooper, from the Radiophysics Laboratory, had installed an Australian-designed radar in Darwin, in response to the first of many Japanese air raids across the Timor Sea.

After the war, the radar team at CSIR then went on to follow up J. S. Hey's wartime research – radio outbursts from the Sun, and emissions from Cygnus – and also to follow up Jansky's 1931 discovery of radio astronomy. In the 1940s, radio astronomy had been initially carried out single-handedly by Grote Reber. Beginning in 1947, the highly successful radio-astronomy group in Sydney was directed by the great Joe Pawsey, also in the group welcoming Appleton in Figure 1.

Figure 2a. A group photo of the URSI delegates and attendees in Sydney in 1952 (photo ©1952 CSIRO/ATNF; used with permission).

Figure 2b. A key to Figure 2a. 1. M. Katzin; 2. Prof. M. Boella; 3. H. E. Dinger; 4. Dr. W. J. G. Beynon; 5. Sir John Madsen; 6. Dr. D. W. R. McKinley; 7. F. J. Gaffney; 8. C. S. Higgins; 9. Dr. M. G. Morgan; 10. Prof. G. A. Woonton; 11. Prof. O. U. Vonwiller; 12. Dr. C. R. Burrows; 13. Mrs. M. G. Morgan; 14. Mrs. C. R. Burrows; 16. Dr. A. R. Hogg; 17. Dr. C. G. Aurell; 19. Dr. L. C. Van Atta; 20. Mrs. F. J. Gaffney; 21. J. C. W. Scott; 22. Dr. Samuel Silver; 23. CDR G. F. E. Knox; 24. A. H. Cannon; 25. Miss R. Appleton; 26. Dr. J. H. Dellinger; 28. Dr. W. Gerber; 29. Prof. B. van der Pol; 30. COL E. Herbays; 32. LCDR G. S. Simpson; 33. Prof. A. Blanc-Lapierre; 35. Jean-P. Voge; 36. R. D. Ryan; 37. A. H. Shapley; 38. Mrs. B. van der Pol; 39. Dr. D. F. Martyn; 40. Dr. C. D. Ellyett; 41. B. E. Swire; 42. R. White; 43. Dr. R. E. B. Makinson; 44. D. S. Robertson; 45. H. E. Ardill; 46. Mrs. E. Herbays; 47. Prof. L. G. H. Huxley, 48. Mlle. R. Straetmans; 49. Dr. R. N. Bracewell; 50. D. Lépéchinsky; 51. Prof. D. M. Myers; 52. Dr. L. Tasny-Tschiassny; 53. W. G. Elford; 54. J. A. Ratcliffe; 55. Dr. J. L. Steinberg; 56. Father Pierre Lejay; 57. A. A. Weiss; 58. Dr. F. W. G. White; 59. F. H. Hibberd; 60. Dr. R. Rivault; 61. Prof. S. Chapman; 62. Dr. F. G. Smith; 63. Dr. L. A. Manning; 64. R. A. Smith; 65. G. J. A. Cassidy; 66. J. Bailey; 67. W. E. Smith; 69. P. G. Guest; 70. Dr. R. A. Helliwell; 71. Dr. P. L. Smith-Rose; 72. Mrs. B. D. H. Tellegen; 73. Sir Edward Appleton; 74. Prof. B. D. H. Tellegen; 77. Dr. L. W. Davies; 78. Dr. Malcolm Fraser; 79. E. Stern; 80. D. J. Sutton; 81. Dr. E. G. Bowen; 82. Sir K. S. Krishnan; 83. O. L. Wirsu; 85. E. Blake; 87. Miss M. Harrison; 88. E. K. Webb; 89. Mrs. R. W. E. McNicol; 91. P. Augimeri; 92. Dr. M. Cutolo; 93. Dr. M. Laffineur; 94. Dr. J. L. Pawsey; 95. Dr. H. Whale; 97. R. D. Davies; 98. Miss B. Grant; 99. Dr. G. H. Briggs; 100. O. B. Slee; 101. J. A. Thomas; 102. E. R. Hill; 103. Dr. G. H. Munro; 104. F. J. Lehany; 105. A. P. Mitra; 106. L. G. Dobbie; 107. Dr. H. Bremmer; 108. B. V. Hammon; 111. J. A. Harvey; 112. M. Stronfeldt; 113. P. Hirschl; 114. K. S. Brown; 115. P. S. Klemens; 116. B. Y. Mills; 117. Dr. W. G. Baker; 118. W. N. Christiansen; 119. Dr. C. A. Muller; 120. Prof. S. K. Mitra; 121. Prof. H. C. Webster; 122. N. R. Labrum; 123. Dr. J. S. Dryden; 124. L. H. Heisler; 125. Dr. J. P. Hagen; 126. Dr. J. W. Dungey; 127. J. Warner; 128. Miss B. Hardwick; 129. L. L. McCready; 130. Dr. H. I. Ewen; 131. Dr. J. H. Piddington; 132. Father E. Gherzi; 133. Prof. H. S. W. Massey; 134. Dr. A. G. Bogle; 135. J. Warburton; 136. A. G. Little; 137. J. P. Wild; 138. G. A. Wells; 139. Dr. C. Wouters; 140. Z. Jeffrey; 141. R. Green; 143. J. G. Bolton; 144. L. S. Prior; 145. Dr. K. C. Westfold; 146. R. E. Price; 147. F. M. Carter; 148. Mrs. J. Jones; 149. F. J. Kerr; 150. Dr. J. C. Jaeger; 151. Dr. F. W. Weed; 152. S. F. Smerd; 153. Dr. S. E. Williams; 156. J. D. Murray; 158. W. E. Gordon; 159. Dr. J. P. Hagn; 160. G. I. Lister; 162. F. F. Gardner; 163. C. A. Shain; 167. E. E. Adderley; 169. Dr. N. Herlofson; 171. Dr. J. B. Smyth; 172. G. Newstead; 173. R. Guertler; 174. R. W. E. McNicol.

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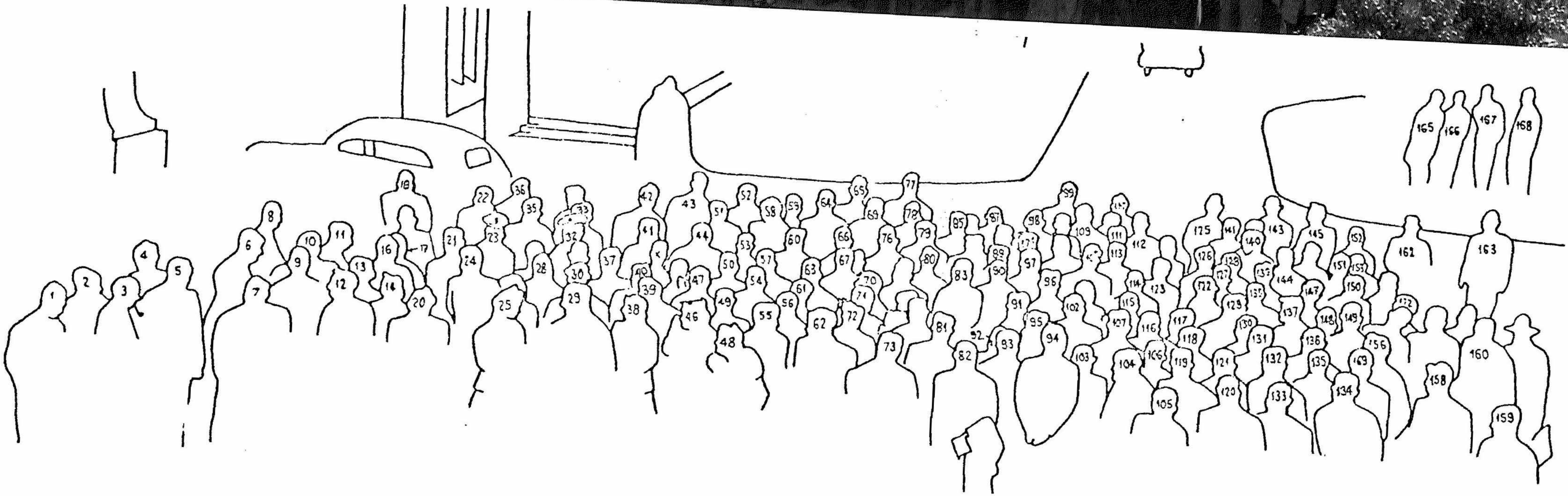

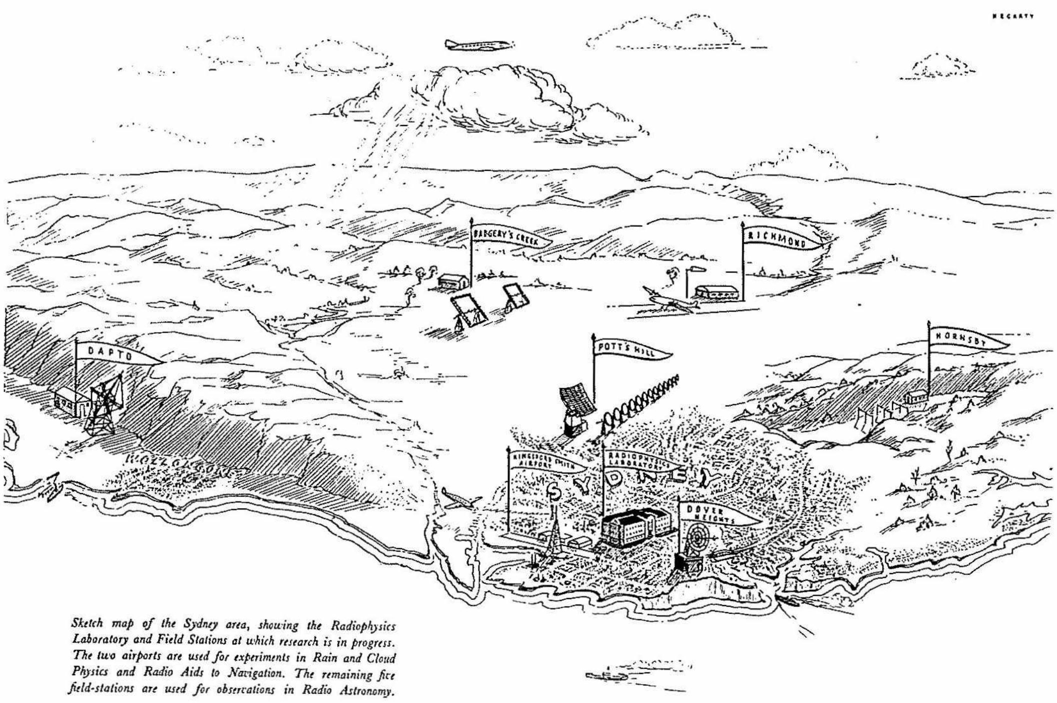

Figure 3. Taken from the inside cover of the booklet that CSIRO presented to URSI delegates in 1952, showing the many radio-astronomy field stations around Sydney. The caption reads, "Sketch map of the Sydney area, showing the Radiophyics Laboratory and Field Stations at which research is in progress. The two airports are used for experiments in Rain and Cloud Physics and Radio Aids to Navigation. The remaining five field-stations are used for observations in Radio Astronomy."

So, there was a strong basis for URSI to hold a General Assembly in Sydney. Figure 3 shows the inside cover of the booklet that the CSIRO Radiophysics Laboratory produced in August, 1952. The many radio-astronomy field stations around Sydney had by then already become key steps in the long history of astronomy, and its lusty new infant, radio astronomy. Appleton's address had included, "I feel I should mention specially the discovery, by J. G. Bolton and G. J. Stanley, of the existence of an intense source of radio emission, with an angular diameter less than 8 minutes of arc, in the constellation of Cygnus." Figure 4 shows the so-called cliff interferometer, used by John Bolton and Gordon Stanley, at Dover Heights, near Sydney's Bondi Beach. In his Presidential Reply, in 1952, Edward Appleton said he wanted to visit "Dover Heights, which is now an historic site." Most of the bright youngsters from the northern hemisphere who had taken the first steps in radio astronomy came to URSI in Sydney. Figure 5 shows a group of them – history being written – with representatives from Cambridge, Harvard, Jodrell Bank, Leiden, Paris, and Washington. There were no delegates from the USSR in those days of the very Cold War.

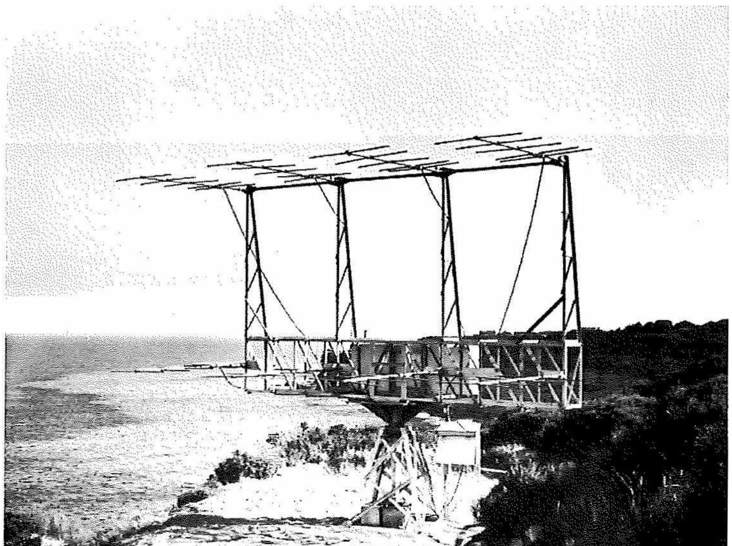

Figure 4. The "cliff interferometer," used by Joe Pawsey in 1946 to measure outbursts on the Sun with high resolution. It was then used by John Bolton, in 1947, in the discovery and accurate measurement of the first four radio stars (photo ©1952 CSIRO/ATNF; used with permission).

Figure 5. The first international meeting of radio astronomers, as Commission V of URSI, 1952. From left are Christiansen, Graham-Smith, Wild, Higgins, Mills, Piddington, Hagen, Steinberg, Smerd, Hindman, Hill, Shain, Ewen, Kerr, Hanbury Brown, Davies, Payne-Scott, Muller, Little, Laffineur, Slee, and Bolton; Pawsey, Bracewell, Purcell, and Stanley are not in the photograph (photo ©1952 CSIRO/ATNF; used with permission).

I was a fresh young graduate in physics in 1951, having worked with Victor Bailey in Sydney, testing his theory of gyro-interaction in the ionosphere. So, 1952 was a superb chance to meet all the big international names who studied the "Appleton Layers." By 1952, I was working in a part of the CSIRO Radiophysics Laboratory, and about to join their radio-astronomy group. I had equally much delight in being close to all the world's young demons of radio astronomy.

Figure 6 shows an URSI group (including Appleton and van der Pol) at Potts Hill Field Station, with Chris Christiansen. Would Appleton, in 1952, have imagined that Christiansen would become URSI President in 1985?

Figure 7 shows an URSI group at the Hornsby Field Station, where Alec Shain had built a radio telescope operating a 18.7 MHz. Hornsby is just 22 km north of Sydney; a radio telescope there is unimaginable today, with the enormous growth of radio traffic and the expansion of the city.

Figure 6. From left: Edward Appleton, Balthasar van der Pol, Fred White, and another delegate with Chris Christiansen at the Potts Hill field station, by the 32-element interferometer (photo ©1952 CSIRO/ATNF; used with permission).

Figure 7. An URSI group visits the 18.3 MHz radio telescope at the Hornsby field station. From left are Christiansen, unknown, McGee, Hanbury Brown, Graham-Smith, Higgins, Warburton, Shain, Hindman, and Slee (photo©1952 CSIRO/ATNF; used with permission).

Appleton's said, in his address, "I feel that the whole authority of our Union should now be used for stressing, to governments and research foundations, the need for financial support for appropriate equipment....It seems to me now the radio astronomer's turn for substantial subventions for building bigger and better radio telescopes and for organising total eclipse studies of coronal emissions in the radio spectrum. I am happy to report, in this connection, that my old Department of Scientific and Industrial Research has decided to join the Nuffield Foundation in sharing the cost (336,000 Pounds) of the construction of a large steerable radio telescope for radio-astronomical studies in Manchester University, under the direction of Professor A. C. B. Lovell. Professor Lovell already has a radio telescope with a diameter of 220 feet, but it is fixed. The new instrument will have a paraboloid aerial with a diameter of 250 feet, and the diameter of the platform on which the telescope will rotate will be 310 feet. Elevating racks from two British battleships, which are now being broken up, will be incorporated in the new design....I will only add to these few remarks...that those of us who follow this subject, either as workers or interested onlookers, would much like to see, in due course, a similar instrument at the disposal of your radio astronomers here in the southern hemisphere."

As I record these echoes from 1952, I am reminded that since the year 2000, the film *The Dish* has delighted millions with its account of the part the 210-foot dish (completed at Parkes, NSW, in 1961) played during the Apollo moon landings in 1969. Appleton would have been delighted by that extension of his view of the future.

At URSI 1952, some did foresee the Space Age. R. G. Casey (the Australian Minister for Foreign Affairs) spoke, in his address of welcome in Sydney, of "the regions hundreds of miles above the stratosphere in which rocket transports may one day be as plentiful as commercial aircraft today...." I don't imagine that many at URSI 1952 would have anticipated Sputnik's launch in 1957. But by URSI 1960, in London, much of URSI's work was profoundly influenced by the new opportunities that satellites provided, and that year, ICSU would set up COSPAR (Committee on Space Research) to extend this work.

In 1952, Appleton was focusing on another key discovery: "I would like to refer also to another matter, which raises an administrative issue. Following a most remarkable suggestion by H. C. van de Hulst in 1944, monochromatic radiation from interstellar hydrogen, on a frequency of 1420 Mc/s [21 cm wavelength] was observed for the first time by the Lyman Laboratory of Harvard University on March 25th, 1951, and shortly afterwards by the Netherlands Foundation for Radio Astronomy and by the Radiophysics Laboratory here in Australia. This discovery opens up new possibilities of observing, by way of Doppler shifts, the large scale motion of interstellar material; and we are also much indebted to the Chairman of Sub-Commission Va of our Union, Dr. A. H. de Voogt, who has drawn the attention of CCIR to the need for reserving a frequency band centred on this hydrogen wavelength free from radio-communication traffic. Professor Dr. B. van der Pol, the Director of CCIR, has given the matter most serious consideration and has already invited the various Government Administrations to leave a clear frequency band, 3 Mc/s wide and centred on the frequency of 1420.4 Mc/s, so that this new and important discovery may be developed without trouble due to radio traffic interference." Figure 8 shows Balthasar van der Pol in Sydney, listening attentively to the words of Dr. H. Bremmer.

Frank Kerr wrote a summary of the 1952 URSI meeting [2], which was published in January, 1953. He pointed out that this was the first international meeting of radio astronomers. His summary showed that, for that infant science, much of the broad picture was already in place. The view of the heavens through six octaves of the radio spectrum was very different from the established optical view through one octave of the EM spectrum, near one million GHz. At radio frequencies, interferometry was a lusty child, but resolution was coarse (minutes of arc). The first steps in aperture synthesis were yet to be made by Chris Christiansen and Martin Ryle. The sensitivity of microwave receivers, using mixer diodes, was appalling (by modern standards). Another decade or more was to pass before larger telescopes and greatly improved receivers led to the discovery of the Big Bang, quasars, neutron stars, interstellar molecules, black holes, etc.

Figure 8. Balthasar van der Pol listens attentively to Dr. H. Bremmer during the URSI meeting in Sydney (photo ©1952 CSIRO/ATNF; used with permission).

Another area of Australian research that had attracted URSI to the Antipodes, in 1952, was aircraft navigation. From the days of Kingsford Smith and Ulm, in the 1930s, flying across great Australian wastes had cried out for radio navigation. The CSIRO work in the 1950s soon had all Australian aircraft fitted with Distance-Measuring Equipment (DME) and with Multiple-Track Range (MTR). Fifty years later, we all use GPS and GLONASS satellite navigation on planes and boats: even in cities, where cars use GPS, and in the Australian bush, where GPS is carried by hikers. In 2001, it was demonstrated that you can fly a plane accurately at a city commercial tower. But back in 1952, it was DME and MTR that made aircraft navigation more certain and safer.

At URSI 1952, Colonel E. Herbays, the perpetual secretary of URSI, said: "Thirty years after the first official meeting [the General Assembly of URSI 1922, in Brussels] we are holding our Xth General Assembly at the antipodes of the URSI cradle. The four pioneers who gave the start to URSI foresaw a large development of the science we serve, but did they foresee that forty years later a Union, as famed and active as URSI, would meet in Australia? Such a question must remain unanswered, but we are sure that we have fulfilled their hopes. That is what I shall try to show for the period since our Zurich meeting in 1950." In particular, he mentioned cooperation with the CCIR, "represented here by one of the most active URSI men, Prof. Dr. B. van der Pol. In 1951, for the first time, this cooperation was made clear to all in an obvious and efficient way. URSI was represented at the VIth Plenary Assembly of CCIR by a delegation under the chairmanship of one of our Vice Presidents, Dr. Dellinger. Colonel Herbays went on to talk about the work of two joint Commissions, and said: "When some of the Commissions realize the magnitude of the work consequent upon such co-operation, they will be perhaps much less disposed to express thanks. But we do not fear, our confidence is based on the URSI spirit. URSI has never been satisfied with the work of the moment, but has always wanted to conquer new fields." If Colonel Herbays could have survived to URSI 2002 in Maastricht, he would have been delighted at the new Commissions that now make up URSI, and the variety of new fields that URSI embraces and encourages.

At the 1950 Zurich General Assembly of URSI, Appleton had said, in his presidential speech, "And here let me pause to say a word in praise of the inventor. For his influence on the development of pure science is often profound. During the last two years, we have all had opportunities to recognize the importance of the new three-electrode crystal device known as the 'transistor,' which, in a number of ways, is likely to become a strong competitor to the thermionic valve." It is surprising to look back to the discussions of Commission VII at the 1952 Sydney URSI General Assembly, and to see that most reports dealt with thermionic valves, plus some others dealing with rectification. The "transistor" had yet to hit the URSI stage.

It was during URSI 1952 that I was first exposed to digital computing, something being discussed at URSI. I particularly remember delegates who stayed on in Sydney after the URSI meeting. Within CSIRO, Trevor Pearcey and Brian Cooper were building the first CSIRO "electronic computer:" just full of 12AT7 valves (in 1952, most of URSI talked about "valves," for the word "tubes" was used only by people from the US). Figure 9 shows Pearcey and his electronic computer, in 1952. That computer still operates, at a science museum in Melbourne!

The 1952 General Assembly accepted unanimously a resolution from Commission I that "...the following value of the velocity of electromagnetic waves in vacuum be adopted for all scientific work: 299,792 +/-2 km/sec." Commission I also discussed the CCIR Study Program on standard frequency transmissions and time signals.

Delegates in Sydney, in 1952, were reminded that during the IXth General Assembly in Zurich (1950), URSI Commission VI had formed a subcommittee to study information theory. The Chairman was Balthasar van der

Pol, and he had communicated with members to subdivide the program into "Theory of Signals" and "Statistical Theory of Communication." During 1950, conferences had been held in Paris (chaired by Louis de Broglie), and in London (chaired by Willis Jackson). At the 1952 General Assembly, F. L. H. M. Stumpers presented a "Bibliography of Information Theory," containing 163 items. D. Gabor then presented a 43-page "Report on Signal Analysis." Sub-Commission VIc was set up to study Fourier transforms. These reports and discussions made a great impression on a young graduate like myself.

In 1952, Colonel Herbays ended his address by asking the assembly to express its thanks to Mlle. Straetmans "...for the services she has rendered as Assistant to the Secretariat of URSI for no less than 32 years." Mlle. Straetmans clearly set a tradition that has kept URSI vital for all its life: a tradition continued by Yela Stevanovitch, and being continued today by Inge Heleu.

At the end of the URSI General Assembly, Father (Père) R.P.P. Lejay, shown in Figure 10, was elected to be the new President of the Union. One of the last activities in 1952 was the presentation to URSI, by the Australian National Committee, of the URSI flag.

Among the other "sister Unions" represented at URSI in 1952 was IUPAP (International Union of Pure and Applied Physics, represented by Marcus Oliphant, who was born in October, 1901). The IUC (International Union of Crystallography) was represented by Tom Iredale, and IUBS (International Union of Biological Sciences) was represented by O. W. Tiegs. It is interesting to see that a link between radio science and the biological sciences can be traced back to 1952. UGGI (IUGG, International Union of Geodesy and Geophysics, the oldest Union) was represented by Sidney Chapman, who just loved eating the Sydney ice cream. The IAU (International Astronomical Union) was represented by Arthur Hogg; I didn't observe his taste in ice cream at that time (but some months later, Arthur was to introduce me, as a budding astronomer, into the craft of measuring sky positions on astronomical plates by triangulating from the images of bright stars).

Little was I to know, as I heard Appleton speak in August, 1952, and listened to speakers during URSI Commission meetings, that:

- In 1953, I was to be one of the CSIRO radio astronomers who first detected the 21 cm hydrogen line from galaxies outside our own, using a 36 ft transit telescope just built at the Radiophysics Potts Hill field station.
- In 1959, the WARC (World Administrative Radio Conference) in Geneva would allocate an exclusive passive band from 1400 to 1427 Mc/s. The work of URSI Sub-Commission Ve was vital in 1959 [see 3].
- In 1959, Balthasar van der Pol would die during the WARC in Geneva.
- In 1960, at the URSI General Assembly in London, the work of URSI Sub-Commission Ve would be transferred to a new ICSU body, IUCAF (Commission on Frequency Allocations for Radio Astronomy and Space Science), which had appointees from URSI, IAU, and the newly-created COSPAR.
- In 1961, the 210-foot-diameter dish would be completed at Parkes, and that I would be associated with it for the next forty years.
- In 1966, at the URSI meeting in Grenoble, I would become a member of IUCAF.
- In 1987, at the URSI General Assembly in Tel Aviv, I would become Chairman of IUCAF, and continue vital work on frequency-protection issues, until the Third UN Meeting on Peaceful Uses of Outer Space (Vienna, 1999).

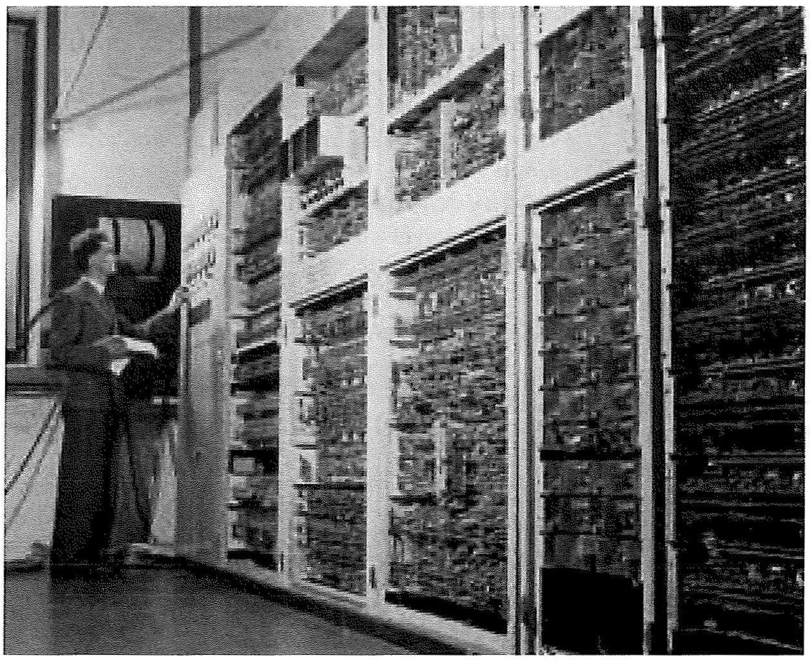

Figure 9. The CSIRO electronic computer in 1952, with Trevor Pearcey watching the lights flash (photo ©1952 CSIRO/ATNF; used with permission).

Figure 10. Father (Père) R.P.P. Lejay (on right) succeeded Edward Appleton as the President of URSI. He is seen here with Dr. M. Laffineur (center) and another delegate (photo ©1952 CSIRO/ATNF; used with permission).

Future Activities of URSI (as seen in 1952)

IGY. During the 1952 General Assembly, particular attention was given to observations and measurements to be carried out during the International Geophysical Year (IGY) 1957-58, the idea for which "had originated with the Joint Commission on the Ionosphere and the general organization of which has been entrusted by ICSU to a Commission of Members from IAU, UGGI, IGU, and URSI."

URSI Venues. The meeting in Sydney in 1952 was the start of the URSI pattern of having one General Assembly in Europe, the next in the Americas (Boulder, Ottawa, Lima, Washington, and Toronto) or in Asia or the Middle East (Sydney, Tokyo, Tel Aviv, and Kyoto).

Member Countries. At URSI 1952, there were 12 Member Committees in URSI. Canada, Spain and West Germany were admitted at the Sydney General Assembly. Fifty years later, there are one or more Member Committees in 48 regions. [Member Committees are not regarded by URSI as representing nations. Thus, two of these regions have two Member Committees each, and one of them, encompassing politically independent states, has a single Member Committee.] The current Membership represents just about 30 percent of those countries that belong to the UN. So, there is much room for URSI to grow. The low number of Members in Africa has always been of concern.

Conferences in Sydney. In 1952, URSI was the first international Union to hold its meeting in Australia. By 2000, Sydney had become a popular convention destination. An international convention is hosted nearly every week: from dental hygienists, to financial planners, to neurosurgeons. For its 174 delegates and attendees, URSI, in 1952, could fit into the facilities of the University of Sydney. Now, congresses with 2000 delegates call upon the facilities of the Sydney Convention and Exhibition Centre. The International Astronomical Union met in Sydney in 1973, and will return in 2003. Radio Science is still most actively pursued in Australia, so we're bound to see URSI here again some time.

Postscript

In the *Radio Science Bulletin* for December, 2001, Simon Radford's report on SITE 2000 [4] seemed to me to encapsulate a lot of the URSI spirit and initiative. It starts when Rodney Marks produces an excellent thesis on the effects of the atmosphere on astronomical observations in the visual and radio range. Rodney died on 12 May 2000, while making measurements at the South Pole. Over 125 scientists met in Marrakech in November 2000, at a conference dedicated to Rodney. The conference concluded with an overnight visit to Oukaimeden, in the High Atlas Mountains. SITE 2000 demonstrated the wide international view of URSI, and echoed the idea of URSI that Abraham, Duddell, Goldschmidt, and Wien put forward in 1912.

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2. F.J. Kerr, *Sky and Telescope*, **12**, 1953, pp. 59-70.
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Radio-Frequency Radiation Safety and Health

James C. Lin

Mobile Phone Safety Testing and Fundamental Scientific Research

In the early 1990s, researchers (biologists, engineers, medical specialists, and physicists) from many institutions, especially in the United States, were the most enthused among the bioelectromagnetics scientists. A major research initiative, with orchestrated monetary and programmatic support from both industry and government, was about to be launched to investigate the biological effects and health implications of radio frequency (RF) radiation emitted from cellular mobile telephones. As readers of this column will note, the subject remains a focus of public concern and shows no sign of relenting soon.

There is a lack of scientific consensus on experimental studies that provide clear evidence either refuting or supporting the cancer induction or promotion potential of RF and microwave radiation from mobile phones. The uncertainties persist, in part, because of the limited number and scope of studies that have been undertaken. Once heralded as a model of industry and government cooperation, the initiative had suffered from a host of problems, which had made it all but impossible for it to meet even minimal responsibilities. The difficulties encountered by the initiative have impacts that extend well beyond the bioelectromagnetics research community. There is a concern that an established effect from wireless radiation, even small, could have a considerable impact in terms of public health.

Recently, US Senator Joseph Lieberman and Representative Edward Markey released a report [1] from the General Accounting Office (GAO), the investigative arm of the US Congress, on May 22, 2001. In releasing the report, Rep. Markey emphasized the need to determine whether there are health impacts. With the large number of mobile-phone users (over 100 million in the US alone, and approaching one billion world-wide), he said that even a small effect could create "an epidemic size problem."

The problem of determining health implications cannot be met without the presence of a critical mass of scientists, working on issues that are crucial to the interaction of mobile-phone RF radiation with biological systems. Science-based research is predicated on replication and accumulated knowledge.

Among the handfuls of studies in the US, conducted under mostly private-sector support (between 10 to 15 millions of dollars per year since 1995, by some estimates), a couple of them are being repeated by other investigators under similar arrangements. It is hoped that the effort can overcome the current situation. The amount of research support is not large, nor is it small. It has been targeted to support a few projects, costing millions a year. An alternative is to support a larger number of, say, 40 to 60 projects, on the order of $250,000 each, per year. Such an option, paired with governmental resources and financial commitment, would present a very different scenario. A crucial question is, what would be the optimal strategy or paradigm to adopt in order for the endeavor to yield pertinent and dependable information for decision-making?

Scientific research alone is insufficient to allay the concerns of mobile-phone safety right away, but without scientific research, it will take a long time to find out if a mobile phone is safe or not. If, by chance, a problem was revealed, some timely interventions that might have minimized the adverse impact on the health of the public could be missed. (Note that I am not addressing another possible input to this discussion: the pluralism of values held by various stakeholders.)

A majority of ongoing research efforts have selected protocols that would test animal and human responses to exposure conditions and signals, unique to a particular modulation and access scheme of the cellular mobile telephone system. This short-term approach can help answer some of the questions concerning a given system's operation, and its effect on health under prescribed or nominal usage conditions. This type of research is akin to product testing,

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or an ongoing process of discovery. It has its place in the overall strategy of a given corporate entity. It is analogous to post-market surveillance, in which a search for problems following from the introduction of a product (in this case, cellular mobile technology) is made, so that timely interventions can be implemented to remedy any problem. It is important from a practical perspective, since the general public has accepted mobile phones en masse. The jury is still out on whether microwave radiation from mobile phones and other wireless devices pose a significant risk to human health. Safe-guarding public health depends on identifying the effect, if any, of these devices, and the level of exposure at which they may become hazardous to humans. Nevertheless, this product-testing approach can yield results that are unique to the device's operation, and that fulfills an important function.

Cellular-communication technology has become one of the most rapidly evolving technologies of recent memory. Technology used for one generation or system is frequently not compatible with another. In the absence of a scientific consensus on biological responses to various modulation schemes, observations made from product testing using one system may be, and often are, irrelevant to another, or to a new wireless-communication technology. This may thus necessitate undertaking a completely new series of studies to satisfy health and safety concerns. Such a product-testing approach is costly and time-consuming. Re-testing is not only ineffective: opportunities to innovate and to produce new knowledge are forfeited when such a trial-and-error process is used in dealing with the issue at hand.

An alternative approach to the study of the health effects of wireless cellular telephones is through a systematic evaluation of causality, and a rational discovery of signals, schemes, processes, modulations, and amplitudes associated with wireless-communication systems and biological responses. This science-based approach may seem tedious and prohibitively costly, upon first encounter, but, in fact, it can be very cost effective.

Moreover, empirical observations can be flawed. They can be subjective, or worse, they may be prone to manipulation and, in some sense, they can be a function of individual conscience. Correspondingly, unreplicated evidence or poorly replicated experimental evidence tends to be taken as defective. This has led to the acceptance of only replicable observations of experimentally determined effects as legitimate evidence for or against scientific claims. This is not to insinuate that individuals or organizations should use this doctrine of an unreplicated result for increasing their influence with motives that are far removed from the actual issues on health effects. It is conceivable that an unreplicated result may be confirmed, at a later point in time, to have some significant influence on the acceptance or rejection of a scientific hypothesis. Therefore, an interesting and plausible new claim, based on experimental results, which has not been replicated or confirmed, should be viewed as a new challenge.

The value of a science-based approach is that it allows, in a systematic manner, the attainment of knowledge and learning about the interaction of various forces in natural or under artificial environments. Fundamental to the scientific approach is *repeatability and confirmation.*

The response of physical systems under most circumstances is deterministic, with fairly confined limits of fluctuations. Thus, the observation of a physical phenomenon can be repeated, by conducting the appropriate experiment in a prescribed manner, and it can be reliably confirmed by comparable other means. Such repeatability can help to declare the observation as not a mere isolated coincidence, but an event that occurs regularly and reproducibly. The beneficiary is a neatly packaged set of theories that explain the natural universe very well. They have permitted us to design and manufacture useful products and systems. And they have showed us how to improve product quality and attain technology innovation in the service of humankind.

Biological systems and organisms are famously complex. The responses of biological systems and organisms are variable. Their behaviors are often uncertain, even under similar circumstances of exposure. It is important that the same investigator replicates a given observation. Moreover, most working scientists are unwilling to accept or reject scientific claims on the basis of unreplicable or poorly replicated experimental evidence. Because a single, self-repeated study – however well conducted – seldom provides the definitive evidence for or against a biological response, several independently repeated or confirmed studies are needed to arrive at a statistically significant association, or at a convincing answer to the health-effect question. Thus, a relatively large number of independent experiments would normally be required to establish a reliable cause and effect relation between microwave exposure and biological response.

This approach to scientific investigation of the potential biological effects of RF/microwave radiation from wireless-communication devices would argue against a few large-scale studies, each costing millions per year. Instead, it argues for a larger number of smaller projects, on the order of $250,000 per year per research team. Partitioned among the large number of multiple projects should be groups of projects that are designed to investigate the effects of various amplitudes, access and modulation schemes, duration of exposure, etc., with appropriate animal models and endpoints. The multiplicity of projects in a given topical group should be designed to be independent studies, aimed at a better fundamental understanding of the interaction. There should be a built-in process of repeating some of the experiments to resolve any uncertainty, as needed. It is emphasized that in all of these projects, there should be a sound regard for investigator-initiated innovations in project design and execution, within the acknowledged scope of objectives and specific aims. This would add value to and strengthen the usefulness of the outcome.

Groups of fundamental research projects, with streamlined specific aims, would be more tractable. They could represent an intrinsic replication. They would also help to encourage a widespread acceptance that the corresponding experimental results are reliable and replicable

The importance of a process designed for independent evaluation of empirical evidence should also be supported. Aside from settling doubts about reliability and uncertainties of experimental results, such a process should be of benefit in evaluating evidences from multiple independent studies of a similar design, possibly without the need for further replication.

Assuming that the number of groups and projects are sufficient to permit investigation of most of the relevant exposure parameters and biological endpoints of interest in a systematic fashion, these fundamental research projects should provide the systematic causal connections to the mobile-phone exposure of interest to each investigator. Collectively, they should be indicative of any scientifically significant effect, and should facilitate the resolution of potential biological effects associated with mobile phones and wireless-communication operations.

Of greater scientific value is that the systematic causal connections, if any, should provide the basis for generalization of the observations, and for integration of accumulated fundamental knowledge. They should render an explanation, a theory, or an instrumentality to predict biological responses that fall within the purview of the relevant experimental domain. In fact, one important difference between product testing and scientific research is that product testing is descriptive in character. Upon successful completion of the tests, a product-testing approach would only describe the potential biological effects associated with a given type of mobile-phone or wireless-communication device or system. In contrast, a scientific approach is prescriptive and predictive, as mentioned above. For a rapidly evolving technology such as cellular mobile telephones, a judiciously designed and a properly executed scientific approach could prove to be most profitable.

US government agencies are not doing enough to inform consumers about the health impact of cellular mobile telephones, according to the GAO report [1]. Moreover, it concluded that while research, to date, does not demonstrate adverse effects from mobile phones, some studies have raised questions about possible effects that "require further investigation." In contrast, a large number of projects have been launched in several European countries, some with programmatic and financial support from the European Union, to investigate the behavioral, carcinogenic, in vitro, neurologic, and functional responses in humans and animals following exposure to wireless-communication radiation.

While the cellular mobile telecommunication sector, by itself, invests a sizeable amount of funds investigating potential biological effects of mobile phones, these investments are focused on product-testing or market-related, short-term activities. There is a critical need for strong federal involvement in science-based fundamental research in this area. By any measure, federal support in this area has been declining for nearly a decade. It has dwindled to a trickle at this moment, while the importance of the health effects of wireless-communication radiation has increased dramatically. Given that several key sectors of the information and telecommunication technology industry are impacted, this retreat cannot be allowed to continue. A diversified research program, including federal support for fundamental research projects of broader scope and longer duration, would have a greater chance of providing the much-needed scientific data base for understanding the health impact of RF and microwave radiation from cellular mobile-communication technology.

There is another matter of equal significance: science-based setting of human-exposure standards. Formulating exposure standards for RF and microwave radiation, including cellular mobile telephones, requires two types of contributions. The first is the scientific data basis for the standards. The second is the level of protection that a society wants to promote: what are we trying to accomplish with the standard concerning human exposure to RF/ microwave radiation? The second is beyond the scope of the present column. (It is related to the pluralism of values, held by various stakeholders who promulgate the standards and for whom the standards are promulgated.)

Mobile-phone testing and fundamental scientific research both would furnish information toward the first contribution. However, knowledge attained from scientific research is fundamental to the establishment of a science-based standard. The scientific knowledge provides the basis for what the standard should be, and how the standard-setting process should proceed, including a cost/benefit analysis. It would facilitate identification of sources of uncertainty for standards, such as derive from the complexities of biological systems, and of exposure assessment and measurement procedures.

It is important to note that the federal and private-sector roles are complementary. The government can provide the critical support to drive fundamental research by scientifically examining the important issues affecting the health impact of RF radiation from cellular mobile-communication technology. The private sector can enhance the federal investment to achieve the essential information needed to safeguard public health.

Reference

1. GAO, 2001, "Research and Regulatory Efforts on Mobile Phone Issues," Report No. 01-545, General Accounting Office, US Congress, Washington, DC.

[Note: A similar version of this column appeared in the *IEEE Antennas and Propagation Magazine*, **43**, 4, August 2001, pp. 156-158.]

News from ITU-R

With the aim of promoting membership of the ITU Radiocommunication Sector, and in particular that of ITU-R Associates, a series of brochures are under development which publicize the activities of the various ITU-R Study Groups. (See http://www.itu.int/ITU-R/associate-members/index.html concerning ITU-R Associates and http://www.itu.int/members/index.html on ITU membership in general). The brochure concerning Study Group 7 (Science Services) is reproduced below.

Each brochure begins with a general preamble on the ITU and the Radiocommunication Sector, and ends with some remarks about ITU-R Associates – this being a category of membership that may well be of interest to the URSI community.

Radiocommunication Study Group 7 "Science services"

ITU and Radiocommunications

Founded in 1865, the International Telecommunication Union (ITU) became a specialized agency of the United Nations in 1947, providing an international forum for its 189 Member States and some 690 Sector and Associate Members to collaborate for the ***world-wide improvement and rational use of telecommunications and radiocommunications.***

The ITU fulfils this fundamental mission through its three Sectors: the Radiocommunication Sector (ITU-R), the Telecommunication Standardization Sector (ITU-T), and the Telecommunication Development Sector (ITU-D).

All ITU work in the sphere of radiocommunications is consolidated in the **Radiocommunication Sector,** which works towards a worldwide consensus in the sound use of a vast and growing range of wireless services, including popular new mobile communication technologies.

ITU-R plays an essential role in the management of the **radio frequency spectrum and satellite orbits,** finite natural resources that are increasingly in demand from a large number of services such as fixed, mobile, broadcasting, amateur, space research, meteorology, global positioning systems, environmental monitoring and communication services that ensure safety of life at sea and in the skies.

Improving communications amongst the peoples of the world, by harmoniously developing the tools made available to them, is the ultimate goal shared by the men and women that contribute to the work of the ITU.

Radiocommunication Sector (ITU-R)

The Mission

The **ITU Radiocommunication Sector** specializes in facilitating international collaboration to ensure the rational, equitable, efficient and economical use of the radio-frequency spectrum and satellite orbits, by:

- Holding World and Regional Radiocommunication Conferences to expand and adopt Radio Regulations and Regional Agreements covering the use of the radio-frequency spectrum;
- Establishing **ITU-R Recommendations,** developed by **ITU-R Study Groups** in the framework set by Radiocommunication Assemblies, on the technical characteristics and operational procedures for radiocommunication services and systems;
- Coordinating endeavours to eliminate harmful interference between radio stations of different countries;
- Maintaining the Master International Frequency Register; and
- Offering tools, information and seminars to assist national radio-frequency spectrum management.

Radiocommunication Sector

The Actors

ITU membership represents a cross-section of the industry, from the world's largest manufacturers, carriers, operators and system integrators to small, innovative players of the new information and communication technology field. Since the creation of the Union and its opening to the private sector, Member States of the ITU and Sector Members have been participating actively in the work of the Radiocommunication Sector.

Current Members include:

- **Member States,** which constitute the Union and contribute to the work of the ITU as a whole;
- **Sector Members,** which participate in the work of a defined Sector (R, T or D). These include operating agencies, scientific or industrial organizations, financial and developmental institutions; other entities dealing with telecommunication matters; regional and other international telecommunication, standardization, financial or developmental organizations;
- **Associate Members,** which work within the framework of a specific **Study Group.**

In its efforts to ensure the widest participation in the enhancement of worldwide communications and that the interests of all stakeholders are taken into consideration, the ITU strongly encourages small entities and organizations to join the Union as **Associate Members.**

ITU-R Study Groups

The Process

ITU-R Study Groups are established and assigned study Questions by a **Radiocommunication Assembly** to prepare draft Recommendations for approval by ITU Member States.

Compliance with ITU-R Recommendations is not mandatory. However, since they are developed by well-respected radiocommunication experts from all over the world, they enjoy a high reputation and are implemented worldwide, getting therefore the status of international standards in their domain of application.

Studies focus on the following:

- Efficient use of the spectrum/orbit resource by space and terrestrial services;
- Characteristics and performance of radio systems;
- Operation of radio stations;
- Radiocommunication aspects of distress and safety matters.

These studies do not generally address economic questions, but when they involve comparing technical or operational alternatives, economic factors may be taken into consideration.

ITU-R Study Groups also carry out preparatory studies for World and Regional Radiocommunication Conferences. On the basis of the input material from the Study Groups, together with any new material submitted by the ITU Member States, the Conference Preparatory Meeting prepares a Report on the technical, operational and regulatory or procedural matters to be considered by a given Conference.

The Study Groups conduct their work keeping in mind and cooperating with other international organizations concerned with radiocommunications. Particular attention is paid to the radiocommunication needs of developing countries.

More than 1 500 specialists, representing ITU Member States and Sector and Associate Members throughout the world, currently participate in the work of the ITU-R Study Groups.

At present, there are seven Study Groups specializing in the following areas:

- SG 1 Spectrum management;
- SG 3 Radiowave propagation;
- SG 4 Fixed-satellite service;
- SG 6 Broadcasting services;
- **SG 7 Science services**;
- SG 8 Mobile, radiodetermination, amateur and related satellite services;
- SG 9 Fixed service.

Specific task forces, such as Working Parties and Task Groups are established to study the Questions assigned to the different Study Groups. This structure allows smaller entities to select the areas of competence they wish to contribute to.

ITU-R Study Group 7 - Science Services

"Science services" refer to the: standard frequency and time signal, space research, space operation, earth exploration-satellite, meteorological-satellite (MetSat), meteorological aids (MetAids) and radio astronomy services.

1. Scope

Systems for space operation, space research, Earth exploration and meteorology, including the related use of links in the inter-satellite service; Radio astronomy and radar astronomy; Dissemination, reception and coordination of standard-frequency and time-signal services, including the application of satellite techniques, on a worldwide basis.

2. Structure

Chairman:	R. M. TAYLOR (USA)
Vice-Chairmen:	R. JACOBSEN (Australia)
	G. de JONG (the Netherlands)
	V. MEENS (France)
	M. B. VASILIEV (Russia)

Five Working Parties (WP) carry out studies on Questions assigned to Study Group 7:

- WP 7A SFTS emissions
- WP 7B Space radio systems
- WP 7C EES and meteorological systems
- WP 7D Radio astronomy service
- WP 7E Inter-service sharing issues

ITU-R Working Party 7A

(Chairman Mr. G. de JONG, the Netherlands)

WP 7A (SFTS emissions) covers standard frequency and time signal (SFTS) services, both terrestrial and satellite. Its scope includes the dissemination, reception and exchange of standard frequency and time signals and coordination of these services, including the application of satellite techniques on a worldwide basis.

The goals of WP 7A activities are to develop and maintain ITU-R Recommendations in the TF Series and Handbooks relevant to SFTS activities, covering the fundamentals of the SFTS generation, measurements and data processing. These ITU-R Recommendations are of paramount importance to telecommunication administrations and industry, to which they are first directed. They also have important consequences for other fields, such as radio navigation, electric power generation, space technology, scientific and metrological activities and cover the following topics:

- Terrestrial SFTS transmissions, including HF, VHF, UHF broadcasts; television broadcasts; microwave link; coaxial and optical cables;
- Space-based SFTS transmissions, including navigation satellites; communication satellites; meteorological satellites;
- Time and frequency technology, including frequency standards and clocks; measurement systems; performance characterization; time scales; time codes

The Handbook "Selection and use of precise frequency and time systems" developed by WP 7A describes basic concepts, frequency and time sources, measurement techniques, characteristics of various frequency standards, operational experience, problems and future prospects.

ITU-R Working Party 7B

(Chairman Ms. S. TAYLOR, USA)

WP 7B (space radio systems) is responsible for space operation, space research, Earth exploration-satellite, telemetry, and MetSat telemetry. It studies communication systems for use with manned and unmanned spacecraft; communication links between planetary bodies; the use of data relay satellites; and the transmission and reception of telecommand, tracking and telemetry data. WP 7B enables both scientific studies and technology programmes by intelligent use of the radio frequency spectrum.

WP 7B develops and maintains the Recommendations that enable sharing of the limited orbital and spectrum resources. The technical and operational characteristics of spacecraft are also studied, defining the preferred frequency bands, bandwidths required, protection and sharing criteria for spacecraft, and orbital locations for data relay satellites. The resulting SA Series ITU-R Recommendations assist administrations, national space agencies and industry in the planning of systems that share frequency allocations used by space radio systems.

Space research, by the very nature of its remote operations, is critically dependent on the radio spectrum for the conduct of its activities.

Extreme distances characterize deep space activities, with some current missions in excess of 11 billion km from Earth. These extraordinary distances require the use of sophisticated communication equipment and advanced technologies to achieve reliable communication links.

The expansion of radiocommunications using the low-Earth orbit, coupled with the requirement for continuous communication, has led to the use of data relay satellites. Placed in geostationary orbit, a data relay satellites can provide continuous communications between a low-Earth orbiting spacecraft and a single earth station, and can support multiple spacecraft simultaneously with low to very high data rate requirements.

With respect to manned missions, the most challenging communication systems are those embedded in the space suits of astronauts engaged in space walks. The fact that the communication system must be integrated into the space suit severely limits the physical size and power consumption of such systems.

Further information on space research systems is documented in the Space Research Handbook., this publication deals with the basic technical and spectrum requirements of the many different programmes, missions and activities. It discusses space research functions and technical implementations, factors that govern frequency selection for space research missions, and space research protection and sharing considerations.

ITU-R Working Party 7C

(Chairman Mr. E. MARELLI, ESA)

WP 7C covers applications in the Earth exploration-satellite service (EESS), both active and passive, systems of the MetSat and MetAids services, as well as space research sensors, including planetary sensors.

The objectives of WP 7C activities are to develop and maintain ITU-R Recommendations and Handbooks relevant to Earth exploration and meteorological activities. This includes the determination of the protection criteria, the assessment of spectrum requirements and the establishment of sharing criteria with other services. The resulting SA Series ITU-R Recommendations are of paramount importance to administrations, inter-national and national space agencies, as well as industry.

The Earth exploration active sensors on-board satellites are used for applications such as altimeters, scatterometers and synthetic aperture radars to carry out:

- Scientific and meteorological measurements of soil moisture, biomass, precipitation, surface winds, ocean topography, etc.
- Measurements related to environmental protection and management of natural disaster situations (e.g. flooding, earthquakes).
- Earth imaging at medium and high resolution for commercial and security applications.

The Earth exploration passive sensors are used for a variety of measurements including important environmental data such as soil moisture, salinity, ocean surface temperature, water vapour, ocean ice, oil spills, rain, snow, ice, winds, chemicals, etc. Because of required measurement accuracy down to fractions of one Kelvin, as well as the inability of the sensor to distinguish between natural and man-made radiation, a high level of protection against interference from active services is necessary to obtain successful results.

The space research active and passive sensors are conceptually similar to the sensors used for Earth exploration, but are used either for the exploration of other planetary bodies of our solar system or for radioastronomical measurements from space.

The meteorological services comprise primarily the MetSat service and the MetAids service. The MetSat service bases its observations on satellites sensors providing global or regional coverage for weather models, including cloud coverage, infrared and water vapour images. The MetAids service uses a large number of local Earth-based systems, mainly radiosondes, weather radars and wind profilers - to gather essential environmental data such as temperature, humidity, pressure, wind speed and direction.

ITU-R Working Party 7D

(Chairman Mr. M. OHISHI, Japan)

WP 7D covers the radio astronomy service. Its scope includes radio astronomy sensors, and radar astronomy sensors, Earth-based and space-based, including space-VLBI.

The goals of WP 7D activities are to develop and maintain the RA Series ITU-R Recommendations, relevant to radio and radar astronomy, covering their spectrum requirements, protection and sharing criteria. These Recommendations are of paramount importance to administrations, national and international space agencies and industries, to which they are first directed.

The Handbook on Radio Astronomy, developed by WP 7D, is concerned with those aspects of radio astronomy that are relevant to frequency coordination, i.e., the management of radio spectrum usage in order to minimize interference between radiocommunication services.

In the Handbook, radio astronomy is introduced to the readers as a radiocommunication service for frequency coordination. It covers areas such as radio astronomy characteristics, preferred frequency bands, special radio astronomy applications, vulnerability to interference from other services, as well as issues associated with the sharing of radio spectrum with other services.

The search for extraterrestrial intelligence and ground-based radar astronomy are also considered in the Handbook.

ITU-R Working Party 7E

(Chairman Mr. J. MILLER, USA)

WP 7E, established in 1999, covers all space science services. Its scope includes collaborative studies concerning the sharing of the radio spectrum between science services and other radio services and the preparation of texts, dealing with WRC agenda items assigned to Study Group 7, to be submitted to the Conference Preparatory Meeting.

WP 7E develops, in cooperation with affected Working Parties of other Study Groups, Recommendations addressing the technical and operational conditions applicable to a specific radio frequency allocation which is to be shared on an equitable basis between the science services and other affected services. The Chairmen of Working Parties 7A, 7B, 7C and 7D will initiate a dialogue on sharing with their counterparts in other Working Parties, and will determine when the time is right to seek further help in resolving sharing issues from the Chairman of WP 7E. This working method draws on experience gained over many years in resolving specific sharing issues between the space science services and other services.

Radiocommunication Sector Associates

Drive the Future: Join the International Telecommunication Union!

The rapid pace of technological development and the deployment of radio systems stimulates increased participation by interested entities in ITU-R Study Group activities.

The ITU Convention enables the ITU-R to invite entities to participate as **Associates** in the work of a given Study Group or its sub-groups.

According to ITU regulations, **Associates** may take part in the process of preparing Recommendations and other texts within a single Study Group. This includes participating in meetings, submitting contributions and providing comments before the adoption of ITU-R Recommendations.

Further, **Associates** have access to all documentation of their chosen Study Group and of other Study Groups as required by the work programme.

Kevin A. Hughes

ISES Annual Report for 2001

1. Introduction

The International Space Environment Service is a permanent service of the Federation of Astronomical and Geophysical Data Analysis Services (FAGS) under the auspices of the International Union of Radio Science (URSI) in association with the International Astronomical Union (IAU) and the International Union of Geodesy and Geophysics (IUGG). The history of ISES is described in its Home Page given in the end of this Annual Report.

Three basic functions accomplish the task of the ISES:

(1) The International URSIgram Service to provide standardized rapid free exchange of space weather information and forecasts,

(2) Publication of the International Geophysical Calendar to give a list of 'World Days' during which scientists are encouraged to carry out their experiments, and

(3) Publication of the monthly Spacewarn Bulletins which summarize the status of satellites in earth orbit and in interplanetary space.

The ISES also sponsors meetings to improve space weather services and to promote the understanding of space weather and its effects for users, researchers, the media, and the general public. Solar-Terrestrial Prediction Workshops were held thus far, in Boulder (1979), Meudon near Paris (1984), Leura near Sydney (1989), Ottawa (1992), and Hitachi near Tokyo (1996). In 2000 and 2001, ISES had its business meeting in conjunction with the Space Weather Week meetings organized by NOAA Space Environment Center. Through such meetings, ISES members play an active role in the transition of scientific results into operational space weather services.

2. The International Ursigram Service in 2001

The International Ursigram Service in 2001 operates through eleven Regional Warning Centers (RWC) and one Associate Regional Warning Center (ARWC). The 11 RWCs are located in: Beijing (China), Boulder (USA), Brussels (Belgium), Lund (Sweden), Moscow (Russia), New Delhi (India), Ottawa (Canada), Prague (Czech Republic), Sydney (Australia), Tokyo (Japan) and Warsaw (Poland); the ARWC in Meudon (France). The RWC in Boulder plays a special role as 'World Warning Agency (WWA)', acting as a hub for data exchange and forecasts.

Each RWC collects data available in its own geographic area, concerning the state of the sun-earth environment, both from its own observatories and from regional scientific institutes and universities. These data and reports are coded according to the ISES code book and distributed daily, on request to users and to other RWCs. Information transmitted through the ISES network is analyzed by Regional Warning Centers which produce a number of "summary" reports and forecasts. The "Geoalert", a forecast of solar-geophysical conditions for the next few days, is a particularly important one of these reports. Each RWC prepares its own forecast ("Geoalert") and sends it to the WWA in Boulder each day. The WWA then issues a Geoalert which is distributed worldwide each day at 0300 UT through the ISES network.

3. The International Geophysical Calender

The International Geophysical Calendar (IGC) is prepared and distributed by Secretary for World Days. The IGC can be accessed on the Home Page and is also printed annually in many international journals. The ISES Directing Board meeting in 2001 decided to continue providing the IGC based on the result of investigation made in 2000 on demands of users for its continuation. 3000 copies of IGC 2002 were printed and distributed in September, 2001.

4. The Spacewarn Bulletin

The World Warning Agency for Satellites issues the Spacewarn Bulletin every month on behalf of COSPAR. The Spacewarn Bulletin provides a listing of launches and brief details of each launch and can be accessed via the internet. The WWA for Satellites is operated by the World Data Center-A for Rockets and Satellites, NASA/GSFC.

5. The ISES Directing Board

The ISES is managed by the Directing Board composed of the ISES officers, a delegate from each ISES center, and liaison delegates from interested ICSU Unions such as URSI, IAU, and IUGG.

The ISES officers in 2001 are: Director (K. Marubashi, Japan), Deputy Director (D. Boteler, Canada), Secretary for Space Weather (J. Kunches, USA), Secretary for World Days (H. Coffey, USA).

The 2001 Directing Board meeting was held in Boulder, Colorado, on April 30 and May 4. The Board decided (1) continuation of the International Geophysical Calender, (2) continuation of ISES working groups organized for the ISES 2000 Meeting, and discussed the possibility for having the next Solar-Terrestrial Predictions Workshop in the near future. The next Directing Board meeting is planned to be held in Boulder on April 15, 2002.

6. ISES Home Page on the Web

ISES has a home page on the Web and this contains information about ISES and its Warning Centers, copies of the ISES code book, and links to the home pages of ISES centers. The page is a good way to navigate the Web to obtain space environment services. The home page addresses related to three ISES tasks are given below.

ISES Home page: http://www.ises-spaceweather.org/
Spacewarn bulletins: http://nssdc.gsfc.nasa.gov/spacewarn
International Geophysical Calendar: http://www.ises-spaceweather.org/geo-calender/

Katsuhide Marubashi, Director of ISES

IUCAF Annual Report for 2001

1. Introduction

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

2. Membership

At the end of 2001 the composition of membership for IUCAF was:

URSI	W.A. Baan	The Netherlands
	M. Davis	USA
	W. van Driel	France
	A. van Eyken	Norway
	P. Poiares Baptista	The Netherlands
	K. Ruf	Germany
	A. Tzioumis	Australia
IAU	S. Ananthkrishnan	India
	R.J. Cohen	United Kingdom
	D.T. Emerson (Chair)	USA
	M. Ohishi	Japan
	K.F. Tapping	Canada
COSPAR	S. Gulkis	USA
	A. Gasiewski	USA

Ex Officio Advisers:

Director ITU Radio Bureau	Robert Jones
ITU Radio Board	Ryszard Struzak
Councilor Study Group 7	Kevin Hughes
Councilor Study Group 1	Albert Nalbandian

During the year 2001, the chairmanship of IUCAF changed from Klaus Ruf to Darrel Emerson. There was also a change in the IUCAF membership representing COSPAR. Daniel Breton retired from France Meteo, and COSPAR agreed with IUCAF on the nomination of Samuel Gulkis. IUCAF wishes to express it's appreciation to the long lasting active work of Dr. Breton, and, at the same time, to welcome Dr. Gulkis.

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

3. International Meetings

During the period of January to December 2001, IUCAF Members and Correspondents took part in the following meetings:

February:	Meeting of UN-Copuos in Vienna, Austria
March:	Workshop on Interference Mitigation, Bonn, Germany
April:	Task Group 1-7 of ITU-R on the Protection of Passive Services in Geneva, Switzerland
May:	ITU-R Working Parties 7C and 7D in Geneva, Switzerland
June:	ITU-R Task Group 1-7 in Maastricht, The Netherlands
September:	Meeting of the Space Frequency Coordination Group in Cayenne, French Guayana
November:	ITU-R Task Group 1-7 in Geneva, Switzerland

Additionally, many IUCAF members and correspondents participated in national or regional meetings, dealing with spectrum issues in general or preparing for WRC-2003.

3.1 IUCAF Meetings

During the year 2001 IUCAF had a number of face-to-face meetings as a committee. These meetings took place in Geneva, Switzerland, and in Maastricht, The Netherlands. They were held before Working Party 7D or Task Group 1-7 meetings, with the purpose of discussing and focusing on important issues on the agenda of WP7D or TG 1-7, in preparation for the public ITU meetings. During these ITU sessions, typically lasting a week to 10 days, a number of ad-hoc meetings of IUCAF were held to discuss further the IUCAF strategy. Other IUCAF business such as changes in the chair and the membership, action plans for future workshops or initiatives, and future contributions to international spectrum meetings were also discussed at these meetings.

Although such face-to-face meetings at the ITU venues have been convenient and effective, throughout the year much IUCAF business continues to be undertaken via email communications between the members and correspondents.

3.2 Meeting of UN-COPUOS

The Meeting of the United Nations' "Committee for the Peaceful Use of Outer Space", COPUOS, February 2001 in Vienna, Austria, had an item on its agenda dealing with the future of observational radio astronomy in a commercially exploited radio spectrum. The concept, which is not new, is to create in effect a "World Heritage Astronomical Site" – or ideally several such sites. The goal is to preserve access to the sky throughout the entire electromagnetic spectrum from at least one site on Earth. The existing protection afforded to Radio Astronomy is limited to a number of relatively narrow bands. Many scientists fear that mankind could blind itself for ever to observations outside these protected bands; some potential discoveries might never be made, because the observational conditions are compromised by active uses of the radio spectrum. This concept has also lead to establishing a Task Group of OECD, in which high-ranking industry representatives discuss the future of radio astronomy with science managers and government officials.

In order to bring this idea to the attention of a UN committee dealing with both scientific and commercial use of satellites and space stations, for the benefit of all mankind, COPUOS invited IAU, ITU, and the OECD Task Force to present the case to the Science and Technology Sub-Committee. IAU invited the chairman of IUCAF, and ITU sent Mr. Nalbandian, one of IUCAF's councillors in ITU-R. Their presentations were very well received and a section of that meeting report is devoted to this topic.

3.3 Workshop on Interference Mitigation

Active radio service spectrum managers often tell us that radio astronomy and the Earth exploration satellite service are simply too sensitive, and that adequate suppression of unwanted emissions from the transmitting radio services cannot be accomplished without unreasonable effort. They recommend that the scientific services rely on so-called mitigation techniques, a term that includes a wide range of technical or operational measures to avoid or excise interference in observations by the passive services. From the very beginning of the science of radio astronomy, many observations have only been possible by ingenious applications of technology and special observing techniques, and further such innovations are being studied and developed in an attempt to minimize the impact of radio interference. Today, in the presence of many man made signals with their diverse characteristics, digital signal processing appears to be the most promising tool, but other technical developments ranging from fast multi-bit samplers to high-temperature superconducting filters are under intense study. Such research is not limited to the field of radio astronomy

Scientists working on the implementation of practical RFI mitigation techniques have not always been in close contact with those involved in spectrum management. To try to foster the exchange of ideas, IUCAF organised a 3-day workshop on interference mitigation, involving about 50 experts from both technical and regulatory fields. Many excellent presentations were given, but the workshop emphasis was in increasing the mutual understanding between the different areas of expertise. This workshop was a great success, and IUCAF intends to organize more such events in the future.

4. Contact with the Unions

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

None of the IUCAF parent unions, IAU, URSI, and COSPAR held general assemblies in 2001, however, IUCAF members actively participated in national URSI meetings and in IAU Seminars and Symposia.

5. Affairs of the International Telecommunication Union

5.1 ITU-R Task Group 1-7 on the Protection of Passive Services from Unwanted Emissions

With three meetings in April, June, and November 2001, Task Group 1-7 of ITU-R constituted the biggest workload on the committees.

As a result of the continued pressure from the active Space Services the protection of the passive services has been limited to a consideration on a "band-by-band" basis. Rather than having general limits that would benefit all spectrum users by reducing unwanted emissions as specified in Rec. 66, compromises are being discussed, limiting the degree of protection afforded to the radio science bands to what is considered practical by the interfering service in specific bands. This "band-by-band study" is continued in Task Group 1-7 of ITU-R Study Group 1.

Additionally, TG 1-7 is responsible for preparing text on agenda item 1.8.2 for the preparatory meeting of WRC-03. This agenda item asks for consideration of regulatory measures to protect the passive scientific radio services in their frequency bands, taking into account the results of the "band-by-band studies". The deadline for the submission of CPM text, which will form part of the CPM Report that helps delegated at the WRC to discuss and take decisions on the agenda items, is May 2002. Hence the concentrated work during and between the meetings. IUCAF had been very active in the formation of TG 1-7, continuing the work of TG 1-5 and with the appropriate mandate. Dr. Willem Baan, IUCAF member and former IUCAF chairman, was nominated to be co-chairman of the new ITU Task Group. Largely due to his and his co-chairman's able guidance, but also due to excellent IUCAF contributions, an initial impass could be overcome in the last meeting of 2001, and timely delivery of input to the Conference Preparatory Meeting is within reach. This text will not go as far as radio astronomers and remote sensing scientists would have liked, but should represent a reasonable compromise that leaves all options open for the World Radiocommunication Conference in 2003.

Many "band-by-band studies" are under way, and more may be started when new satellite systems are proposed by industry. These studies may become part of the normal life of the frequency managers of the scientific services.

5.2 ITU-R Working Parties 7D and 7C

Working Parties 7C and 7D met once this year, in May 2001. WP7C addresses the issues of the remote sensing community. WP7C met at the same time as WP7D, which is devoted to Radio Astronomy.

The largest fraction of the work was devoted to issues related to TG1-7 matters. A number of band-by-band studies was brought forward and liaison statements written for TG1-7. From the other work, one topic deserves special mention; one satellite company is working on wide-band communication systems, including earth-to-space, space-to-earth and satellite-to-satellite links, which will operate at optical frequencies. This early-stage study was brought to the attention of WP7D. 7D radio astronomers are now talking to their colleagues who observe at optical wavelengths, to try to convince them of the benefits of ITU-R work; the ITU now considers optical frequencies to be within its scope. Optical astronomers have been fighting "light pollution" for long time and with good success in some cases. However, the use of the optical spectrum has so far not been regulated by an international agency like ITU, and protection of optical telescopes against light pollution has to be done locally, and individually for each site. At least for the use of the optical spectrum for communication purposes, this picture may change in future.

The more regular work in WPs 7C and 7D comprises revisions of many ITU-R recommendations, which need to be updated following the very significant changes in the frequency bands above 71 GHz that occurred at WRC-2000, and also to accommodate improved technical parameters. One new recommendation, which could be completed within WP7D and handed upwards to the approval process, deals with radio frequency bands above the current limit of 275 GHz, and which are of importance to radio astronomy. Additionally, WP7D has started to revise the ITU-R Handbook on Radio Astronomy and plans to publish a second edition soon. In all cases, IUCAF members play key roles in bringing these issues forward.

6. Publications and Reports

IUCAF has contributed a number of documents to the proceedings of Task Group 1-7 and Study Group 7. These documents have all become available on the ITU-R web pages, so have not necessarily been distributed separately by email. IUCAF now has a permanent web address, http://www.iucaf.org/ , where the latest updates on the organization's activities will always become available.

7. Conclusion

IUCAF interests and activities range from preserving what has been achieved through co-ordination or mitigation techniques, to looking very far into the future of highest frequency use. Current priorities, which will certainly keep us busy through the next two years, include the band-by-band studies for cases where allocations are made to satellite down-link services close in frequency to the radio astronomy bands, and the preparations for WRC-03.

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

Darrel Emerson, Chairman
Klaus Ruf, Retiring Chairman IUCAF
http://www.iucaf.org

URSI Commission B International Electromagnetics Prize

URSI Commission B with the approval of the URSI Board of Officers has established the International Electromagnetics Prize to be awarded annually. The prize is $10,000 US plus a commemorative plaque and is sponsored by the Summa Foundation. It is awarded for an accurate approximate solution of a designated scattering or related problem in electromagnetics and is presented at an appropriate URSI meeting. The first prize will be awarded in Spring 2003.

General Information

The last 30 years have seen enormous advances in the application of numerical techniques in electromagnetics, but there have not been comparable advances in our knowledge of the scattering from simple geometric shapes. It is hoped that the prize will encourage the development of accurate physically based approximate analytical expressions for the solution of canonical and similar problems.

On 15 September of each year the designated problem will be announced on the URSI web page (http://www.intec.rug.ac.be/ursi/EM%20Prize.htm) and elsewhere, and solutions are due by 15 January, 16 months after the announcement date. Entries must be in English in the format of a paper submission to the journal *Radio Science* and not exceed 25 pages in length, including tables, figures and references. Hard copy or electronic submission is acceptable. Entries will be judged by a panel appointed by the chair of URSI Commission B and the Summa Foundation. Factors taken into account in the judging will be the simplicity and elegance of the expressions, their conformity with the known physical properties of the solution, and their accuracy for all values of the parameters involved in the problem. The winner will be announced on 15 April of the year of submission. There is the right to withhold the award if, in the opinion of the panel, no worthy entry is received.

All scientists are eligible for the prize apart from an officer or director of the Summa Foundation, a member of the panel, or one of their immediate working associates.

Since the prize is awarded for the best paper submitted, multiple authorship is allowed.

2003 Prize Topic (Announced 15 September 2001)

The topic is the scattering of a uniform plane wave by a perfectly conducting right circular cone of semi-infinite extent. In terms of spherical coordinates with the cone axis coincident with the polar (z) axis and the tip of the cone at the origin, the conical surface is $q = q_c$ with $0 < q_c < p/2$. The objective is the determination of the scattering matrix for the exterior problem for either time harmonic or time dependent excitation.

There is a sizable body of literature on this problem but it is incomplete in that solutions are not known for all ranges of the problem parameters, nor are there accuracy bounds known for the solutions that are available. A solution should be in the form of analytical expression(s) accompanied by conditions indicating the ranges of validity and an inclusive specification of the accuracy. A minimally acceptable solution might be one for which either the incident or scattered wave (but not both) is axial. Contestants are encouraged to submit a solution which is as general as feasible for which the accuracy is specified. A solution whose specified range of validity is limited but whose accuracy is tightly bounded will be looked upon more favorably than one which holds over a greater range but whose accuracy is not proved or tightly bound.

Submission

The members of the interim panel are C.E. Baum, C.M. Butler, and T.B.A. Senior. Entries in the format described above must be received by 15 January 2003 and submitted to:

Professor Thomas B.A. Senior
Electrical Engineering and Computer Science
Department The University of Michigan
Ann Arbor, MI 48109-2122, USA
Phone: 734-764-0501
Fax: 734-647-2106
Email: senior@eecs.umich.edu

Maastricht General Assembly

CURRENT STATUS OF THE SCIENTIFIC PROGRAMME

The preparations for the scientific programme are now in the most busy phase. The paper-submission site has now been closed, and the Commissions are busy reviewing all papers. The site has had a few problems due to hardware failure, but on the whole, the automatic submission system has worked very well, thanks to the careful supervision of Dr. Maurice Borgeaud of ESA. In total, some 2000 submissions have been processed by the system, including those that were withdrawn and/or resubmitted later.

The final number of valid abstracts submitted was 1617, which is about 90 lower than the total submissions for the 1999 Toronto Assembly. The division among Commissions and sessions is shown in the table below. What is very good to see is the increased number of submissions for Commission D and, in particular, Commission C. This leads to a much more even spread of papers over the Commissions than previously.

The Local Organising Committee and the Conference Bureau of Van Namen and Westerlaken are busy sorting out all details for a successful organisation. So far, the preparations are running according to schedule. From the Management Office, Dr. Leon Kamp and I are trying to answer the many questions that are inevitably received when organising an event of this scale.

The next events to happen are:

- by March 1, all authors who have submitted an abstract will receive notification of the decision on their proposed paper. For accepted papers, this will include the session (with location, date, and time) to which the contribution has been allocated and the form of presentation (oral or poster). Poster papers will be presented in two poster sessions, on Tuesday and Thursday afternoon. They will remain on display for 24 hours adjacent to the exhibition, so that there is a high level of exposure.
- by mid-March, the Preliminary Programme, based on the review decision, will be on the Web site of the Assembly.
- by April 15, full Proceedings versions of all papers must be received by the Management Office. Submission will again be electronic, by means of PDF files.

In this phase, all colleagues who have enthusiastically submitted abstracts will be the ones who are busy! We wish all authors success in the preparation of the Proceedings Papers, and hope to meet all our readers at the most exciting event that the URSI community knows!

On behalf of the Local Organising Committee,
Gert Brussaard
Associate Scientific Coordinator

Commission A		Commission B		Commission C		Commission D		Commission E	
Session	Papers	Session	Papers	Session	Papers	Session	Papers	Session	Papers
A1	15	B1	49	C1	4	D1	16	E1	4
A2	8	B2	42	C2	30	D2	6	E2	4
A3	10	B3	29	C3	8	D3	8	E3	10
A4	5	B4	25	C4	23	D4	9	E4	14
A5	5	B5	10	CAF	13	D5	5	E5	8
AB1	25	B6	9	CBF	15	D6	1	E6	6
AB2	7	B7	16	CF	9	D7	6	E7	22
AC1	7	B8	32	CFA	15	DB	15	E8	12
AC2	8	BCF	26	CFAB	11	DJ	8	EA	6
AD	10	BD	10			DJA	4	EF	16
AE	9	BP	42			DP	10	EGH	22
Total	109	Total	290	Total	128	Total	88	Total	124

Commission F		Commission G		Commission H		Commission J		Commission K	
Session	Papers	Session	Papers	Session	Papers	Session	Papers	Session	Papers
F1	17	G1	29	H Special	19	J1	11	K1	13
F2	13	G2	20	H1	30	J2	10	K2	18
F3	12	G3	46	H2	20	J3	10	K3	5
F4	2	GF	14	H3	20	J4	15	K4	26
F5	24	GH1	29	H4	25	J5	19	K5	0
F6	15	GH2	11	H5	32	J6	24	K6	2
F7	13	GHE	19	HG1	29	J7	15	KA	18
F8	2	GJ	27	HG2	15	J8	23	KB	14
F9	3	GP1	14	HGE1	23	JBC	17	KC	11
FG	14	GP2	13	HGE2	18	JFC	19	KE	4
FP	17			HGJC	12				
Total	132	Total	222	Total	243	Total	163	Total	111

Session of LOC: 7, Total number of papers submitted: 1617

URSI
Maastricht 2002

REGISTRATION FORM XXVIIth General Assembly URSI 2002
August 17 – August 24, 2002, MECC, Maastricht, the Netherlands

Please complete this form, sign it and return it by mail or fax to the Conference Bureau:

Van Namen & Westerlaken Congress Organization Services
P.O. Box 1558
6501 BN NIJMEGEN
The Netherlands
Phone: + 31 24 323 44 71 Fax: + 31 24 360 11 59
E-mail: reg.ursi2002@congres.net

A. REGISTRATION PARTICIPANT AND ACCOMPANYING PERSON

Participant

O Mr Omrs O Ms Title: ____________ Initials: ____________
First name: ____________
Family name: ____________
Company/Institute: ____________
Department: ____________
Postal address: ____________
Postal code: ____________ City: ____________
Country: ____________
Telephone: ____________ Fax: ____________
Email: ____________
URSI commission of interest*: ____________
Dietary wishes: ____________

* Commission: A, B, C, D, E, F, G, H, J or K

Accompanying person

O Mr O MrsO Ms Title: ____________ Initials: ____________

First name: ____________

Family name: ____________

Dietary wishes: ____________

B. REGISTRATION

Registration fee	Payment received before May 15, 2002	Payment received after May 15, but before August 1, 2002*	Payment
O Participant	585	645	....
O Student**	475	515	....
O Young Scientist	0	0	n.a.
O Accompanying person	125	135	....
			____________ +
Subtotal payment for registration			....

* After August 1, 2002 only registration at the conference at same fee as indicated here

** Students have to enclose a proof of full-time student status or a letter of endorsement from their supervisor

O I require a letter of invitation to arrange the appropriate visa to enter the Netherlands/leave my country to attend the Conference.

O I do **not** agree that the above mentioned details are published in the list of participants.

C. SOCIAL ACTIVITIES

Event	Date	Price per Persons	Number of Persons	Payment
O Young Scientists Reception*	August 19, 2002	0	...	n.a.
O Banquet "Caves of Geulhem"	August 21, 2002	65	...	....
				____________ +
Subtotal social activities				....

* only open for Young Scientists

D. ACCOMPANYING PERSONS' PROGRAMME*

Activity	Date	Price per person	Number of Persons	Payment
O Visit Domein Bokrijk	August 19, 2002	27,50	...	....
O A Cultural walk in Maastricht (incl. lunch La Bonbonnière)	August 20, 2002	57	...	....
O Visit Caves Zonneberg or the Caves of the Jesuits and Bonnefantenmuseum	August 21, 2002	32,50	...	....
O Maastricht by Adventure	August 22, 2002	27	...	....
O Visit to a Vineyard in Maastricht	August 22, 2002	25	...	....
				____________ +
Sub total Accompanying Persons' Programme				....

* also open for registered participants

E. PAYMENT

Section B	Registration Fees	....
Section C	Social Activities	....
Section D	Accompanying Persons' Programme	....
		———— +
Total payment		....

METHODS OF PAYMENT

O **Bank transfer**

Payable to "URSI 2002", bank account number 17.82.76.235 of the Rabobank Eindhoven, the Netherlands. Please state your full name and make sure that your remittance is free of bank charges. In case you transfer an amount for a group, please specify the payment per person in writing.

O **Certified bank cheque**

Drawn on a Dutch bank, made out to "URSI 2002" and to be send to the Conference Bureau. The Conference Bureau cannot be held responsible for cheques lost in the mail.

O **Credit card***

The following cards are accepted (please check): O VISA O Euro/MasterCard

* I authorize the Conference Bureau to use my credit card information to charge the total amount to be paid for participation in this Conference. Enclose a copy of both sides of the credit card.

Name cardholder: ______________________________

Full address cardholder: ______________________________

Credit card number: _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ Expiration date: _ _ _ _

CVC code: _ _ _ (to be found on the back of the card in the signature strip of Visa, EuroCard and MasterCard cards. It appears as a three-digit code at the top right corner of the signature panel)

Amount to be charged: ....

Signature of cardholder: ....

Date: .... Signature: ....

The Hotel Reservation Form has to be sent to MECC Hotel Service directly (not to the Conference Bureau).

<u>Please note</u> that your signature is mandatory for credit card payment in which case you are requested to send the form by regular mail or fax. Also for credit card payments please enclose a copy of both sides of the credit card.

URSI

Maastricht 2002

HOTEL RESERVATION FORM XXVIIth General Assembly URSI 2002
August 17 - 24, 2002, MECC, Maastricht, the Netherlands

Please complete this form (one room per Reservation Form), sign it and return it by regular mail or fax (**not by email**) to Maastricht Exhibition & Congress Centre

MECC Hotel Service (MHS)
P.O. Box 1630
6201 BP MAASTRICHT
The Netherlands

Telephone: +31-(0)43-3838383
Fax: +31-(0)43-3838300
Email: mhs@mecc.nl

Personal details

Mrs/Mr (Family name): ______________________ Initials: __________

Company/Institute : ______________________

Postal address : ______________________

Postal Code : ______________________ City: __________

Country : ______________________

Telephone : ______________________ Fax: __________

Hotel rooms

Date of arrival : __________ day ______ August, 2002 __________ hour

Date of departure : __________ day ______ August, 2002

O single room O double room

	Single room Price ( )	Double room Price ( )
Category *	193—241	230—266
Category A	143—193	168—230
Category B	93—143	107—168
Category C	55— 93	55—107

All rooms are equipped with shower or bath and toilet.
Prices are excluding breakfast and excluding city tax. Price level 2002.

Category 1st choice: __________ Category 2nd choice: __________

Remarks: ______________________

Hotel deposit

One of the following guarantees is required:

Swift transfer: Payment of Euro 113.45 to bank account 57.55.85.692 of the ABN-AMRO Bank Maastricht, the Netherlands, in the name of MECC Hotel Service. Please mention above account number clearly. Please include name of participant, address and reference code: URSI02.
Payment may only be made in Euro, free of bank charges.
In the event of bank charges, 9.08 will be deducted from your hotel deposit.

Credit card guarantee.: Please include the following information. The credit card will only be charged in case of cancellation or no-show.

O American Express   O Euro Card   O Diners Club   O Visa Card

O Company Card   O Private Card

In the name of : ______________________________

Company name: ______________________________

Mrs./Mr. : ______________________________

Card number : ______________________________

Expiry date : ______________________________

Signature Cardholder: ___________________________

After receipt of your payment/credit card guarantee, the required accommodation will be booked and a voucher will be sent to you. Any deposit will be deducted from your hotel bill when you trade in the voucher at the hotel reception desk.

General terms and conditions:
Cancellations/changes will only be accepted by MECC Hotel Service in writing.
The cancellation policy is in conformity with the Uniform Hotel Conditions (UVH) and applicable on all reservations.
Cancelled rooms, for which no cancellation costs are invoiced by the hotel(s), will be charged with 35.00 administration costs.
If you do not check-in on the above mentioned arrival date, without written notification, your room will automatically be cancelled for the rest of the period. The room will become subject to cancellation charges.
When checking out before the confirmed departure date, the hotel is entitled to charge an early departure fee. Please make clear arrangements with the hotel upon arrival

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Conferences

CONFERENCE REPORTS

INTERNATIONAL SPACE ENVIRONMENT CONFERENCE (ISEC 2001)

Queenstown, New Zealand, 23 - 27 July 2001

On 23-27 July 2001, the International Space Environment Conference (ISEC2001) was held at the Millennium Hotel, Queenstown, New Zealand (see http://spacsun.rice.edu/~aac/isec2001/). This was the seventh in a series of international meetings devoted to advancing our understanding of Earth's space environment and its effects on technology and on humans in space. Previous meetings were held in Dubna (Russia), Taos (USA), Brussels (Belgium), The Hague (The Netherlands), Moscow (Russia), and Farnborough (United Kingdom).

The 2001 ISEC meeting was subtitled "Radiation Belt Science and Technology ", which described the primary emphasis of ISEC 2001, although papers on other energetic charged particles and their effects were also encouraged. The principal organisation of the meeting was undertaken by Dr. Anthony Chan (on the science-side) and Ms. Umbe Cantù (for almost everything else), both of the Rice Space Institute. I was also asked to join the organising committee, and played a small role assisting the Houston-based organisers with local details, particularly around the social side of the program. Financial support was gratefully acknowledged from S-RAMP/SCOSTEP and the Rice Space Institute, with additional support coming from URSI and the Royal Society of New Zealand.

Participation

The workshop attracted 44 registered participants, of which almost all came from the northern hemisphere. As a New Zealander I was particularly pleased to welcome the participants who had travelled from a quarter to half-way round the world to attend a meeting in my country. Dr. Anthony Chan, an ex-pat New Zealander, was the guiding force behind bringing ISEC2001 to Queenstown, and I believe many participants enjoyed the chance to visit my country's most beautiful winter resort. The break-down of conference participants was as follows 25 USA, 4 United Kingdom, 4 Japan, 3 New Zealand, 2 Belgium, 2 Germany, 1 Switzerland, 1 Russia, Brazil, and 1 Australia.

Topics

ISEC2001 operated as an informal, workshop-style meeting, with plenty of time for discussion and communication. A significant fraction of the papers dealt with radiation belt particle acceleration and loss mechanisms, particularly the loss and acceleration of outer zone relativistic electrons around the times of geomagnetic storms. ULF and/or VLF waves have been suggested as important parts of these processes. These waves were the focus of very interesting sessions most likely to be of interest to the URSI community. As such, the meeting was strongly focused on basic problems and processes involved in "Space Weather". The sessions included both theoretical and experimental studies and the workshop nature of the meeting allowed for useful and immediate feedback on the papers. Each day ended with a general discussion to allow all players to discuss the significance of the days reports and their impacts on wider scientific questions.

The meeting's great strength was that it brought together many of the main players in both the "wave" and "particle" radiation-belt communities. Senior scientific representatives from the USA, Japan, and Europe were present and took away the workshops request for high resolution wave and particle measurements to be made on the same spacecraft in orbits near the geomagnetic equator. A presentation was also made on NASA's Living with a Star (LWS) program providing an opportunity to inform this community as to current state of this program.

Other Activities

The working days of the conference were 23-24 and 26-27 July. Before the formal start of the meeting most participants gathered at the Millennium Hotel for registration and an evening cocktail reception on the 22nd July. The meeting opened on the 23rd July with brief speeches and a welcome from a group of local Maori (the first settlers of New Zealand). The end of first two days of formal scientific activity was marked by the poster session, which was held at the Skyline Restaurant. Workshop participants travelled up to the mountaintop facility by gondola, and a draw was held for one "lucky" participant to experience a 47 meter Bungy jump from "The Ledge" just outside the restaurant. The poster session was accompanied by a buffet meal and a selection of New Zealand wines. This may have influenced two more of our participants to leap from the Ledge Bungy jump that evening, including Anthony Chan himself! The 25th of July was a compulsory conference break to allow our participants the chance to undertake a wider range of activities and "talk-shop" in more relaxed atmospheres. Although nothing was formally arranged, many participants used the day to visit the Milford Sound World Heritage Area, while others went jet boating, horse trekking, skiing, or walking. At the end of the second two days of formal scientific activity we gathered for a lake cruise upon a vintage steamship, immediately followed by the conference banquet. Queenstown is located in the South Island of New Zealand (Aotearoa), on the shores of Lake Wakatipu, adjacent to the dramatic remarkables mountain range, and is known as the "adventure capital of New Zealand". This location provided a lot opportunities for interesting experiences and informal scientific discussions in a social setting, and our participants made good use of the possibilities offered!

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The Sixth International School/ Symposium for Space Plasma Simulations (ISSS-6)

Garching, Germany, 3 - 7 September 2001

The International School for Space Plasma Simulation series (ISSS) was set up in the early eighties under the sponsorship of the International Union of Radio Science (URSI). Its purpose is to promote computer simulation related to space plasma physics, by training of young scientists as well as by
presenting the most recent advances in this field.

The previous meetings were held in Japan (Kyoto, Nara, Uji), USA (Hawaii) and France (Nice). The Sixth International School / Symposium for Space Plasma Simulation was held from September 3 -7 in Garching (Munich), Germany.

It was hosted by the Max Planck Institut für Extraterrestrische Physik and the Centre for Interdisciplinary Plasma Science (CIPS).

It was attended by about 125 researchers and students from 16 countries. Financial Support we received enabled in particular a number of students from Eastern Europe to participate in the symposium.

Topics

The topics of the conference spanned a wide range. Naturally, they concentrated on techniques and results on simulation of space plasmas by kinetic particle (PIC) or Vlasov codes, hybrid codes (in which some components are represented by fluid models), multi-fluid codes and magnetohydrodynamic codes. The latter (MHD codes) play an especially important role in the global simulation of the earth-space environment. Computational techniques (massively parallel computation) which allow to make full use of the most recent advances in computer technology were also discussed in detail. A series of special tutorial lectures was aimed at students new to these techniques.

Aim

Although the aims of these symposia are distinct from that of a general (space) plasma physics conference, presentations on laboratory experiments related to space physics, on dusty or colloidal plasmas and on the most recent space missions were also included, as was the case at previous conferences. The aim is cross fertilization by informing, on the one hand, about possibly new challenges for "simulationists" and, on the other hand, about the capabilities of existing simulation models.

Book of Abstracts

A good overview of the topics covered at the symposium can be gleaned from the book of abstracts published by the Copernicus Society (and for now still from the web pages http://www.copernicus.org/ISSS-6). The extended abstracts (typically four pages) comprise a total of 413 pages.

Next Symposium

The next symposium in this series is planned for 2003 in Japan.

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The International Conference on Electromagnetics in Advanced Applications (ICEAA 2001)

Torino, Italy, 10 - 14 September 2001

The International Conference on Electromagnetics in Advanced Applications was held in Torino (Turin), Italy, 10-14 September 2001. This was the seventh biennial conference in the series, which started in 1989. The conference was organized by the Politecnico Di Torino and IRITI-CNR, and was held in cooperation with URSI, the IEEE Antennas and Propagation Society, the IEEE Electromagnetic Compatibility Society, the IEEE Electron Devices Society, the IEEE North Italy Section, and the IEEE North Italy Joint AP/ED/MTT Chapter. Administrative support was provided by COREP. The meeting was sponsored by the Istituto Superiore Mario Boella sulle Tecnologie dell'Informazione e delle Telecomunicazioni, and ALENIAAerospazio – Divisione Aeronautica. The venue was the excellent Torino Incontra Congress Center, in the heart of downtown Torino.

The Chair of the Organizing Committee was Roberto Graglia, of the Politecnico di Torino. The Committee also included Rodolfo S. Zich, President of the Politecnico di Torino and President of the Istituto Superiore Mario Boella; Filippo Bagnato, Head of Aeronautics Division – ALENIA Aerospazio; Corrado Cugiani, Director of IRITI-CNR di Torino; and George Uslenghi, of the University of Illinois at Chicago (see Figure 1).

True to its title, this meeting has traditionally been focused on advanced applications of electromagnetics, and this was reflected in the major themes of the 2001 conference: Scattering and RCS; EMC, EMP, and EMI; interaction with and applications of complex materials and frequency-selective surfaces (FSS); applications of advanced computational electromagnetics; advanced antennas; and wireless applications. I have been fortunate to attend this conference several times, including the first two or three meetings. Part of its value is that it has remained relatively small and tightly focused, with many opportunities for attendees to interact outside of the sessions. As in the past, this was facilitated by the inclusion of an excellent lunch for all participants for each day of the conference, included in the registration. This time, the conference had 232 registrants, with representatives from about 34 different countries. Italy was the best-represented country, with 71 registrants, followed by 55 from the US.

The initial terrorist attacks in the US occurred on the second day of the conference. After careful consideration, the organizers and the vast majority of the attendees were in agreement that the conference should continue. Moments

Figure 1. Sponsors and members of the Organizing Committee at the opening session of the ICEAA. (l-r) Filippo Bagnato, Head of Aeronautics Division – ALENIA Aerospazio; Rodolfo Zich, President of the Politecnico di Torino and President of the Istituto Superiore Mario Boella; Roberto Graglia, Chair of the Organizing Committee; George Uslenghi, of the University of Illinois at Chicago; Ross Stone, URSI representative.

Figure 2. Allen Taflove organized and chaired the session on "The State of FDTD Computational Electromagnetics."

of silence were observed in all of the sessions on September 12, in memory of those who had lost their lives. As an American, I was particularly grateful for the expressions of sympathy and support from our hosts and from the attendees from other countries. Of course, the conference ended before air travel had been restored to the US, and that created significant problems for many attendees. The organizers and especially, Roberto Graglia, the General Chair, and the conference travel agency, ACTA did an outstanding and very generous job of keeping people informed and of making alternative arrangements, including extending people's stays in Italy, in a very difficult situation.

The meeting had a total of 25 sessions, plus one short course. The session titles were as follows: "Finite Methods and Integral Equation Methods," "Optoelectronics," "Electromagnetic Theory," "Intentional EMI I and II," "Novel Methods in Computational Electromagnetics," "Wave Modeling in Complexity: Relevance of Analysis in an Age of Computers," "FSS, Radomes, and Printed Antennas," "High-Frequency Scattering," "EMC," "The State of FDTD Computational Electromagnetics," "Scattering by Wedges," "Antennas," "Integral Equation Methods," "Radar Imaging and Inverse Scattering," "New Challenges in Modeling and Simulation of Antennas and Radomes," "Patents and Research," "Electromagnetic Modeling of Devices and Circuits," "Engineering Education in the 21st Century: Issues and Perspectives," "Electromagnetics in Wireless Communications," "Electromagnetics in Special Media," "Arrays," "Wireless Communications," "Numerical Methods in Electromagnetics," "Electromagnetic Measurements," and the "Short Course on Wireless Data Networking." There were only three parallel sessions at any time.

In what follows, an effort has been made to highlight those presentations that seemed particularly notable to the chairs of the sessions in which they were presented, or to me (with apologies to the many of authors of excellent papers not mentioned). Many of the comments are from summaries provided by the chairs of the sessions.

One of the highlights of the meeting was a special Plenary Session on "Engineering Education in the 21st Century: Issues and Perspectives," organized by Leo Felsen. Summaries of the papers presented in this session appeared in a separate report in the December 2001 issue of the *IEEE Antennas and Propagation Magazine* (Vol. 43, No. 6, December 2001, pp. 110-121). Another particularly noteworthy session was "The State of FDTD Computational Electromagnetics," organized by Allen Taflove (Figure 2). This session included examples of solutions to some of the most interesting and complex currently solvable computational electromagnetics problems.

Also of note was the session on "Electromagnetics in Special Media," organized by Frank Olyslager. His paper, co-authored by I. V. Lindell, "Electromagnetic Fields in Bianisotropic Media," provided a nice overview of an interesting result: fields in decomposable media can be derived from two scalar potentials that satisfy second-order partial differential equations. Closed-form plane-wave solutions, and, in some cases, closed-form Green's dyadics for such media, can be found. In the same session, Nader Engheta presented his paper on "Compact Cavity Resonators Using Metamaterials with Negative Permittivity and Permeability." This included a very clear introduction to such materials, and a particularly intuitive, physics-based derivation of how to use such materials for building compact cavity resonators. Using a two-layer structure, consisting of such a metamaterial in one layer and a conventional dielectric in the other, it was shown that the primary design constraints for a cavity resonator filled with such a structure can be made to depend on the *ratio* of the thicknesses of the two layers, rather than on the total thickness. In theory, this should permit making such components much thinner that is possible with conventional materials.

The papers in the "Antennas" session, chaired by P. H. Pathak and P. D. Smith, dealt mainly with reflector antennas and/or feeds for such antennas of a variety of different electrical sizes. Thus, a diverse range of techniques were employed. The papers by V. Yurchenko, J. A. Murphy, and J.-M. Lamarre ("Optimization of the Coupling of High-Frequency Horn Antenna Array to the ESA Planck Sub-Millimeter-Wave Telescope") and by P. Bolli, V. Natale, R. Nesti, G. Pelosi, G. Tofani, and G. Valsecchi ("Design of 100 GHz Corrugated Horn for ALMA") dealt with radio-astronomy applications, using PO for beam prediction and a hybrid of modal and MoM techniques for feed analysis. In "A Rigorous Approach for Analyzing the Effectiveness of Flanges on Parabolic Reflector Antennas," E. D. Vinogradova and P. D. Smith used the semi-analytical method of regularization to analyze the effects of flanges on reflectors. Corner reflectors with various beam antennas were analyzed numerically (using NEC) by H. M. El Kamchouchi and M. M. Abd El-Wahab in "Log-Periodic Corner Reflector Antenna." In "Mirror Antenna Assembly for Wireless Net," S. Guerouni used standard properties of spherical reflectors to design a microwave network. The optimization of microwave antennas was examined by V. Otevrel and Z. Raida ("Design of Microstrip Antennas: Novel Polytope Algorithms Versus Genetic Optimization") and by L. Boccia, G. Amendola, and G. Di Massa ("A Dual-Frequency Microstrip-Patch Antenna for Global Positioning System"). The first of these papers compared a new optimization approach with genetic algorithms for use with generic microstrip antennas, while the second optimized a patch-antenna design for GPS handsets, subject to the constraints of such systems. Beam steering was considered in two papers: Y.-J. Park, A. Herschlein, and W. Wiesbeck ("Application of Rotationally Symmetric Corrugated Flares to Two-Dimensional Luneburg Lenses") used Luneburg lenses, while L. Boccia, F. Venneri, and G. Di Massa ("A Varactor-Loaded Reflectarray Antenna") used a varactor-loaded array. In the paper by A. A. Lestari, A. G. Yarovoy, and L. P. Ligthart ("Numerical Analysis of Transient Antennas"), the impedance of infinite structures was inferred from frequency-domain analysis of finite (truncated) antennas. The bowtie antenna was examined in detail.

The session on "Radar Imaging and Inverse Scattering" was chaired by O. M. Bucci and A. G. Tijhuis. Special aspects of radar imaging were considered in the first part of this session. Two particularly interesting papers were those by E. G. Pusone, P. van Genderen, and J. S. van Sinttruijen ("A Predictive Model of Sea Backscatter Doppler Spectrum at X-Band Frequencies at Low Grazing Angles," and "Multipath Effects On Polarimetric Radar Response from Sea Backscatter for Low Grazing Angles at X-Band Frequencies"). The second part of the session dealt with electromagnetic inverse scattering. The paper by A. Franchois and A. G. Tijhuis ("Quantitative Microwave Imaging in a Complex Environment") extended existing imaging algorithms to a complex environment. The paper by O. M. Bucci, L. Crocco, and T. Isernia ("A Novel Two-Step Solution Procedure in Inverse Scattering Problems") showed how to extract the significant information from measured data to enhance the efficiency of inverse-scattering algorithms.

Session 14, on "Integral Equation Methods," was chaired by G. Manara and G. Di Massa. In "A Furtivity Problem in Time-Dependent Acoustic Obstacle Scattering," F. Mariani, M. C. Recchioni, and F. Zirilli presented an unconventional approach to the problem of scattering by a passive obstacle. They looked at how the scattering from such an object could be minimized, making the object "furtive." S. Costanzo and G. Di Massa ("Electromagnetic Scattering from Metallic Plates Solved by Improved Spectral-Iteration Technique") presented a solution to the problem of the convergence of the spectral-iteration technique. An original integral-equation formulation for a slot in a finite conducting screen was presented in a paper by V. Volski and G. A. E. Vandenbosch. G. Manara, A. Monorchio, and S. Rosace authored a paper that analyzed the time-domain scattering from arbitrarily shaped dielectric objects, introducing criteria for the stability of the results.

The session on "FSS, Radomes, and Printed Antennas" was chaired by Riccardo Tascone. It was particularly interesting to see a number of newcomers in this area of research. The FSS papers covered a presentation on finite arrays (B. A. Munk, D. S. Janning, G. B. Pryor, and R. J. Marhefka, "Scattering from Surface Waves on Finite FSS"), a synthesis technique (R. Tascone, D. Trinchero, R. Orta, and J. C. Vardaxoglou, "Scattering Approach for the Design of Frequency Selective Surfaces"), and a new application of FSS to high-gain antennas (A. P. Feresidis and J. C. Vardaxoglou, "Double Layer Partially Reflective Surfaces for High-Gain Planar Antennas"). A monolithic radome was treated by J. Sokoloff, S. Bolioli, and P. F. Combes ("Computation of Transmitted and Reflected Fields by a Monolithic Radome Using the Vectorial Multimodal Gaussian Beam Formalism"). L. I. Basilio, J. T. Williams, and D. R. Jackson presented a theoretical paper on "The Characterization of a Slot Discontinuity Between Two Microstrip Patch Conductors." A method for obtaining high gain by using a high-permittivity dielectric layer above a patch antenna was explain in a paper by A. Hoorfar and R. Sun. F. Bilotti, L. Vegni, and A. Alù presented a paper on "Generalized Transmission Line and Helmholtz Equations for the Analysis of Integrated Conformal Antennas and Circuits." L. Vegni, A. Toscano, and F. Bilotti presented a theoretical paper on cavity-backed patch antennas, and Z. N. Chen and M. Y. W. Chia had an applied paper dealing with "Enhanced Radiation Performance of a Suspended Plate Antenna." T. Y. Lee, J. H. Yun, J. D. Park, and K. H. Bae presented a design for a low-SAR mobile-telephone antenna.

The session on "Wireless Communications," organized by Magdy Iskander, covered issues ranging from antenna technology and transmission codes to software for planning wireless networks and for coverage prediction. Magdy Iskander presented a overview of various results obtained by different research groups funded by the National Science Foundation. The paper by V. K. Garg and H. Xu provided a paper on turbo codes. It gave rise to an interesting question that uncovered technical as well as political motivations behind some wireless standards currently in use. L. W. Carstensen, C. E. Bostian, and G. E. Morgan added a different flavor with their description of software for wireless service planning that accounts for geographical, financial, and propagation considerations. A paper by L.

Jofre, B. A. Cetiner, and F. De Flaviis presented a novel, miniature multi-element antenna for application with diversity techniques. W. W. Milroy discussed the application of the continuous transverse stub array to some advanced broadband-access applications. Two papers – by U. G. Crovella, D. Erricolo, and P. L. E. Uslenghi, and by G. D'Elia, D. Erricolo, and P. L. E. Uslenghi – discussed the analysis of propagation measurements, in both the frequency and time domains, carried out on *scale models* of an urban environment. A paper by F. Brunello, D. Disco, D. Gambin, P. Gianola, and G. Lacerenza described a new software tool to help in the prediction of electromagnetic pollution. Magdy Iskander concluded the session with a description of an efficient ray-tracing method for predicting propagation in an urban environment. The results of the method compared well with COST231 measurements taken in the city of Munich.

The two sessions on "Intentional EMI" were organized by Carl Baum, and co-chaired by Fred Tesche and F. Sabath. The sessions were organized into four parts: Sources, Electromagnetic Interaction, General, and Effects. The 22 papers covered a sufficiently broad spectrum that there was "something for everyone." There were many questions and much discussion from the audience. Subjects included HPEM (high-power electromagnetic) environments, HPEM standards, sources, antennas, waveforms, and EM interaction with complex systems. Effects on both military systems and civilian systems were considered.

The session on "Finite Methods and Integral-Equation Methods" was chaired by Atef Elsherbeni. Four papers were presented by authors from Egypt, the US, the Netherlands, the UK, and France. A paper by H. H. Abdullah, F. M. El-Hefnawi, E. A. Hashish, and A. Z. Elsherbeni introduced three different approaches for analyzing dispersive media using the FDTD technique. The dispersive media were described by a multipole Debye relation. The formulation was for three-dimensional problems, and one of the approaches provided a simple iterative procedure for representing multipole Debye dispersive media. The remaining papers dealt with integral-equation formulations. A paper by F. Remis and P. van den Berg presented a Lanczos reduction method for computing three-dimensional static fields in two-dimensional anisotropic media. A paper by S. M. Kirkup presented a simulation technique for designing metallized-film capacitors. The last paper in the session, by N. Bartoli and F. Collinoin, introduced an iterative integral-equation method for solving two-dimensional scattering problems. With simple manipulations of the integral operators, the authors managed to develop an iterative algorithm that involves only real, symmetric matrices. Active discussions took place following the last few talks in the session. Interesting questions about iterative integral-equation techniques were raised. One example of these concerned the feasibility of using one of the presented techniques for objects with sharp edges, or for objects that are not defined by a closed contour.

Figure 3. Weng Cho Chew (l) and P. Pirinoli in the session on "Novel Methods on Computational Electromagnetics."

The session on "Novel Methods in Computational Electromagnetics" was organized and chaired by Weng Cho Chew (Figure 3). It started with two papers about the Multilevel Fast Multipole Algorithm (MLFMA) and its derivatives, which is one of the most-efficient approaches for analyzing three-dimensional large scattering problems involving a very large number of unknowns. In the first paper, by W. C. Chew, B. Hu, and Y. C. Pan, a derivative of MLFMA, called the Fast Inhomogeneous Plane Wave Algorithm (FIPWA), was implemented for multilayered media. This was done using the Sommerfeld integral with steepest-descent evaluation to compute the Green's function, instead of the complex image approach that had been used in previous implementations. The cost of analyzing a layered medium resulted only in a marginal increase in CPU time and memory usage, compared to the free-space algorithm. In the second paper, by J. S. Zhao and W. C. Chew, the Low-Frequency MLFMA (LF-MLFMA) was implemented with a loop-tree basis. A Method of Moments discretization of the EFIE, with loop-star or loop-tree sets of basis functions, separated the contribution of the vector potential from that of the scalar potential, avoiding the breakdown of the EFIE at low frequencies. The third paper, by S. Wang, F. L. Teixeira, R. Lee, and J.-F. Lee, addressed the optimization of sub-gridding schemes in the Finite-Difference Time-Domain (FDTD) method. In order to efficiently solve complex problems with FDTD, different cell sizes must be used in different regions. In this paper, the FDTD coefficients were optimized in order to minimize wave reflections at the boundary between cells of different sizes. In the paper by R. Schuhmann, T. Wittig, I. Munteanu, B. Trap, and T. Weiland, several novel techniques to enhance the efficiency of electromagnetic simulations of highly resonant RF devices were reported. These algorithms allowed reliable computation with Q factors of the order of millions: results which could not even be estimated using conventional techniques. UHF radiowave propagation in urban environments was addressed in the paper by C. Brennan, P. J. Cullen, and J. Volakis. A simplified two-dimensional model, consisting of perfectly conducting screens, was analyzed, using a smart nested version of the forward/backward iterative technique together with the Fast Far-Field Algorithm (FAFFA). The sixth paper, by J. M. Rius and J. R. Mosig, dealt with the use of multilevel matrix-decomposition algorithms (MLMDA) and a macro-basis-function method for analyzing printed antennas. The paper showed that the combined use of both methods could produce a more efficient algorithm. The method suggested the use of RWG basis functions to approximate the equivalent currents in the MLMDA approach. A paper by G. Vecchi, P. Pirinoli, F. Vipiana, L. Matekovits, and M. Orefice reported on the role of the spectral properties of the MoM basis function in affecting the condition number of the MoM matrix, using printed antennas as a study case. It was shown that the use of entire-domain basis functions gave rise to MoM matrices with diagonal terms that were in good agreement with the singular values of the matrix, yielding a nice way to pre-condition the matrix. A multi-resolution (MR) scheme to generate an entire-domain basis, as well as a hybrid scheme, were proposed. It was shown that these schemes could predict the singular values of the MoM matrix very well. The last paper, by S. Velamparambil and W. C. Chew, reported on large-scale computing by the parallelization of the Multilevel Fast Multipole Algorithm (MLFMA). The parallelized, highly scaleable code was called *ScaleME*. A new algorithm that reduced both memory usage, as well as communication cost, was proposed. Due to the highly scaleable nature of the new algorithm, it can solve for the scattering solution of a full-size aircraft at 8 GHz (over 400 wavelengths long), as well as solving for the solution of scattering problems involving over 10 million unknowns.

One session had the title "Electromagnetic Theory" in the program, but was perhaps more descriptively titled "Electromagnetic Properties of Materials and Plasma-Wave Interaction" in the conference *Proceedings*. It was chaired by V. Perevodchikov and Fred Tesche. The paper by V. Volpi, M. Apra, M. D'Amore, M. S. Sarto, and A. Scarlatti dealt with lightning. To establish the effective capability of an aircraft to withstand the lightning environment, Alenia Aeronautica, in collaboration with the Electrical Engineering Department of "La Sapienza" University, Rome, have developed the electromagnetic simulation tool *VAM-LIFE* (Virtual Aircraft electroMagnetic Lightning Indirect effect Evaluation). The aim of the tool is to predict all physical phenomena related to the interaction of lightning with an aircraft, and to evaluate the indirect lightning effects on a full three-dimensional digital model of an aircraft. The tool, approved by the Italian aeronautic authority, has been successfully used for indirect lightning-effect certification of the C-27J tactical transport aircraft. A paper by R. Mazar and A. Bronshtein, "Reference-Wave Solutions for the High-Frequency Fields Propagating in Random Media," used ray theory to determine the propagation properties of high-frequency fields and their statistical measures in complicated random environments. According to the ray approach, the field at the observer can be synthesized from a variety of field species arriving along multiple-ray trajectories, resulting from refraction and scattering from boundaries and scattering centers embedded in the random medium. For computations of the statistical measures, it is therefore desirable to possess a solution for the high-frequency field propagating along an isolated ray trajectory. To do this, a new reference-wave method was developed to obtain an approximate solution of the parabolic wave equation. The paper by R. Guinvarc'h, B. Uguen, and C. Chassay described modeling of the propagation through a discrete random medium. A model was developed based on the observation of simulations of clouds of dipoles, computed with the Method of Moments. A Bayesian framework, applied to a feed-forward neural network, was then used to improve the generalization capacity of the network performing the interpolation of the main parameter in the model. The properties of an epoxy resin that included titanium dioxide and carbon particles were studied at 50-110 GHz by T. Soh and O. Hashimoto. Their goal was to realize a millimeter-wave absorber coating that has good durability for outside use. They confirmed that a millimeter-wave absorber, having a maximum absorption of over 23 dB, and showing absorption of more than 20 dB over a bandwidth of 5 GHz, can be realized using epoxy resin incorporating titanium dioxide of 32 phr (parts per hundred parts of resin) and carbon particles of 1 phr. A paper by S. Collardey, P. Pouliguen, A-C. Tarot, and K. Mahdjouhi described a method for extracting the reflection coefficients of photonic bandgap (PBG) materials from radar cross section (RCS) data. The proposed technique allowed identification of the PBG characteristics when the structures were illuminated by a plane wave with varying angles of incidence. V. Perevodchikov, P. Borovikov, S. Cusev, M. Zavialov, Yu. Kuznetsov, A. Shapiro, and P. Tyuryukanov reported on the results of the development of a new type of powerful broadband microwave tube: a plasma-filled traveling wave tube (TWT). The physical principles of the device were presented, along with the problems of its design and construction, and the main characteristics and quality of the signal amplification achieved. In continuous operation, the plasma TWT had a power output of 10-25 kW over a frequency bandwidth of 25-30%. This is significantly better than that of a vacuum TWT.

The session on "EM Modeling of Devices and Circuits" was chaired by R. Orta and Z. Raida. The spectrum of presentations ranged from novel modeling techniques (including the analysis of waveguide discontinuities by the MOM/BI-RME method, in a paper by M. Bozzi, F. Bruni, and L. Perregrini) to practically oriented papers (the EM design of comb filters, in a paper by G. G. Gentili, G. Macchiarella, V. Minerva, and M. Politi, and stepped twisted rectangular waveguide transitions for feeding networks, in a paper by R. Tascone, R. Orta, M. Baralis, A. Olivieri, and O. A. Peverini). Attention was given to nano-technologies (in a paper by A. Neto, P. Focardi, and W. R.

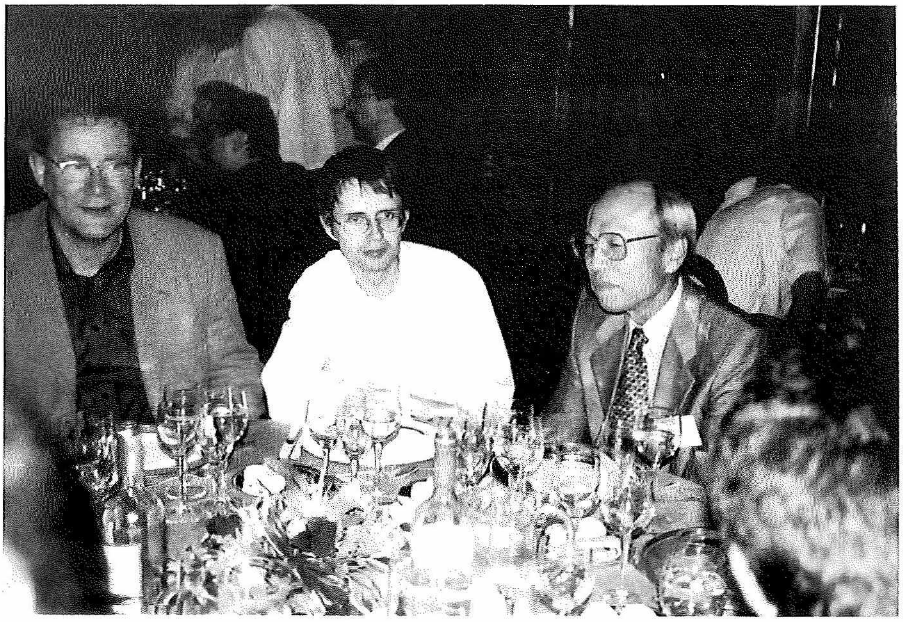

Figure 4. (l-r) Anton Tijhuis, Frank Olyslager, and J-W Ra at the ICEAA banquet.

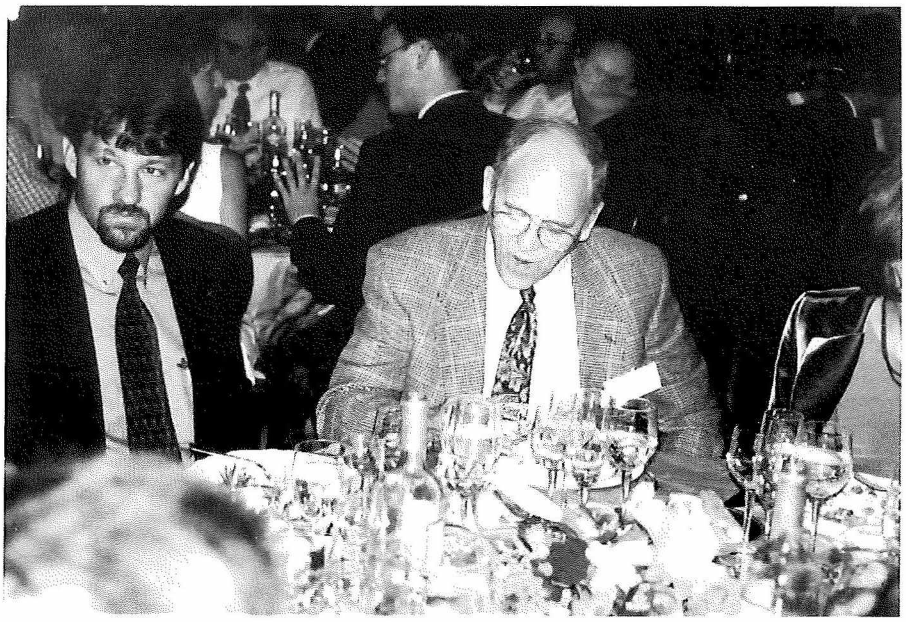

Figure 5. (l-r) Jeff Williams and Don Wilton at the banquet.

Mc Grathseries, on series-fed coplanar waveguide embedding circuits). The improvement of liquid-crystal displays was examined using a reduced-order modeling technique for the analysis of anisotropic media in a paper by O. A. Peverini, D. Olivero, C. Oldano, R. Orta, R. Tascone, D. K. G. de Boer, and R. Cortie. The application of neural-network techniques to the electromagnetic optimization of the shape of planar transmission lines of atypical cross section was described in a paper by Z. Raida. A device with an innovative design was presented in a paper by R. Tascone, D. Trinchero, R. Orta., A. Olivieri, M. Baralis, and O. A. Peverini: a waveguide hybrid phase discriminator, to be flown on the International Space Station. The main trend common to most presentations in this session was the exploitation of sophisticated numerical techniques. Primarily, various Moment Methods were adopted and modified in an original manner, in order to obtain better efficiency and accuracy. As a result, rather complicated devices and circuits could be numerically modeled using today's PCs.

On the last evening of the conference, an excellent banquet was held (Figures 4, 5). It was representative of the outstanding hospitality provided for the attendees. One other, very important aspect of this meeting is that it has always been held in Torino. Torino is a wonderful city, combining a long and fascinating history; one of the leading engineering universities in Europe; a renown center of industrial engineering; beautiful and interesting buildings, churches, monuments, and parks; excellent food; and the marvelous hospitality of the people of Piedmonte. Many of the attendees were able to find time to enjoy this unique city. The ICEAA will again be held in Torino in September, 2003. I urge you to consider attending.

A comprehensive *Proceedings of the International Conference on Electromagnetics in Advanced Applications (ICEAA 01)* is available, in both a printed version (ISBN 88-8202-098-3; 932 pp) and on CD-ROM (ISBN 88-900636-9-6). Information on ordering either version can be obtained from the Conference Secretariat: COREP - ICEAA 01, Politecnico di Torino, corso Duca degli Abruzzi 24, 10129 Torino, Italy; Tel: +39-011-564-5103; Fax: +39-011-564-5199; E-mail: iceaa@polito.it.

This report incorporated substantial contributions regarding the sessions they chaired from Carl Baum, O. M. Bucci, Weng Cho Chew, Danilo Erricolo, Roberto Graglia,, G. Di Massa, G. Manara, Renato Orta, V. Perevodchikov, P. D. Smith, Riccardo Tascone, Fred Tesche, and Anton Tijhuis. Their contributions are gratefully acknowledged. A similar version of this report appeared in the *IEEE Antennas and Propagation Magazine*, Vol. 43, No. 5, October 2001, pp. 108-112.

W. Ross Stone
E-mail: r.stone@ieee.org

THE SPECIALIST MEETING ON MICROWAVE REMOTE SENSING '01

Boulder, CO, USA, 5 - 9 November 2001

The Specialist Meeting on Microwave Remote Sensing'01 was held in Boulder, Colorado, on November 5-9, 2001. This meeting combined the 8th International Union of Radio Science (URSI) Commission F Symposium on Microwave Remote Sensing of the Earth, Oceans, Ice, and Atmosphere and the 7th Specialist Meeting on Microwave Radiometry. Both of these meetings have been conducted on a regular basis since the late 1970's. Papers presented during the 2001 meeting illustrated state-of-the-art international remote sensing techniques and applications using microwave radar and radiometry - from spacebar, airborne, and surface-based platforms. Both oral and interactive sessions were held on the following topics: Radar and Radiometric Polarimetry, including Imaging; Radar and Radiometric Calibration; Advanced Instrument Techniques; Satellite Remote Sensing of the Land Surface and Vegetation; Ground-based Remote Sensing of the Atmosphere and Ocean; Satellite; Radiometric/Radar Modeling of Scattering Emission, and Radiative Transfer, and Special Campaigns and Field experiments.

Roughly 150 participants from 20 countries attended and a number of leading microwave specialists presented papers representing their state-of-the-art research. The keynote presentation was given by Dr. Albin Gasiewski of National Oceanic and Atmospheric Administration's Environmental Technology Laboratory (ETL) and the conference banquet speaker was Dr. Michael Glantz or the National Center for Atmospheric Research's Environmental and Societal Impacts Group. The meeting was organized by Dr. Ed R. Westwater of the Environmental Technology Laboratory's joint institute partner, the Cooperative Institute for Research in environmental Sciences, University of Colorado, and Dr. Jothiram Vivekanandan of the National Center for Atmospheric Research (NCAR) At the end of the conference, special tours of local facilities were made. These included ETL (polarimetric radiometers), NCAR (aircraft icing prediction) and Radiometrics Corporation (construction of microwave radiometers). Detailed information on the conference is available on the website: http//www.etl.noaa.gov/mrs01.

In addition to Commission F of URSI, sponsors of the meeting included: the IEEE Geoscience and Remote Sensing Society (GRSS), NOAA, NCAR, and the National Aeronautics and Space Administration. Selected papers of the conference will be published in an upcoming special issue of Radio Science.

Session Summaries

Radar and Radiometric Polarimetry, including Imaging
In addition to the keynote talk by Dr. Gasiewski on "Airborne vectorized microwave imaging of the Earth", 6 additional oral arid 4 interactive presentations were made on SAR, DSMP SSM/I. , and other polarimetric and imaging instruments.

Radar and Radiometric Calibration
Ten oral and 2 interactive presentations were made, with several devoted to calibration of synthetic aperture radiometers. Other topics included calibration of FMCW millimeter wave radars, SAR and polarimetric radars.

Advanced Instrument Techniques
Eighteen oral and 4 interactive presentations were made, with almost equal emphasis on radiometric and radar techniques. In radiometric several papers described polarimetric and synthetic aperture instruments for remote sensing of the Earth's surface. Several radar papers outlined techniques for measuring rain from ground-, aircraft- and space-based platforms.

Ground-based Remote Sensing of the Atmosphere and Ocean
Twenty one oral and 10 interactive papers were given describing both radiometric, GPS, and radar techniques. Geophysical parameters that are sensed include sea spikes; foam and ocean roughness; sea-air temperature difference; boundary layer turbulence; atmospheric temperature, water vapor, cloud liquid, and rain; refractivity parameters; satellite validation.

Satellite Remote Sensing of the Land, Surface, and Vegetation
Ten oral and 1 interactive papers were presented and topics included modeling of land surface processes; remote sensing of soil moisture, forests, snow; and AMSUoperational hydrological products.

Satellite Remote Sensing of the Atmosphere and Ocean
Satellite remote sensing of the ocean and atmosphere is now a very mature, but active, science, as evidenced by 20 oral and 12 interactive presentations. Topics included precipitation and hurricane monitoring, joint GPS and satellite water vapor measurements, data assimilation of satellite data into forecast models sensing of wind speed and direction, salinity, sea surface temperature, and surface velocity in rivets.

Radiometric/Radar Modeling of Scattering, Emission, and Radiative Transfer
The derivation of geophysical parameters from remote measurements depends strongly on models that relate these parameters to the radiometric, GPS, or radar measurements. Sophisticated models describing electromagnetic interactions with the ocean surface, soil, ice, rain, snow, and water vapor were presented in the 16 oral and 9 interactive papers of this session.

Special Campaigns and field Experiments
Several papers in this session were devoted to the Tropical Rainfall Monitoring Mission; other topics included a European campaign (wise-2000) for salinity measurements, a cold-land processes experiment, and arctic water vapor measurement. Three interactive and 6 oral papers were presented.

In addition to the Specialist Meeting, several related meetings were held in Boulder during the same week, including a meeting on Radio Frequency Interference hosted by NOAA NESDIS, a planning meeting for the upcoming Cold Land Processes Experiment, and a workshop organized by NOAA/NASDA (National Space Development Agency of Japan) on Microwave Algorithms. The RFI meeting provided a forum for users of NOAA satellite data to develop criteria for frequency allocations to be proposed at upcoming World Radio Conferences.

Ed R.Westwater
Email: Ed.R.Westwater@noaa.gov
and J. Vivekanandan
Email: vivek@ucar.edu

Radio Africa 2001

Cape Coast, Ghana, 5 - 9 November 2001

The international workshop on Radio Digital Communication Network for Sustainable Development in Africa was the fourth Regional Workshop on Radio Communication to be held at the University of Cape Coast. The workshop was organised from 15th – 19th October, 2001 which was jointly organised by Laser and Fibre Optics Centre and Computer Science Centre of the University of Cape Coast as well as Electrical and Electronic Engineering Department of the Kwame Nkrumah University of Science and Technology, Kumasi Ghana. Such organisation was in collaboration with Abdus Salam International Centre for Theoretical Physics, ICTP, Trieste, Italy and the International Union of Radio science. (URSI).

The workshop was sponsored by URSI, ICTP, National Computer Systems (NCS), Ghana Telecommunication Company, Volta River Company, National Communication Authority, DDB Media One Co. Ltd., Centre for Scientific and Industrial Research (CSIR), Millicom and Ghana Civil Aviation Authority.

The workshop was opened to Scientists, Policy makers, Planners and Engineers working and involved in planning, co-operation, research or training in the area of radio communications or related fields from both the public and private sectors.

The workshop, at the opening ceremony, on the 15th October, 2001 was chaired by Mr. Kwabena Sarpong-Anane of Ghana Broadcasting Company and the keynote address was given by the Deputy Minister of Communications and Technologies. The Welcome Address was delivered by the Vice Chancellor of the University of Cape Coast.

The Workshop itself was attended by lecturers, one each from India, Nigeria, Ghana, and Kenya. There were 31 Ghanaian participants in all from universities, industries and companies including the foreign participants from Nigeria, Kenya, Liberia USA were present.

Broad areas such as Antenna and Radio propagation, frequency management and utilisation, mobile communication, optical communication and satellite communication were covered.

In all each-sub committee and the secretarial staff worked very hard to make the workshop a big success as the participants could testify. We are most grateful to NCS, Ghana Telecommunication and national Communication Authority for their assistance in organising this workshop. Excellent Hotel services were provided including audio visual equipment for the various paper presentation.

P.K. Buah Bassuah
Email: lafoc@ncs.com.gh

CONFERENCE ANNOUNCEMENT

BIANISOTROPICS 2002

Marrakech, Morocco, 8 - 10 May 2002

The 9th International Conference on Electromagnetics of Complex Media, Bianisotropics 2002, will be held in Marrakech, Morocco. Authors are invited to submit papers on any aspect of electromagnetics relating to complex media. The scope of the meeting encompasses a broad spectrum from fundamental theoretical work to technological applications for novel devices from the microwaves to the optical regime.

The conference will comprise 5-6 half-day sessions on a variety of research concerned with theory and applications of composite and complex media pertaining to electromagnetics (i.e., chiral media, pseudochiral media, anisotropic media, bianisotropic media, temporally agile media,nonlocal media, nonlinear media, random media, metamaterials, photonic bandgap materials, multifunctional materials, functional gradient materials, piezo-electric, ferroelectric thin films...).

The programme will include special talks by key speakers, oral and poster sessions with contributed papers and discussions on hot topics bringing together engineers, physicists, applied mathematicians,material scientists from Research Institutes, Universities and Industries. Furthermore, a panel discussion will be conducted by the committee members to scrutinise most recent research.

Topics of the conference include, but are not limited to:

- Electromagnetic theory of bianisotropic media
- Radiation and propagation of electromagnetic waves in chiral and bianisotropic media
- Waveguides and printed structures using chiral and bianisotropic media
- Scattering by bodies with complex media and complex shapes
- Inverse scattering techniques for complex materials
- Electromagnetics of nonlinear media
- New microwave and optical devices using complex media
- Modeling and applications of composite materials
- Experimental research on complex composite materials

Contact information

Dr. S. Zoudhi
Conference Chairman
E-mail : sz@ccr.jussieu.fr
http://www.ccr.jussieu.fr/bian02

ENDOGENOUS PHYSICAL FIELDS IN BIOLOGY

Prague, Czech Republic, 1 - 3 July 2002

The international symposium on Endogenous Physical Fields in bIology is organized under the aegis of URSI Commission K and of the URSI National Committee of the Czech Republic

Topics

- Biological structures generating electromagnetic fields, experimental evidence
- Effects of external electromagnetic fields on living matter
- Medical applications

Contact

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Institute of Radio Engineering and Electronics
Chaberska 57, CZ - 182 51 Prague 8
Czech Republic
Tel: +420 2 688 1804
Fax: +420 2 688 0222
E-mail: pokorny@ure.cas.cz
http://ww.ure.cas.cz/events/epfb2002

ISAR-3

Trieste, Italy, 25 November - 13 December 2002

The Third International School on Atmospheric Radar (ISAR-3) will he held at the Abdus Salam International Centre for Theoretical Physics in Trieste, Italy.

Over the past decades the application of radar techniques to study the structure and dynamics of the mesosphere, stratosphere and the troposphere has continuously grown and quite a few new systems of this kind have been added in the past years. This MST - radar technique has even evolved into applications for operational meteorology, which have become known as wind profiling.

The wide-spread applications of these radars for scientific research of the atmosphere and for meteorological operations demand a proper knowledge of such atmospheric radar systems, and of the analysis, validation and interpretation of the acquired data. The school ISAR-3 is held for the purpose of training young researchers and students, who are active in or have a proven relation to this area, or can certify a solid interest and a sound perspective on this research and the technique.

The school will cover the following subjects: Fundamentals of atmospheric radar, hardware and basics of signal acquisition, data analysis and validation, special applications such as interferometry, scattering of radar waves, atmospheric winds, waves and turbulence, meteorology of the troposphere and stratosphere, mesosphere and the aeronomy of the lower ionosphere.

Distinguished lecturers from the MST radar community will be available for teaching and training. The school will be held at the impressive premises of the Abdus Salam International Centre for Theoretical Physics (ICTP) in Trieste, northern Italy. Students from third-world and developed countries, who can verify the mentioned requirements, are invited to apply to ICTP for admittance to the school and for funding support. The required format of such applications will be issued as an ICTP publication and in the Second Announcement of ISAR-3.

The ISAR-3 directors are: Professors J. Röttger, D.N. Rao, and S. Radicella. ISAR-3 is sponsored by the Abdus Salam International Centre for Theoretical Physics (ICTP), the Scientific Committee on Solar Terrestrial Physics (SCOSTEP) and the International Union of Radio Science (URSI).

Visit **www.ictp.trieste.it** for more and future information.

URSI CONFERENCE CALENDAR

May 2002

Bianisotropics 2002 - 9th International Conference on Electromagnetics of Complex Media

Marrakech, Morocco, 8-10 May 2002

Contact: Dr. A. Ghammaz, University Cadi Ayyad, FSTG Guéliz - Marrakech, B.P. 618 Av. Abdelkrim Khattabi, Marrakech, Morocco, Tel: +212-4 44 43 31 61, Fax.: +212-4 4 43 31 70, Email : ghammaz@fstg-marrakech.ac.ma, and Dr. S. Zouhdi, LGEP-Supelec, Plateau du Moulon, 91192 Gif sur Yvette Cedex, Tel : +33-1 69 85 16 32, Fax. : +33-1 69 41 83 18, Email : sz@ccr.jussieu.fr, http://www.ccr.jussieu.fr/bian02/

Third URSI International Commission G High Latitude Ionosphere Symposium

Fairbanks, Alaska, USA, 15-19 May 2002

Contact : Dr. Robert Hunsucker, Oregon Institute of Technology, Electronic Engineering Technology, 3201 Campus Drive, Purvine Building, Room PV282, Klamath Falls, OR 97601, USA, Tel: +1 541-885-1515, Fax:+ 1 541-885-1666, E-mail: hunsuckr@oit.edu@aol.com

EMC 2002

Beijing, China, 21-24 May 2002

Contact: Prof. L. Dayong, EMC 2002 Secretary, Chinese Institute of Electronics, P.O. Box 165, Beijing 100036, China, Tel: +8610 68283463, Fax: +861068283458, E-mail: dyliu@public.bta.net.cn, http://www.cie-china.org/emc2002

June 2002

AMEREM 2002 Symposium

Maryland, USA, 2-7 June 2002

Contact: Dr. Terence J. Wieting, Naval Research Laboratory, Washington, DC, Fax: +1 202-767-6980, E-Mail: terence.wieting@nrl.navy.mil, http://www.amerem.org

EUSAR 2002

Cologne, Germany, 4-6 June 2002

Contact: Dr. Richard Klemm, FFM-FGAN, Neuenahrer Strasse 20, D-53343 Wachtberg, Germany, Fax: +49 229 9435 618, Email: r.klemm@fgan.de, http://www.fhr.fgan.de/eusar/

EMC Wroclaw 2002
Wroclaw, Poland, 27-30 June 2002
Contact: Mr. W. Moron, EMC Symposium, Box 2141, 51-645, Wroclaw 12, Poland, Tel: +4871-348-3051, Fax: +4871-372-8878, Email: emc@il.wroc.pl, http://www.emc.wroc.pl

July 2002

Endogenous Physical Fields in Biology
Prague, Czech Republic, 1-3 July 2002
Contact: J. Pokorny, Symposium Office, Institute of Radio Engineering and Electronics, Chaberska 57, Prague 8, Czech Republic, Tel: +420 2 6881804, Fax: +420 2 6880222, Email: pokorny@ure.cas.cz, http://www.ure.cas.cz/events/epfb2002

August 2002

URSI General Assembly 2002
Maastricht, The Netherlands, 17-24 August 2002
Contact: Dr. Leon P.J. Kamp, Eindhoven University of Technology, Department of Applied Physics, P.O. Box 513, NL-5600 MB Eindhoven, The Netherlands, Tel: +31 40-2474292, Fax: +31 40-2445253, Email: URSI2002@tue.nl, http://www.URSI-GA2002.nl/

September 2002

EMC Europe 2002 - International Symposium on Electromagnetic Compatibility
Sorrentino, Italy, 9-13 September 2002
Contact: EMC Europe 2002 Secretariat, AEI Ufficio Centrale, Piazzale R. Morandi 2, 20121 Milano, Italy, Phone: +39-02-77790-205/218, Fax: +39-02-798817, E-mail: emceurope 2002@aei.it,http://www.aei.it/emceurope2002.html

October 2002

World Space Congress 2002, 34th COPSPAR Scientific Assembly
Houston, Texas, USA, 10-19 October 2002
Contact: COSPAR Secretariat, 51 bd de Montmorency, 75016 Paris, France, Tel: +33 1 4525 0679, Fax: +33 1 4050 9827, E-mail:cospar@cosparhq.org,Internet:http://www.copernicus.org/COSPAR/COSPAR.html

November 2002

12th International Symposium on Antennas (JINA 2002)
Nice, France, 12-14 November 2002
Contact: Secrétariat JINA 2002, France Télécom R&D, Fort de la Tête de Chien, 06320 La Turbie, France, Fax: +33 4 9210 6519, E-mail: jina.cnet@wanadoo.fr, Internet: http://www. jina2002.com

APMC2002, Asia-Pacific microwave Conference
Kyoto, Japan, 19-22 November 2002
Contact: Prof. Shozo Komaki, Chair, Steering Committee, c/o Realize Inc., 4-1-4 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan, Tel: +81-3-3815-8590, Fax: +81-3-3815-8529, Email: mweapmc@bleu.ocn.ne.jp, http://www.apmc-mwe.org

URSI cannot be held responsible for any errors contained in this list of meetings.
Do you wish to announce your meeting in this Calendar? More information about URSI-sponsored meetings can be found on our Homepage at : http://www.intec.rug.ac.be/ursi/Rules.html

UTC Time Step

On n'introduira pas de seconde intercalaire à la fin de juin 2002.
La différence entre UTI et le Temps Atomique International TAI est :
du 1er janvier 1999, 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 June 2002.
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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News from the URSI Community

NEWS FROM THE MEMBER COMMITTEES

UNITED KINGDOM & IRELAND

UK - IRELAND SYMPOSIUM CELEBRATES MARCONI'S FIRST TRANSATLANTIC TRANSMISSION

(l - r) Prof. M. Sexton, Prof. P. Cannon, Prof. Sir Bernard Lovell

A UK-Ireland Symposium took place on 11th and 12th December 2001, hosted by the centre for RF Propagation and Atmospheric Research (CPAR) at QinetiQ, Malvern. This coincided with the 100th anniversary celebrations of the first Transatlantic Wireless Transmission by Guglielmo Marconi.

A special event amateur radio station was set up with call-sign GB4QQ as part of the Anniversary Celebrations. This gave some of the delegates (several of whom are licensed amateurs) a chance to pass on their greetings to GB100GM at the Marconi Transmitter site at Poldhu, Cornwall and other stations around the world. Radio operators made contact with almost 200 amateur radio stations in six continents – including about thirty stations in Canada and the USA.

Professor Sir Bernard Lovell, the former director of Jodrell Bank Radio Telescope, was guest speaker at the symposium. He gave an illuminating talk on the development of radar (much of which was carried out at Malvern during the Second World War) and on Radio Astronomy.

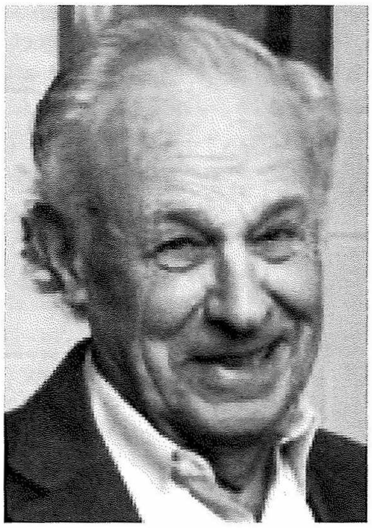
Professor Lovell, seen in the photograph (above), later took the microphone to send a greetings message to the Poldhu Amateur Radio Club. He was followed by several other active members of URSI. Sitting behind Sir Bernard is the symposium organiser, Prof. Paul Cannon, QinetiQ Fellow and Professor of Communications Systems and Atmospheric Research at Bath University. Prof. Michael Sexton (who gave the keynote address) of the Royal Irish Academy, Dublin, is standing on the left.

A magnificent collection of vintage radio sets was also displayed including a crystal set from a 1917 WWI seaplane and an early Marconi V2 'bright emitter' receiver from 1922.

Millett G. Morgan
1915-2002

Prof. Millett G. Morgan, founder of the Radiophysics Laboratory at Dartmouth's Thayer School of Engineering and a leading researcher in the field of ionospheric physics, died on January 14, 2002, at the Dartmouth-Hitchcock Medical Center in Hanover, New Hampshire, after suffering a heart attack and a stroke.

In the early 1950s, Prof. Morgan established a research program to use the newly discovered phenomena of naturally occurring audio-frequency radio waves, produced by lightning and the aurora, as a tool to study the properties of space plasma in the vicinity of the Earth, a region now known as the upper ionosphere and the magnetosphere. These studies made it possible to gain insights about the properties of this region of near-Earth space in the years before spacecraft began to make direct observations. Prof. Morgan recorded the naturally occurring signals, referred to by descriptive names such as "whistlers" and the "dawn chorus," at a network of receiving stations, and interpreted them to obtain some of the earliest measurements of the density of free electrons many thousands of kilometers above the Earth. His work provided experimental foundations for early studies of how the Earth and its magnetic field interact with the solar wind.



During the International Geophysical Year (IGY, 1957-8) Prof. Morgan chaired the US National Committee's Panel on Ionospheric Research of the National Research Council, which oversaw radio studies conducted all around the Earth. In early 1958, he joined the re-supply mission to the US Antarctic station on the Weddell Sea as the senior scientific representative. In his own IGY research he maintained an extensive series of stations throughout the Americas.

In studies in the late 1940s and early 1950s, at a field station that he established near his home in Hanover, New Hampshire, Prof. Morgan and his colleagues conducted radar studies to experimentally observe the two modes of propagation that magneto-ionic theory predicted would occur when a radio wave enters the ionosphere. In the 1980s, Professor Morgan built a network of radar observing stations to conduct studies of gravity waves that propagate to lower latitudes from the arctic. The waves appear as propagating undulations in the lower layers of the ionosphere.

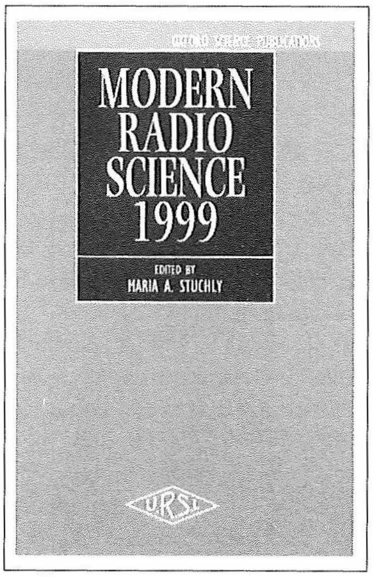
A long-time "ham" radio operator (W1HDA), Prof. Morgan first developed his life-long interest in radio as a teenager, growing up in Hanover, New Hampshire. He studied at the Clark School in Hanover, where his father, mathematician Frank M. Morgan was Head Master. He earned a BA in Physics in 1937, and an MSc in Electrical Engineering in 1938, at Cornell University. He began further graduate studies in electrical engineering at Stanford, and earned the "Engineer" degree in 1939. He interrupted his graduate studies during the Second World War to work on the development of X-band radars for destroyer-escort vessels at the Submarine Signal Company in Boston, MA, and to develop radar countermeasures at the California Institute of Technology in Pasadena, CA. In 1946, he completed his PhD in electrical engineering at Stanford. After a year in the Naval Antenna Group at UC Berkeley, he joined the faculty of the Thayer School of Engineering at Dartmouth College in 1947, where he continued for the balance of his career. In 1971, he became the first occupant of the Sydney E. Junkins Professorship.

Prof. Morgan is widely credited with leading the early development of graduate research at the Thayer School, where he and his colleagues and graduate students ran an active program of research and published widely in the scientific literature. For many years, he taught courses in electromagnetic field theory, antenna design, magneto-ionospheric physics, and related topics. Prof. Morgan was a fellow of the IEEE, a member of the American Geophysical Union, and of Sigma Xi, the Scientific Research Society. He was active in URSI Commissions G and H for more than 40 years, both in the US and at many URSI General Assemblies.

Prof. Morgan married Eleanor Walbridge of Enfield, New Hampshire, in 1937. He is survived by his beloved wife of sixty-five years, and their four children: M. Granger Morgan of Pittsburgh, PA; Deborah Morgan Olsen of Tigard, OR; Janet E. Morgan of Ithaca, NY; and Jessica Ryder (formerly Beverly S. Morgan) of North Attleboro, MA. He is also survived by five grandchildren and three great-grandchildren.

[Material for the above was taken from an obituary written by Millett Granger Morgan, e-mail: gm5d@andrew. cmu.edu.]

URSI Publications



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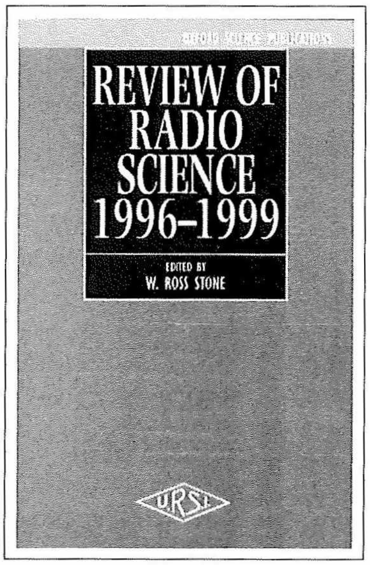

Review of Radio Science 1996-1999

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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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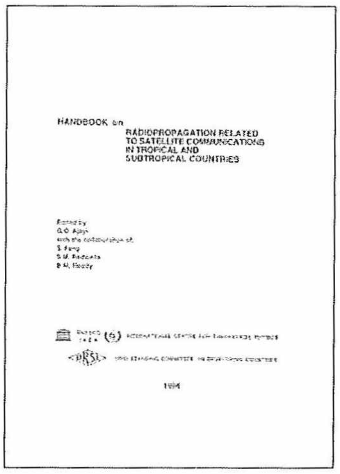

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SPECIAL OFFER TO URSI CORRESPONDENTS

AIMS AND SCOPE

The *Journal of Atmospheric and Terrestrial Physics* (JASTP) first appeared in print in 1951, at the very start of what is termed the "Space Age". The first papers grappled with such novel subjects as the Earth's ionosphere and photographic studies of the aurora. Since that early, seminal work, the Journal has continuously evolved and expanded its scope in concert with - and in support of - the exciting evolution of a dynamic, rapidly growing field of scientific endeavour: the Earth and Space Sciences. At its Golden Anniversary, the now re-named *Journal of Atmospheric and Solar-Terrestrial Physics* (JASTP) continues its development as the premier international journal dedicated to the physics of the Earth's atmospheric and space environment, especially the highly varied and highly variable physical phenomena that occur in this natural laboratory and the processes that couple them. The *Journal of Atmospheric and Solar-Terrestrial Physics* is an international journal concerned with the inter-disciplinary science of the Sun-Earth connection, defined very broadly. The journal referees and publishes original research papers, using rigorous standards of review, and focusing on the following: The results of experiments and their interpretations, and results of theoretical or modelling studies; Papers dealing with remote sensing carried out from the ground or space and with in situ studies made from rockets or from satellites orbiting the Earth; and, Plans for future research, often carried out within programs of international scope. The Journal also encourages papers involving: large scale collaborations, especially those with an international perspective; rapid communications; papers dealing with novel techniques or methodologies; commissioned review papers on topical subjects; and, special issues arising from chosen scientific symposia or workshops. The journal covers the physical processes operating in the troposphere, stratosphere, mesosphere, thermosphere, ionosphere, magnetosphere, the Sun, interplanetary medium, and heliosphere. Phenomena occurring in other "spheres", solar influences on climate, and supporting laboratory measurements are also considered. The journal deals especially with the coupling between the different regions. Solar flares, coronal mass ejections, and other energetic events on the Sun create interesting and important perturbations in the near-Earth space environment. The physics of this subject, now termed "space weather", is central to the Journal of Atmospheric and Solar-Terrestrial Physics and the journal welcomes papers that lead in the direction of a predictive understanding of the coupled system. Regarding the upper atmosphere, the subjects of aeronomy, geomagnetism and geoelectricity, auroral phenomena, radio wave propagation, and plasma instabilities, are examples within the broad field of solar-terrestrial physics which emphasise the energy exchange between the solar wind, the magnetospheric and ionospheric plasmas, and the neutral gas. In the lower atmosphere, topics covered range from mesoscale to global scale dynamics, to atmospheric electricity, lightning and its effects, and to anthropogenic changes. Helpful, novel schematic diagrams are encouraged. Short animations and ancillary data sets can also be accommodated. Prospective authors should review the *Instructions to Authors* at the back of each issue.

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